

1.3: Experimental Design

The section is an introduction to experimental design. This is how to actually design an experiment or a survey so that they are statistical sound. Experimental design is a very involved process, so this is just a small introduction.

Guidelines for planning a statistical study

1. Identify the individuals that you are interested in. Realize that you can only make conclusions for these individuals. As an example, if you use a fertilizer on a certain genus of plant, you can't say how the fertilizer will work on any other types of plants. However, if you diversify too much, then you may not be able to tell if there really is an improvement since you have too many factors to consider.
2. Specify the variable. You want to make sure this is something that you can measure, and make sure that you control for all other factors too. As an example, if you are trying to determine if a fertilizer works by measuring the height of the plants on a particular day, you need to make sure you can control how much fertilizer you put on the plants (which would be your treatment), and make sure that all the plants receive the same amount of sunlight, water, and temperature.
3. Specify the population. This is important in order for you know what conclusions you can make and what individuals you are making the conclusions about.
4. Specify the method for taking measurements or making observations.
5. Determine if you are taking a census or sample. If taking a sample, decide on the sampling method.
6. Collect the data.
7. Use appropriate descriptive statistics methods and make decisions using appropriate inferential statistics methods.
8. Note any concerns you might have about your data collection methods and list any recommendations for future.

There are two types of studies:

Definition 1.3.1

An **observational study** is when the investigator collects data merely by watching or asking questions. He doesn't change anything.

Definition 1.3.2

An **experiment** is when the investigator changes a variable or imposes a treatment to determine its effect.

Example 1.3.1 observational study or experiment

State if the following is an observational study or an experiment.

- a. Poll students to see if they favor increasing tuition.
- b. Give some students a tutor to see if grades improve.

Solution

- a. This is an observational study. You are only asking a question.
- b. This is an experiment. The tutor is the treatment.

Many observational studies involve surveys. A **survey** uses questions to collect the data and needs to be written so that there is no bias.

In an experiment, there are different options.

Randomized Two-Treatment Experiment:

In this experiment, there are two treatments, and individuals are randomly placed into the two groups. Either both groups get a treatment, or one group gets a treatment and the other gets either nothing or a placebo. The group getting either no treatment or the placebo is called the control group. The group getting the treatment is called the treatment group. The idea of the placebo is that a person thinks they are receiving a treatment, but in reality they are receiving a sugar pill or fake treatment. Doing this helps to account for the placebo effect, which is where a person's mind makes their body respond to a treatment because they think they are

taking the treatment when they are not really taking the treatment. Note, not every experiment needs a placebo, such when using animals or plants. Also, you can't always use a placebo or no treatment. As an example, if you are testing a new blood pressure medication you can't give a person with high blood pressure a placebo or no treatment because of moral reasons.

Randomized Block Design:

A block is a group of subjects that are similar, but the blocks differ from each other. Then randomly assign treatments to subjects inside each block. An example would be separating students into full-time versus part-time, and then randomly picking a certain number full-time students to get the treatment and a certain number part-time students to get the treatment. This way some of each type of student gets the treatment and some do not.

Rigorously Controlled Design:

Carefully assign subjects to different treatment groups, so that those given each treatment are similar in ways that are important to the experiment. An example would be if you want to have a full-time student who is male, takes only night classes, has a full-time job, and has children in one treatment group, then you need to have the same type of student getting the other treatment. This type of design is hard to implement since you don't know how many differentiations you would use, and should be avoided.

Matched Pairs Design:

The treatments are given to two groups that can be matched up with each other in some ways. One example would be to measure the effectiveness of a muscle relaxer cream on the right arm and the left arm of individuals, and then for each individual you can match up their right arm measurement with their left arm. Another example of this would be before and after experiments, such as weight before and weight after a diet.

No matter which experiment type you conduct, you should also consider the following:

Replication:

Repetition of an experiment on more than one subject so you can make sure that the sample is large enough to distinguish true effects from random effects. It is also the ability for someone else to duplicate the results of the experiment.

Blind Study:

Blind study is where the individual does not know which treatment they are getting or if they are getting the treatment or a placebo.

Double-Blind Study:

Double-blind study is where neither the individual nor the researcher knows who is getting which treatment or who is getting the treatment and who is getting the placebo. This is important so that there can be no bias created by either the individual or the researcher.

One last consideration is the time period that you are collecting the data over. There are three types of time periods that you can consider.

Cross-Sectional Study:

Data observed, measured, or collected at one point in time.

Retrospective (or Case-Control) Study:

Data collected from the past using records, interviews, and other similar artifacts.

Prospective (or Longitudinal or Cohort) Study:

Data collected in the future from groups sharing common factors.

Homework

1. You want to determine if cinnamon reduces a person's insulin sensitivity. You give patients who are insulin sensitive a certain amount of cinnamon and then measure their glucose levels. Is this an observation or an experiment? Why?
2. You want to determine if eating more fruits reduces a person's chance of developing cancer. You watch people over the years and ask them to tell you how many servings of fruit they eat each day. You then record who develops cancer. Is this an

observation or an experiment? Why?

3. A researcher wants to evaluate whether countries with lower fertility rates have a higher life expectancy. They collect the fertility rates and the life expectancies of countries around the world. Is this an observation or an experiment? Why?
4. To evaluate whether a new fertilizer improves plant growth more than the old fertilizer, the fertilizer developer gives some plants the new fertilizer and others the old fertilizer. Is this an observation or an experiment? Why?
5. A researcher designs an experiment to determine if a new drug lowers the blood pressure of patients with high blood pressure. The patients are randomly selected to be in the study and they randomly pick which group to be in. Is this a randomized experiment? Why or why not?
6. Doctors trying to see if a new stint works longer for kidney patients, asks patients if they are willing to have one of two different stints put in. During the procedure the doctor decides which stent to put in based on which one is on hand at the time. Is this a randomized experiment? Why or why not?
7. A researcher wants to determine if diet and exercise together helps people lose weight over just exercising. The researcher solicits volunteers to be part of the study, randomly picks which volunteers are in the study, and then lets each volunteer decide if they want to be in the diet and exercise group or the exercise only group. Is this a randomized experiment? Why or why not?
8. To determine if lack of exercise reduces flexibility in the knee joint, physical therapists ask for volunteers to join their trials. They then randomly select the volunteers to be in the group that exercises and to be in the group that doesn't exercise. Is this a randomized experiment? Why or why not?
9. You collect the weights of tagged fish in a tank. You then put an extra protein fish food in water for the fish and then measure their weight a month later. Are the two samples matched pairs or not? Why or why not?
10. A mathematics instructor wants to see if a computer homework system improves the scores of the students in the class. The instructor teaches two different sections of the same course. One section utilizes the computer homework system and the other section completes homework with paper and pencil. Are the two samples matched pairs or not? Why or why not?
11. A business manager wants to see if a new procedure improves the processing time for a task. The manager measures the processing time of the employees then trains the employees using the new procedure. Then each employee performs the task again and the processing time is measured again. Are the two samples matched pairs or not? Why or why not?
12. The prices of generic items are compared to the prices of the equivalent named brand items. Are the two samples matched pairs or not? Why or why not?
13. A doctor gives some of the patients a new drug for treating acne and the rest of the patients receive the old drug. Neither the patient nor the doctor knows who is getting which drug. Is this a blind experiment, double blind experiment, or neither? Why?
14. One group is told to exercise and one group is told to not exercise. Is this a blind experiment, double blind experiment, or neither? Why?
15. The researchers at a hospital want to see if a new surgery procedure has a better recovery time than the old procedure. The patients are not told which procedure that was used on them, but the surgeons obviously did know. Is this a blind experiment, double blind experiment, or neither? Why?
16. To determine if a new medication reduces headache pain, some patients are given the new medication and others are given a placebo. Neither the researchers nor the patients know who is taking the real medication and who is taking the placebo. Is this a blind experiment, double blind experiment, or neither? Why?
17. A new study is underway to track the eating and exercise patterns of people at different time periods in the future, and see who is afflicted with cancer later in life. Is this a cross-sectional study, a retrospective study, or a prospective study? Why?
18. To determine if a new medication reduces headache pain, some patients are given the new medication and others are given a placebo. The pain levels of a patient are then recorded. Is this a cross-sectional study, a retrospective study, or a prospective study? Why?
19. To see if there is a link between smoking and bladder cancer, patients with bladder cancer are asked if they currently smoke or if they smoked in the past. Is this a cross-sectional study, a retrospective study, or a prospective study? Why?
20. The Nurses Health Survey was a survey where nurses were asked to record their eating habits over a period of time, and their general health was recorded. Is this a cross-sectional study, a retrospective study, or a prospective study? Why?
21. Consider a question that you would like to answer. Describe how you would design your own experiment. Make sure you state the question you would like to answer, then determine if an experiment or an observation is to be done, decide if the question needs one or two samples, if two samples are the samples matched, if this is a randomized experiment, if there is any blinding, and if this is a cross-sectional, retrospective, or prospective study.

Answer

1. Experiment
3. Observation
5. No, see solutions
7. No, see solutions
9. Yes, see solutions
11. Yes, see solutions
13. Double blind, see solutions
15. Blind, see solutions
17. Prospective, see solutions
19. Retrospective, see solutions
21. See solutions

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