Observational Studies

An observational study in similar to a survey — we observe the values of various variables in a sample of units from some population.

But unlike a survey such as an election poll, we are mostly interested in the *relationship* of one variable to the others. In particular, do these other variables have a *causal* effect?

For instance:

> Does higher education lead to higher income?
>
> Does eating a diet high in calcium reduce blood pressure?
>
> Does smoking cause cancer?

Problem: We can't really answer such questions from an observational study!

The Problem of Confounding

Suppose we find that people who eat a diet high in calcium tend to have lower blood pressure than those who eat a diet low in calcium.

Can we conclude that the calcium in the diet is responsible for the low blood pressure?

No. Other factors may be *confounded* with the effect of calcium.

For instance:

> Perhaps as people get older, they tend to eat diets that are lower in calcium.
>
> And perhaps as people get older, their blood pressure tends to get higher, regardless of diet.

Another possibility:

> Perhaps most people who eat a diet high in calcium get most of their calcium from milk.
>
> And perhaps milk contains *something other than calcium* that tends to lower blood pressure.

Trying to Control for Confounding

We might try to avoid being misled by measuring various possible confounding variables.

For instance, we could record the age of our subjects along with the amount of calcium in their diet and their blood pressure.

If we then find a relationship between calcium and blood pressure *within each age group*, we can be sure that the overall relationship isn't due to confounding with age.

But this won't avoid the problem of possible confounding with a variable we don't even realize exists!

Randomized Experiments

Confounding can be avoided by conducting a *randomized experiment*, in which we *impose* values for the variables whose effect we are interested in.

For the study of calcium on blood pressure, the 21 men were randomly divided into two approximately equal groups. One group took calcium supplements, the other *control* group did not.

If we have many subjects, a random division is likely to produce groups that are similar with respect to any possible confounding variable — even ones we don't realize exist.

If we do know of some possible confounding variables, we can do a bit better by equalizing their effects explicitly — eg, by using *matched pairs*, such as pairs of men matched for age.

Double-Blind Experiments

In medical experiments, two problems can arise even if subjects are randomly assigned to receive treatment or not:

- If the *experimenter* knows who is being treated, they may unconsciously bias the results:
  - Give better treatment of other sorts to one group or the other.
  - Give a biased evaluation of whether a patient improved.
- If the *patient* knows whether they are receiving the treatment, this can have a psychological effect, on the disease itself, or on their reports of symptoms.

In a *double blind* experiment, neither the patients nor the experimenters know who is receiving the treatment. Patients in the control group receive an inactive *placebo*.

There Can Still be Problems

- In practice, subjects will be drawn from a sampled population that isn't the same as the target population.
- Randomized experiments may be unethical — eg, for testing whether smoking causes lung cancer.
- Double-blind experiments may be impossible to do in practice.
- Some patients may drop out of the study. What should be done then?
- The experimental situation may not be the same as the real-life situation (eg, better motivation).
- Even if all bias is eliminated, there is still random variation.