

1. Complete exercise 4 in Chapter 11. The data are on the canvas site. Some notes about what to hand in:
 - For parts (a) and (b), hand in graphs for 10 of the children, not all of them.
 - For part (c), you are being asked to model intercept and slope as a function of treatment and age at baseline. You should think about how to model age (i.e., linear or nonlinear) and justify your choice using residual plots.
 - For part (c), prepare a table showing the regression results, including point estimates and standard errors.
2. Complete exercise 2 in Chapter 12. What to hand in for this:
 - For parts (a) and (b), write down the model using multilevel model notation. Also hand in code and output.
 - For part (c), decide on the quantitative comparison you will make and summarize in a table. Hand in the table and the graphs you decide to create, along with the chunk of R code used to derive them.
3. Complete exercise 5 in Chapter 12. For this, make sure to write the model using multilevel model notation, defining all terms. Hand in the chunk of R code used to fit the model and a regression table with the results.
4. (Bonus). Consider the following multilevel model:

$$\begin{aligned}Y_{ij} &\sim \mathcal{N}(\alpha_j, \sigma^2) \\ \alpha_j &\sim \mathcal{N}(\mu, \tau^2)\end{aligned}$$

For this example, suppose $j = 1, \dots, J$ indexes clusters and $i = 1, \dots, n$ indexes units within cluster. Each cluster has the same number of units, so that the total number of observations is $N = n \times J$. An estimate of the overall mean μ is the sample mean of the Y_{ij} , namely

$$\bar{Y} = (1/N) \sum_{j=1}^J \sum_{i=1}^n Y_{ij}$$

- (a) Derive an expression for the standard error of \bar{Y} in terms of the model parameters.
- (b) Assume $\mu = 0$, $\sigma^2 = \tau^2 = 1$ and $J = 10$. Graph the standard error as a function of the number of units per cluster, n .
- (c) Repeat this for $J = 100$ and $J = 1000$.
- (d) What conclusions do you draw about the effect of the number of clusters versus the number of units per cluster as it relates to standard error?