2023 RMHI/ARMP Problem Set 2

Hello everyone! This is the description for the assignment, which is due on Canvas on Friday May 12, 2023 before 11:59pm Melbourne time. You'll need to submit a Word-knitted version of the completed R Markdown file found in this zip file, according to the following instructions:

1. Rename the document called pset2.Rmd as studentID-pset2.Rmd. (Replace studentID with your student ID number). This is your R Markdown file, where you'll be putting all your code and answers.

2. Replace "Your name and ID goes here" in the header of the R Markdown file with your name and student ID. (Keep the quotes or it won't knit properly.)

3. While we encourage collaboration in tutorials and learning in general, *you should not be collaborating with anybody AT ALL for this assignment*. **That means sharing code privately or publicly; even talking in the abstract about problems will effectively be collusion.** You should be completing it independently, with no help from any other person in any capacity. Of course, as always, you are free to use any of the resources from the class to help you, and you're also free to google or look anything up that you like (as long as you aren't asking anybody, including discussion boards or AIs, questions related to this assignment). Note that I do look at places like chegg and will follow up if anything from this problem set is posted there.

4. Plagiarism check is enabled and you can check the similarity report on your submission. In previous years we have found people who tried to cheat, so please don't risk it! That said, understand that we will not be naively looking at the overall % figure: with this sort of assignment a certain amount of overlap is inevitable, so don't worry if you get what looks like a high % score as long as you know you didn't plagiarise or collude. With this sort of assessment, that % overlap is higher than essays and the like. We will be using the plagiarism check for the parts of the assignment where we'd expect some variability, and to give a general sense of the overall gestalt.

5. Complete all of the problems below in the R Markdown document. *Do not remove any of the arguments to the code chunks, like the names of the code chunks or where it says message=FALSE or whatever*. If a problem asks you to display a tibble or variable so it shows up in the knitted version, **make sure that you do** as the marker cannot evaluate it without seeing it, and if they can't see it then they won't be able to award you points for it! Remember that to display a tibble (or any variable) you just type its name on a line of its own within the R chunk.

6. I've structured this so that, as much as possible, **questions do not build on each other**. That means that if, say, you can't get Q5 then you can still get Q6. Try to do all of them.

7. **Go for partial credit!** Many of these questions have some form of partial credit possible. What that means is that if it is asking for some R code, break down the problem into pieces. Even if you can only do some of the pieces, or do them part of the way, that will be worth something. [Note that there is no question-by-question rubric available because designing one would mean giving away the answers. In general we will give full credit for responses that correctly address all of the parts of the question.] Short answer questions (SAQs) can also be given partial credit and are generally asking for some thoughtful interpretation. If it is based on a previous graph or test you've done, if you did the first part wrong but discuss it well, you can still get most or all points for the SAQ part. If your code does not run but you want to include it for possible partial credit, just comment it out (using the # sign) so that it shows up in the knitted document but R does not try to run it. If you include a lot of commented-out code and some is correct and some isn't, we will not give you credit for the commented-out code; put the thing in there that you think is the closest to the correct answer, don't just include everything.

8. We are not overly worried about what decimal place you round answers to and you will not lose credit for this unless you round so much that your answer is impossible to discern (e.g., don't round p-values to the nearest integer!). Similarly, you will not lose points for trivial presentation things like using parentheses instead of commas around statistical references, as long it's clear.

That said, for those who want a guideline, I'll suggest that you follow APA format or round p-values to three decimal places, degrees of freedom to one, and test statistics and probabilities to two.

9. Some questions specify a word count. In that case you need to either calculate it from the knitted document or type up your answer in Word[1] and then cut and paste it into the R Markdown file. (Please put your answer in between the word ANSWER and [Word count: XX]; needless to say, those two bits do not count towards your word count.) I know that's annoying; sorry. Anything else I thought of, like specifying a number of sentences or having no limit, was worse in terms of equity across students. The word counts I've specified in each question are designed to give you a guideline about the maximum amount of words you should need answer completely and correctly. So don't feel like you must use all of the words; if you can answer it fully with less, that's fine. In fact, the total word count for the solution set I wrote up is around 1300, so it's possible to fully answer the questions while going substantially under the word limit. That said, it is okay to go over the word limit for individual questions as long as the total word count for all of the questions combined is fewer than 1760 words (i.e., fewer than 1600+10%, with the standard penalty if it is 1600+10% or over. See the student manual for details on word count penalties).

10. There is no word count for code chunks. Word count only applies to the short answer questions as indicated. **Remember to report** your total word count for the assignment as a whole at the top of the document. Your total word count is the sum of the word counts where those are reported.

10. You'll be turning in the knitted output of your R Markdown file. We prefer that you knit to Word but if you can't get Word to knit then html is okay. In the worst case, you can turn in the completed Rmd file. **I highly, *highly* recommend that you knit as you go**: (a) knitting can identify problems in your code that you would have otherwise missed; and (b) you do not want to get close to the deadline and think you're done only to find that you're having trouble knitting. Save yourself the panic and knit often.

11. Similarly, you can turn in the assignment multiple times before the deadline, so I strongly encourage you to turn it in even before it's perfectly polished. That will save you last-minute panic or computer issues. Also, take a screenshot for proof of having turned it in just in case you need it. If you run into last-minute computer issues and can't even succeed in uploading an Rmd, email Andy your assignment as soon as possible to demonstrate that it was done at that time. We cannot make promises about whether you will receive any late penalties if you do this, but if you don't, you very probably will get penalised because we have no way of knowing if the problems were genuine.

*** IMPORTANT NOTE ***

Making figures is an important part of doing your data analysis, and in many of these problems creating the appropriate figure will help you understand what is going on with your data. Deciding out *what* figure is necessary and *when* is also a key skill.

What this means is that **even if a problem does not explicitly say you should make a figure or what it should look like, you may benefit from making one anyway!** As a result, all of the code chunks include options for figure sizes regardless of whether one is necessary; you can leave the code chunk as is even if you don't make a figure. You will always be evaluated on the correctness of your analysis only. Thus, if you can understand and explain[2] the data without creating a figure that is fine. However, much of the time a figure will help you interpret it, and you will never be penalized for making a figure that you don't need (unless you interpret it wrong or something). So if in doubt, make figure(s) or tables as you see fit! If you do make one, you won't be evaluated on its beauty but if it is unclear then you will not benefit from making it.

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[1] I know different software calculates word count in slightly different ways, so we are using Word as the standard.

[2] **If you are asked to include descriptive statistics, showing a figure with the relevant information is sufficient;** as long as the information is clear in the figure (and the marker can see the figure) then you don't need to also list all of the descriptive statistics in the text. If the figure contains error bars, the error bars can indicate either standard error or standard deviation; either is fine as long as you indicate which it is in the subtitle or text. If you calculate the descriptive statistics in your code but there is no figure then you need to report them in the text.

The story of LFB and Foxy

* * *

For this assignment, we're going to go back to meet up with LFB and Foxy and hear their story. As you'll recall, a few weeks ago they, Doggie, and Flopsy went on a mission to Otherland to steal some of their data. The mission was successful but LFB and Foxy went missing! In your assignment we get to see what happened to them.

* * *

LFB and Foxy are acting as lookout as Doggie and Flopsy enter the building. Standing on one side of the building, LFB is squinting through the darkness trying to see when she hears a rustle. Then another one, then another one, coming ever closer. Not wanting to raise the alarm prematurely, LFB holds still, but when she hears another rustle only meters from where she is, she whistles, giving the signal.

Foxy dashes around the building as quickly as she can, just in time to see the bushes near LFB part. She catches a hasty glimpse as three very large shapes -- bears? dogs? something else? -- jump out at LFB. Startled, LFB whistles as loud as she can, but it is abruptly cut off by one of the animals covering her mouth.

Forgetting her normal shyness, Foxy shouts "stop!" as loud as she can and charges at the two creatures. She growls at them, surprising herself, and they turn. She trembles: one of them is the largest bear she has ever seen, but it's too late to go back now. She growls again, and then the bear rushes at her and hits her and she is knocked unconscious.

After a short and frightening journey through the dark, LFB and Foxy are put into a small, bright room. LFB is relieved to see Foxy start to stir after a moment — she hasn't been hit that hard — and the two of them cuddle together in fear. The room they are in looks like a library, but it has very large chairs and books. LFB has to jump just to get down from the high sofa and reach the door handle. It is locked.

After about a half an hour of worry, the door opens and seven people come in. The first is an enormous bear, larger than anybody LFB has ever seen; she suspects that is the main person who subdued them. He is followed by an owl, a small unicorn with a rainbow mane, a hippo, and a cute penguin carrying a snake. The entire group is trailed by what looks, to their astonishment, to be a sentient guitar (that's right, a musical instrument that can walk and talk). *This is a very strange place*, thinks LFB.

Q1 [7% of total mark]

The seven strangers introduce themselves. The tibble `do`, which has been loaded for you in the R Markdown document, contains the information about them that LFB and Foxy have gleaned. Each row is one of the seven individuals, and the five columns are as follows:

name: the name of that person
species: the species of that person
height: the height of that person in centimeters
scariness: how scary that person seems (1 = not scary at all, 10 = extremely scary)
loudness: how loud that person seems (1 = not loud at all, 10 = extremely loud)

LFB wonders if there is a correlation between *height* and *scariness*. Based on the data in `do`, what would you tell her? In your answer, explain which statistical test you used and why, include the appropriate stats reference, and interpret what this result means about the nature and/or presence of a relationship between these two variables. [Suggested word count: 90]

* * *

LFB and Foxy are both feeling a little calmer now that it appears nobody is going to try to kill them on sight. Still, the Others seem rather suspicious (not that that is surprising, really).

“What are your names?" the giant bear, Super Size, asks.

"LFB," says LFB, trembling.

"What kind of name is LFB?" asks Kevin, the guitar.

LFB bites her tongue and narrowly avoids asking what kind of guitar is named Kevin, and just says "It stands for Lovable Fluffy Bunny. My mum named me."

The unicorn shakes her tail and says "It's a lovely name. I like it," and glares at Kevin.

“How about hers?” the snake hisses, pointing at Foxy.

“*She* can answer for herself,” Foxy says, bristling a bit. “My name is Foxy. Because I am a fox.”

“Okay, okay,” says Hugo the hippo. “That’s fine. Are you okay? We didn’t mean to hurt you when we captured you, we just didn’t want to let you get away.”

Mollified, Foxy nods. “Head hurts a bit but I’m okay.”

"What are you doing here?" the giant owl interrupts.

Trading back and forth, LFB and Foxy tell everyone the whole story -- how they fear they are running out of food, and they wanted to see if the Others were stealing it (at this point LFB trembled a little bit more, and Foxy gave her a reassuring hug) or were having similar problems. As they get into the story, they can't help but notice that most of their listeners seem stunned. The penguin whispers to the unicorn and the giant bear several times during the explanation. When they stop, there is a long silence.

"How do we know you're telling the truth?" the snake, Sissily, finally asks.

"I... don't know," LFB says. “We are, I swear."

After a pause, Little Blue (the penguin) raises her wing. "I have an idea," she says. "We can give them a lie detector test. I just invented it, and it seems to work based on my initial experiments.”

“How does it work?” asks the unicorn curiously.

“The test has 50 questions,” says Little Blue. “Half of them are **control** questions where we know the answer and which people would tell the truth for – questions like *what colour is the sky?* The other half are **test** questions which the person might be lying on. The lie detector measures people’s heart rate as they answer. If their heart rate is higher on the test questions than the control questions, then that means they are nervous and thus probably lying on the test questions.”

“Oh dear,” says Foxy. “That alone makes me terribly nervous.”

“I can take the test,” LFB volunteers. “I mean, I know that we’re telling the truth and I’d like to demonstrate that.”

Foxy pauses, and then says, “I guess I can take it as well if you need me to.”

Kevin bursts out suspiciously, “How do we know they won’t cheat?”

LFB bristles, but Rainbow the unicorn just smiles. “Don’t worry,” she says. “They can take it at the same time, in separate rooms. Plus, we randomise the order of the questions, so Q1 for LFB won’t be the same as Q1 for Foxy, and so forth. Even if they could communicate somehow, they wouldn’t possibly be able to coordinate answers under these circumstances.”

After a moment, Kevin nods, mollified, and the rest of the Others join in. It seems to be settled.

I hope this works, Foxy thinks nervously. *I know I’m telling the truth, but what if I mess this up? What if their test isn’t very good after all?*

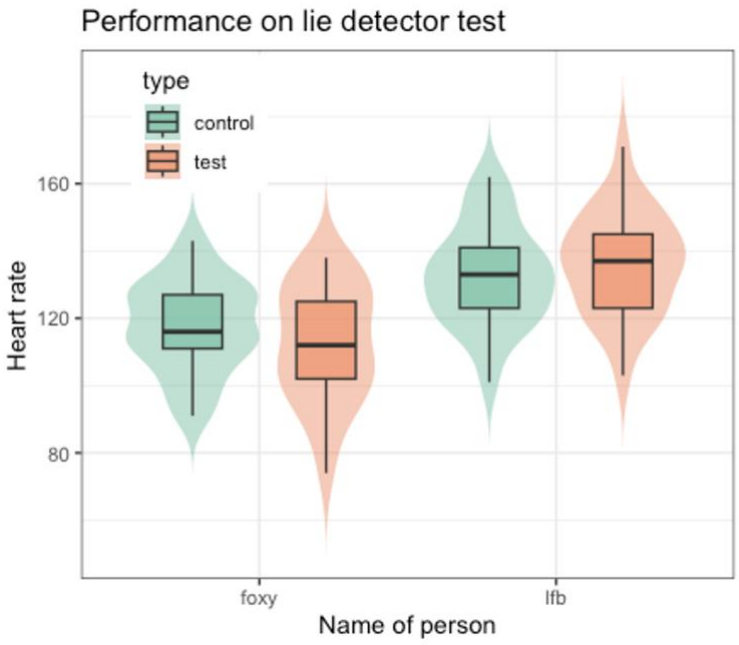
But there is no choice – she can’t think of anything else that would persuade them better, so she nods and tries to look confident. She can’t help but notice that LFB and Little Blue look nervous also, but everyone gets up and the two of them go to separate rooms to take the test.

The tibble dl, which has been loaded for you in the R Markdown document, contains the results of the lie detector test. Each row corresponds to one question (remember, Q1 for LFB is not the same as Q1 for Foxy, etc.). The four columns are as follows:

question: the question number indicating the order it was given for that person (Q1=first, etc.)
type: whether that question was a test or control for that person
name: the name of the person who answered that question
hr: the heart rate (in beats per minute) of that person while answering that question

Q2 [6% of total mark]

Let’s visualise some data. In the code chunk for this question make a plot like the one below. Note that this plot only uses geoms that you have been taught but it *does* involve some arguments to the geoms that you have not seen; part of the purpose of this question is to evaluate your ability to figure this kind of thing out by using the help files for the geoms and googling. For full credit, your figure should have all the components in the figure below with everything in approximately the same places (e.g., the legend should be in the upper left corner, etc). It is fine if your colours and the degree of transparency aren’t exactly the same (you aren’t expected to guess what palette or alpha values were used here) as long as you use a sensible palette and the colours vary as shown.



Q3 [9% of total mark]

Run the appropriate statistical test to evaluate whether the lie detector test indicates LFB and/or Foxy lied, as well as whether their performance was different from each other; don't worry about testing for an interaction. (For simplicity, let's assume that all the assumptions of the relevant statistical test have been met, so you don't have to evaluate any assumptions.) In your report, don't worry about descriptive statistics (the figure above suffices) but do include a description of which statistical test you used, the outcome and predictor variable(s), the appropriate stats reference, and the interpretation of this data in terms of the research question. Don't worry about effect size or any post-hoc tests. [Suggested word count: 115]

* * *

The Others confer a bit and realise that regardless of the results of the lie detector test, over the course of working and talking with LFB and Foxy they have realised that the two are at least reasonably trustworthy. Following a long, whispered conference amongst each other, Rainbow the unicorn steps forward and unties them.

“Sorry for our suspicion. We've been having food problems ourselves," she confides quietly. "We haven't known what to do about it, and are pretty worried."

"Maybe we could help?" LFB offers. "I mean, I don't know much, but perhaps if we compare problems we'll be able to figure out what's going on. We can tell you what we know about our situation too."

Foxy nods and shares the survey data we saw in previous weeks. The Others share their food data that you went over in the tutorials, and everyone agrees that there is a problem.

"The thing is," Super Size observes (everyone is now very companionable and speaking frankly), "I fear that this is having a lot of bad indirect effects on everything else. People are more irritable and fighting more, they're sick more often, and things like that.”

"Do you have any data about that?" LFB asks, curious.

Little Blue thinks, and then nods finally. “It's not as big of a dataset as some of the others, but myself and a bunch of my friends have been using an app that track different measures about our life. We have data from the last two years. We could look at that.”

She brings it out and everybody clusters around and looks at it. "There is a sentient string in Otherland?" LFB asks incredulously.

Kevin looks up, miffed. "That's my best friend, Kevin Clark," he says. "What, do you think a string can't be intelligent? Or a guitar?"

"No, no, just curious," LFB backpedals hastily. "All good."

Rainbow whispers to her, "We don't understand it either. Just go with it."

Super Size clears his enormous throat. "Ahem. So now you have a sense of our dataset. That's reasonably representative of Otherland, I would say."

Sissily nods. "Yes. Mostly birds, bears, and bunnies, with a bunch of other things too."

“This is super fascinating,” Foxy interrupts, “but let's have a close look!”

The data is in the tibble called `dd`, which has been loaded for you. It has the following columns:

name: the name of each person
species: the species of the person
type: whether the person is a mammal, bird, or something else (other)
time: when the data was collected. There are two time points separated by a year each (t1 and t2). Each person contributes two rows to the dataset, one for each time point. The most recent time period, t2, ended a few months ago.
health: that person's overall health rating on a scale of 0-100 where higher equals better
income: that person's income during that time period in thousands of dollars (thus, 100 indicates an annual salary of $100K, and higher equals better)
height: the person's height in cm
size: the size of the person (small is less than 15cm, medium is between 15 and 30cm, and large is greater than 30cm)
disability: TRUE if the person was officially classified as disabled at that time (indicating health problems that meant they could not work full-time); FALSE otherwise

"There is a lot of data in this," says LFB, impressed. "Wow."

Hugo nods. "Little Blue likes this sort of thing," he said. "Rainbow helped a lot too."

"But where do we begin?" Super Size asks. "There's so much it's a little overwhelming."

"One thing at a time, I always say," says Foxy. "What is our most important question?"

"I guess… we want to see if people's health has actually been getting worse," says Sissily.

Everyone is silent for a moment, thinking.

"Luckily Little Blue did collect health data," Kevin points out. "We could look at that."

"Yeah!" LFB says. "We could see if the average health ratings are different at time 1 and time 2."

Q4 [17% of total mark]

Q4a. There is one main assumption you need to test before implementing the analysis LFB is suggesting. Do so and report the results. Be sure to include the assumption, the name of the test you did, the variable(s) involved, the results including stats reference, whether the assumption was violated, and how you could tell. [Suggested word count: 65]

Q4b. Given the answer in Q4a, use the appropriate statistical test to implement the analysis LFB suggests and report on the results. Your answer should present the descriptive statistics in some way. It should also include the predictor and outcome variable(s), the effect size and interpretation, and the appropriate stats reference. In addition, it should explain which statistical test you used and why, and also interpret the result in terms of the research question. [Suggested word count: 115]

* * *

"That's all fine," Kevin says, "but how do we know we can trust this health rating data? If it's self-report, maybe it just reflects people's willingness to complain or level of stress or something."

Rainbow is clearly annoyed. "Self-report data is actually quite reliable if you ask good questions," she says. "Besides, are you suggesting Little Blue's friends aren't trustworthy?"

“Stop being defensive,” Sissily snaps. “It’s a good question.”

Hugo rolls his eyes. “Both of you, ugh.”

Foxy and LFB exchange a look. *It seems the Others are just like normal people*, LFB thinks.

Super Size raises his hands. “It *is* a good question but it could also have been stated in a much nicer way,” he says firmly. Foxy is really starting to appreciate his calmness and diplomacy. “Do we have any other measures we could look at as well?”

The owl, who has been mostly silent so far, raises a wing. “How about disability?” she asks. “That indicates if someone is getting government assistance because they can’t work due to health problems. Since it’s an official measure it means somebody has gone out and investigated to make sure there is something actually going on, so it’s not just self-report.”

“It doesn’t capture just health problems,” Kevin points out. “I’m on disability because I have no hands or legs so I can’t do most jobs, but I don’t have health problems.”

“And my health isn’t great – I’m tired all of the time – but I’m not on disability because I am so big that I can still do useful things,” Super Size says.

“Still, though, it’s better than nothing,” Foxy says. “At the very least, if it suggests a pattern similar to what we found with the health rating, that is convergent information about what’s going on.”

“So,” says Little Blue, “what we need to look at is the disability information at time 1 and time 2. How many people have it at each time; how many changed from being on disability to being off it, or vice versa. Then we want to see if that indicates a significant difference between t1 and t2.”

* * *

Q5 [8% of total mark]

Perform the analysis that Little Blue suggests and report the results. Be sure to explain what test you did and why, present the descriptive statistics in some way, include the stats reference, and interpret the result in terms of the research question. Don’t worry about effect size. [Suggested word count: 140]

* * *

“Not to be a pain,” says Foxy after a while, “but even though it’s nice to have this data, it doesn’t tell us anything about *why* we’re seeing these patterns.”

“It’s very hard to infer causation from most data,” says Kevin chidingly.

Foxy is too polite of a person to roll her eyes, but LFB can tell she wants to. “I know,” she says instead. “We can’t infer it for sure but if we could look at other variables and how they change at the same time, that can indicate something.”

Rainbow nods in support. “Yeah. Like, if some people’s health is getting worse and other people’s isn’t, or some are deteriorating faster, that might suggest what is going on.”

“What if there was some other variable causing both?” asks Hugo. “Like maybe people’s health is getting worse *and* there is less food because people are getting poorer and so can’t afford it.”

“Or maybe there’s some disease causing health to drop, which makes people not feel well enough to harvest crops, and that is why the food is going down,” chimes in Super Size.

"We can't tell for sure," LFB repeats again. "But these hypotheses all imply different patterns and relationships, and at least we can look to see what patterns there *are*."

Everyone nods again, but the mood is down. The task seems impossibly hard.

This time the owl breaks the silence. "Okay. What other variables are there in our dataset?"

Hugo frowns. "Well, there are three sizes of people: small, medium, and large. We could see if they have different health outcomes."

"Good idea," says Little Blue. "But if we don't care about change over time, and only are concerned about how health relates to size, let's exclude time t1 from our analysis. We can't use all of the data from both time points if we're not explicitly analysing the time points separately, and it makes more sense to look at the more recent time period than the one that was longer ago."

Little Blue is correct. Therefore, **for Q7 through Q10,** you should use `ddt2`, which has been created for you and which is identical to `dd` except that it contains only data from time t2.

Q6 [3% of total mark]

Why is Little Blue correct? In other words, why is it better to exclude data from time point 1 for the kinds of analyses she mentions, i.e., the statistical analyses you will do in Q7-Q10? Your answer should discuss one or more of the assumption(s) that underlie these analyses, and explain why excluding one of the time points is necessary in light of this. Are there other things we could do instead that would also solve the same issue? [Suggested word count: 115]

Q7 [9% of total mark]

There are two main assumptions you need to test before implementing the analysis in Q8 below. Evaluate each report the results. For each, be sure to include the assumption, the name of the test you did to evaluate it, the results including stats reference, whether the assumption was violated, and how you could tell. [Suggested word count: 95]

Q8 [9% of total mark]

Given your findings in Q7, run the appropriate statistical test to evaluate whether there is a significant difference in health rating between small, medium, and large animals. In your report, be sure to present the descriptive statistics in some way. In addition, include a description of which statistical test you used and why, the predictor and outcome variable(s), the appropriate stats reference, and the interpretation of this data in terms of the research question. Include effect size and its interpretation but don't worry about post-hoc tests. [Suggested word count: 95]

* * *

"You know," LFB says, "if we want to look at how the size of the person and health rating are related we should use the predictor variable *height* instead of *size,* since it has the exact height instead of only three size categories."

"I don't see why that would make a difference," Rainbow says doubtfully.

"I think she's right," Little Blue says. "That's a much better idea."

Q9 [14% of total mark]

Q9a. Do as LFB suggests: run the appropriate statistical test to evaluate whether height is a significant predictor of health rating. You do not need to test any assumptions and can act as if none have been violated. In your report, don't worry about including descriptive statistics but do include an explanation of which statistical test you used, the stats reference(s), the predictor and outcome variable(s), the effect size of the model as a whole, and the interpretation of this data in terms of the research question. Include a description and interpretation of any significant unstandardised coefficients (not including the intercept) but don't worry about standardised ones. [Suggested word count: 115]

Q9b. Compare the result you got in Q9a with the one you got in Q8. Is it the same or not? Explain why that is the case. [Suggested word count: 185]

* * *

"You know," Super Size says, "We can look at how other things affect health besides the height of the person. What about income? Maybe poorer people are unhealthier."

"It's easy enough to look at that," says Foxy. "Just add income into the same analysis we just did."

Q10 [6% of total mark]

Create a new analysis which is like the one in Q9 except it adds income, and thus is the appropriate statistical test to evaluate whether income and/or height are significant predictors of health rating. Do not include an interaction term.

Compare the result you got here with the one you got in Q9. You need only report on what *result suggests about the effect of height*. (That means you don't need to report or talk about the model as a whole, nor discuss the effect of income on its own, nor report the model, nor explain what test you ran, nor describe the outcome and predictor variables, nor provide stats references, etc.).

Is the effect of height the same here as it was with the model in Q9? If it is the same, explain in what respects it is the same and why adding income made no difference. If it is different, explain in what respects it is different and why adding income made the difference that it did. [Suggested word count: 115]

Q11 [6% of total marks]

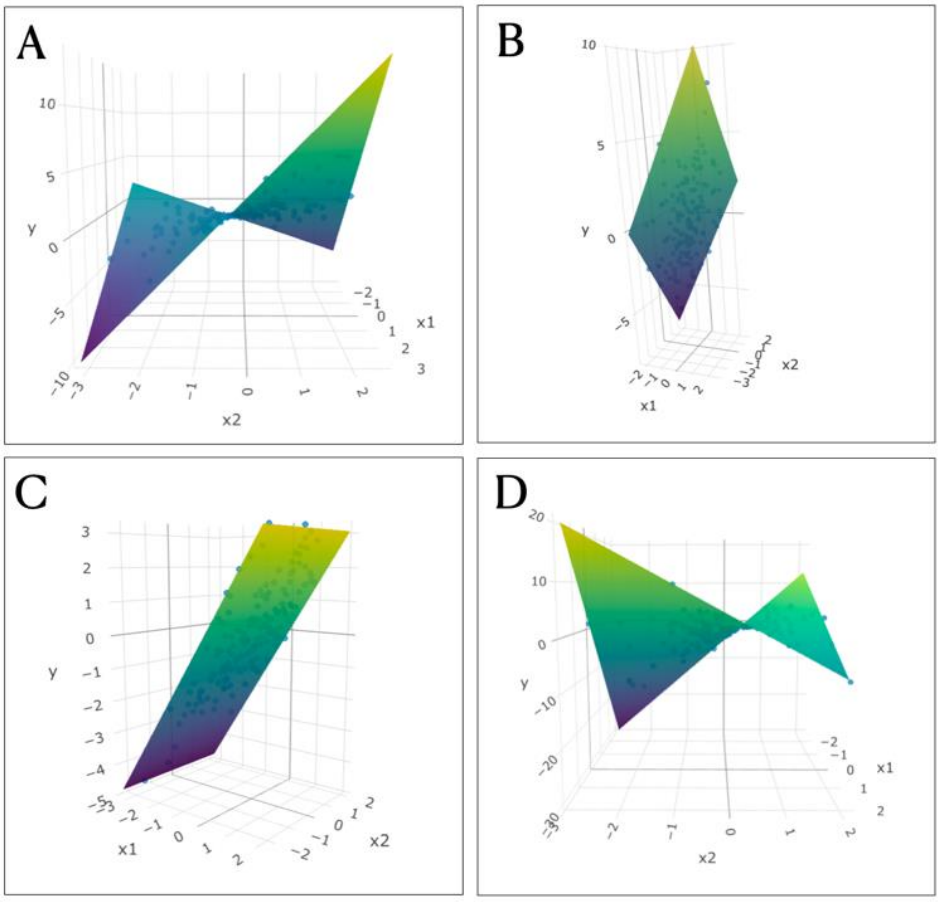
Q11a. Which of the following statistical references is impossible? For each, indicate your answer by reporting A or B. Use your knowledge about each test statistic and how it is related to degrees of freedom and/or p-values to answer this question. You do not need to do any coding.

(i) A. $\chi^2(3) = 75.3, p = .936$ or B. $\chi^2(1) = 1.44, p = .231$

(ii) A. $t(44) = 0.67, p = .003$ or B. $t(35) = -2.68, p = .011$

(iii) A. $F(2,88) = 0.12, p = .854$ or B. $F(3,112) = -82.9, p < .001$

Q11b. For each answer in Q11a, explain it by describing intuitively what the test statistic captures and thus why you chose the answer you did, making reference to the degrees of freedom and/or p-value as appropriate. [Suggested word count: 190]



Q12 [4% of total marks]

Q12a. For each of the following equations, indicate which figure above it corresponds to. (Note: you do not need to code anything for this problem; just use your understanding about what the various coefficients mean, and pay special attention to the positive and negative signs).

(i) $y = 1.5x_1 + \epsilon$
(ii) $y = x_1 + x_2 + x_1x_2 + \epsilon$
(iii) $y = 2x_1 - 1.5x_2 + \epsilon$
(iv) $y = 2x_1 + x_2 - 3x_1x_2 + \epsilon$

Q12b. For each answer in Q12a, explain why you chose it by discussing the relevant aspects of the equation and how they map onto the figure. You do not need to discuss every single part of the equation and the figure, only the ones that were relevant for distinguishing them. Note: we are not looking for answers of the form "I ruled out all of the other possibilities, so it must be this one"; although you can mention this if it was part of your reasoning process, each answer must make reference to that equation and the figure in some way. [Suggested word count: 165]

Q13 [2% of total mark]

These marks are free as long as you say anything! Who is your favourite character in the Bunnyland story, and why? (This can be anyone, whether from Bunnyland or Otherland or whatever). (No word limit here, say as much or as little as you want)