Surveys, Experiments, and Observational Studies

Going Deeper

**Essential question:** What kinds of statistical research are there, and which ones can establish cause-and-effect relationships between variables?

A survey measures characteristics of interest about a population using a sample selected from the population. A sample needs to be representative of the population in order for the measurements obtained from the sample to be accurate. Random sampling is generally the best way to ensure representation.

Even when random sampling is used for a survey, the survey's results can have errors. Some of the sources of errors are:

- **Biased questions:** The wording of questions in a survey can influence the way people respond to the questions. Survey questions need to be worded in a neutral, unbiased way.
- **Interviewer effect:** If the questions in a survey are being asked by an interviewer, the person being interviewed may give inaccurate responses to avoid being embarrassed. For instance, if the questions involve sensitive issues, the person may not tell the truth, or if the questions involve complex or unfamiliar issues, the person may resort to guessing.
- **Nonresponse:** Some people may be difficult or impossible to contact, or they may simply refuse to participate once contacted. If nonresponse rates are higher for certain subgroups of a population, such as the elderly, then those subgroups will be underrepresented in the survey results.

**Detecting Errors in Surveys**

Explain why the results of each survey are likely to be inaccurate and then suggest a way to improve the accuracy of the survey.

A Mrs. Ruben, the owner of a business, conducts one-on-one interviews with a random sample of employees to have them rate how satisfied they are with different aspects of their jobs.

B In a random sample of town residents, a survey asks, “Are you in favor of a special tax levy to renovate the dilapidated town hall?”
REFLECT

1a. Even if the survey question in part B is revised to give a factual list of repairs that need to be made to the town hall, do the people surveyed have enough information to give an informed and accurate response? Explain.

An **observational study** can be used to determine whether an existing condition, called a **factor**, in a population is related to a characteristic of interest. For instance, an observational study might be used to find the incidence of heart disease among those who smoke. In the study, being a smoker is the factor, and having heart disease is the characteristic of interest.

In an observational study, the condition already exists in the population. In an **experiment**, the condition is created by imposing a **treatment** on the sample. For instance, an experiment might be conducted by having a group of people with eczema take a vitamin E pill daily, and then observing whether their symptoms improve. In the experiment, taking the vitamin E pill is the treatment, and improvement of symptoms is the characteristic of interest.

**EXAMPLE**  
**Identifying Observational Studies and Experiments**

Determine whether each research study is an observational study or an experiment. Identify the factor if it is an observational study or the treatment if it is an experiment. Also identify the characteristic of interest.

**A** Researchers measure the cholesterol of 50 subjects who report that they eat fish regularly and 50 subjects who report that they do not eat fish regularly.

**B** Researchers have 100 subjects with high cholesterol take fish oil pills daily for two months. They monitor the cholesterol of the subjects during that time.

REFLECT

2a. Suppose the researchers in part A find that considerably more people who eat fish regularly have normal cholesterol levels than those who do not eat fish regularly. Is it reasonable to conclude that eating fish regularly has an effect on cholesterol? Explain.
2b. In medical research, subjects sometimes respond to a treatment even if the treatment, called a \textit{placebo}, is designed not to have an effect. (For instance, a placebo may be a pill with no active ingredients.) If the researchers in part B find that taking fish oil pills lowers cholesterol, what should they do to rule out the possibility of a placebo effect?

Whether a study is observational or experimental, it should be \textit{comparative} in order to establish a connection between the factor or treatment and the characteristic of interest. For instance, determining the rate of car accidents among people who talk on cell phones while driving is pointless unless you compare it with the rate of car accidents among people who don’t talk on cell phones while driving and find that it is significantly different.

While a comparative observational study can suggest a relationship between two variables, such as cell phone use while driving and car accidents, it cannot establish a cause-and-effect relationship because there can be \textit{confounding variables} (also called \textit{lurking variables}) that influence the results. For instance, perhaps people who talk on cell phones while driving are more likely to drive aggressively, so it is the aggressive driving (not the cell phone use) that leads to a higher rate of car accidents.

In an experiment, randomization can remove the problem of a confounding variable by distributing the variable among the groups being compared so that its influence on the groups is more or less equal. Therefore, the best way to establish a cause-and-effect relationship between two variables is through a \textit{randomized comparative experiment} where subjects are randomly divided into two groups: the \textit{treatment group}, which is given the treatment, and the \textit{control group}, which is not.

\textbf{Example 3}

\textbf{Identifying Control Groups and Treatment Groups}

Identify the control group and treatment group in each experiment. Assume all subjects of the research are selected randomly.

\textbf{A} To see whether zinc has an effect on the duration of a cold, half the subjects took tablets containing zinc at the onset of cold symptoms, and half took tablets without any zinc. The durations of the colds were then recorded.

\begin{itemize}
  \item Control group: ________________
  \item Treatment group: ________________
\end{itemize}

\textbf{B} To see whether reviewing for a test with a classmate improves test scores, half the subjects studied with a classmate prior to taking a test, and half studied for the test alone. The test scores were then recorded.

\begin{itemize}
  \item Control group: ________________
  \item Treatment group: ________________
\end{itemize}
REFLECT

3a. How does using a control group help a researcher interpret the results of an experiment? How does using randomization help?

When you encounter media reports of statistical research in your daily life, you should judge any reported conclusions on the basis of how the research was conducted. Among the questions you should consider are:

- Is the research a survey, an observational study, or an experiment? In broad terms, a survey simply measures variables, an observational study attempts to find a relationship between variables, and an experiment attempts to establish a cause-and-effect relationship between variables.

- Was randomization used in conducting the research? As you know, random sampling is considered the best way to obtain a representative sample from a population and therefore get accurate results. Randomization also helps to dilute the effect of confounding variables.

- Does the report include the details of the research, such as sample size, statistics, and margins of error?

Evaluating a Media Report

Evaluate the article about the effect of doctor empathy on the duration and severity of a cold.

A. Is this a survey, an observational study, or an experiment? How do you know?

B. Was randomization used in the research? If so, how?

C. Does the report include the details of the research? If not, what information is missing?

Caring Doctors Shorten and Ease the Common Cold

Researchers have found that among patients with colds, those who gave their doctors perfect scores on a questionnaire measuring empathy had colds that did not last as long and were less severe. Empathy on the part of doctors included making patients feel at ease, listening to their concerns, and showing compassion.

A total of 350 subjects who were experiencing the onset of a cold were randomly assigned to one of three groups: no doctor-patient interaction, standard interaction, and enhanced interaction. Only subjects in the third group saw doctors who had been coached on being empathetic.
Explain why the results of each survey are likely to be inaccurate and then suggest a way to improve the accuracy of the survey.

1. A store offers its customers a chance to win a cash prize if they call a toll-free number and participate in a survey of customer satisfaction.

2. In a random sample of parents in a school district, a survey asks, “Are you willing to pay a small fee for each school sport that your child participates in?”

For Exercises 3 and 4, determine whether each research study is an observational study or an experiment. Identify the factor if it is an observational study or the treatment if it is an experiment. Also identify the characteristic of interest.

3. Researchers found that of patients who had been taking a bone-loss drug for more than five years, a high percent also had an uncommon type of fracture in the thigh bone.
4. Researchers found that when patients with chronic illnesses were randomly divided into two groups, the group that got regular coaching by phone from health professionals to help them manage their illnesses had lower monthly medical costs than the group that did not get the coaching.

5. Is the research study in Exercise 4 a comparative randomized experiment? If so, identify the treatment group and the control group.

6. Evaluate the article about doctors working when sick.
   a. Is this a survey, an observational study, or an experiment? How do you know?
   b. Was randomization used in the research? If so, how?
   c. Does the report include the details of the research? If not, what information is missing?
   d. What is your overall evaluation of the report? Why?

Doctors Work When Sick
Doctors know that they can get sick from their patients, but when they are sick themselves, do they stay away from their patients? Researchers asked 537 doctors-in-training to anonymously report whether they had worked while sick during the past year. The researchers found that 58% said they had worked once while sick and 31% said they had worked more than once while sick.

7. Evaluate the article about antibiotic use in infants.
   a. Is this a survey, an observational study, or an experiment? How do you know?
   b. Was randomization used in the research? If so, how?
   c. Does the report include the details of the research? If not, what information is missing?
   d. What is your overall evaluation of the report? Why?

Antibiotic Use Tied to Asthma and Allergies
Antibiotic use in infants is linked to asthma and allergies, says a study involving 1401 children. Researchers asked mothers how many doses of antibiotics their children received before 6 months of age as well as whether their children had developed asthma or allergies by age 6. Children who received just one dose of antibiotics were 40% more likely to develop asthma or allergies. The risk jumped to 70% for children who received two doses.
Additional Practice

Explain whether each situation is an experiment or an observational study. The first problem has been completed for you.

1. A park ranger measures the change in height of all trees of a similar species and age over a month. Half the trees are within a quarter of a mile from a large lake and half are further away.

   Observational study; the park ranger gathers data without controlling the individuals or applying a treatment.

2. A park ranger plants 10 trees within a quarter of a mile from a large lake and 10 trees of a similar species and age further than half of a mile from the lake. He then measures the growth of all trees over a month.

   The study described below is a randomized comparative experiment.

   Describe the treatment, the treatment group, and the control group.
   The first problem has been completed for you.

4. A researcher feeds one group of rats high-fat and high-calorie foods like cheesecake, bacon, and pastries. She feeds a second group of rats a normal, nutritious diet. For two weeks, the researcher records how many calories each rat eats daily, as well as how often it goes to its feeding bowl. She compares the data from the one group to the data from the other and finds that the rats that eat the nutritious food get hungry less often and eat a smaller number of calories overall.

   The treatment is feeding high-fat and high-calorie foods. The treatment group is the rats that were fed the diet that was not nutritious. The control group is the rats that were fed the nutritious diet.

5. A college professor wants to know if students learn as well in an online class as in person. He decides to offer the same course both online and in a classroom. Students who sign up for the course are told they will be assigned to either class randomly. The professor then gives the same test to both classes and compares the scores.

Explain whether the research topic is best addressed through an experiment or an observational study. Then explain how you would set up the experiment or observational study.

6. Does being a smoker cause people to get minor sicknesses more often?
Problem Solving

Explain whether each situation is an experiment or an observational study.

1. A teacher plays music during all tests given in a one-month period and compares the class grades with a similar class that does not have music played during tests.
   **Solution:** The teacher applies a treatment (playing music during tests) to some of the individuals (the class). This situation is an example of an experiment.

2. A real estate developer records the listing and selling prices of all homes in one area to determine the difference in the listing price and the selling price.
   Does the real estate developer control the individuals or apply a treatment? ____________
   Is the situation an experiment or an observational study? ___________________________

The study described below is a randomized controlled experiment.
**Describe the treatment, the treatment group, and the control group.**

3. At a seed farm, 50 randomly chosen seeds were treated to temperatures above 100°F, and 50 other randomly chosen seeds were left at normal temperatures. At the end of the growing season, the heated group sprouted 20% faster than the non-heated group.

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4. An engineer recruits 40 volunteers, and randomly assigns them to two groups. One group fills their cars with gasoline with an additive. The other group fills their cars with plain gasoline. The group that uses the additive sees a 5% decrease in fuel efficiency.

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_________________________________________________________________________________________

**Choose the method that would be least biased.**

5. An ice cream company wants to test whether the quality of ingredients it uses affects the taste of the product.
   A randomized comparative experiment
   B observational study
   C survey

6. An auto manufacturer wants to measure the fuel efficiency of a new hybrid car.
   F randomized comparative experiment
   G observational study
   H survey