Introduction to Epidemiological and Biostatistical Thinking

UW Neurology Fellowship

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Goal

Introduce you to epidemiological thinking and key (bio)statistical concepts that you can use to critically interpret scientific studies in health and medicine.

Learning Objectives I.

1. **Basics**. Identify key elements of an epidemiological study and how they relate to the scientific question
2. **Study Design**. Recognize the basic types of epidemiological study design and identify when each design is appropriate for the scientific question
3. **Bias**. Recognize sources of bias in study designs or measurements and understand how they might affect your ability to answer the scientific question

Learning Objectives II.

4. **Modeling**. Understand how you can formulate your understanding about a data generating process, assumptions, and a hypothesis to test in a statistical model
5. **Inference**. Recognize the distinction between an effect size, a confidence interval, and a p-value as they relate to parameters that are estimated in a statistical model

Basics

A epidemiological study should be generated by a *scientific question of interest*. Broadly, you can think of these scientific questions falling into two main categories:

- **Descriptive**: What is the incidence rate of ischemic stroke (IS) in women aged 45 - 60 years old?
- **Inferential**: What is the effect of an experimental treatment on mortality following ischemic stroke in women aged 45 - 60?

From a statistical point of view it is not a clean distinction because you still use statistical tools to *infer* the incidence rate for a descriptive study.

Basics

The questions *who, what, where, when* have never been more important than in the context of epidemiology!

Having a well-defined scientific question means having clear answers for the following components:

- **Exposure**: What is the group in study exposed to that you want to measure the effect of, and over what period of time?
- **Population**: Who is the group being studied?
- **Outcome**: What outcome is being studied (either in relation to the exposure or on its own) and over what period of time?

The *why* is also important! Epidemiological studies should serve some purpose.

Basics: Measures

Once you've defined your target exposure, outcome, and population that makes up your scientific questions, understanding **measurement** of the outcomes is of utmost importance.

Some common outcome measurements in the context of health sciences are

- **prevalence**: proportion of a population with an outcome
- **incidence**: rate of getting the outcome among individuals in a population that did not already have the outcome ("risk")
- **remission**: rate of returning to be outcome-free among those that had the outcome

Think about denominators!

Basics

What are the exposure, outcome, and population for each of these scientific questions?

- **Descriptive**: What is the incidence rate of ischemic stroke (IS) in women age 45 - 60 years old?
- **Inferential**: What is the effect of an experimental treatment on mortality following ischemic stroke in women age 45 - 60?

Table 1: Basic Elements of Study Design

	Descriptive	Inferential
Exposure		
Outcome		
Population		

Basics

What are the exposure, outcome, and population for each of these scientific questions?

- **Descriptive**: What is the incidence rate of ischemic stroke (IS) in women age 45 - 60 years old?
- **Inferential**: What is the effect of an experimental treatment on mortality following ischemic stroke in women age 45 - 60?

	Descriptive	Inferential
Exposure		experimental treatment
Outcome	ischemic stroke (IS)	death from IS
Population	women age 45-60 without IS	women age 45-60 with IS

How would you make these questions more precise?

Study Design

Biases

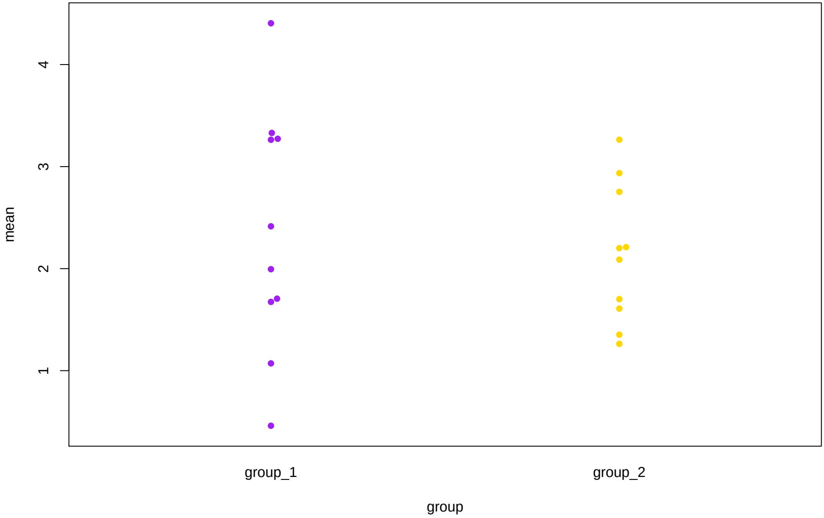
Biases in the epidemiological context are any factors in your study that *prevent* you from being able to answer your precise scientific question.

Biases may result from systematically incorrect measurements of the outcome, the exposure, or the population.

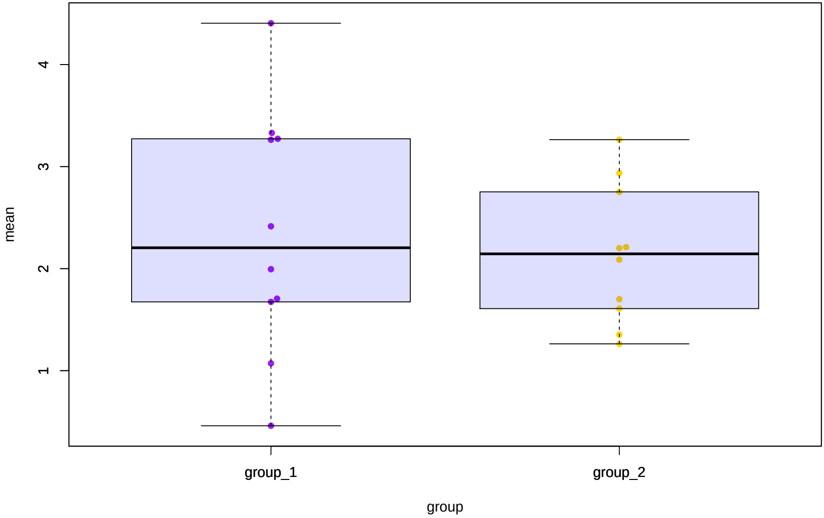
Examples of biases include:

- **Selection bias**: the population that you want to study is not the population that is actually in your study
- **Recall bias**: individuals are being asked about exposures or outcomes that they do not remember correctly
- **Social desirability bias**: individuals are not comfortable disclosing their true exposure or outcome status for fear of judgement by others

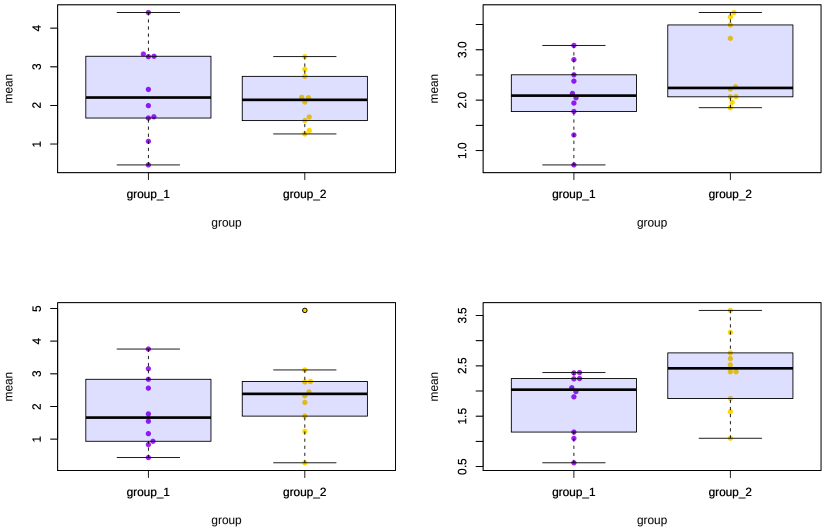
Inference: Simple Means



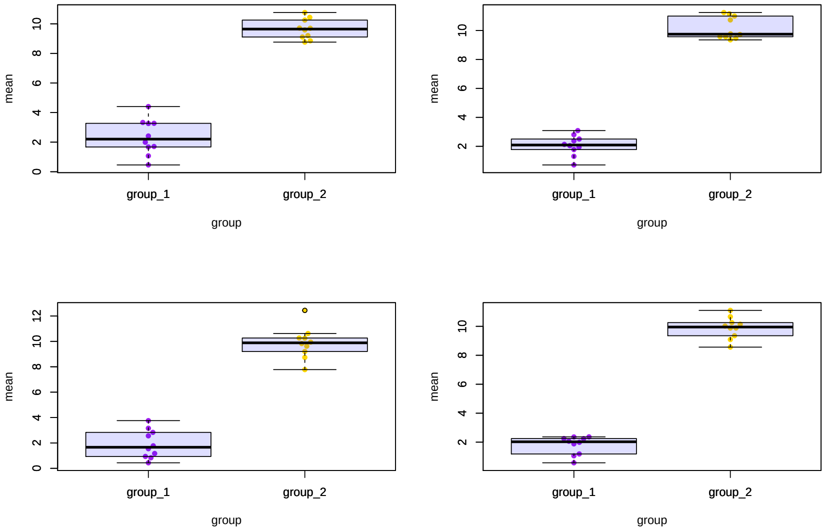
Inference: Simple Means



Inference: Small Effect Size, Small Sample Size



Inference: Large Effect Size, Small Sample Size



Inference: Small Effect Size, Large Sample Size