Introduction

Patrick Breheny

August 25

What is statistics?

- Statistics is the science of learning from experience
- In principle, people do this every day of their lives, and should be really good at it . . .
- . . . but we're not

Limitations of human reasoning

- Human beings are not natural statisticians
- We are not good at picking out patterns from a sea of noisy data
- On the flip side, we are *too good* at picking out non-existent patterns from small numbers of observations
- We also find it difficult to sort out the effects of multiple factors occurring simultaneously
- Finally, we are subject to all sorts of biases depending on our personalities, emotions, and past experiences

Biostatistics

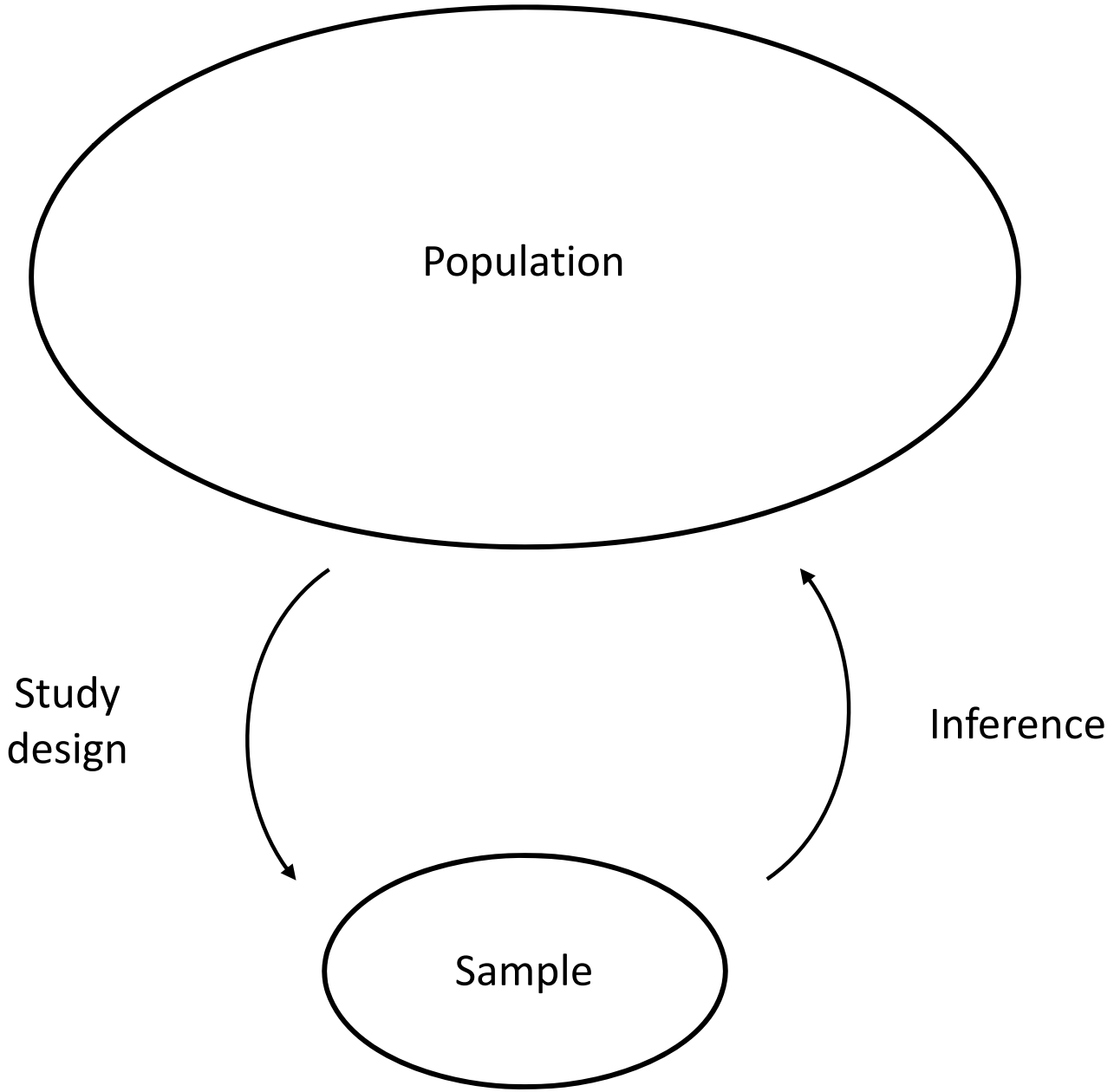
- In medicine, public health, and the biological sciences, we must often make decisions in the presence of uncertainty:
  - Which drug should a doctor prescribe to treat an illness?
  - An individual has a certain genetic mutation; what are the chances that she will develop breast cancer?
  - Does a certain pesticide cause cancer? Should it be banned?
- These questions are too important to be left to opinion, superstition, and conjecture, which is why there has been a tremendous push for objective, *evidence-based* decision making in medicine and public health in the past several decades

Why do we need biostatistics?

- Statistics is the science which allows us to make these decisions
- Statistics is particularly important in research concerning humans, for several reasons:
  - Humans are incredibly diverse and variable
  - Humans are expensive to perform research upon
  - There is a moral imperative to make decisions on potentially life-saving therapies as fast as possible
- For these reasons, and because of the sheer volume of medical research that is now being carried out, Biostatistics has emerged as an important field within statistics, and biostatisticians have become important collaborators in fields such as medicine, biology, and public health

Terms

- Scientists want to make generalizations about classes of people on the basis of their findings
- The class of people that they are trying to make generalizations about is called the population
- It is impractical to study the entire population, so people study only a small portion of it called the sample
- The researchers then make generalizations about the entire population based on studying the sample; this process is called *inference*
- In general, a population does not have to consist of people; a broader definition is that a *population* is any set of objects of interest, and a *sample* is a subset of the population


Population
Study design
Inference
Sample

Three essential questions

- How should I collect my data? (study design)
- How should I describe and summarize the data that I've collected? (descriptive statistics)
- What does my data tell me about the way that the world works? (inference)

Parameters

- Specifically, there is some numerical fact about the population that the investigator is interested in, such as the percent of children who are obese or the average reduction in cholesterol upon taking a certain drug
- These numbers that describe the population are called *parameters*
- Parameters cannot be observed directly; they can only be *estimated* from a sample
- An *estimate* (or *statistic*) is a number that can be computed from a sample

How good are our estimates?

- So,
  - Estimates are what investigators know
  - Parameters are what investigators want to know
- We would like to know whether or not our estimate is measuring the parameter of interest well
- There are two major issues:
  - On average, does our estimate tend to be centered around the right answer, or is it *biased*?
  - How much *variability* is there likely to be in our estimate?

Summary

- We've discussed three important pairs of concepts:
  - Population / Sample
  - Parameter / Estimate
  - Bias / Variability
- The conceptual framework of statistics is represented in this figure (slide 7):