Discussion Points for Unmeasured Confounding

- General Point: It might seem like adjusting for missing data, for measurement error, and for unmeasured confounding are very different problems, but from a Bayesian viewpoint the solutions are all very similar:
  - In each case there is "something missing" that creates a bias:
    - Non-response in the case of missing data
    - The true value of the covariate in the case of measurement error, but we have a proxy value which is close
    - Again the true value of the covariate in the case of unmeasured confounding, but now there is not even a proxy value, it is completely missing.
  - In each case, the solution is to use whatever information may be at hand to simulate the missing data:
    - Imputation in the case of missing data, taking a best guess at the missing data using non-missing data or outside information.
    - Bias adjustment via correction for measurement error: Using the mis-measured data, "impute" a guess at a correct value.
    - Take a guess at the value for the unmeasured confounder. This is perhaps the most difficult of the three, since we often have no idea of the values, no proxy measures, and even, perhaps, no idea what the nature of the variable may be. So more of a sensitivity analysis for the possibility of unmeasured confounding, to see the sorts of changes one could expect if there were such a confounder.
  - In each case, the guessed value surely has uncertainty around it, so take many guesses across a reasonable distribution. In other words, use "multiple imputation,"

a word often used in missing data problems, but the concept applies equally well to measurement error and unmeasured confounding.

  - For each guess, do a "complete case" analysis. Then, average inferences across these different analyses, keeping track of variance within and between analyses to fully account for all uncertainty.
  - proper tracking of all variability happens automatically in WinBUGS.

- Greenland 2003: Adjusts for biases in unmeasured confounding and response bias in childhood leukemia. He shows that such adjustments can have an impact on final inferences.

- Steenland and Greenland 2004: Similarly, this paper adjusts for unmeasured confounding from missing smoking data in estimating the possible effect of this concern on the relationship between lung cancer and silica.

- Greenland 2005: Is a paper about the concept of Bayesian bias modeling in general, with the first two pages containing a commentary about the typical analysis that does not investigate this issue.

- McCandless et al 2007: Provides the main methods for bias adjustment for unmeasured confounding from the Bayesian viewpoint. Section 2 provides the main model ideas, and we will use a simplified version of this model in the assignment. Equations (1) and (2) are key, plus prior choice.

- McCandless et al 2012: Continues on from the previous paper, considering hierarhcical priors for the bias parameters, but using the same basic ideas as McCandless et al 2007.

- **Important:** All of these adjustments rely on prior information within **non-identifiable models**. Outputs are only as good as the inputs, which are necessarily uncertain. Thus

these methods should be considered as **sensitivity analyses**, and results across a range of priors may be indicated.