Chapter 2: Observational studies

What's next?   **33**

Last chapter

- Controlled experiments (ch 1)
- Best design: double-blind randomized controlled study
  - Take a representative sample of study units
  - Randomize the study units into a treatment/control group (*randomized controlled*)
  - Use placebo and don't let study units know that whether they get treatment or placebo. Don't let evaluators know who gets treatment or placebo (*double-blind*)
  - Evaluate the response in both groups
- Why is this such a good design?
  - Because of randomization, two groups will be similar except for the treatment.
  - Hence, if there is a difference in the responses, then this is likely *caused* by the treatment.

New chapter

- Observational studies (ch 2)
- Why look at these when controlled experiments are so good? Because controlled experiments are sometimes hard to do or even impossible. Examples:
  - Does smoking cause cancer?
  - Does pollution cause global warming?
- Problem with observational studies: often the groups are not comparable.
- We'll look at various examples.
- New terminology: confounding, confounders/confounding factors, 'controlling' for factors, association, causation, Simpson's paradox, historical vs. contemporaneous controls.

Treatment and control

■ We again use the method of comparison: we compare a treatment (or exposed) group to a control group. Examples:

◆ Studying the effect of a new surgery:

■ treatment group: patients who get new surgery

■ control group: patients who get standard surgery

◆ Studying the effect of smoking:

■ 'treatment' group: smokers

■ control group: non-smokers

Observational study vs controlled experiment

■ How to distinguish between observational studies and controlled experiments?

■ The difference is in who decides on treatment assignment:

◆ Controlled experiment: investigators decide assignment to treatment/control groups.

◆ Observational study: subjects assign themselves to the treatment/control groups. The investigator just *observes* what happens.

Association

■ Two variables are called *associated*, if knowing the value of one variable gives you information on the other.

■ Examples:

◆ Weight and height of people are associated:

■ If you know that somebody is tall, it is more likely that the person is heavy.

■ Also, if you know that somebody is heavy, it is more likely that the person is tall.

◆ Smoking habits and the height of adults are *not* associated:

■ If you know that somebody is smoking, that gives you no information about her/his height.

■ Also, if you know somebody's height, that gives you no information on whether he/she is a smoker.

Association vs. causation

- A good randomized controlled experiment can establish *causation*.
    - Example: acne drug causes mice to be less mobile.
- An observational study can establish *association* between variables.
    - Example: smokers tend to have a higher rate of liver cancer.
- What does association mean here?
- If we compare smokers and non-smokers, then there is a higher rate of liver cancer among the smokers. So if you smoke, you are more likely to get liver cancer. But this does not imply that smoking *causes* liver cancer!

8 / 34

Other explanation

- What could explain the fact that smokers have a higher rate of liver cancer?
    - Smokers tend to drink more alcohol than non-smokers
    - Excessive alcohol consumption causes liver cancer
- The effect of smoking is *confounded* (mixed-up) with the effect of alcohol consumption. Alcohol is a *confounding factor* or a *confounder*.

9 / 34

Confounding

Confounding

- Confounding: the treatment and control group differ by some factor (other than the treatment) that *influences* the response/outcome that is studied.
- Example:
    - A study finds that having yellowish fingertips is associated with lung cancer.
    - Does having yellow fingertips *cause* lung cancer? Should we advice people to better wash their hands?
    - Answer: no. Smoking is a confounding factor:
        - People with yellowish fingertips tend to smoke, while people with normal colored fingertips don't. The two groups differ w.r.t. smoking.
        - Smoking causes lung cancer.

11 / 34

More examples

■ Study finds that smokers tend to have higher rates of lung cancer. Does smoking cause lung cancer? What are possible confounding factors?

◆ Diet is a plausible confounding factor:

■ Smokers may have a poorer diet than non-smokers

■ Poor diet may cause lung cancer

◆ Clothing style is not a plausible confounding factor:

■ Smokers may have a different clothing style than non-smokers

■ But clothing style is not likely to influence the development of lung cancer

In short

■ If the two groups are similar in *all aspects that may affect the outcome*, then there is *no confounding*. In this case different outcomes for the two groups must be caused by the treatment.

■ If the groups differ in an *aspect that affects the outcome*, then there is *confounding*. In this case different outcomes for the two groups may be caused by the treatment *or by the other factor*. The two effects are mixed-up.

Solution for confounding

Make groups comparable

■ Make groups similar in all aspects that may affect the outcome, by dividing them into subgroups.

■ Example: smoking is associated with liver cancer, alcohol consumption is potential confounding factor.

◆ divide smokers and non-smokers into three groups: heavy drinkers, medium drinkers, light drinkers

◆ compare heavy drinking smokers to heavy drinking non-smokers

◆ compare medium drinking smokers to medium drinking non-smokers

◆ compare light drinking smokers to light drinking non-smokers

■ This is called *controlling for the factor alcohol consumption*

Controlling for a factor

■ Controlling for a factor works well

■ But we do not know all the factors that may affect the outcome

■ Therefore it is hard to conclude that difference between treatment group is *caused* by the treatment. There may be something else going on.

■ This is why it took very long to establish that smoking causes lung cancer. A lot of studies were done, controlling for diet, lifestyle, living environment, etc.

Examples

Pellagra

■ Background:
  ◆ Pellagra is disease, prevalent in 18th - 20th century
  ◆ Pellagra seemed to hit households with primitive sanitary conditions
  ◆ Blood sucking flies (Simulium) tended to be in these areas
  ◆ The flies were most active in spring, just when most pellagra cases developed
  ◆ Many epidemiologists concluded that the disease was infectious, and transmitted by the Simulium fly

Pellagra

■ Truth:
  ◆ Pellagra is caused by poor diet

■ What was going on?
  ◆ People who had more flies tended to get more pellagra (association)
  ◆ But the flies did not *cause* pellagra
  ◆ Diet was a *confounding factor*:
    ▪ People who had more flies tended to be poor and have a bad diet
    ▪ Poor diet caused pellagra

Cervical cancer

- Background:
  - ◆ In the 1950s cervical cancer was found to be quite rare among Jewish and Muslim women
  - ◆ Jewish and Muslim men are circumcised
  - ◆ Several investigators concluded that male circumcision protects against cervical cancer

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Cervical cancer

- Truth:
  - ◆ Cervical cancer is caused by HPV, a sexually transmitted virus
- What was going on?
  - ◆ Women with circumcised men tended to get less cervical cancer (association)
  - ◆ But male circumcision does not *protect* against cervical cancer
  - ◆ The number of sexual partners was a confounding factor:
    - ■ Women with circumcised men tended to have fewer sexual partners
    - ■ A low number of sexual partners decreases the risk of getting HPV, and therefore the risk of cervical cancer

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Simpson's paradox

Death penalty

- Is there racial discrimination in imposing the death penalty?
- From: Radelet, M. (1981), Racial characteristics and imposition of the death penalty, *American Sociological Review* bf 46, 918 − 927.
- People convicted for first degree murder:

Race	death row	prison	total	% death penalty
white	19	141	160	19 out of 160 $= 12\%$
black	17	149	166	17 out of 166 $= 10\%$

- It looks as if there is no discrimination. And if anything, it looks as if white people are discriminated against.

Death penalty

- But were the two groups comparable?

- No. They differed w.r.t. the race of the victim. Blacks tend to kill blacks and whites tend to kill whites.

- The race of the victim may affect the imposition of the death penalty.

- So race of the victim is a potential confounding factor that we must control for.

- How? Compare similar groups!

- We must compare:
  whites who killed whites ⇔ blacks who killed whites
  whites who killed blacks ⇔ blacks who killed blacks.

Three tables

- People convicted for first degree murder:

Race	death row	prison	total	% death penalty
white	19	141	160	19 out of 160 = 12%
black	17	149	166	17 out of 166 = 10%

- People convicted for first degree murder with *white victim*:

Race	death row	prison	total	% death penalty
white	19	132	151	19 out of 151 = 13%
black	11	52	63	11 out of 63 = 17%

- People convicted for first degree murder with *black victim*:

Race	death row	prison	total	% death penalty
white	0	9	9	0 out of 9 = 0%
black	6	97	103	6 out of 103 = 6%

- Both for black and white victims, it now looks as if blacks are discriminated against! The results have switched around!

Simpson's paradox

- The phenomenon we just saw is called Simpson's paradox: results switch around when controlling for a variable. Examples:

  ◆ Racial bias in assigning death penalty. Overall it looks as if there is no discrimination against blacks in imposing the death penalty, but if we control for the race of the victim there is.

  ◆ Sex bias in graduate admissions to Berkeley (chapter 2, section 4). Overall it looks as if women are discriminated against, but if we control for department, this is not the case. The women just applied to the departments that were harder to get into.

Conclusion death penalty

- Summary:
  - ◆ White person kills black person: 0% death penalties
  - ◆ Black person kills black person: 6% death penalties
  - ◆ White person kills white person: 13% death penalties
  - ◆ Black person kills white person: 17% death penalties
- This definitely looks like discrimination
- Does this mean judges/juries take into account skin color when deciding about the death penalty? Can you think of other factors that we may want to control for?

Historical controls

Historical controls

- See chapter 1, section 3
- Treatment group is compared to a group of patients that were treated in the old way in the past.
- Not as good as contemporaneous controls! Because groups may not be comparable.

Example

- Patients who got a new surgical treatment are compared to historical controls that got the old treatment
- Possible problems:
  - ◆ Perhaps overall health care standards have improved over time, so that historical controls had worse survival rates. That will make it look as if the new surgical method is better.
  - ◆ Perhaps the new surgical method is only done for relatively healthy patients, while the old method was used for all patients. That will also give an unfair comparison.

Types of study

Determining the type of a study

- See decision tree on overhead

What's next?

- Sampling (Chapter 19)
- How to get a good sample, i.e. one that represents the population?

34 / 34