Chapter 5

# Experiments and Observational Studies

# Thought Question 1:

In a study to relate two conditions, researchers often define one as the ***explanatory variable*** and other as the outcome or ***response variable***.

In a study to determine whether surgery or chemotherapy results in higher survival rates for a certain type of cancer, whether the patient survived is one variable, and whether he or she received surgery or chemotherapy is the other.

Which is the explanatory variable and which is the response variable?

# Thought Question 2:

In an **experiment**, researchers assign “treatments” to participants, whereas in an **observational study**, they simply observe what the participants do naturally.

Give an example of a situation where an **experiment would not be feasible** for ethical reasons.

# Thought Question 3:

Interested in determining whether a daily dose of vitamin C helps prevent colds. Recruit 20 volunteers, want half to take vitamin C and other half to agree not to take it. Ask each which they prefer, and ten say take vitamin and other ten say not. Ask each to record how many colds he or she gets during the next ten weeks. At end of time, compare the results reported from the two groups.

Give 3 reasons why this is ***not a good experiment***.

# Thought Question 4:

When experimenters want to compare two treatments, such as an old and a new drug, they use ***randomization*** to assign the participants to the two conditions.

If you had 50 people participate in such a study, how would you go about randomizing them?

Why do you think randomization is necessary?

Why shouldn't the experimenter decide which people should get which treatment?

# 5.1 Defining a Common Language

**Explanatory variable** is one that may explain or may cause differences in a **response variable** (or outcome variable).

**Example:**

Study found that overall left-handed people die at a younger age than right-handed people.

Explanatory = ***Handedness***

Response = ***Age at death***

A **treatment** is one or a combination of categories of the explanatory variable(s) assigned by the experimenter.

**Example: Salk Experiment (Chapter 1)**

Explanatory = ***whether or not the baby listened to a heartbeat***

➡ **Two treatments: heartbeat or silent**

Response = ***Weight gain***

# Randomized Experiment versus Observational Studies

- **Randomized experiment**: create differences in the explanatory variable and examine results (response variable).
- **Observational study**: observe differences in the explanatory variable and notice whether these are related to differences in the response variable.

# Two reasons why we must sometimes use an observational study instead of an experiment …

1. It is **unethical** or **impossible to assign people** to receive a specific treatment.
2. Certain explanatory variables are **inherent traits** and cannot be randomly assigned.

# Confounding Variables

A confounding variable is …

- *related to the explanatory variable*, and
- *affects the response variable*.

The effect of a confounding variable on the response variable ***cannot be separated*** from the effect of the explanatory variable on the response variable.

Confounding variables are a **bigger problem in observational studies**. Researchers try to measure possible confounding variables and see if related to the response variable.

# Example: Confounding Variables

Study of the relationship between smoking during pregnancy and child's subsequent IQ a few years after birth.

- **Explanatory variable**: whether or not the mother smoked during pregnancy
- **Response variable**: subsequent IQ of the child
- Women who smoke also have poor nutrition, lower levels of education, or lower income.
- **Possible Confounding Variables**: Mother's nutrition, education, and income.

# Interactions Between Variables

An *interaction between explanatory variables* occurs when the effect of one explanatory variable on the response variable depends on what's happening with another explanatory variable.

**Example:**

If smoking during pregnancy reduces IQ when the mother does not exercise, but raises or does not influence IQ when the mother does exercise, then we would say **smoking interacts with exercise** to produce an effect on IQ.

***If two variables interact, results should be given separately for each combination.***

# Experimental Units, Subjects, and Volunteers

- **Experimental Units**: smallest basic objects to which we assign different treatments *in a randomized experiment*.
- **Observational Units**: objects or people measured *in any study*.
- When they are people, often called **participants** or **subjects.**
- Participants are often **volunteers** (passive or recruited).

# 5.2 Designing a Good Experiment

- Randomization
- Control Groups, Placebos, and Blinding
- Matched Pairs, Blocks, and Repeated Measures

# Randomization: The Fundamental Feature of Experiments

## Randomly Assigning the Type of Treatments

- In the basic experiment, each participant is assigned to receive one treatment.
- Randomly assigning the treatments to the experimental units helps protect against hidden or unknown biases.

## Randomizing the Order of the Treatments

- In some experiments, all treatments are applied to each unit.
- Randomization should be used to determine the *order* in which the treatments are applied.

# Example 1: Randomly Assigning Mindfulness Meditation

**News Story #1: Would the regular practice of meditation enhance the immune system?**

**Details:**

- A total of 41 volunteers were recruited who were willing to be assigned to meditate or not.
- The 25 randomly assigned to the *treatment group* completed an 8-week meditation program.
- The 16 randomly assigned to the *control group* did not receive this training during the study (offered it afterwards).

Randomization → ***possible confounding factors*** (such as daily stress) should have been ***similar*** for the two groups.

# Control Groups, Placebos, and Blinding

## Control Groups

- Handled identically to the treatment group(s) in all respects, except that they don't receive the actual treatment.

## Placebos

- Research shows people also respond to placebos – looks like the real drug but has no active ingredients.
- Randomly assign some patients to receive the drug and others to receive a placebo, without telling which they are receiving.

## Blinding

- ***Double-blind***: neither the participant nor the researcher taking measurements know who had which treatment.
- ***Single-blind***: only one of the two (participant or researcher) knows which treatment the participant was assigned.

# Example 2: Blindly Lowering Cholesterol

**News Story #3: Which lowers cholesterol more?**
**Special diet (*portfolio*) versus drug (*lovastatin*)?**

**Details:**

- **Three treatments**: portfolio diet, low-fat diet with lovastatin, low-fat diet with placebo.
- The 46 volunteers were **randomized** by a statistician using a random number generator.
- **Blinding**: researchers and participants both blind as to which drug (lovastatin or placebo) people in those two groups were taking. However, participants and dieticians could not be blind to what the participants were eating. Lab staff evaluating cholesterol measurements were blinded to the treatment.

# Matched Pairs, Blocks, and Repeated Measures

## Matched-Pair Design

- Use two matched individuals or the same individual to receive each of two treatments.
- Randomization used to assign the *order* of the two treatments.

## Randomized Block Design

- Extension of matched-pair to three or more treatments.

## Repeated-Measures Design

- Block designs in which the same participants are measured repeatedly.

# Reducing and Controlling Natural Variability and Systematic Bias

1. **Random assignment to treatments** is used to reduce *unknown* systematic biases due to confounding variables, that might otherwise exist between treatment groups.
2. **Matched pairs, repeated measures and blocks** are used to reduce *known* sources of natural variability in the response variable, so that differences due to explanatory variable can be detected more easily.

# Case Study 5.1: *Quitting Smoking with Nicotine Patches*

## Study Details:

- 240 smokers recruited (all met entry criteria).
- Randomly assigned to either nicotine patch or placebo patch for 8 weeks. All received counseling.
- Double-blinded.
- After 8 weeks: 46% of nicotine group quit, only 20% of placebo group quit.
- After 1 year: 27.5% of nicotine group quit, only 14.2% of placebo group quit.

**Source: Hurt et al., 23 February 1994**

# 5.3 Difficulties and Disasters in Experiments

**Potential Complications**

1. Confounding variables
2. Interacting variables
3. Placebo, Hawthorne, and experimenter effects
4. Ecological validity and generalizability

# Confounding Variables

**Problem:** variables connected with explanatory variable can distort results because they may be agent actually causing change in the response.

**Solution:** randomization => effects of confounding variables should apply equally to each treatment.

## Example 3: Nicotine Patch Therapy

- Nicotine patch more effective when no other smokers in home.
- If first 120 volunteers assigned to placebo and last 120 to nicotine patch, and if those with no other smokers in home more eager to volunteer => treatment would have been confounded with whether there were other smokers at home.
- **Randomization** => impact would be similar across two groups.

# Interacting Variables

**Problem:** second variable interacts with explanatory variable but results reported without noting it.

**Solution:** researchers should measure/report variables that may interact with explanatory variables.

## Example 4: Other Smokers at Home

- Interaction between treatment and whether other smokers in home. Researchers measured and reported it.
- After 8 weeks: proportion of nicotine group quitting **only 31% if other smokers at home**, whereas **58% if not**; proportions quitting were same whether other smokers or not for placebo.
- Misleading if only reported the 46% of nicotine group quit.

# Placebo, Hawthorne, and Experimenter Effects

**Problem:** power of suggestion (placebo effect), just being included in a study (Hawthorne effect), and experimenter recording data erroneously, treating subjects differently – all these can bias results.

**Solution:** use double-blinding and control group, have data entered automatically in computer as collected.

## Example 5: Dull Rats (Rosenthal and Fode, 1963)

- 12 experimenters each given 5 rats that had been taught to run a maze, all similar: six experimenters were told rats were bred to do well and other six told rats were not expected to do well.
- Experimenters told they had ‘maze bright’ rats reported much faster learning rates than those with ‘maze dull’ rats.

# Ecological Validity and Generalizability

**Problem:** variables measured in labs or artificial setting, results do not accurately reflect impact in real world; results for volunteers may not extend to larger group.

**Solution:** try to design experiment that can be performed in natural setting with a random sample from the population of interest; measure other variables to see if related to the response or the explanatory variables.

## Example 6: Real Smokers with a Desire to Quit

- Used a standard intervention that other physicians could follow.
- Used participants at three different locations around country with a wide range of ages (20 to 65).
- Recorded other variables and checked to be sure not related to the response variable or the patch treatment assignment.

# Case Study 5.2: *Exercise Yourself to Sleep*

## Would regular exercise help reduce sleep difficulties in older adults?

## Study Details:

- 43subjects: sedentary volunteers, 50-76 years old, with moderate sleep problems but no heart disease.
- Randomly assigned to either moderate community based exercise program or continue to be sedentary.
- Exercise group fell asleep 11 minutes faster on average and slept 42 minutes longer on average.
- Couldn’t be double-blind, sleep problems self-reported; but otherwise a well-designed experiment.

**Source: King et al., 1 January 1997, pp. 32-37.**

# 5.4 Designing a Good Observational Study

## Case Study 5.3: *Baldness and Heart Attacks*

> *"men with typical male pattern baldness … are anywhere from 30 to 300 percent more likely to suffer a heart attack than men with little or no hair loss at all."* Newsweek, March 8, 1993, p. 62.

- Observational study: compared 665 men admitted to hospital with 1st heart attack to 772 men (same age group) admitted to same hospitals for other reasons.
- Percent with pattern baldness higher for heart attack group (42%) compared to no heart attack (34%).
- Included adjustments for age and other heart attack risk factors.
- Speculated about 3rd variable, possibly a male hormone.

# Types of Observational Studies

## Case-Control Studies

- ‘Cases’ who have particular attribute or condition are compared with ‘controls’ who do not.

## Retrospective or Prospective Studies

- ***Retrospective***: participants are asked to recall past events.
- ***Prospective***: participants followed into future, and events recorded. Better because people often do not remember past events accurately.

# Advantages of Case-Control Studies

## Efficiency

- Efficient in terms of time, money, inclusion of enough people with disease.

## Reducing Potential Confounding Variables

- Controls chosen to try to reduce potential confounding variables (but must be careful not to introduce new ones).

# 5.5 Difficulties and Disasters in Observational Studies

## Potential Complications

1. Confounding variables and the implication of causation
2. Extending the results inappropriately
3. Using the past as a source of data

# Confounding Variables and the Implications of Causation

**Problem:** no way to establish causation with an observational study – can't separate out all potential confounding factors w/o randomization.

**Solution:** measure potential confounding variables; choosing controls as similar as possible to cases.

## Example 7: Smoking During Pregnancy

- IQs lower for children of women who smoked.
- Difference as high as 9 points before accounting for confounding variables (diet and education); reduced to 4 points after accounting for those factors.
- Can't conclude smoking *caused* lower IQs in children.

# Extending the Results Inappropriately

**Problem:** many use convenience samples, not representative of any population.

**Solution:** researchers should use entire segment of population of interest.

## Example 8: Baldness and Heart Attacks

- Observational study only used men who were hospitalized.
- Should consider whether results should be extended to all men.

# Using the Past as a Source of Data

**Problem:** retrospective studies unreliable –ask people to recall past behavior; confounding variables in past not similar current ones.

**Solution:** use prospective studies if possible; else use authoritative sources versus memory.

## Example 9: Do Left-Handers Die Young?

- Retrospective: sent letters to next of kin asking about handedness of deceased.
- Average age of death of LH was 66 versus 75 for RH.
- In early 20th century, many children forced to write RH. Many in study may have been influenced.

# 5.6 Random Sample versus Random Assignment

**Extending Results to a Larger Population:**

***Random Sampling***

- Often impractical to obtain a random sample.
- Extent to which results extend depends on extent to which participants are representative of population.

**Establishing Cause and Effect:**

***Random Assignment***

- Evens out confounding variables across treatments.
- Without it, naturally occurring confounding variables can result in an apparent relationship.