Class 1: An introduction to Bayesian Hierarchical Modelling

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https://andrewcparnell.github.io/bhm_course

Let's get started

- Introduction from Oliver Hooker, PR Statistics
- Tell me:
  - who you are,
  - where you are from,
  - your previous experience in working with R and regression models,
  - what you are working on,
  - what you want to get out of the week
- Timetable for the week
- Pre-requisites

How this course works

- This course lives on GitHub, which means anyone can see the slides, code, etc, and make comments on it
- The timetable document (`index.html`) provides links to all the pdf slides and practicals
- The slides and the practicals are all written in `Rmarkdown` format, which means you can load them up in Rstudio and see how everything was created
- Let me know if you spot mistakes, as these can be easily updated on the GitHub page
- There is a `bhm_course.Rproj` R project file from which you should be able to run all the code

Copyright statement

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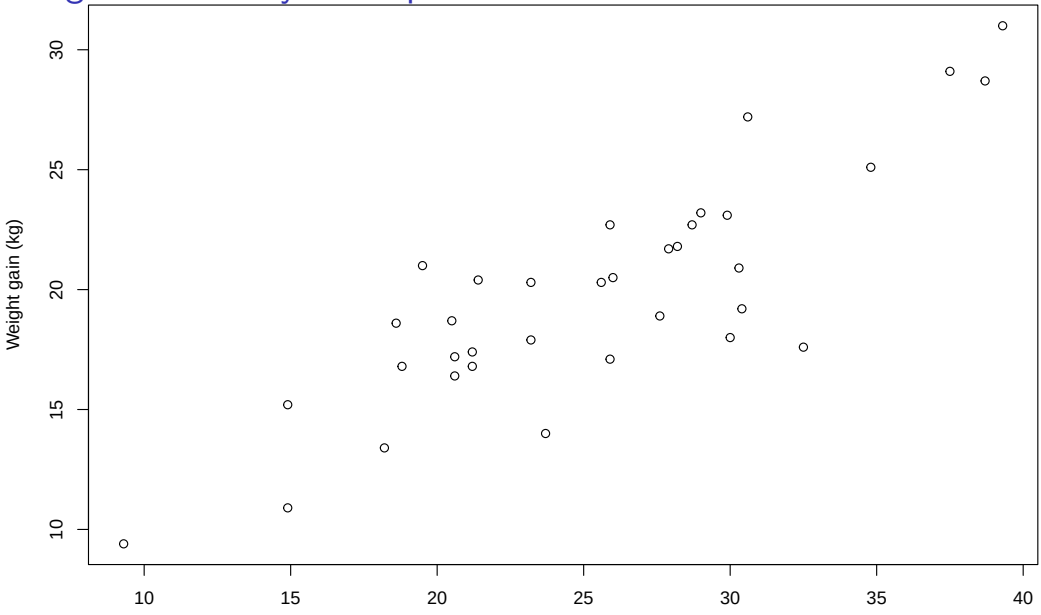
Course format and other details

- Lectures will take place in the morning via Zoom, practical classes in the afternoon
- In the practical classes I will go round the room asking people how they are getting on
- If you want to send me a private message use Slack
- Please ask lots of questions
- Some good books:
  - *Data Analysis using Regression and Hierarchical Models* by Gelman and Hill
  - *Bayesian Data Analysis* by Gelman et al

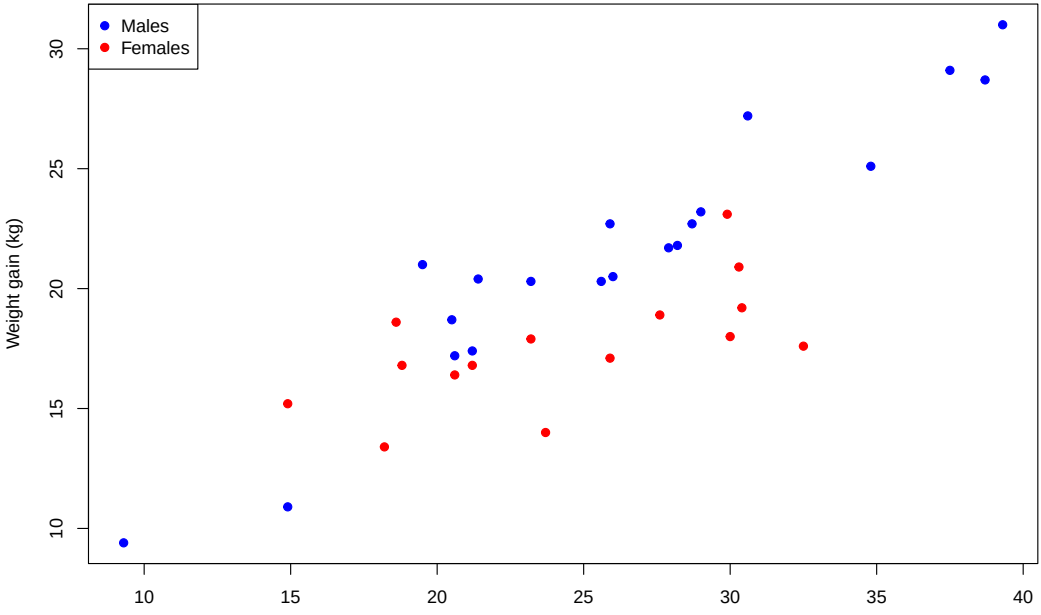
What is a Bayesian hierarchical model?

- **A model** is just a representation/approximation of the real world, here expressed in equations
- **Hierarchical** means that the model is built up in *ordered layers* which makes it easier to fit very complex models
- **Bayesian** means the model involves both a *likelihood* and a *prior* probability distribution (more on this tomorrow)

Thinking hierarchically: example 1



More information:



Example 2: 8 Schools

We have 8 schools in a region, with a relative performance score (column `score`) compared to the national average and a standard deviation (`sigma`) based on 3 repeated visits

```
##   school score sigma
## 1      1    28    15
## 2      2     8    10
## 3      3    -3    16
## 4      4     7    11
## 5      5    -1     9
## 6      6     1    11
## 7      7    18    10
## 8      8    12    18
```

- If you had to pick an overall score for this region how would you calculate it?
- If you had to guess the score of a new measurement for school 1 what value would you use?

Example 3: Earnings data

1192 observations on earnings (in USD) and various measurements about ethnicity, age, height, etc

```
##    earn age eth height height_cm        y  x x_centered
## 1 50000   2   3     74    187.96 10.81978 74   6.932011
## 2 60000   3   3     66    167.64 11.00210 66  -1.067989
## 3 30000   1   3     64    162.56 10.30895 64  -3.067989
## 4 51000   2   3     63    160.02 10.83958 63  -4.067989
## 5  9000   1   3     64    162.56  9.10498 64  -3.067989
## 6 29000   2   3     62    157.48 10.27505 62  -5.067989
```

- Does height affect earnings?
- Are there different rates of change for different groups (e.g. age/ethnic groups)?

Example 4: Swiss Willow Tit data

3 replicate measurements on whether Swiss Willow Tits were found with covariates on forest cover and elevation

```
##   rep.1 rep.2 rep.3 c.2 c.3 elev forest dur.1 dur.2 dur.3 length alt
## 1     0     0     0   0   0  420      3   240    58    73    6.2 Low
## 2     0     0     0   0   0  450     21   160    39    62    5.1 Low
## 3     0     0     0   0   0 1050     32   120    47    74    4.3 Med
## 4     0     0     0   0   0 1110     35   180    44    71    5.4 Med
## 5     0     0     0   0   0  510      2   210    56    73    3.6 Low
## 6     0     0     0   0   0  630     60   150    56    73    6.1 Low
```

- How do the covariates affect the chance of finding the birds?
- Are these effects linear?
- What do we do with the missing data?

More data sets in the data directory

- The data directory contains a few more data sets which we will play with throughout the week
- The `data_descriptions.txt` file shows what they contain
- If you have some spare time it's worth loading them in, exploring relationships, and fitting some simple models

Summary

- In hierarchical models we avoid fitting models separately as much as possible
- By fitting models together we **borrow strength** from the different groups in the data and reduce uncertainty
- Bayesian models allow us to incorporate all the available data into providing information on the question we want to answer