431 Quiz 3

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Corrections Since the original posting of this Quiz, Dr. Love has corrected small typos in **Questions 11 and 32**.

0.1 Introduction

You must complete this quiz by **Noon on Tuesday December 12**. The documents you will need to take the Quiz include this PDF document, and the Google Form located at https://goo.gl/forms/yj5YuBusGF7hVvnx1 where you will submit your answers.

This document is **35** pages long. Be sure you have all of the pages.

Please *select* or type in your best response for each of the 40 questions. The questions are not arranged in order of difficulty, and you should answer all of them. Some questions will require a few minutes of work, others you should be able to answer almost instantly. Some questions (include the last seven questions on the Quiz) require you to code in R to obtain answers, others provide all necessary output in this document. Each question is worth 3 points for a potential total score of 120.

In addressing questions involving R code, you may assume that Love-boost.R and the tidyverse packages have been pre-loaded.

Assume 5% significance in two-sided testing unless otherwise specified.

Data and code relevant to several questions are available to you online. Look for these three files at https://github.com/thomaselove/431data:

- `hospsim.csv`
- `surveyday1_2017.csv`
- `wc_code.R`

You will have the opportunity to edit your responses after completing the quiz, but this must be completed by the deadline. If you wish to complete part of the quiz and then return to it later, please scroll to the end of the quiz and complete the affirmation after the final Question. Then, you will be able to exit the quiz and save your progress.

You are welcome to consult the materials provided on the course website, but you are not allowed to discuss the questions on this quiz with anyone other than Professor Love or the Teaching Assistants. They may be reached at `431-help at case dot edu`. Any further announcements about this Quiz will be posted to your preferred email and https://github.com/THOMASELOVE/431slides/tree/master/wrapup.

1 Q01

Suppose you have a data frame named `dat` containing a variable called `height`, which shows the participant's height in centimeters. Which of the following lines of code will create a new variable `tall` in the `dat` data frame which takes the value **TRUE** when a subject is more than 175 cm tall, and **FALSE** when a subject's height is at most 175 cm.

- a. `dat %>% tall <- height > 175`
- b. `dat$tall <- ifelse(dat$height > 175, "YES", "NO")`
- c. `tall <- dat %>% filter(height > 175)`
- d. `dat %>% mutate(tall = height > 175)`
- e. None of these will do the job.

2 Q02

I fit two linear regression models, called `m1` and `m2`, to predict the same outcome (y), where `m2` includes a proper subset of the five predictors included in `m1`. I then ran `anova(m1, m2)`.

```
anova(m1, m2)
```

```
Analysis of Variance Table

Model 1: y ~ x1 + x2 + x3 + x4 + x5
Model 2: y ~ x1 + x2 + x4

  Res.Df   RSS Df Sum of Sq     F  Pr(>F)
1     94 42667
2     96 45546 -2   -2879.5 3.172 0.04644
```

From the p value provided in this output, which of the following statements is the most appropriate conclusion at a 5% significance level?

- a. `x1` carries statistically significant predictive value for `y`, assuming that the other four predictors are in the model.
- b. The combination of `x1`, `x2` and `x3` contains statistically significant predictive value for `y`, assuming that none of the other predictors are in the model.
- c. The combination of `x3` and `x5` contains statistically significant predictive value for `y`, assuming that `x1`, `x2` and `x4` are already in the model.
- d. The combination of `x3` and `x5` contains statistically significant predictive value for `y`, assuming that `x1`, `x2` and `x4` are NOT already in the model.
- e. None of these statements are appropriate.

3 Q03

Using the `surveyday1_2017.csv` data file from https://github.com/thomaselove/431data, I developed the following table of information describing the association of these two items:

- `sex`: What is your sex? (f = Female, m = Male)
- `smoke`: Do you smoke? (1 = Non-Smoker, 2 = Former Smoker, 3 = Current Smoker)

–	`smoke` = 1	`smoke` = 2	`smoke` = 3	Total
Female	91	5	0	**96**
Male	94	9	3	**106**
Total	**185**	**14**	**3**	**202**

The resulting Pearson chi-squared test p-value is 0.157. Note that you could check this yourself using the data, but there is no need to do so.

Which of the following statements is appropriate?

- a. The assumptions required by the usual chi-squared test are reasonable here.
- b. The p value for a chi-square test is below our usual level to indicate significance.
- c. `sex` and `smoke` are independent of each other.
- d. The presented p value means that the `smoke` score is statistically significantly higher in females.
- e. None of these statements are appropriate.

4 Q04

The lab component of a core course in biology is taught at the Watchmaker's Technical Institute by a set of five teaching assistants, whose names, conveniently, are Amy, Beth, Carmen, Donna and Elena. On the second examination of the semester (each section takes the same set of exams) an administrator at WTI wants to compare the mean scores across lab sections. She produces the following output in R.

```
Analysis of Variance Table

Response: exam2
           Df  Sum Sq Mean Sq F value  Pr(>F)
ta          4  1199.8 299.950  3.3355 0.01174
Residuals 165 14837.8  89.926
```

Emboldened by this result, the administrator decides to compare mean `exam2` scores for each possible pair of TAs, using a Bonferroni correction. If she wants to maintain an overall α level of 0.05 for the resulting suite of pairwise comparisons, and plans to do each of them separately with a two-sample t test, then what significance level should she use for each of the individual two-sample t tests?

- a. She should use a significance level of 0.20 on each test.
- b. She should use 0.005 on each test.
- c. She should use 0.0125 on each test.
- d. She should use 0.05 on each test.
- e. None of these answers are correct.

5 Q05

If the administrator at the Watchmaker's Technical Institute that we mentioned in Q04 instead used a Tukey HSD approach to make her comparisons, she might have obtained the following output.

```
Tukey multiple comparisons of exam2 means, 95% family-wise confidence level
```

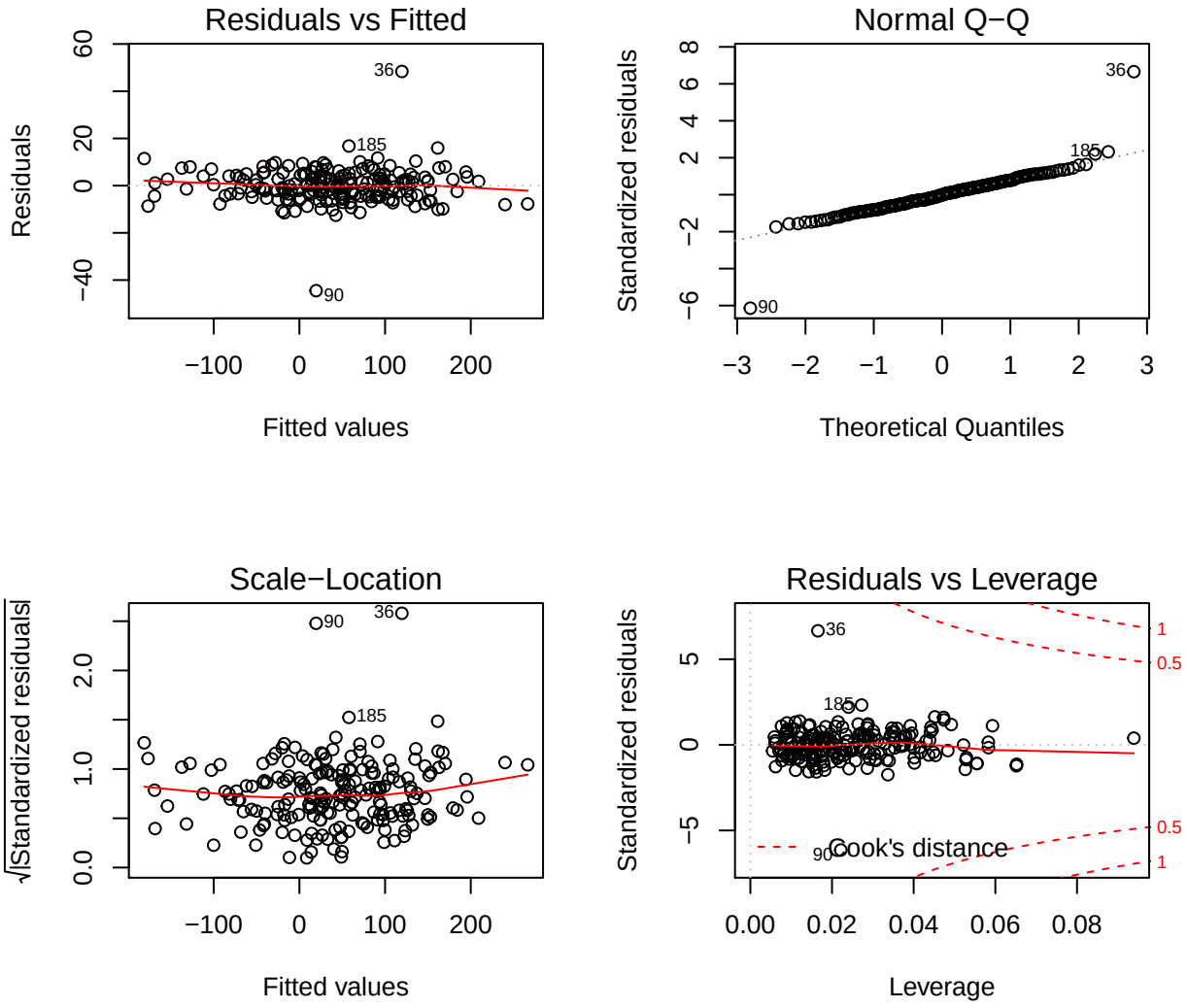
	diff	lwr	upr			diff	lwr	upr
Beth-Amy	-3.09	-9.43	3.26		Donna-Beth	-3.74	-10.08	2.61
Carmen-Amy	-7.03	-13.37	-0.69		Elena-Beth	-2.53	-8.87	3.81
Donna-Amy	-6.82	-13.17	-0.48		Donna-Carmen	0.21	-6.14	6.55
Elena-Amy	-5.62	-11.96	0.73		Elena-Carmen	1.41	-4.93	7.76
Carmen-Beth	-3.94	-10.28	2.40		Elena-Donna	1.21	-5.14	7.55

Note that when we refer in the responses below to Beth's scores, we mean the scores of students who were in Beth's lab section. Which conclusion of those presented below would be most appropriate?

- a. Beth's scores were significantly lower than Amy's.
- b. Amy's scores are significantly higher than Carmen or Donna.
- c. Amy's scores are significantly lower than Carmen or Donna.
- d. Elena's scores are significantly higher than Beth, Carmen or Donna.
- e. None of these answers are correct.

6 Q06

A regression model was developed to predict an outcome, `y`, based on a linear model using the four predictors `x1`, `x2`, `x3` and `x4`, in a sample of 200 subjects. The following residual plots emerged from R.

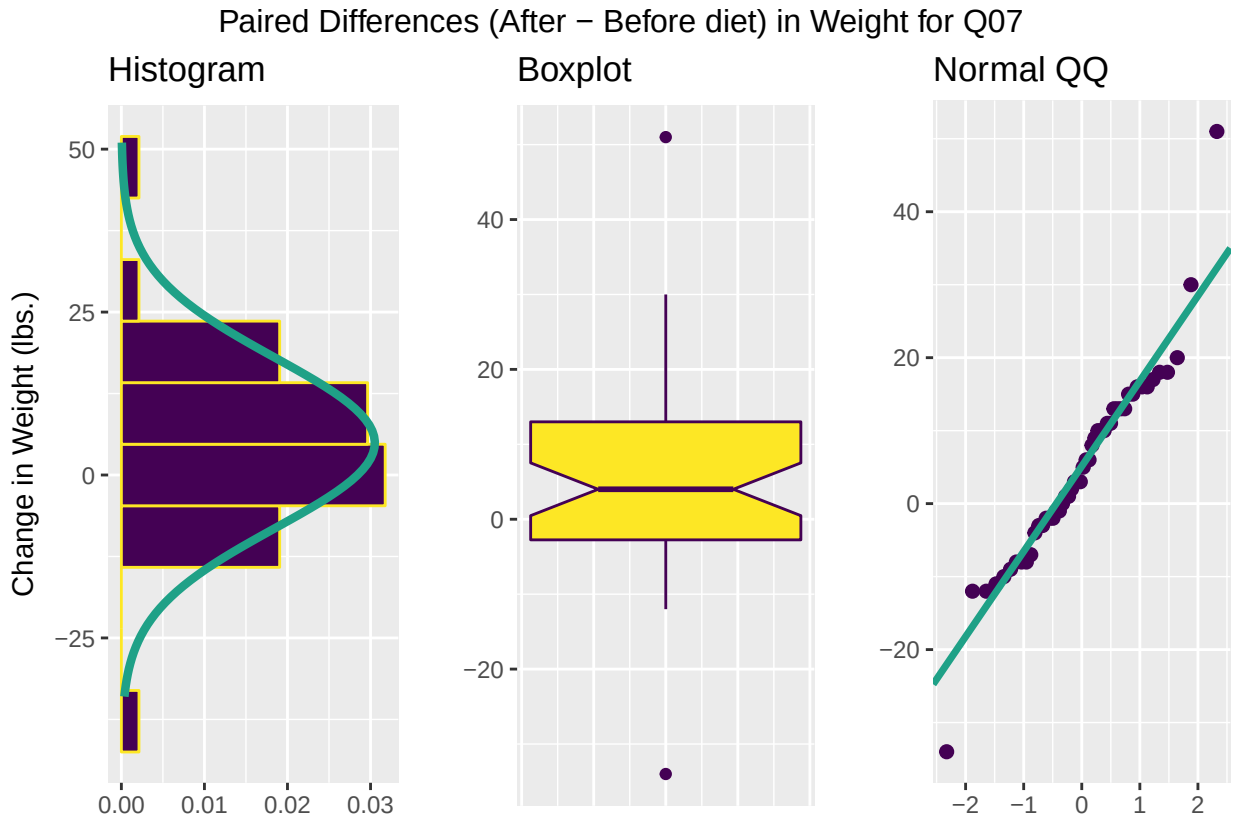


Which of the following conclusions best describes this situation, based on the output?

- a. Our main problem is with collinearity.
- b. Our main problem is with the assumption of linearity.
- c. Our main problem is with the assumption of constant variance.
- d. Our main problem is with the assumption of normality.
- e. We have no apparent problems with regression assumptions.

7 Q07

Suppose we compare the change in weight (after - before, in pounds) for 50 overweight male adult subjects who enter into a rather strict nutritional regimen. Specifically, the subjects drink nothing other than water, and eat nothing but a variety of potatoes for two weeks, then spend four weeks eating only high-nutrition vegetables, and still drinking nothing but water. The team's statistical analyst prepares the following output.



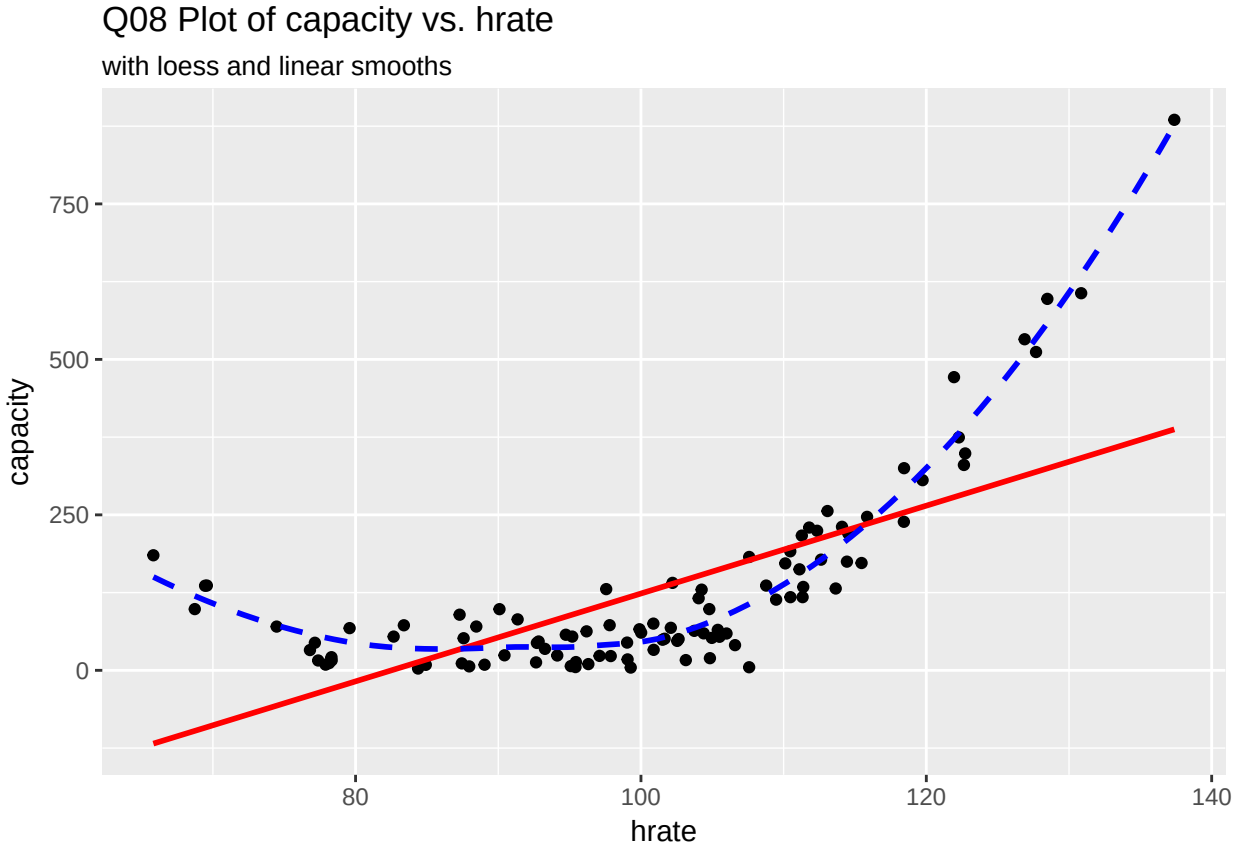

```
One Sample t-test

data:  dat07$diff
t = 2.6613, df = 49, p-value = 0.0105
alternative hypothesis: true mean is not equal to 0
99 percent confidence interval: -0.035  9.875
sample estimates: mean of x = 4.92


Result of applying Hmisc::smean.cl.boot
with a 99% confidence level

  Mean  Lower  Upper
4.9200 0.5191 9.7413
```

If the researchers are committed to the use of a 99% confidence level, then which of the following conclusions is most appropriate, given the output above?

- a. These should be treated as independent samples, and the t test is appropriate, so we find no significant difference with 99% confidence.
- b. These should be treated as independent samples, and the bootstrap is appropriate, so we find no significant difference with 99% confidence.
- c. These should be treated as paired samples, the boxplot suggests that we use the t-based interval and so we conclude that the mean weight loss was significantly more than zero.
- d. These should be treated as paired samples, the boxplot suggests that we use the t-based interval and so we conclude that the mean weight loss was not significantly more than zero.
- e. These should be treated as paired samples, the boxplot suggests that we use the bootstrap and so we conclude that the mean weight loss was significantly more than zero.

8 Q08

Suppose we plotted the relationship between an outcome related to blood flow capacity, labeled `capacity`, and a predictor called `hrate`, which is a measure of peak comfortable heart rate. Each is measured for a cross-section of 100 subjects. We then used the `geom_smooth` function in `ggplot2` to fit both a linear smooth and a loess smooth, producing the plot below. If you have trouble distinguishing colors, I'll say that one smooth is shown with blue dashes and the other is in red without dashes, but just solid color.



Which of the following statements is true?

- a. The linear fit is shown as a blue dashed line in this plot.
- b. The linear model provides a better fit to the data than does the loess smooth.
- c. The Pearson correlation of `hrate` and `capacity` is negative.
- d. The linear model describing `capacity` using `hrate` has a problem with independence.
- e. None of these statements are true.

9 Q09

Data describing a sample of subjects participating in the Western Collaborative Group Study (discussed in our Course Notes in several places) were used here to fit a model to predict the natural logarithm of systolic blood pressure (`sbp`) using the subject's age, height, smoking status (yes/no) and the natural logarithm of their weight. The `wcgs` file is on our website, but this question uses a sample from that data that is unknown to you, so you will not be able to duplicate the output that follows.

```
m09 <- lm(log(sbp) ~ age + log(weight) + height + smoke, data = wcgs09)
arm::display(m09, digits = 3)
```

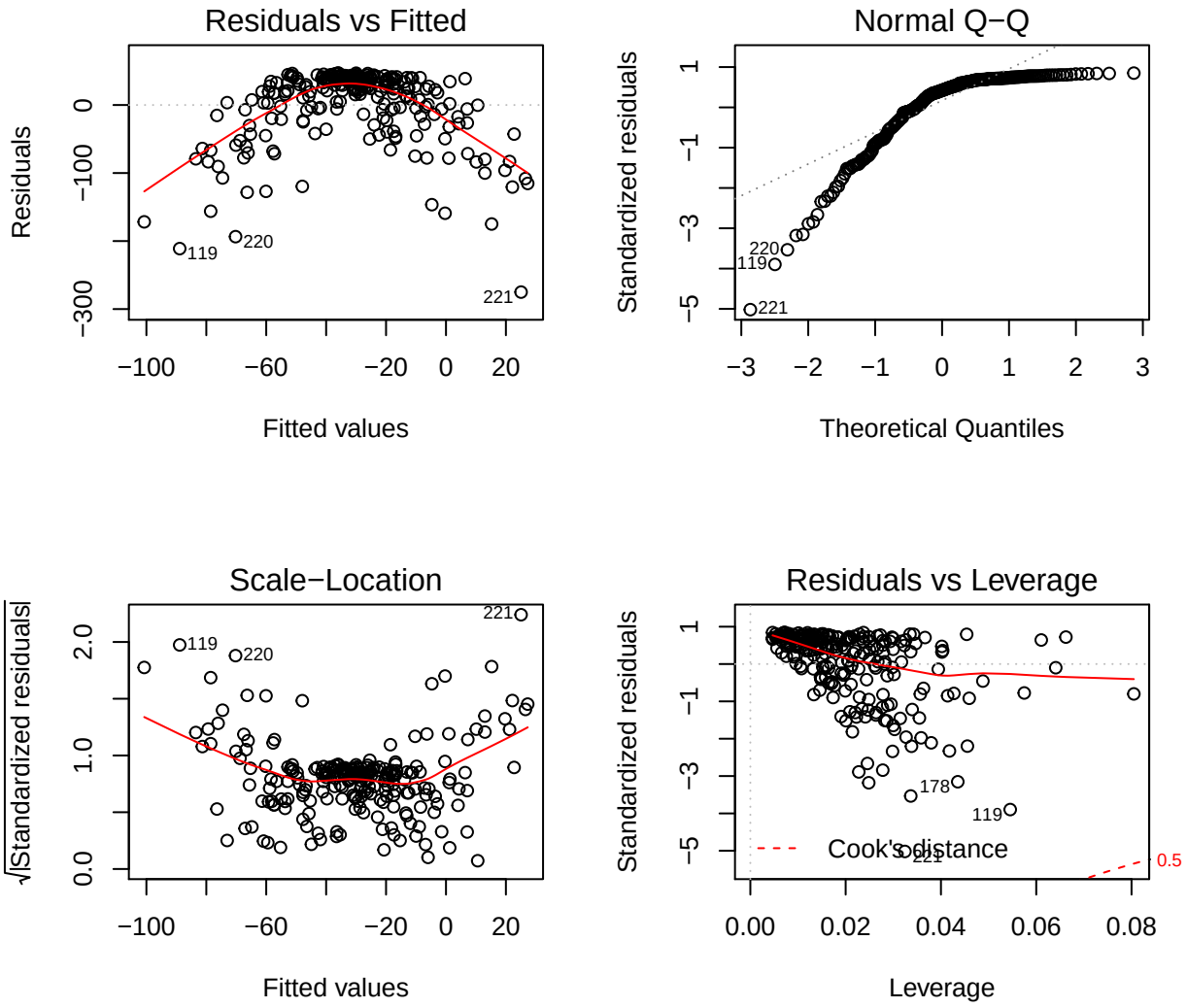
```
lm(formula = log(sbp) ~ age + log(weight) + height + smoke, data = wcgs09)
            coef.est coef.se
(Intercept)  4.528    0.414
age          0.008    0.002
log(weight)  0.163    0.084
height      -0.012    0.004
smokeYes    -0.023    0.021
---
n = 150, k = 5
residual sd = 0.122, R-Squared = 0.17
```

What conclusions can you draw from this output, using a 5% significance level?

- a. Smokers have significantly lower systolic blood pressures than non-smokers, after we account for age and size (height and weight).
- b. Older people have lower blood pressures on average than do younger people.
- c. Larger height is associated with significantly lower blood pressure, even after we've accounted for age, weight and smoking status.
- d. This model accounts for about 12% of the variation in the log of systolic blood pressure.
- e. None of these statements are true.

10 Q10

A regression model was developed to predict an outcome, `y`, based on a linear model using four predictors in a sample of 240 subjects. The following residual plots emerged.



Which of the following conclusions best describes this situation, based on the output?

- a. The first thing we should try is dropping a highly influential point.
- b. The first thing we should try is transforming `y` to improve linearity.
- c. The first thing we should worry about is the assumption of constant variance.
- d. The first thing we should try is to focus on the problem of collinearity.
- e. We're all set. We have no apparent problems with assumptions.

11 Q11

(Note that this background information will be used in Q11 - Q15.) Suppose you fit three candidate models to predict the natural logarithm of a measure of predatory behavior in leopards. The four models are nested, in that D is a proper subset of C, which is a proper subset of B, which is a proper subset of A. Specifically, Model A contains seven predictors, Model B contains five of those seven predictors, and Model C contains three of the five Model B predictors, while Model D is a simple regression, using one of the predictors in Model C. You obtain the following results.

```
modelA <- lm(log(predatory.behavior) ~
               x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8, data = leopard)
modelB <- lm(log(predatory.behavior) ~
               x1 + x2 + x3 + x4 + x5, data = leopard)
modelC <- lm(log(predatory.behavior) ~
               x1 + x2 + x3, data = leopard)
modelD <- lm(log(predatory.behavior) ~
               x1 , data = leopard)

AIC(modelA, modelB, modelC, modelD)
```

```
       df      AIC
modelA 10 4380.234
modelB  7 4375.219
modelC  5 5088.652
modelD  3 5329.352
```

Which of these models does this output suggest will be the best choice to predict the natural logarithm of the predatory behavior measure?

- a. Model A
- b. Model B
- c. Model C
- d. Model D
- e. The output doesn't suggest a "best" choice.

12 Q12

The following output relates to `modelA` described in Q11.

```
round(car::vif(modelA),3)
```

```
   x1    x2    x3    x4    x5    x6    x7    x8
1.012 1.014 1.107 1.020 1.015 2.610 2.491 1.015
```

Which of the following statements is the best conclusion from this output?

- a. Model A has no sign of meaningful collinearity.
- b. Model A has a serious problem with collinearity.
- c. Model A's residuals will show no problem with independence.
- d. Model A's residuals will show a serious problem with independence.
- e. Model A's residual variance will be larger than the residual variance of Model B, which is the model that includes predictors `x1, x2, x3, x4` and `x5`, only.

13 Q13

Which of the following R commands would calculate fitted values of `log(predatory.behavior)` using the equation in Model A (from Q11 and Q12), for a new set of data contained in the `newleopard` tibble?

- a. `predict(modelA, newdata = newleopard)`
- b. `glance(modelA, newdata = newleopard)`
- c. `tidy(modelA, newdata = newleopard)`
- d. `augment(modelA)`
- e. `split(modelA, newdata = newleopard)`

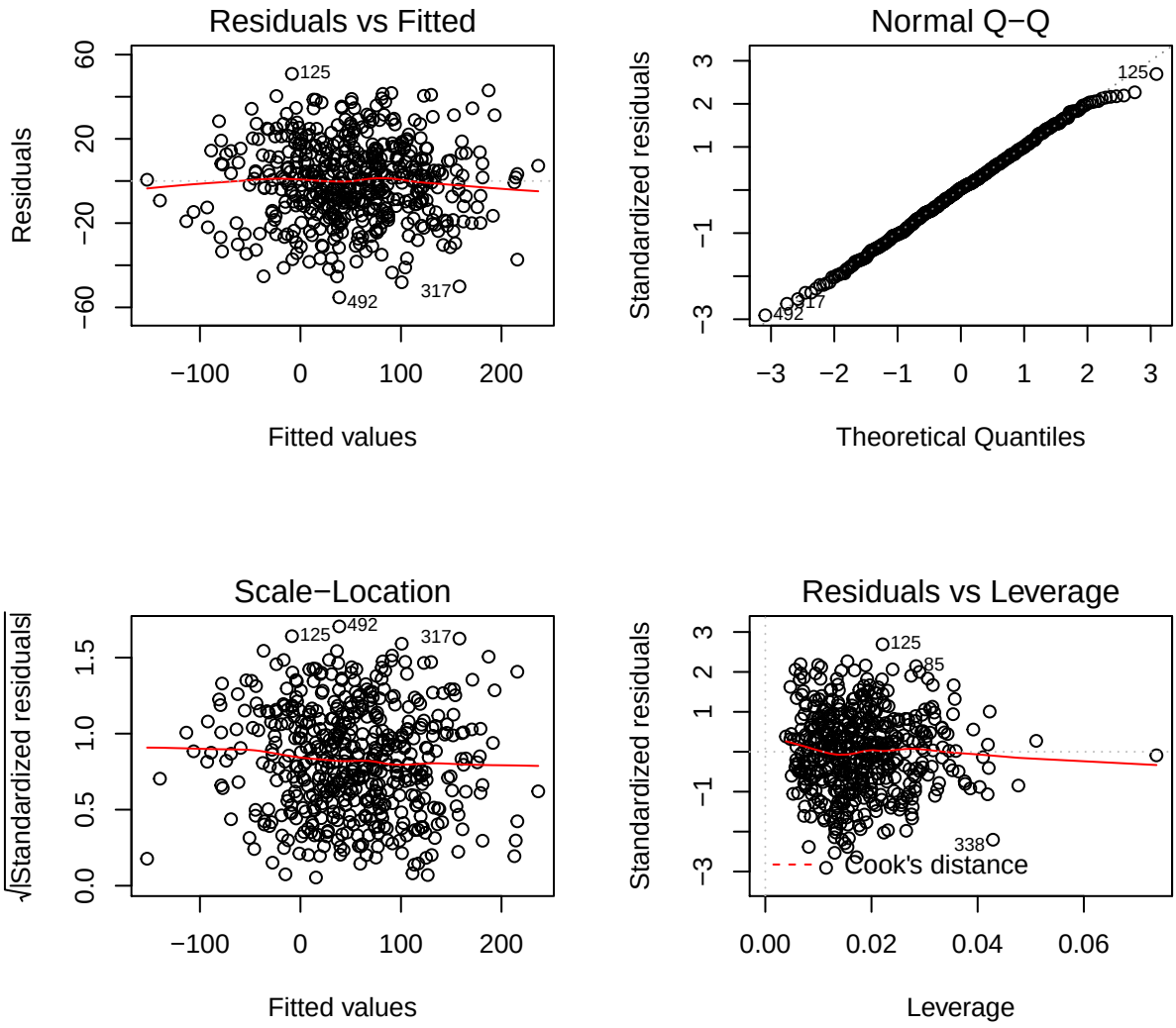
14 Q14

Suppose the first predicted subject in the `newleopard` tibble yields a prediction of `log(predatory.behavior)` of 3.5, with a 95% uncertainty interval of (3, 4). To convert that uncertainty interval back to the original scale on which the predatory behavior measurements were obtained, we would obtain which of the following results?

- a. 3 to 4
- b. `log(3)` to `log(4)`
- c. `10*3` to `10*4`
- d. `exp(3)` to `exp(4)`
- e. None of these methods would work.

15 Q15

Behold the residual plots for Model A from Q11.



Which of the following conclusions is most appropriate?

- a. There is a serious problem with the assumption of linearity.
- b. There is a serious problem with the assumption of constant variance
- c. There is a serious problem with the assumption of Normality.
- d. There are no serious problems evident in these residual plots.
- e. None of these conclusions are appropriate.

16 Q16

A series of 90 models were built by a team of researchers interested in systems biology. 37 of the models showed promising results in an attempt to validate them out of sample. Define the hit rate as the percentage of models built that show these promising results. Which of the following intervals appropriately describes the uncertainty we have around a hit rate estimate in this setting, using a SAIFS approach and permitting a 10% rate of Type I error?

- a. (30.4%, 52.1%)
- b. 0.411 plus or minus 4.1 percentage points.
- c. (32.1%, 50.4%)
- d. (27.0%, 55.4%)
- e. None of these intervals.

17 Q17

The `Pottery` data are part of the `car` package in R. Included are data describing the chemical composition of ancient pottery found at four sites in Great Britain. This data set will also be used in Q18. Here, we will focus here on the Na (Sodium) levels, and our goal is to compare the mean Na levels across the four sites.

```
anova(lm(Na ~ Site, data = car::Pottery))
```

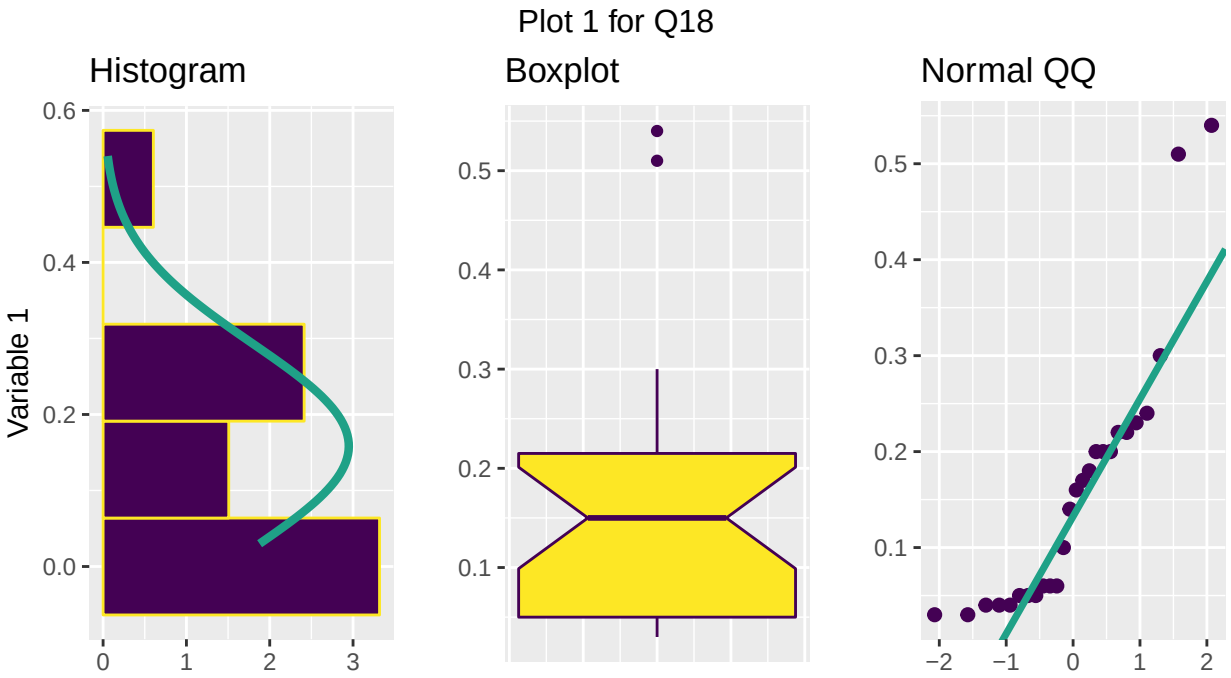
```
Analysis of Variance Table

Response: Na
          Df  Sum Sq  Mean Sq F value    Pr(>F)
Site       3 0.25825 0.086082  9.5026 0.0003209 ***
Residuals 22 0.19929 0.009059
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

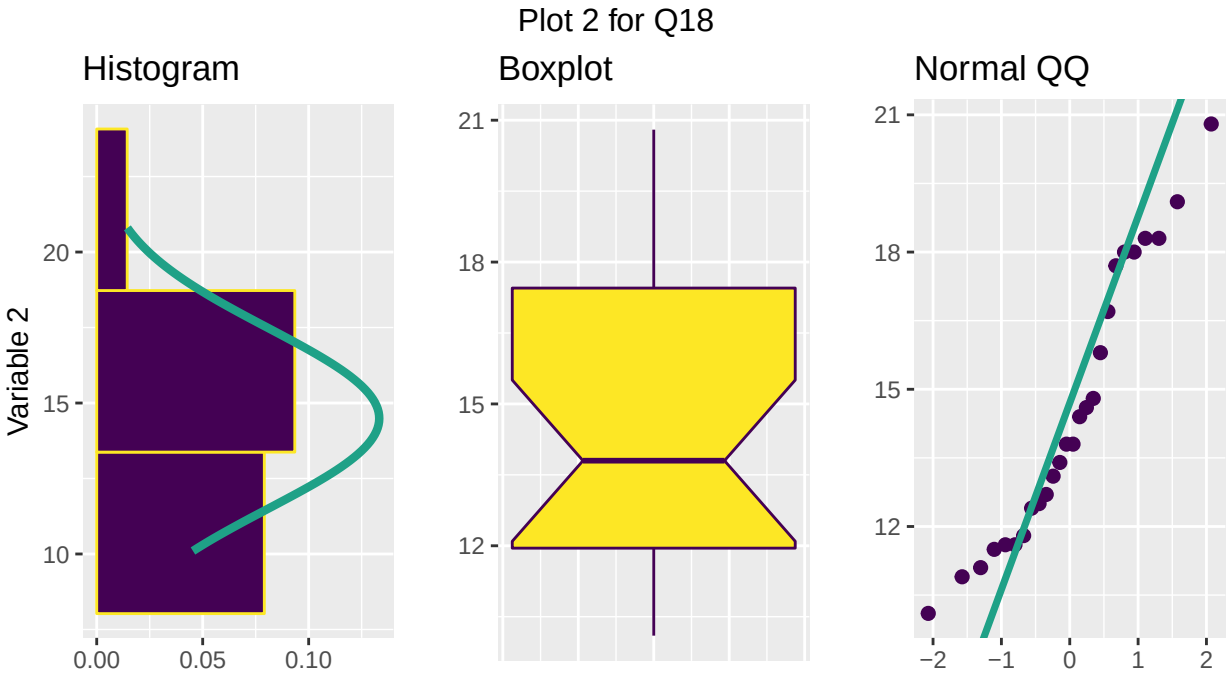
Which of the following conclusions is most appropriate, based on the output above?

- a. The F test allows us to conclude that the population mean Na level in at least one of the four sites is different than the others, at a 1% significance level.
- b. The F test allows us to conclude that the population mean Na level in each of the four sites is different than each of the others, at a 1% significance level.
- c. The F test allows us to conclude that the population mean Na level is the same in all four sites, at a 1% significance level.
- d. The F test allows us to conclude that the population mean Na level may not be the same in all sites, but is not statistically significantly different at the 1% level.
- e. None of these conclusions are appropriate.

18 Q18

Consider these two sets of plots, generated by the `eda.1sam` function to describe variables from the Pottery data set within the `car` package.





And now, here are descriptive summary statistics from the `summary` function describing the variables contained in the Pottery data set.

```
          Site          Al              Fe              Mg
 AshleyRails: 5   Min.   :10.10   Min.   :0.920   Min.   :0.530
 Caldicot   : 2   1st Qu.:11.95   1st Qu.:1.700   1st Qu.:0.670
 IsleThorns : 5   Median :13.80   Median :5.465   Median :3.825
 Llanedyrn  :14   Mean   :14.49   Mean   :4.468   Mean   :3.142
                  3rd Qu.:17.45   3rd Qu.:6.590   3rd Qu.:4.503
                  Max.   :20.80   Max.   :7.090   Max.   :7.230
       Ca              Na
 Min.   :0.0100   Min.   :0.0300
 1st Qu.:0.0600   1st Qu.:0.0500
 Median :0.1550   Median :0.1500
 Mean   :0.1465   Mean   :0.1585
 3rd Qu.:0.2150   3rd Qu.:0.2150
 Max.   :0.3100   Max.   :0.5400
```

Based on this output, and whatever other work you need to do, which of the statements below is true, about Variable 1 (as shown in Plot 1) and Variable 2 (shown in Plot 2)?

- a. Variable 1 is Sodium (Na), Variable 2 in Plot 2 is Aluminum (Al).
- b. Variable 1 is Calcium (Ca), Variable 2 is Aluminum (Al).
- c. Variable 1 is Iron (Fe), Variable 2 is Magnesium (Mg).
- d. Variable 1 is Iron (Fe), Variable 2 is Calcium (Ca).
- e. Variable 1 is Sodium (Na), Variable 2 is Magnesium (Mg).

19 Q19

A special method using regression strategies uses a sample of data to estimate a parameter as 2.35, with a standard error of 0.5. Which of the following statements best describes a 95% uncertainty interval (confidence interval) for that parameter, based on this sample?

- a. (2.35 - 0.5, 2.35 + 0.5)
- b. (2.35 - 0.1, 2.35 + 0.1)
- c. (2 - 2.35, 2 + 2.35)
- d. (2.35 - 0.35, 2.35 + 0.35)
- e. None of these.

20 Q20

In *The Signal and The Noise*, Nate Silver writes repeatedly about a Bayesian way of thinking about uncertainty, for instance in Chapters 8 and 13. Which of the following statistical methods is **NOT** consistent with a Bayesian approach to thinking about variation and uncertainty?

- a. Updating our forecasts as new information appears.
- b. Establishing a researchable hypothesis prior to data collection.
- c. Significance testing of a null hypothesis, using, say, Fisher's exact test.
- d. Combining information from multiple sources to build a model.
- e. Gambling using a strategy derived from a probability model.

21 Q21

Which of the following statements is **NOT** part of what Silver is trying to tell us in *The Signal and The Noise*? (You may wish to focus on Chapter 13, which summarizes the preceding arguments nicely.)

- a. Our bias is to think we are better at prediction than we really are.
- b. Make a lot of forecasts. It's the only way to get better.
- c. State, explicitly, how likely we believe an event is to occur before we begin to weigh the evidence.
- d. Revise and improve your estimates as you encounter new information.
- e. Nature's laws change quickly, and do so all the time.

22 Q22

Consider the `weather_check` data frame within the `fivethirtyeight` package. We will use these data for Q22-Q24.

Suppose you want to build a table containing information from the `female`, `ck_weather` and `age` variables in that data frame. I suggest you use the following approach to place the data in the `wc` tibble, and adjust some of the coding.

Note I have provided this code snippet to you in a file called `wc_code.R` at https://github.com/thomaselove/431data.

```
wc <- fivethirtyeight::weather_check %>%
  select(female, ck_weather, age) %>%
  mutate(female = fct_recode(factor(female),
                             "Female" = "TRUE",
                             "Male" = "FALSE"),
         ck_weather = fct_recode(factor(ck_weather),
                            "Check" = "TRUE",
                            "No Check" = "FALSE")) %>%
  mutate(female = fct_relevel(female, "Female"),
         ck_weather = fct_relevel(ck_weather, "Check"))
```

Build the specified table using your `wc` tibble. Which age group has exactly 105 female respondents who answered yes to the question "Do you typically check a daily weather report?"

- a. Ages 18-29
- b. Ages 30-44
- c. Ages 45-59
- d. Ages 60+
- e. None of these.

23 Q23

Perform an appropriate test to see if the odds ratio for a Yes answer to "Do you typically check a daily weather report?" comparing Female to Male respondents is essentially consistent across age categories. What is the name of the test that you ran, and what is the conclusion? As usual, use a 5% significance level here.

- a. I ran a chi-square test on a 2x2 table using the `Epi` package's `twoby2` function, and the conclusion is that there is a significant association.
- b. I ran a chi-square test on a 2x2 table using the `Epi` package's `twoby2` function, and the conclusion is that there is not a significant association.
- c. I ran Woolf's test (`woolf_test`) to assess the homogeneity of odds ratios from the `vcd` package, and I conclude that the odds ratio is sufficiently consistent across age categories to allow me to collapse on age.
- d. I ran Woolf's test (`woolf_test`) to assess the homogeneity of odds ratios from the `vcd` package, and I conclude that the odds ratio is NOT sufficiently consistent across age categories to allow me to collapse on age.
- e. None of these statements describes an appropriate test.

24 Q24

Use the data we have been working with in the previous two questions, regardless of how you answered those questions. Suppose we want to use the Cochran-Mantel-Haenszel approach to estimate the common odds ratio across all age categories comparing Females to Males as to whether they check the weather daily. Which of the following statements is true?

- a. Females have higher odds of checking the weather, and a 95% confidence interval includes 1.
- b. Females have higher odds of checking the weather, and a 95% confidence interval does not include 1.
- c. Females have lower odds of checking the weather, and a 95% confidence interval includes 1.
- d. Females have lower odds of checking the weather, and a 95% confidence interval does not include 1.
- e. None of these statements are accurate.

25 Q25

You have a tibble called `mydat` that contains 500 observations on 1 outcome and 5 predictors. Which of the following codes would most appropriately split the data into a test sample (called `mydat.test`) containing 20% of the observations, and a training sample containing the rest?

- a. `mydat.test <- sample_n(mydat, 100)` and `mydat.train = anti_join(mydat, mydat.test)`
- b. `mydat.test <- partition(mydat, 400:100)` and `mydat.train = anti_join(mydat, mydat.test)`
- c. `mydat.test <- slice(mydat, 100)` and `mydat.train = anti_join(mydat, mydat.test)`
- d. `mydat.test <- sample_frac(mydat, 0.80)` and `mydat.train = anti_join(mydat, mydat.test)`
- e. None of these approaches would work.

26 Q26

The southern white rhinoceros (*Ceratotherium simum simum*) has a wild population exceeding 20,000, making them the most abundant rhino species in the world, according to Wikipedia. Your outcome of interest is a measure of size. Suppose that you want to compare those living in an area of southern Africa subject to serious problems from poaching (you have data on 20 rhinos living near Watering Hole A) and those living in an area of southern Africa more than 1,000 km away with a less serious poaching problem (you have data on 20 rhinos living near Watering Hole B). Your interest is to understand how exposure to poaching is associated with average rhino size. An enormous amount of output follows, from R. The data are, alas, simulated. **Some of the output is useful, some is not**.

26.1 Specifying the data frames

```
rhino1 <- data.frame(B, A)
rhino2 <- gather(rhino1, key = "Location", value = "Size") %>%
  mutate(Location = factor(Location))

summary(rhino1)
```

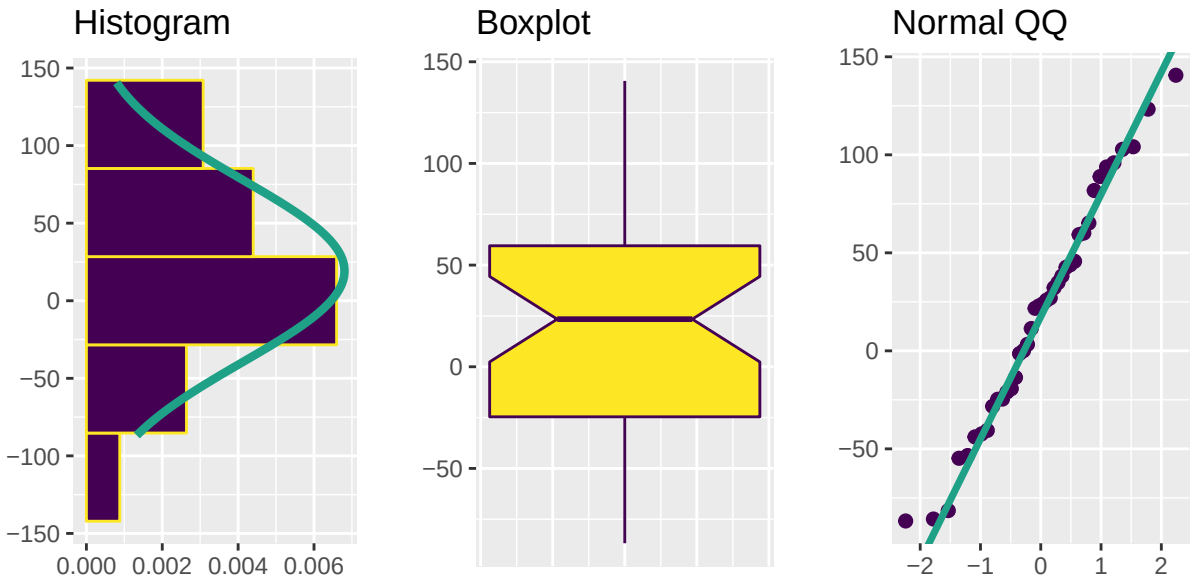
```
       B                A         
 Min.   :477.0   Min.   :396.7  
 1st Qu.:498.2   1st Qu.:466.6  
 Median :521.5   Median :502.1  
 Mean   :520.3   Mean   :501.1  
 3rd Qu.:536.2   3rd Qu.:534.4  
 Max.   :586.0   Max.   :617.8  
```

```
summary(rhino2)
```

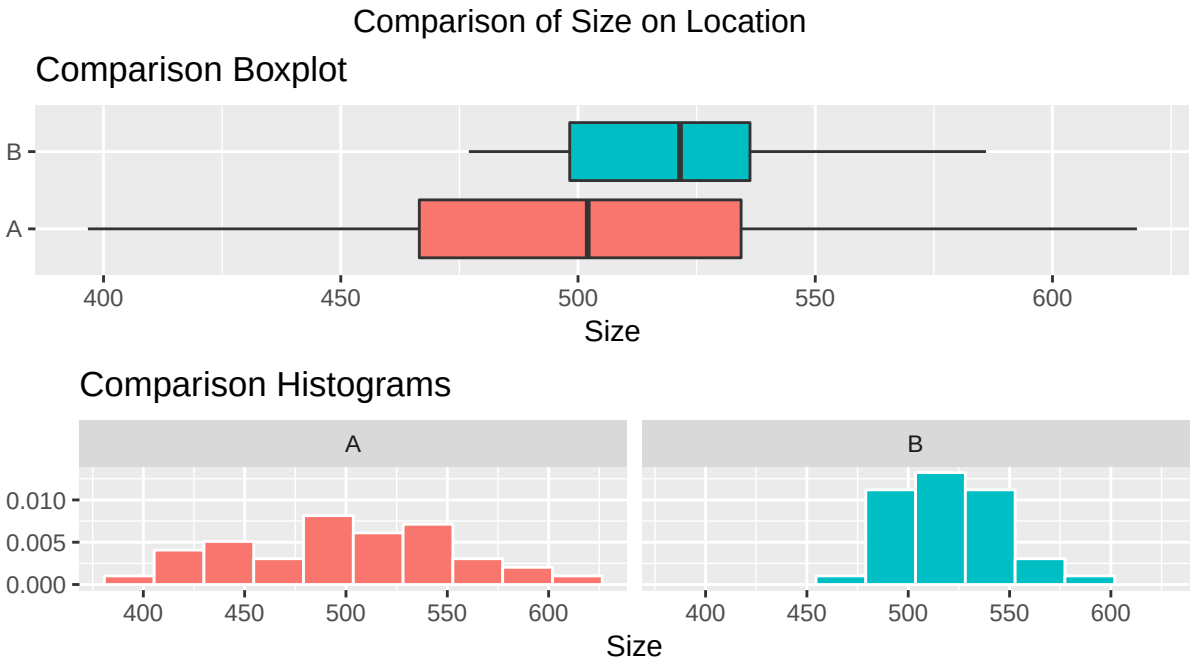
```
 Location      Size      
 A:40     Min.   :396.7  
 B:40     1st Qu.:489.2  
          Median :515.6  
          Mean   :510.7  
          3rd Qu.:535.9  
          Max.   :617.8  
```

26.2 Plotting the data from each data frame

```
rhino1$diff <- rhino1$B - rhino1$A
eda.1sam(dataframe = rhino1, variable = rhino1$diff)
```




```
eda.ksam(outcome = rhino2$Size, group = rhino2$Location, notch = FALSE)
```



26.3 Inference attempts using the rhino1 data frame

```
t.test(rhino1$B - rhino1$A)
```

```

    One Sample t-test

data:  rhino1$B - rhino1$A
t = 2.0691, df = 39, p-value = 0.04521
alternative hypothesis: true mean is not equal to 0
95 percent confidence interval:
  0.4298566 37.9301434
sample estimates:
mean of x
    19.18
```

```
wilcox.test(rhino1$B - rhino1$A, conf.int = TRUE)
```

```

    Wilcoxon signed rank test with continuity correction

data:  rhino1$B - rhino1$A
V = 554.5, p-value = 0.05292
alternative hypothesis: true location is not equal to 0
95 percent confidence interval:
 -0.3999593 38.6999512
sample estimates:
(pseudo)median
      19.43694
```

26.4 Inference attempts using the rhino1 data frame

```
t.test(Size ~ Location, data = rhino2)
```

```
    Welch Two Sample t-test

data:  Size by Location
t = -2.0468, df = 56.567, p-value = 0.04534
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -37.9480188  -0.4119812
sample estimates:
mean in group A mean in group B
        501.145         520.325
```

```
wilcox.test(Size ~ Location, data = rhino2, conf.int = TRUE)
```

```
    Wilcoxon rank sum test with continuity correction

data:  Size by Location
W = 599, p-value = 0.05368
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 -39.0999437   0.5999544
sample estimates:
difference in location
             -18.25373
```

26.5 Now, finally, here is the question for Q26

Consider all of the provided output, remembering that **some of it is useless**. Your job is to specify the correct study design, and the resulting 95% confidence interval for the true mean difference in size, where the difference is defined as location B - location A.

- a. Paired samples, and the best estimate shown is (0.43, 37.93)
- b. Paired samples, and the best estimate shown is (-0.40, 38.70)
- c. Independent samples, and the best estimate shown is (0.41, 37.94)
- d. Independent samples, and the best estimate shown is (-0.60, 39.10)
- e. None of these statements are correct.

27 Q27

Building on our story in Q26, we saw that in location B, where poaching is modest, 29 of the 40 rhinos were of size 500 or greater, while in location A, only 21/40 met that standard.

Suppose that a new set of tough regulations on rhino poaching is to be put into effect in a third location much like location A. We are attempting to calculate the power of a test to detect a change in this new third location. Assume the new location starts at a level of 52.5% without the change in regulations and suppose we assume that changing the regulations will bring the percentage to 70%, which begins to approach the level we saw in location B? Assume a two-sided comparison with a 5% significance level, and that you will be able to study a sample of 100 rhinos in this third location.

Which of the following statements contains the power of this new study?

a. 0 to 20%
b. 21 to 40%
c. 41 to 60%
d. 61 to 80%
e. More than 80%.

28 Q28

You are comparing two regression models for the same outcome, which you built using a training sample of data. You then use each model to predict data in a test sample, that was not used to calculate the original regression equations. Which of the following summaries will **NOT** be useful to you in assessing which model does a better job of out-of-sample prediction?

- a. The mean of the squared prediction errors.
- b. The mean of the absolute values of the prediction errors.
- c. The maximum of the absolute values of the prediction errors.
- d. The AIC statistic calculated in the training sample.
- e. All of these measures would be useful to you.

29 Q29

According to Jeff Leek in *The Elements of Data Analytic Style*, which of the following is **NOT** a good reason to create graphs for data exploration?

- a. To understand properties of the data.
- b. To inspect qualitative features of the data rather than a huge table of raw data.
- c. To discover new patterns or associations.
- d. To consider whether transformations may be of use.
- e. To look for statistical significance without first exploring the data.

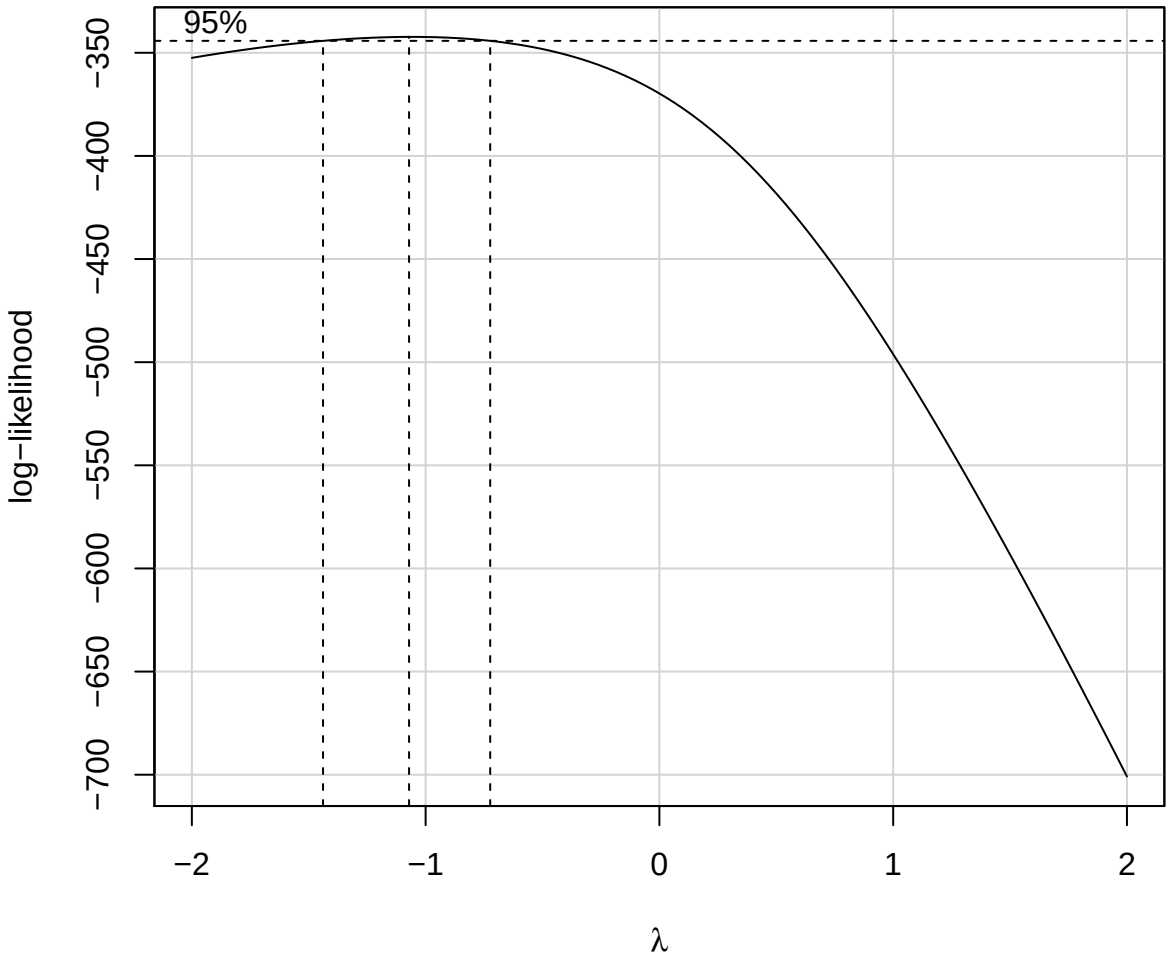
30 Q30

According to Jeff Leek in *The Elements of Data Analytic Style*, which of the following is **NOT** a good idea in creating graphs you will share with other people to describe your work?

- a. If you have multiple plots to compare, use the same scale on the vertical axis.
- b. Axis labels should be large, easy to read, in plain language.
- c. Add a third dimension, perhaps with animation.
- d. Include units in figure labels and legends.
- e. Use color and size to help communicate information, for instance to point out confounding.

31 Q31

Consider the Box-Cox plot below, which addresses a model we've built to predict an outcome called `score` using four predictors.



What transformation of our response does this plot suggest?

- a. The inverse of our outcome, $1/score$.
- b. The square root of our outcome, $\sqrt{score}$.
- c. The logarithm of our outcome, $log(score)$.
- d. The square of our outcome, $score^2$.
- e. The original, untransformed outcome, $score$.

32 Q32

Suppose we have several potential models for a particular outcome, and we obtain the following output.

Model	Multiple R-squared	Adjusted R-squared
A	0.41	0.40
B	0.49	0.41
C	0.53	0.43
D	0.55	0.47

Which of these models is most likely to retain its nominal R-square value in predicting new data?

- a. Model A
- b. Model B
- c. Model C
- d. Model D
- e. It is impossible to tell from the information provided.

33 Q33

Suppose you have a tibble with two variables. One is a factor called Exposure with levels High, Low and Medium, arranged in that order, and the other is a quantitative outcome. You want to rearrange the order of the Exposure variable so that you can then use it to identify for ggplot2 a way to split histograms of outcomes up into a series of smaller plots, each containing the histogram for subjects with a particular level of exposure (Low then Medium then High.)

Which of the pairs of `tidyverse` functions identified below has Dr. Love used to accomplish such a plot?

- a. `fct_reorder` and `facet_wrap`
- b. `fct_relevel` and `facet_wrap`
- c. `fct_collapse` and `facet_wrap`
- d. `fct_reorder` and `group_by`
- e. `fct_collapse` and `group_by`

33.1 Setup for Q34-40

For Q34 - Q40, consider the data I have provided in the `hospsim.csv` file at https://github.com/thomaselove/431data. The data describe 750 patients at a metropolitan hospital. They are simulated. Available are:

- `subject.id` = Subject Identification Number (not a meaningful code)
- `age` = the patient's age, in years (all subjects are between 21 and 75)
- `sex` = the patient's sex (FEMALE or MALE)
- `ldl` = the patient's LDL cholesterol level (in mg/dl)
- `sbp` = the patient's systolic blood pressure (in mm Hg)
- `bmi` = the patient's body mass index (in kg/square meter)
- `statin` = does the patient have a prescription for a statin medication (YES or NO)
- `insurance` = the patient's insurance type (MEDICARE, COMMERCIAL, MEDICAID, UNINSURED)
- `hsgrads` = the percentage of adults in the patient's home neighborhood who have at least a high school diploma (this measure of educational attainment is used as an indicator of the socio-economic place in which the patient lives)
- `clinictype` = whether the patient goes to a newly built clinic or an old clinic

34 Q34

Using the `hospsim` data, what is the 95% confidence interval for the odds ratio which compares the odds of receiving a statin if you are MALE divided by the odds of receiving a statin if you are FEMALE. Do **NOT** use a Bayesian augmentation here.

- a. Odds Ratio is 0.48, CI is (0.33, 0.70)
- b. Odds Ratio is 0.86, CI is (0.81, 0.93)
- c. Odds Ratio is 1.16, CI is (1.07, 1.24)
- d. Odds Ratio is 2.07, CI is (1.42, 3.01)
- e. None of these answers are correct.

35 Q35

Perform an appropriate analysis to determine whether insurance type is associated with the education (`hsgrads`) variable, ignoring all other information in the `hospsim` data. Which of the following conclusions is most appropriate based on your significance tests?

- a. The ANOVA F test is not significant, so it doesn't make sense to compare insurance types pairwise.
- b. The ANOVA F test is significant, and a Tukey HSD comparison reveals that Medicare shows significantly higher education levels than Uninsured.
- c. The ANOVA F test is significant, and a Tukey HSD comparison reveals that Medicaid's education level is significantly lower than either Medicare or Commercial.
- d. The ANOVA F test is significant, and a Tukey HSD comparison reveals that Uninsured's education level is significantly lower than Commercial or Medicare.
- e. None of these conclusions is appropriate.

36 Q36

Build a model to predict LDL cholesterol using all of the other available variables except subject ID. After adjusting for all of the other variables, which of the following statements appears true? Do not transform your outcome.

- a. Whether you were in an old or new clinic type doesn't seem to matter significantly for LDL.
- b. Older clinics had significantly higher LDL levels, holding everything else constant, and the model accounts for less than 20% of the variation in LDL.
- c. Older clinics had significantly lower LDL levels, holding everything else constant, and the model accounts for less than 20% of the variation in LDL.
- d. Older clinics had significantly higher LDL levels, holding everything else constant, and the model accounts for 20% or more of the variation in LDL.
- e. Older clinics had significantly lower LDL levels, holding everything else constant, and the model accounts for 20% or more of the variation in LDL.

37 Q37

Run a backwards elimination stepwise procedure. After doing so, how many of the original nine regression inputs (clinic.type, age, sex, insurance, hsgrads, a1c, bmi, sbp and statin) remain in the model?

- a. 1, 2, or 3
- b. 4
- c. 5
- d. 6
- e. 7 or 8

38 Q38

Compare your initial "kitchen sink" model with all 9 inputs to the model generated by the stepwise approach in Q37 using adjusted R^2, AIC and BIC. What conclusions can you draw?

The smaller model (stepwise result from Q37) is ...

- a. better on adjusted R^2, worse on AIC and worse on BIC.
- b. better on AIC, worse on BIC and adjusted R^2
- c. better on AIC and BIC, and worse on adjusted R^2
- d. worse on all three measures
- e. better on all three measures

39 Q39

Now build a model using sex and insurance type to predict hemoglobin A1c. Which of the following statements best describes the result?

- a. The model R^2 is below 10%, and both sex and insurance type have a significant impact on hemoglobin A1c given the other predictor.
- b. The model R^2 is above 10%, and both sex and insurance type have a significant impact on hemoglobin A1c given the other predictor.
- c. The model R^2 is below 10%, and neither sex nor insurance type have a significant impact on hemoglobin A1c given the other predictor.
- d. The model R^2 is above 10%, although neither sex nor insurance type have a significant impact on hemoglobin A1c given the other predictor.
- e. None of these statements are true.

40 Q40

In your model for Q39, identify the subject with the largest residual. Which of the following characteristics best describes this subject?

- a. This is a female Medicare patient visiting a new clinic.
- b. This is a female Medicare patient visiting an old clinic.
- c. This is a male Medicare patient visiting a new clinic.
- d. This is a male Medicare patient visiting an old clinic.
- e. None of these accurately describe the subject in question.

41 Q41

Question 41 requires you to type in your name to affirm that your work is yours and yours alone, and that you haven't discussed any of the questions with anyone other than Dr. Love and the 431 teaching assistants.

This is the end of the Quiz.