Self-screening tool for MPhil in Population Health Sciences candidates

Please attempt all questions (except in the "Coding" section, where you should do one of the tasks). Write down your answers, and note how you reached them, before looking at the answer key and the suggested resources.

Units and Orders of Magnitude

Population health sciences can involve very large numbers (and very small probabilities). It can involve comparing data across multiple datasets, which might not be displaying numbers in the same way, or even using the same units.

1. A respiratory mask filters out particles with diameter larger than 0.3×10^{-6}m. Which of the following hazardous substances would the mask filter out?
    a) Asbestos fibres with a diameter of 2.5×10^{-4}m
    b) Diesel exhaust carbon particles with a diameter of 1.2×10^{-5} cm
    c) Benzene molecules with a diameter of 6.2×10^{-10} m

2. On average a 70kg man has 1.35×10^{5}kcal of potential energy stored in fat, 1.2×10^{3}kcal of potential energy stored in glycogen and 2.4×10^{4}kcal of potential energy available from metabolising protein. What is the total potential energy stored in these sources? Express your answer in units of kcal using standard form to 4 significant figures.

Programming – Coding

As part of the MPhil you will be doing statistical programming/ data science in the R programming language. We don't assume any programming knowledge, however, it is useful to be familiar with some of the basics of how code is constructed.

3. If you don't have experience with programming, please complete Part 2 (Also called "Normal" on the app) of the RodoCodo Hour of Code game:

https://game.rodocodo.com/hour-of-code/

You will see that this programming game is aimed at children. Please don't be put off by this. If you didn't learn basic programming as a young child, it helps to go through these fundamental ways of thinking, in much the same way as you would do if you were trying to learn a foreign language as an adult.

If you have experience with programming, please do this question instead:

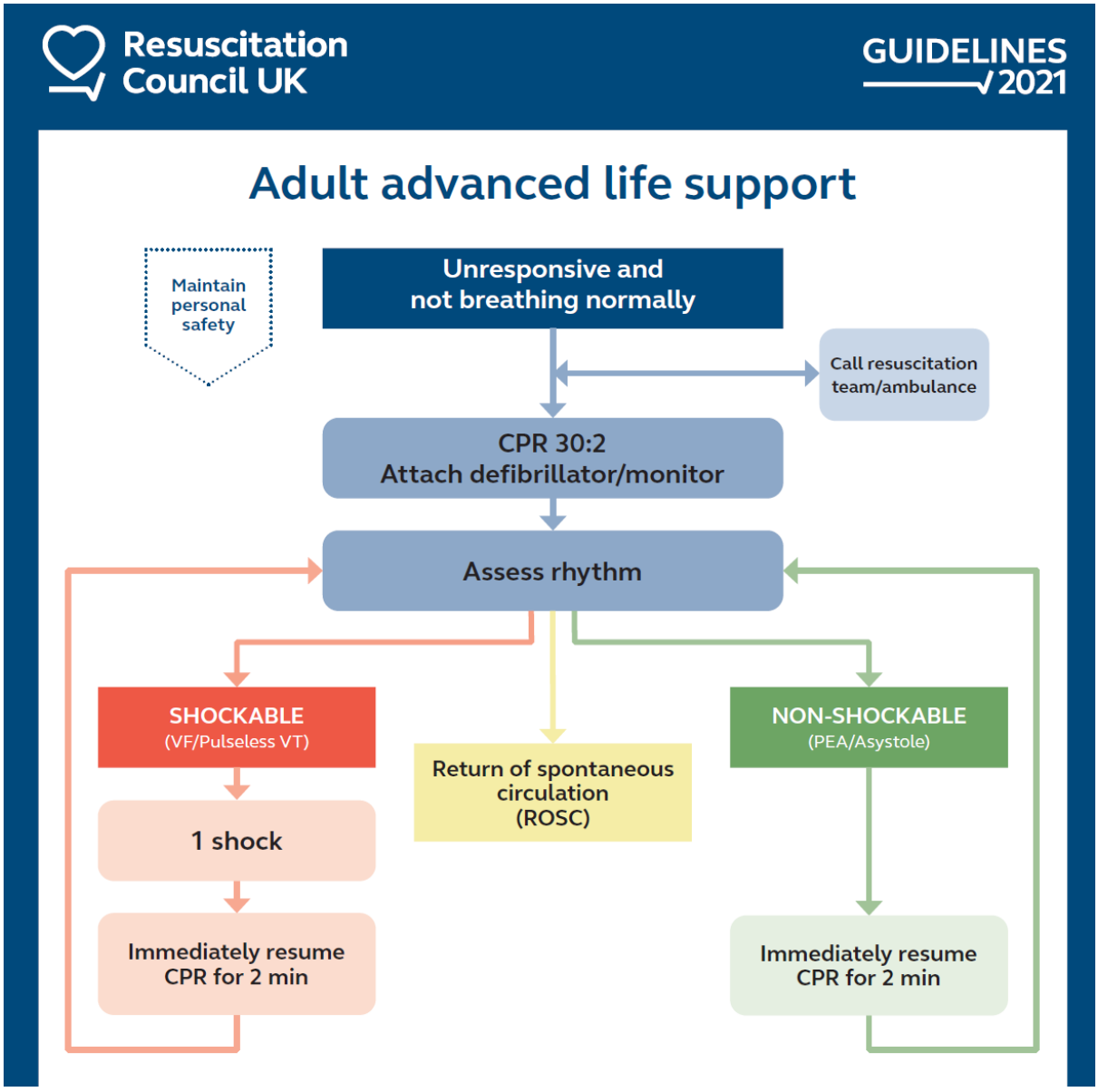
3. In the programming language of your choice:
    a. Write code which will print the statement "Hello World!"
    b. Write some code which will load a dataset saved in csv format
    c. Write some code which uses a for loop (or otherwise performs a task which would typically be done with a for loop).

d. Write some code which uses an if-else statement (or otherwise performs a task which would typically be done with an if-else statement).
e. Write some code which defines a function that takes as input two numbers and returns their sum

Programming – Algorithmic Thinking

As part of the MPhil you will be doing statistical programming/ data science in the R programming language. We don't assume any programming knowledge, however, it is useful to be familiar with the kind of logical thinking behind writing algorithms.

However, algorithmic thinking is not just used in programming. You will have encountered many algorithms in your day to day work and life. For instance, below is the Resuscitation Council UK's 2021 algorithm for adult advanced life support:



4. Think of an algorithm you have used in your work/ study. Write it down as a flow chart.

5. You and two of your friends are at a coffee shop. You have decided you will pick who pays for all the coffees at random. However, all you have is a fair (two sided!) coin.
    a. Come up with an algorithm which picks one of the three of you at random, with equal probability, and write it down as a flow chart.
    b. Can you extend your algorithm to when there are more than three of you?

6. The life support algorithm above has a loop – the command "Immediately resume CPR for 2 min" is repeated endlessly (or until ROSC is achieved). Come up with an algorithm you have used in work/study/life which has a loop, and write it down as a flow chart.

Algebra of Regression

One of the most common statistical tools used, particularly when we wish to control for the effect of confounding variables or make predictions, is regression. The Principles of Biostatistics module will cover linear regression and logistic regression. In order to interpret the output of these models, you will need to be able to comfortable with some algebra.

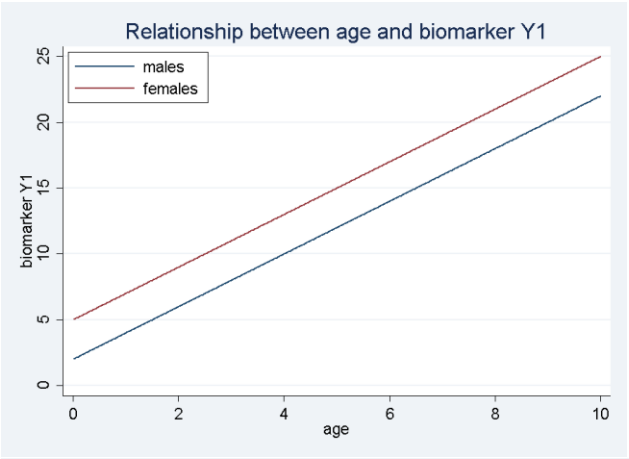
Note: for all of these questions, log means natural logarithm, base e; exp(x) means e^x

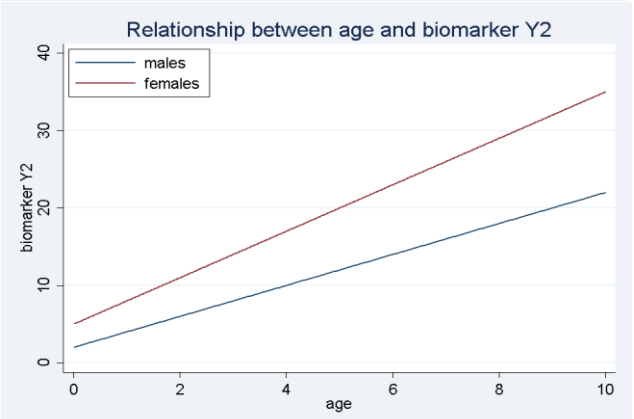
7. Write each of the following expressions as a single logarithm:
    a. log(a) + log(b)
    b. log(a) – log(b)

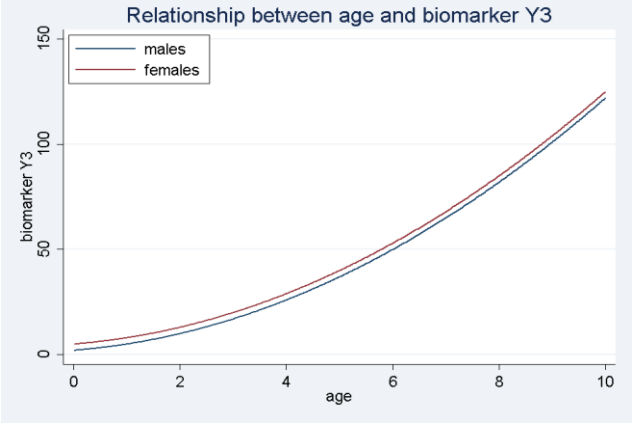
8. Write each of the following expressions as a single exponential term:
    c. exp(a) x exp(b)
    d. exp(a) / exp(b)

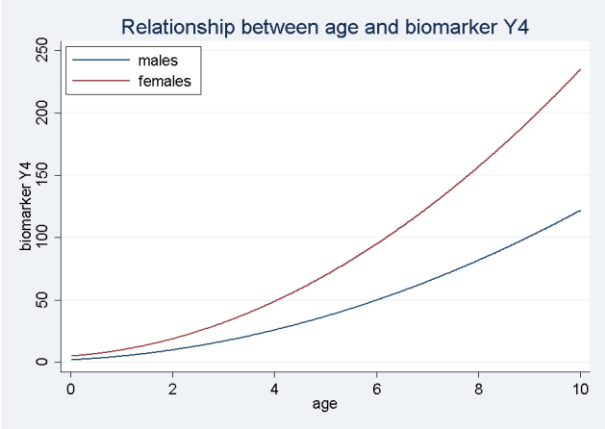
9. Assuming x and y are real numbers, rearrange and simplify the following equations to express X as a function of Y.
    a. Y=log(X)
    b. Y =log(X^a)
    c. Y=X^2-3
    d. Y= 10^{-4} x X
    e. Y =exp(2X+6)
    f. Y=(exp(X))/(1+exp(X))

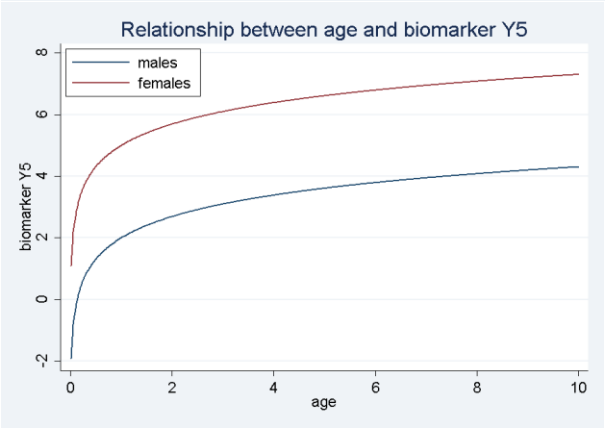
10. The graphs below show the relationships between various biomarkers (blood chemicals) labelled Y1-Y5 and age, amongst male and female children aged 0-10 years. Let *female* represent a binary variable which equals 0 for males, and 1 for females and *age* represent a continuous variable for age in years. Which of the following equations represent the lines drawn for the biomarkers labelled Y1, Y2, Y3, Y4 and Y5 in the figures above?
    a. Equation 1: Y = 2 + 2 x age + age^2 + 3 x female + age x female + age^2 x female
    b. Equation 2: Y = 2 + log(age) + 3 x female
    c. Equation 3: Y = 2 + 2 x age + 3 x female + age X female
    d. Equation 4: Y = 2 + 2 x age + age^2 + 3 x female
    e. Equation 5: Y = 2 + 2 x age + 3 x female


Relationship between age and biomarker Y1
males
females
biomarker Y1
0
5
10
15
20
25
0
2
4
6
8
10
age


Relationship between age and biomarker Y2
males
females
biomarker Y2
0
10
20
30
40
0
2
4
6
8
10
age


Relationship between age and biomarker Y3
males
females
biomarker Y3
0
50
100
150
0
2
4
6
8
10
age





11. Select the single most correct answer for each of the following:

a. $\sum_{r=1}^{4} r^2$ =

(i) 1 + 2 + 3 + 4

(ii) $1^2 + 2^2 + 3^2 + 4^2$

(iii) $(1 + 2 + 3 + 4)^2$

(iv) $1^2 + 4^2$

b. $\sum_{r=1}^{4} \log(r)$ =

(i) log (1 x 2 x 3 x 4)

(ii) log 1 x log 2 x log 3 x log 4

(iii) log (1 + 2 + 3 + 4)

(iv) $e^{(1 + 2 + 3 + 4)}$

12. Solve the following simultaneous equations for x and y:

a. 2y = 6 and 10y + x = 20

b. 14x + 5y = 31 and 2x – 3y = -29

Statistics and Probability

When doing Population health science, we must deal with uncertainty constantly. Often we have only a small sample, and wish to make an inference about a wider population. Often we are interested in understanding risk factors (that is, the probability of an outcome

occurring) rather than dealing with a deterministic process. This is why statistics is such a key tool.

The following tables give data from a non-randomised study medical study comparing the success rates of two treatments for kidney stones – open surgery vs percutaneous nephrolithotomy

Patients with small kidney stones	Treatment Success	Treatment Failure
Open Surgery	81	6
Percutaneous Nephrolithotomy	234	36

Patients with large kidney stones	Treatment Success	Treatment Failure
Open Surgery	192	71
Percutaneous Nephrolithotomy	55	25

13. Based upon this data:
    a. Which of the two treatments results in the greatest chance of success overall?
    b. Looking only at patients with small kidney stones, which of the two treatments results in the greatest chance of success?
    c. Looking only at patients with large kidney stones, which of the two treatments results in the greatest chance of success?
    d. What would be your clinical recommendation based on this data?

Medical data was collected from a sample of adults in the UK. The following table shows the percentage of adults in each age group who had a diagnosis of cardiovascular disease

Age	18-34 years	35-44 years	45-54 years	55-64 years	65 years and over
Percentage Diagnosed	6%	13%	27%	47%	65%

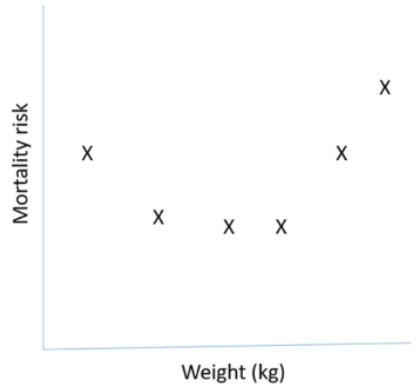
14. For each of the following questions, either answer the question or explain which piece(s) of additional information you would need to answer the question:
    a. In which age group is a diagnosis of cardiovascular disease most common?
    b. In which age group are the majority of people in the sample with cardiovascular disease?
    c. What is the overall prevalence of cardiovascular disease in the sample?
    d. What is the overall prevalence of cardiovascular disease in the UK?
    e. Is there a statistically significant difference between risk of heart disease in those who are 45-54 years old and those who are 55-64 years old?

f. Five people are chosen at random from the sample – one from each age group. What is the probability that none have been diagnosed with cardiovascular disease?

Drawing Conclusions from Data

The key task when performing any kind of quantitative research or data science is to be able to draw meaningful conclusions from the data collected. In order to do this, we need to be able to design good experiments, make sure the correct data is gathered, and that our statistical methods are appropriate to the task. However, sometimes even once we have the results of the study, the correct interpretation is not straightforward…

Note: these questions are not about statistical significance – there is no need to include p-values, etc, in your answer.



15. A doctor has been monitoring the relationship between patients' body weight and mortality (dying). In the graph, each point represents 100 patients, with their mortality risk (proportion of the 100 who died) shown in relation to their body weight. The correlation between body weight and mortality risk is 0.03.
    a. The doctor concludes that weight is of no use in predicting mortality risk. Do you agree?
    b. A different doctor concludes that weight is of use in predicting mortality risk. They suggest an intervention aimed at helping patients reach a healthy weight would reduce mortality. Do you agree?