Exercises for Section 1.1

SKILL BUILDER 1

For the situations described in Exercises 1.1 to 1.6:

(a) What are the cases?

(b) What is the variable and is it quantitative or categorical?

1.1 People in a city are asked if they support a new recycling law.

1.2 Record the percentage change in the price of a stock for 100 stocks publicly traded on Wall Street.

1.3 Collect data from a sample of teenagers with a question that asks "Do you eat at least five servings a day of fruits and vegetables?"

1.4 Measure the shelf life of bunches of bananas (the number of days until the bananas go bad) for a large sample.

1.5 Estimate the bending strength of beams by bending 10 beams until they break and recording the force at which the beams broke.

1.6 Record whether or not the literacy rate is over 75% for each country in the world.

SKILL BUILDER 2

In Exercises 1.7 to 1.10, a relationship between two variables is described. In each case, we can think of one variable as helping to explain the other. Identify the explanatory variable and the response variable.

1.7 Lung capacity and number of years smoking cigarettes

1.8 Amount of fertilizer used and the yield of a crop

1.9 Blood alcohol content (BAC) and number of alcoholic drinks consumed

1.10 Year and the world record time in a marathon

1.11 Student Survey Variables Data 1.1 introduced the dataset **StudentSurvey**, and Example 1.2 identified seven of the variables in that dataset as categorical or quantitative. The remaining variables are:

Year	FirstYear, Sophomore, Junior, Senior
Height	In inches
Weight	In pounds
Siblings	Number of siblings the person has
VerbalSAT	Score on the Verbal section of the SAT exam
MathSAT	Score on the Math section of the SAT exam
SAT	Sum of the scores on the Verbal and Math sections of the SAT exam
HigherSAT	Which is higher, Math SAT score or Verbal SAT score?

(a) Indicate whether each variable is quantitative or categorical.

(b) List at least two questions we might ask about any one of these individual variables.

(c) List at least two questions we might ask about relationships between any two (or more) of these variables.

1.12 Countries of the World Information about the world's countries is given in **AllCountries**, introduced in Data 1.2 on page 7. You can find a description of the variables in Appendix B. For the full dataset:

(a) Indicate which of the variables are quantitative and which are categorical.

(b) List at least two questions we might ask about any one of these individual variables.

(c) List at least two questions we might ask about relationships between any two (or more) of these variables.

1.13 Goldilocks Effect: Read to Your Kids! The American Academy of Pediatrics recommends that parents begin reading to their children soon after birth, and that parents set limits on screen time. A new study[9] reinforces these recommendations. In the study, 27 four-year-olds were presented with stories in three different formats: audio (sound only), illustrated (sound and pictures), and animated (sound and animation). During the presentations, a magnetic resonance imaging (MRI) machine measured each child's brain connectivity. The researchers found a "Goldilocks effect," in which audio was too cold (with low brain connectivity as the children strained to understand) and animation was too hot (with low brain connectivity as the animation did all the work for the children). The highest connectivity (just right!) was found with the illustrated format, which simulates reading a book to a child.

[9]Hutton J et al., "Differences in functional brain network connectivity during stories presented in audio, illustrated, and animated format in preschool-age children," *Brain Imaging and Behavior*, October 30, 2018.

(a) What is the explanatory variable? Is it categorical or quantitative?

(b) What is the response variable? Is it categorical or quantitative?

(c) How many cases are there?

1.14 Female Gamers Face Sexual Harassment A research firm[10] questioned 1151 female gamers in Great Britain and found that 40% had received obscene messages while playing online. In addition to asking whether they had received obscene messages, the gamers were also asked how many hours a week they played, and whether they felt there were enough strong female characters in games.

(a) What are the cases in this study?

(b) What are the variables? Indicate whether each is categorical or quantitative.

(c) How many rows and how many columns will the dataset have if cases are rows and variables are columns?

1.15 Active Learning vs Passive Learning: Which is Best? Active learning in a classroom implies that students are actively involved and working during class time (either individually, in pairs, or in groups) while passive learning indicates that students are primarily taking notes while the instructor lectures. A recent study[11] measured students actual learning under these two formats as well as their feelings of learning. The study was very well designed: students in a college physics course were randomly assigned to a class period with either active learning or passive learning, the same content and handouts were used in both, and both instructors were highly rated. After the class, students were asked to rate how much they thought they had learned (on a 5-point Likert scale) and they also took a 20-question multiple choice exam to test how much they had actually learned. The results were very interesting: students *thought* that they learned more in the passive learning class but they *actually* learned more in the active learning class.

(a) What are the cases?

(b) What are the variables? Indicate whether each variable is quantitative or categorical.

(c) Indicate explanatory and response variables.

(d) There were 154 students in the passive learning lecture and 142 students in the active learning class. Indicate how many rows and how many columns the dataset will have if cases are rows and variables are columns.

1.16 Spider Sex Play Spiders regularly engage in spider foreplay that does not culminate in mating. Male spiders mature faster than female spiders and often practice the mating routine on not-yet-mature females. Since male spiders run the risk of getting eaten by female spiders, biologists wondered why spiders engage in this behavior. In one study,[12] some spiders were allowed to participate in these near-matings, while other maturing spiders were isolated. When the spiders were fully mature, the scientists observed real matings. They discovered that if either partner had participated at least once in mock sex, the pair reached the point of real mating significantly faster than inexperienced spiders did. (Mating faster is, apparently, a real advantage in the spider world.) Describe the variables, indicate whether each variable is quantitative or categorical, and indicate the explanatory and response variables.

1.17 Hormones and Fish Fertility When women take birth control pills, some of the hormones found in the pills eventually make their way into lakes and waterways. In one study, a water sample was taken from various lakes. The data indicate that as the concentration of estrogen in the lake water goes up, the fertility level of fish in the lake goes down. The estrogen level is measured in parts per trillion (ppt) and the fertility level is recorded as the percent of eggs fertilized. What are the cases in this study? What are the variables? Classify each variable as either categorical or quantitative.

1.18 Fast-Twitch Muscles and Race Example 1.5 studied a variant of the gene *ACTN3* which inhibits fast-twitch muscles and seems to be less prevalent in sprinters. A separate study[13] indicated ethnic differences: Approximately 20% of a sample of Caucasians, approximately 25% of a sample of Asians, and approximately 1% of a sample of Africans had the gene variant. What are the variables in this study? Classify each as categorical or quantitative.

[10]"Research: One in 3 Female Gamers Face Gender Discrimination, 32% Deal with Sexual Harassment," *Bryter-research.co.uk*, October 2019.

[11]Deslauriers L, et al., "Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom," *PNAS*, 116(39), September 24, 2019.

[12]Pruitt, J., paper presented at the Society for Integrative and Comparative Biology Annual Meeting, January 2011, and reported in "For spiders, sex play has its pluses," *Science News*, January 29, 2011.

[13]North, K., et al., "A common nonsense mutation results in α-actinin-3 deficiency in the general population," *Nature Genetics*, April 1999; 21(4): 353–354.

1.19 Largest Cities in the World Seven of the ten largest cities in the world are in the Eastern Hemisphere (including the largest: Tokyo, Japan) and three are in the Western Hemisphere.[14] Table 1.3 shows the populations, in millions of people, for these cities.

(a) How many cases are there in this dataset? How many variables are there and what are they? Is each categorical or quantitative?

(b) Display the information in Table 1.3 as a dataset with cases as rows and variables as columns.

Table 1.3 ***Population, in millions, of the world's largest cities***

Eastern hemisphere:	37, 26, 23, 22, 21, 21, 21
Western hemisphere:	21, 20, 19

1.20 How Fast Do Homing Pigeons Go? Homing pigeons have an amazing ability to find their way home over extremely long distances. How fast do they go on these trips? In the 2019 Midwest Classic, held in Topeka, Kansas, the fastest bird went 1676 YPM (yards per minute), which is about 56 miles per hour.[15] The top seven finishers included three female pigeons (Hens) and four male pigeons (Cocks). Their speeds, in YPM, are given in Table 1.4.

(a) How many cases are there in this dataset? How many variables are there and what are they? Is each variable categorical or quantitative?

(b) Display the information as a dataset with cases as rows and variables as columns.

Table 1.4 ***Speed of homing pigeons, in yards per minute***

Hens:	1676, 1452, 1449
Cocks:	1458, 1435, 1418, 1413

1.21 Pigeon Racing Exercise 1.20 gives the speed of the top seven finishers in the 2019 Midwest Classic homing pigeon race. In fact, 1412 pigeons finished the race, and their home loft, sex, distance, and speed were all recorded. A loft may have several different pigeons finish the race.

(a) How many cases are in this dataset?

(b) How many variables are there? How many of these variables are categorical? How many are quantitative?

(c) How many rows and how many columns will the dataset have?

1.22 Trans-Generational Effects of Diet Can experiences of parents affect future children? New studies[16] suggest that they can: Early life experiences of parents appear to cause permanent changes in sperm and eggs. In one study, some male rats were fed a high-fat diet with 43% of calories from fat (a typical American diet), while others were fed a normal healthy rat diet. Not surprisingly, the rats fed the high-fat diet were far more likely than the normal-diet rats to develop metabolic syndrome (characterized by such things as excess weight, excess fat, insulin resistance, and glucose intolerance.) What surprised the scientists was that the daughters of these rats were also far more likely to develop metabolic syndrome than the daughters of rats fed healthy diets. None of the daughters and none of the mothers ate a high-fat diet and the fathers did not have any contact with the daughters. The high-fat diet of the fathers appeared to cause negative effects for their daughters. What are the two main variables in this study? Is each categorical or quantitative? Identify the explanatory and response variables.

1.23 Trans-Generational Effects of Environment In Exercise 1.22, we ask whether experiences of parents can affect future children, and describe a study that suggests the answer is yes. A second study, described in the same reference, shows similar effects. Young female mice were assigned to either live for two weeks in an enriched environment or not. Matching what has been seen in other similar experiments, the adult mice who had been exposed to an enriched environment were smarter (in the sense that they learned how to navigate mazes faster) than the mice that did not have that experience. The other interesting result, however, was that the offspring of the mice exposed to the enriched environment were also smarter than the offspring of the other mice, even though none of the offspring were exposed to an enriched environment themselves. What are the two main variables in this study? Is each categorical or quantitative? Identify explanatory and response variables.

[14] *http://www.worldatlas.com/citypops.htm*. Accessed June 2015.

[15] Data downloaded from the Midwest Homing Pigeon Association final race report at *http://www.midwesthpa.com/MIDFinalReports.htm*.

[16] Begley, S., "Sins of the Grandfathers," *Newsweek*, November 8, 2010; 48–50.

1.24 Pennsylvania High School Seniors The data in **PASeniors** shows results for a sample of 457 high school seniors in the state of Pennsylvania, selected at random from all students who participated in the Census at Schools project[17] between 2010 and 2019. Each of the questions below relate to information in this dataset. Determine whether the answer to each question gives a value for a quantitative variable, a categorical variable, or is not a value for a variable for this dataset.

(a) What mode of transportation do you use to get to school?

(b) Do you have any allergies?

(c) What proportion of students in this sample are vegetarians?

(d) How many hours did you spend last week working at a paid job?

(e) What is the difference between typical hours of sleep you get on school nights and non-school nights?

(f) What is the maximum time (in minutes) that a student in this sample needs to get to school?

(g) If you could have a super power would you choose invisibility, telepathy, super strength, ability to fly, or ability to freeze time?

1.25 US College Scorecard The data in **CollegeScores** contains information from the US Department of Education's College Scorecard[18] on all postsecondary educational institutions in the US. Each of the questions below relate to information in this dataset. Determine whether the answer to each question gives a value for a quantitative variable, a categorical variable, or is not a value for a variable for this dataset.

(a) What is the total tuition and fees for in-state students at the school?

(b) How many of these schools are located in the Northeast?

(c) Is the school public, private, or for profit?

(d) How many undergraduates are enrolled at the school?

(e) What percentage of undergraduates at the school are part-time students?

(f) Which school has the highest average faculty salary?

[17]Sample data obtained from the Census at Schools random sampler sponsored by the American Statistical Association at *https://ww2.amstat.org/censusatschool.*

[18]Data downloaded from the US Department of Education's College Scorecard at *https://collegescorecard.ed.gov/data/* (November 2019.)

1.26 Hookahs and Health Hookahs are waterpipes used for smoking flavored tobacco. One study[19] of 3770 university students in North Carolina found that 40% had smoked a hookah at least once, with many claiming that the hookah smoke is safer than cigarette smoke. However, a second study observed people at a hookah bar and recorded the length of the session, the frequency of puffing, and the depth of inhalation. An average session lasted one hour and the smoke inhaled from an average session was equal to the smoke in more than 100 cigarettes. Finally, a third study measured the amount of tar, nicotine, and heavy metals in samples of hookah smoke, finding that the water in a hookah filters out only a very small percentage of these chemicals. Based on these studies and others, many states are introducing laws to ban or limit hookah bars. In each of the three studies, identify the individual cases, the variables, and whether each variable is quantitative or categorical.

1.27 Is Your Nose Getting Bigger? Next time you see an elderly man, check out his nose and ears! While most parts of the human body stop growing as we reach adulthood, studies show that noses and ears continue to grow larger throughout our lifetime. In one study[20] examining noses, researchers report "Age significantly influenced all analyzed measurements:" including volume, surface area, height, and width of noses. The sex of the 859 participants in the study was also recorded, and the study reports that "male increments in nasal dimensions were larger than female ones."

(a) How many variables are mentioned in this description?

(b) How many of the variables are categorical? How many are quantitative?

(c) If we create a dataset of the information with cases as rows and variables as columns, how many rows and how many columns would the dataset have?

1.28 Don't Text While Studying! For the 2015 Intel Science Fair, two brothers in high school recruited 47 of their classmates to take part in a two-stage study. Participants had to read two different passages and then answer questions on them, and each person's score was recorded for each of the two

[19]Quenqua, D., "Putting a Crimp in the Hookah," *New York Times*, May 31, 2011, p A1.

[20]Sforza, C., Grandi, G., De Menezes, M., Tartaglia, G.M., and Ferrario, V.F., "Age- and sex-related changes in the normal human external nose," *Forensic Science International*, January 30, 2011; 204(1–3): 205.e1–9.

tests. There were no distractions for one of the passages, but participants received text messages while they read the other passage. Participants scored significantly worse when distracted by incoming texts. Participants were also asked if they thought they were good at multitasking (yes or no) but "even students who were confident of their abilities did just as poorly on the test while texting."[21]

(a) What are the cases?

(b) What are the variables? Is each variable categorical or quantitative?

(c) If we create a dataset of the information with cases as rows and variables as columns, how many rows and how many columns would the dataset have?

1.29 Help for Insomniacs A recent study shows that just one session of cognitive behavioral therapy can help people with insomnia.[22] In the study, forty people who had been diagnosed with insomnia were randomly divided into two groups of 20 each. People in one group received a one-hour cognitive behavioral therapy session while those in the other group received no treatment. Three months later, 14 of those in the therapy group reported sleep improvements while only 3 people in the other group reported improvements.

(a) What are the cases in this study?

(b) What are the relevant variables? Identify each as categorical or quantitative.

(c) If we create a dataset of the information with cases as rows and variables as columns, how many rows and how many columns would the dataset have?

1.30 How Are Age and Income Related? An economist collects data from many people to determine how age and income are related. How the data is collected determines whether the variables are quantitative or categorical. Describe how the information might be recorded if we regard both variables as quantitative. Then describe a different way to record information about these two variables that would make the variables categorical.

1.31 Political Party and Voter Turnout Suppose that we want to investigate the question "Does voter turnout differ by political party?" How might we collect data to answer this question? What would the cases be? What would the variable(s) be?

1.32 Wealth and Happiness Are richer people happier? How might we collect data to answer this question? What would the cases be? What would the variable(s) be?

1.33 Choose Your Own Question Come up with your own question you would like to be able to answer. What is the question? How might you collect data to answer this question? What would the cases be? What would the variable(s) be?

[21] Perkins, S., "Studying? Don't answer that text!" *Science News*, July 23, 2015.

[22] Ellis, J.G., Cushing, T., and Germain, A., "Treating acute insomnia: a randomized controlled trial of a 'single-shot' of cognitive behavioral therapy for insomnia," *SLEEP*, 2015; 38(6): 971–978.

1.2 SAMPLING FROM A POPULATION

While most of this textbook is devoted to analyzing data, the way in which data are *collected* is critical. Data collected well can yield powerful insights and discoveries. Data collected poorly can yield very misleading results. Being able to think critically about the method of data collection is crucial for making or interpreting data-based claims. In the rest of this chapter, we address some of the most important issues that need to be considered when collecting data.

Samples from Populations

The US Census is conducted every 10 years and attempts to gather data about all people living in the US. For example, the census shows that, for people living in the US who are at least 25 years old, 84.6% have at least a high school degree and 27.5% have at least a college bachelor's degree.[23] The cases in the census dataset are all residents of the US, and there are many variables measured on these cases. The US census attempts to gather information from an entire *population*. In **AllCountries**,

[23] *http://factfinder.census.gov.*

Exercises for Section 1.2

SKILL BUILDER 1

In Exercises 1.34 to 1.37, state whether the data are best described as a population or a sample.

1.34 To estimate size of trout in a lake, an angler records the weight of 12 trout he catches over a weekend.

1.35 A subscription-based music website tracks its total number of active users.

1.36 The US Department of Transportation announces that of the 250 million registered passenger vehicles in the US, 2.1% are electro-gas hybrids.

1.37 A questionnaire to understand athletic participation on a college campus is emailed to 50 college students, and all of them respond.

SKILL BUILDER 2

In Exercises 1.38 to 1.41, describe the sample and describe a reasonable population.

1.38 A sociologist conducting a survey at a mall interviews 120 people about their cell phone use.

1.39 Five hundred Canadian adults are asked if they are proficient on a musical instrument.

1.40 A cell phone carrier sends a satisfaction survey to 100 randomly selected customers.

1.41 The Nielsen Corporation attaches databoxes to televisions in 1000 households throughout the US to monitor what shows are being watched and produce the Nielsen Ratings for television.

SKILL BUILDER 3

In Exercises 1.42 to 1.45, a biased sampling situation is described. In each case, give:

(a) The sample

(b) The population of interest

(c) A population we can generalize to given the sample

1.42 To estimate the proportion of Americans who support changing the drinking age from 21 to 18, a random sample of 100 college students are asked the question "Would you support a measure to lower the drinking age from 21 to 18?"

1.43 To estimate the average number of tweets from all twitter accounts in 2019, one of the authors randomly selected 10 of his followers and counted their tweets.

1.44 To investigate interest across all residents of the US in a new type of ice skate, a random sample of 1500 people in Minnesota are asked about their interest in the product.

1.45 To determine the height distribution of female high school students, the rosters are collected from 20 randomly selected high school girls basketball teams.

SKILL BUILDER 4

In Exercises 1.46 to 1.51, state whether or not the sampling method described produces a random sample from the given population.

1.46 The population is incoming students at a particular university. The name of each incoming student is thrown into a hat, the names are mixed, and 20 names (each corresponding to a different student) are drawn from the hat.

1.47 The population is the approximately 25,000 protein-coding genes in human DNA. Each gene is assigned a number (from 1 to 25,000), and computer software is used to randomly select 100 of these numbers yielding a sample of 100 genes.

1.48 The population is all employees at a company. All employees are emailed a link to a survey.

1.49 The population is adults between the ages of 18 and 22. A sample of 100 students is collected from a local university, and each student at the university had an equal chance of being selected for the sample.

1.50 The population is all trees in a forest. We walk through the forest and pick out trees that appear to be representative of all the trees in the forest.

1.51 The population is all people who visit the website *CNN.com*. All visitors to the website are invited to take part in the daily online poll.

IS IT BIASED?

In Exercises 1.52 to 1.56, indicate whether we should trust the results of the study. Is the method of data collection biased? If it is, explain why.

1.52 Ask a random sample of students at the library on a Friday night "How many hours a week do you study?" to collect data to estimate the average number of hours a week that all college students study.

1.53 Ask a random sample of people in a given school district, "Excellent teachers are essential to the well-being of children in this community, and teachers truly deserve a salary raise this year.

Do you agree?" Use the results to estimate the proportion of all people in the school district who support giving teachers a raise.

1.54 Take 10 apples off the top of a truckload of apples and measure the amount of bruising on those apples to estimate how much bruising there is, on average, in the whole truckload.

1.55 Take a random sample of one type of printer and test each printer to see how many pages of text each will print before the ink runs out. Use the average from the sample to estimate how many pages, on average, all printers of this type will last before the ink runs out.

1.56 Send an email to a random sample of students at a university asking them to reply to the question: "Do you think this university should fund an ultimate frisbee team?" A small number of students reply. Use the replies to estimate the proportion of all students at the university who support this use of funds.

1.57 Do Parents Regret Having Children? In Data 1.4 on page 25, we describe the results of a question asked by a national newspaper columnist: "If you had it to do over again, would you have children?" In addition to those results and a follow-up national survey, the *Kansas City Star* selected a random sample of parents from Kansas City and asked them the same question. In this sample, 94% said "Yes." To what population can this statistic be generalized?

1.58 Wearing a Uniform to Work The website *fox6now.com* held an online poll in June 2015 asking "What do you think about the concept of having an everyday uniform for work, like Steve Jobs did?" Of the people who answered the question, 24% said they loved the idea, 58% said they hated the idea, and 18% said that they already wore a uniform to work.

(a) Are the people who answered the poll likely to be representative of all adult workers? Why or why not?

(b) Is it reasonable to generalize this result and estimate that 24% of all adult workers would like to wear a uniform to work?

1.59 Canadians Stream Music In a random sample of 3500 Canadian consumers, about 71% report that they regularly stream music.[31]

(a) Is the sample likely to be representative of all Canadian consumers? Why or why not?

(b) Is it reasonable to generalize this result and estimate that about 71% of all Canadian consumers regularly stream music?

1.60 Climate Change In June 2018, a poll asked a random sample of 1000 US adults whether global warming will be a serious problem for the United States.[32] The results show that 51% think global warming will be a very serious problem, 27% think it will be a somewhat serious problem, and 21% think it will not be a serious problem.

(a) What is the sample? What is the intended population?

(b) Is it reasonable to generalize this result and estimate that 21% of US adults think that global warming will not be a serious problem for the United States?

1.61 Do You Use a Food Delivery App? A 2019 study conducted by eMarketer[33] asked 800 US smartphone users whether they had used a food delivery app at least once in the last month. The survey also asked which food delivery app, if any, was used. The survey showed that 16.3% of respondents had used a food delivery app in the last month. Of those that had used one, 27.6% used DoorDash, 26.7% used Grubhub, 25.2% used UberEats, while the rest used another.

(a) What is the sample? What is the intended population?

(b) What are the cases? What are the variables? Classify variables as quantitative or categorical.

1.62 Pennsylvania High School Seniors Exercise 1.24 describes a dataset, stored in **PASeniors**, for a sample of students who filled out a survey though the US Census at School project. When downloading the sample[34] we specified Pennsylvania as the state and Grade 12 as the school year, then the website chose a random sample of 457 students from among all students who matched those criteria. We'd like to generalize results from this sample to a larger population. Discuss whether this would be reasonable for each of the groups listed below.

[31] "What Moves Today's Teenage Canadian Music Fan?," *http://www.nielsen.com/ca/en/insights/news/2015/what-moves-todays-teenage-canadian-music-fan.html*, Neilsen, Media and Entertainment, June 2, 2015.

[32] *https://www.rff.org/energy-and-climate/surveying-american-attitudes-toward-climate-change-and-clean-energy/*. Accessed July 2019.

[33] "US Food Delivery App Usage Will Approach 40 Million Users in 2019," *www.eMarketer.com*, July 2, 2019. Sample size is approximated.

[34] Sample data obtained Data from U.S. Census at School (*https://www.amstat.org/censusatschool*) used with the permission of the American Statistical Association.

(a) The 457 students in the original sample

(b) All Pennsylvania high school seniors who participated in the Census at School survey

(c) All Pennsylvania high school seniors

(d) All students in the United States who participated in the Census at School survey

1.63 How Easily are You Influenced? Mentally simulate ten tosses of a coin by writing down a sequence of Heads and Tails that might result from ten flips of a fair coin. (Try this now!) When a random sample of people were asked to do this, over 80% of them wrote down Heads as the first flip. Expanding on this result,[35] when the instructions asked for a sequence of "Tails and Heads," participants were more likely to put Tails as the first flip. Indeed, when they were told that an imaginary coin was purple on one side and orange on the other (with the two colors presented in random order), participants were more likely to start with whichever color was mentioned first.[36] Researchers could influence the results just based on the order in which they listed the options.

(a) Is this an illustration of sampling bias or wording bias or both or neither?

(b) If you are letting a friend choose between Option Q and Option W, and you are really hoping that they pick Option W, in what order should you present the options?

1.64 Does Chocolate Milk Come from Brown Cows? The US National Dairy Council, a dairy advocacy group, conducted a survey that appears to show that 7% of Americans (which is about 16.4 million people) believe that chocolate milk comes from brown cows. This result was picked up and shared widely, including by CNN.com, the Washington Post, the Today show, and NPR (National Public Radio).[37] The goal of the survey was to find some fun facts to share and the advocacy group has not made the full survey results, or the sampling method, publicly available.

(a) Do you think it is likely that there is sampling bias in this study? Without knowing how the sample was determined, can we know if it is appropriate to generalize to all Americans? Can you think of a way in which the sample might have been determined that would create sampling bias?

(b) While we don't know how the sample was determined, interviewers on NPR were able to find out how the question was phrased.[38] Survey respondents were asked to select one option to the following: "Where does chocolate milk come from? (a) Brown cows, (b) Black and white spotted cows, (c) I don't know." Do you think the way the question was worded might have biased the results? Give a different possible way to word the question that might give more accurate results.

1.65 How Many People Wash Their Hands after Using the Washroom? In Example 1.10 on page 18, we introduce a study by researchers from Harris Interactive who were interested in determining what percent of people wash their hands after using the washroom. They collected data by standing in public restrooms and pretending to comb their hair or put on make-up as they observed patrons' behavior.[39] Public restrooms were observed at Turner's Field in Atlanta, Penn Station and Grand Central Station in New York, the Museum of Science and Industry and the Shedd Aquarium in Chicago, and the Ferry Terminal Farmers Market in San Francisco. Of the over 6000 people whose behavior was observed, 85% washed their hands. Women were more likely to wash their hands: 93% of women washed, while only 77% of men did. The Museum of Science and Industry in Chicago had the highest hand-washing rate, while men at Turner's Field in Atlanta had the lowest.

(a) What are the cases? What are the variables? Classify each variable as quantitative or categorical.

(b) In a separate telephone survey of more than 1000 adults, more than 96% said they always wash their hands after using a public restroom. Why do you think there is such a discrepancy in the percent from the telephone survey compared to the percent observed?

1.66 Teaching Ability In a sample survey of professors at the University of Nebraska, 94% of them described themselves as "above average" teachers.[40]

[35] Bar-Hillel M, Peer E, Acquisti A, "Heads or tails? A Reachability Bias in Binary Choice," *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 40(6), April 28, 2014.

[36] This is called the primacy effect, in which the first option given is more likely to be selected.

[37] Griffin L and Campbell T, "Take that chocolate milk survey with a grain of salt," *The Conversation*, June 28, 2017.

[38] Meikle G, "This survey is as murky as chocolate milk," *Columbia Journalism Review*, June 21, 2017.

[39] Bakalar, "Study: More people washing hands after using bathroom," *Salem News*, September 14, 2010.

[40] Cross, P., "Not can, but *will* college teaching be improved?," *New Directions for Higher Education*, 1977; 17: 115.

(a) What is the sample? What is the population?

(b) Based on the information provided, can we conclude that the study suffers from sampling bias?

(c) Is 94% a good estimate for the percentage of above-average teachers at the University of Nebraska? If not, why not?

1.67 Effects of Alcohol and Marijuana In 1986 the Federal Office of Road Safety in Australia conducted an experiment to assess the effects of alcohol and marijuana on mood and performance.[41] Participants were volunteers who responded to advertisements for the study on two rock radio stations in Sydney. Each volunteer was given a randomly determined combination of the two drugs, then tested and observed. Is the sample likely representative of all Australians? Why or why not?

1.68 What Percent of Young Adults Move Back in with Their Parents? The Pew Research Center polled a random sample of $n = 808$ US residents between the ages of 18 and 34. Of those in the sample, 24% had moved back in with their parents for economic reasons after living on their own.[42] Do you think that this sample of 808 people is a representative sample of all US residents between the ages of 18 and 34? Why or why not?

1.69 Do Cat Videos Improve Mood? As part of an "internet cat videos/photos" study, Dr. Jessica Gall Myrick posted an on-line survey to Facebook and Twitter asking a series of questions regarding how individuals felt before and after the last time they watched a cat video on the Internet.[43] One of the goals of the study was to determine how watching cat videos affects an individual's energy and emotional state. People were asked to share the link, and everyone who clicked the link and completed the survey was included in the sample. More than 6000 individuals completed the survey, and the study found that after watching a cat video people generally reported more energy, fewer negative emotions, and more positive emotions.

(a) Would this be considered a simple random sample from a target population? Why or why not?

(b) Ignoring sampling bias, what other ways could bias have been introduced into this study?

1.70 Diet Cola and Weight Gain in Rats A study[44] fed one group of rats a diet that included yogurt sweetened with sugar, and another group of rats a diet that included yogurt sweetened with a zero-calorie artificial sweetener commonly found in diet cola. The rats that were fed a zero-calorie sweetener gained more weight and more body fat compared to the rats that were fed sugar. After the study was published, many news articles discussed the implication that people who drink diet soda gain more weight. Explain why we cannot conclude that this is necessarily true.

1.71 Armoring Military Planes During the Second World War, the U.S. military collected data on bullet holes found in B-24 bombers that returned from flight missions. The data showed that most bullet holes were found in the wings and tail of the aircraft. Therefore, the military reasoned that more armor should be added to these regions, as they are more likely to be shot. Abraham Wald, a famous statistician of the era, is reported to have argued against this reasoning. In fact, he argued that based on these data more armor should be added to the center of the plane, and NOT the wings and tail. What was Wald's argument?

1.72 Employment Surveys Employment statistics in the US are often based on two nationwide monthly surveys: the Current Population Survey (CPS) and the Current Employment Statistics (CES) survey. The CPS samples approximately 60,000 US households and collects the employment status, job type, and demographic information of each resident in the household. The CES survey samples 140,000 nonfarm businesses and government agencies and collects the number of payroll jobs, pay rates, and related information for each firm.

(a) What is the population in the CPS survey?

(b) What is the population in the CES survey?

(c) For each of the following statistical questions, state whether the results from the CPS or CES survey would be more relevant.

i. Do larger companies tend to have higher salaries?

[41] Chesher, G., Dauncey, H., Crawford, J., and Horn, K., "The Interaction between Alcohol and Marijuana: A Dose Dependent Study on the Effects on Human Moods and Performance Skills," Report No. C40, Federal Office of Road Safety, Federal Department of Transport, Australia, 1986.

[42] Parker, K., "The Boomerang Generation: Feeling OK about Living with Mom and Dad," Pew Research Center, March 15, 2012.

[43] Gall Myrick, J., "Emotion regulation, procrastination, and watching cat videos online: Who watches Internet cats, why, and to what effect?," *Computers in Human Behavior*, June 12, 2015.

[44] Swithers, S.E., Sample, C.H., and Davidson, T.L., "Adverse effects of high-intensity sweeteners on energy intake and weight control in male and obesity-prone female rats." *Behavioral neuroscience*, 2013; 127(2), 262.

ii. What percentage of Americans are self-employed?

iii. Are married men more or less likely to be employed than single men?

1.73 National Health Statistics The Centers for Disease Control and Prevention (CDC) administers a large number of survey programs for monitoring the status of health and health care in the US. One of these programs is the National Health and Nutrition Examination Survey (NHANES), which interviews and examines a random sample of about 5000 people in the US each year. The survey includes questions about health, nutrition, and behavior, while the examination includes physical measurements and lab tests. Another program is the National Hospital Ambulatory Medical Care Survey (NHAMCS), which includes information from hospital records for a random sample of individuals treated in hospital emergency rooms around the country.

(a) To what population can we reasonably generalize findings from the NHANES?

(b) To what population can we reasonably generalize findings from the NHAMCS?

(c) For each of the questions below, indicate which survey, NHANES or NHAMCS, would probably be more appropriate to address the issue.

i. Are overweight people more likely to develop diabetes?

ii. What proportion of emergency room visits in the US involve sports-related injuries?

iii. Is there a difference in the average waiting time to be seen by an emergency room physician between male and female patients?

iv. What proportion of US residents have visited an emergency room within the past year?

1.74 Interviewing the Film Crew on Hollywood Movies There were 1295 movies made in Hollywood between 2012 and 2018. Suppose that, for a documentary about Hollywood film crews, a random sample of 5 of these movies will be selected for in-depth interviews with the crew members. Assuming the movies are numbered 1 to 1295, use a random number generator or table to select a random sample of five movies by number. Indicate which numbers were selected. (If you want to know which movies you selected, check out the dataset **HollywoodMovies**.)

1.75 Sampling Some Starbucks Stores The Starbucks chain has about 24,000 retail stores in 70 countries.[45] Suppose that a member of the Starbucks administration wishes to visit six of these stores, randomly selected, to gather some first-hand data. Suppose the stores are numbered 1 to 24,000. Use a random number generator or table to select the numbers for 6 of the stores to be in the sample.

[45] *https://www.starbucks.com/about-us/company-information/starbucks-company-profile.*

1.3 EXPERIMENTS AND OBSERVATIONAL STUDIES

Association and Causation

Three neighbors in a small town in northern New York State enjoy living in a climate that has four distinct seasons: warm summers, cold winters, and moderate temperatures in the spring and fall. They also share an interest in using data to help make decisions about questions they encounter at home and at work.

- Living in the first house is a professor at the local college. She's been looking at recent heating bills and comparing them to data on average outside temperature. Not surprisingly, when the temperature is lower, her heating bills tend to be much higher. She wonders, "It's going to be an especially cold winter; should I budget for higher heating costs?"
- Her neighbor is the plant manager for a large manufacturing plant. He's also been looking at heating data and has noticed that when the building's heating plant is used, there are more employees missing work due to back pain or colds and flu. He wonders, "Could emissions from the heating system be having adverse health effects on the workers?"

Exercises for Section 1.3

SKILL BUILDER 1

In Exercises 1.76 to 1.81, we give a headline that recently appeared online or in print. State whether the claim is one of association and causation, association only, or neither association nor causation.

1.76 Daily exercise improves mental performance.

1.77 Among college students, no link found between number of friends on social networking websites and size of the university.

1.78 Cell phone radiation leads to deaths in honey bees.

1.79 Wealthy people are more likely than other folks to lie, cheat, and steal.

1.80 Cat owners tend to be more educated than dog owners.

1.81 Want to lose weight? Eat more fiber!

SKILL BUILDER 2

Exercises 1.82 to 1.87 describe an association between two variables. Give a confounding variable that may help to account for this association.

1.82 More ice cream sales have been linked to more deaths by drowning.

1.83 The total amount of beef consumed and the total amount of pork consumed worldwide are closely related over the past 100 years.

1.84 People who own a yacht are more likely to buy a sports car.

1.85 Sales of toboggans tend to be higher when sales of mittens are higher.

1.86 Air pollution is higher in places with a higher proportion of paved ground relative to grassy ground.

1.87 People with shorter hair tend to be taller.

SKILL BUILDER 3

In Exercises 1.88 to 1.91, we describe data collection methods to answer a question of interest. Are we describing an experiment or an observational study?

1.88 To examine whether eating brown rice affects metabolism, we ask a random sample of people whether they eat brown rice and we also measure their metabolism rate.

1.89 To examine whether playing music in a store increases the amount customers spend, we randomly assign some stores to play music and some to stay silent and compare the average amount spent by customers.

1.90 To examine whether planting trees reduces air pollution, we find a sample of city blocks with similar levels of air pollution and we then plant trees in half of the blocks in the sample. After waiting an appropriate amount of time, we measure air pollution levels.

1.91 To examine whether farm-grown salmon contain more omega-3 oils if water is more acidic, we collect samples of salmon and water from multiple fish farms to see if the two variables are related.

REVISITING QUESTIONS FROM SECTION 1.1

Exercises 1.92 to 1.94 refer to questions of interest asked in Section 1.1 in which we describe data collection methods. Indicate whether the data come from an experiment or an observational study.

1.92 "Is there a sprinting gene?" Introduced in Example 1.5 on page 9.

1.93 "Do metal tags on penguins harm them?" Introduced in Data 1.3 on page 10.

1.94 "Are there human pheromones?" Introduced on page 11. Three studies are described; indicate whether each of them is an experiment or an observational study.

1.95 Salt on Roads and Accidents Three situations are described at the start of this section, on page 31. In the third bullet, we describe an association between the amount of salt spread on the roads and the number of accidents. Describe a possible confounding variable and explain how it fits the definition of a confounding variable.

1.96 Height and Reading Ability In elementary school (grades 1 to 6), there is a strong association between a child's height and the child's reading ability. Taller children tend to be able to read at a higher level. However, there is a very significant confounding variable that is influencing both height and reading ability. What is it?

1.97 Golfing for a Long Life? A recent quote[60] on an online health site tells us "golfers' average life expectancy was 5 years longer than other people's."

[60] *www.webmd.com*, September 4, 2019.

(a) What are the cases in this reported result? What is/are the variable(s)?

(b) Does this information appear to come from an experiment or an observational study?

(c) Give a confounding variable and explain how it meets the definition of a confounding variable.

1.98 How to Debate a Science Denier Science deniers oppose robust and valid results of scientific inquiry. A recent study[61] investigates the most effective ways to debunk scientific misinformation. Science advocates can respond to misinformation using topic rebuttal (providing scientific facts on the subject) or technique rebuttal (explaining more generally the false techniques used by science deniers). In the study, 1773 participants first listened to a science denier and were then randomly assigned to one of four conditions: no rebuttal, topic rebuttal, technique rebuttal, or both topic and technique rebuttal. Participants' attitudes toward the science topic were measured and recorded three times: before participation, after the science denier, and after the rebuttal. Results indicate the importance of having a rebuttal: participants on average were influenced by the science denier, but the influence was mitigated by having any rebuttal. The study further showed that topic or technique rebuttal worked equally well, and having both provided no additional benefit.

(a) What are the cases in this study?

(b) What is the explanatory variable? Is it categorical or quantitative?

(c) Is this an observational study or an experiment?

(d) How many rows and how many columns will the dataset have, if we use cases as rows and variables as columns?

1.99 Music Volume and Beer Consumption A study[62] was conducted measuring the impact that music volume has on beer consumption. The researchers went into bars, controlled the music volume, and measured how much beer was consumed. The article states that "the sound level of the environmental music was manipulated according to a randomization scheme." It was found that louder music corresponds to more beer consumption. Does this provide evidence that louder music causes people to drink more beer? Why or why not?

1.100 Nuts and Cholesterol Several studies have been performed to examine the relationship between nut consumption and cholesterol levels. Here we consider two such studies. In Study 1,[63] participants were assigned into two groups: one group was given nuts to eat each day, and the other group was told to consume a diet without nuts. In Study 2,[64] participants were free to follow their own diet, and reported how many nuts they consumed. Cholesterol levels were measured for all participants, and both studies found that nut consumption was associated with lower levels of LDL ("bad") cholesterol. Based on the information above, which study do you think provides better evidence that nut consumption reduces LDL cholesterol? Explain your answer.

1.101 Antibiotics in Infancy and Obesity in Adults "Antibiotics in infancy may cause obesity in adults," claims a recent headline.[65] A study in mice randomly assigned infant mice to either be given antibiotics or not, and the mice given antibiotics were more likely to be obese as adults. A separate study in humans found that children who had been given antibiotics before they were a year old (for example, for an ear infection) were more likely to be obese as adults. (Researchers believe the effect may be due to changes in the gut microbiome.) Based on these studies, is the headline an appropriate conclusion to make:

(a) For mice?

(b) For humans?

1.102 Fast-Food Diet and Depression A study[66] involving 84 middle-school students investigates the link between a diet high in processed foods and rates of depression. Researchers collected the urine of the participants and measured levels of sodium and potassium. A diet high in processed food, such

[61]Schmid P and Betsch C, "Effective Strategies for Rebutting Science Denialism in Public Discussion," *Nature Human Behaviour*, June 24, 2019.

[62]Gueguen, N., Jacob, C., Le Guellec, H., Morineau, T., and Lourel, M., "Sound Level of Environmental Music and Drinking Behavior: A Field Experiment with Beer Drinkers," *Alcoholism: Clinical and Experimental Research*, 2008; 32: 1795–1798.

[63]Morgan, W.A., and Clayshulte, B.J., "Pecans lower low density lipoprotein cholesterol in people with normal lipid levels." *Journal of the American Dietetic Association*, 2000; 100(3), 312–318.

[64]Li, T.Y., Brennan, A.M., Wedick, N.M., Mantzoros, C., Rifai, N., and Hu, F.B. "Regular consumption of nuts is associated with a lower risk of cardiovascular disease in women with type 2 diabetes." *The Journal of Nutrition*, 2009; 139(7), 1333–1338.

[65]Saey, T.H., "Antibiotics in infancy may cause obesity in adults," *Science News*, September 20, 2014.

[66]LaMotte S, "Fast food may contribute to teen depression, study says," *CNN Health*, August 29, 2019.

as fast food, is high in sodium and low in potassium. The students were also evaluated on a 100-point scale for depressive symptoms. The study found that high levels of sodium and low levels of potassium were both associated with higher depression levels.

(a) Is this an experiment or an observational study?

(b) Can we conclude that eating a diet high in sodium and low in potassium increases the likelihood of having depression? Why or why not?

(c) Give a possible confounding variable in this study, and explain how it meets the definition of a confounding variable.

1.103 Potassium Levels in Spinach A study examining spinach leaves from a variety of different locations finds that spinach grown in soil with high amounts of iron tends to have lower levels of potassium.[67]

(a) What are the two variables? Is each quantitative or categorical?

(b) Which is the explanatory variable?

(c) Does the result appear to come from an observational study or an experiment?

(d) Can we assume that higher levels of iron in the soil cause spinach to have less potassium?

(e) Describe anything that might be a possible confounding variable.

1.104 Encourage Kids to Read! Researchers[68] asked parents of 19 American children, ages 8 to 12, to complete surveys on the number of hours their children spent reading and on the number of hours they spent on screen-based media time. Each of the children also underwent magnetic resonance imaging to assess connectivity in the brain. More time spent reading was associated with higher connectivity, while more screen time was associated with lower connectivity in the brains of the children.

(a) How many cases are there in this study? How many variables are there?

(b) Identify each of the variables as quantitative or categorical. Also, identify each of the variables as an explanatory variable or a response variable.

(c) Is this an experiment or an observational study?

(d) Can we conclude that more time spent reading increases connectivity in children's brains?

(e) Identify a possible confounding variable and explain how it meets the definition of a confounding variable.

1.105 Want to Be Healthier? Take a Vacation! A study[69] measured health characteristics (including triglyceride level, cholesterol, and blood glucose) for each of 63 adult participants and also asked participants how many vacations they had taken in the last year. Results showed that those who had taken more vacations had better results on the health measures.

(a) Is this an experiment or an observational study?

(b) Give a possible confounding variable and explain how it meets the definition of a confounding variable.

(c) Indicate whether each of the following is an appropriate conclusion (Yes or No) from this study:

(i) People who are healthier tend to take more vacations.

(ii) People who take vacations tend to be healthier.

(iii) Taking vacations will improve a person's health.

(iv) Improving one's health will allow a person to take additional vacations.

(d) Is the title of this exercise an appropriate conclusion from this study?

1.106 Do Online Cat Videos Improve Mood? Exercise 1.69 on page 30 introduced a study on cat videos, in which people who clicked on the link were asked questions regarding their mood before and after the most recent time they watched a cat video. Overall, participants reported that after watching a cat video they had significantly more energy, fewer negative emotions, and more positive emotions. Can we conclude from this study that watching cat videos increases energy and improves emotional state?

1.107 Green Spaces Make Kids Smarter A recent article[70] claims that "Green Spaces Make Kids Smarter." The study described in the article involved 2623 schoolchildren in Barcelona. The

[67] Shea K, *Health & Nutrition Update*, Tufts University, August 11, 2019.

[68] Horowitz-Kraus T and Hutton J, "Brain connectivity in children is increased by the time they spend reading books and decreased by the length of exposure to screen-based media," *Acta Paediatrica*, 107, 2018.

[69] Voelker R, "Vacationing More Often May Reduce Metabolic Syndrome Risk," *JAMA*, August 14, 2019.

[70] Khazan, O., "Green Spaces Make Kids Smarter," *The Atlantic*, June 16, 2016.

researchers measured the amount of greenery around the children's schools, and then measured the children's working memories and attention spans. The children who had more vegetation around their schools did better on the memory and attention tests.

(a) What are the cases in this study?

(b) What is the explanatory variable?

(c) What is the response variable?

(d) Does the headline imply causation?

(e) Is the study an experiment or an observational study?

(f) Is it appropriate to conclude causation in this case?

(g) Suggest a possible confounding variable, and explain why it meets the requirements of a confounding variable.

1.108 Infections Can Lower IQ A headline in June 2015 proclaims "Infections can lower IQ."[71] The headline is based on a study in which scientists gave an IQ test to Danish men at age 19. They also analyzed the hospital records of the men and found that 35% of them had been in a hospital with an infection such as an STI or a urinary tract infection. The average IQ score was lower for the men who had an infection than for the men who hadn't.

(a) What are the cases in this study?

(b) What is the explanatory variable? Is it categorical or quantitative?

(c) What is the response variable? Is it categorical or quantitative?

(d) Does the headline imply causation?

(e) Is the study an experiment or an observational study?

(f) Is it appropriate to conclude causation in this case?

1.109 Sitting Is the New Smoking A 2014 headline reads "Sitting Is the New Smoking: Ways a Sedentary Lifestyle is Killing You,"[72] and explains the mounting evidence for ways in which sitting is bad for you. A more recent large 2015 study[73] contributed to this evidence by following 69,260 men and 77,462 women and finding that for women, those who spent more leisure time sitting were significantly more likely to get cancer.

(a) What are the explanatory and response variables for the 2015 study?

(b) Is the 2015 study an observational study or a randomized experiment?

(c) Can we conclude from the 2015 study that spending more leisure time sitting causes cancer in women? Why or why not?

(d) Can we conclude from the 2015 study that spending more leisure time sitting does not cause cancer in women?

1.110 Late Night Eating It is well-known that lack of sleep impairs concentration and alertness, and this might be due partly to late night food consumption. A study[74] took 44 people aged 21 to 50 and gave them unlimited access to food and drink during the day, but allowed them only 4 hours of sleep per night for three consecutive nights. On the fourth night, all participants again had to stay up until 4 am, but this time participants were randomized into two groups; one group was only given access to water from 10 pm until their bedtime at 4 am while the other group still had unlimited access to food and drink for all hours. The group forced to fast from 10 pm on performed significantly better on tests of reaction time and had fewer attention lapses than the group with access to late night food.

(a) What are the explanatory and response variables?

(b) Is this an observational study or a randomized experiment?

(c) Can we conclude that eating late at night worsens some of the typical effects of sleep deprivation (reaction time and attention lapses)?

(d) Are there likely to be confounding variables? Why or why not?

1.111 Does Early Language Reduce Tantrums? A recent headline reads "Early Language Skills Reduce Preschool Tantrums, Study Finds,"[75] and

[71] "Infections can lower IQ," *The Week*, June 12, 2015, p. 18.

[72] "Sitting Is the New Smoking: Ways a Sedentary Lifestyle Is Killing You," *http://www.huffingtonpost.com/the-active-times/sitting-is-the-new-smokin_b_5890006.html*, September 29, 2014, Accessed July 17, 2015.

[73] Patel, A.V., et al., "Leisure-time spent sitting and site-specific cancer incidence in a large US cohort," *Cancer Epidemiology, Biomarkers & Prevention*, June 30, 2015, doi:10.1158/1055-9965.EPI-15-0237.

[74] University of Pennsylvania School of Medicine. "Eating less during late night hours may stave off some effects of sleep deprivation." *ScienceDaily*, June 4, 2015 *www.sciencedaily.com/releases/2015/06/150604141905.htm*.

[75] "Early Language Skills Reduce Preschool Tantrums, Study Finds," *US News and World Report*, *http://health.usnews.com/health-news/news/articles/2012/12/20/early-language-skills-reduce-preschool-tantrums-study-finds*, 20 December 2012, Accessed July 17, 2015.

the article offers a potential explanation for this: "Verbalizing their frustrations may help little ones cope." The article refers to a study that recorded the language skill level and the number of tantrums of a sample of preschoolers.

(a) Is this an observational study or a randomized experiment?

(b) Can we conclude that "Early Language Skills Reduce Preschool Tantrums"? Why or why not?

(c) Give a potential confounding variable.

1.112 Does Buying Organic Food Improve Your Health? The National Health and Nutrition Examination Survey (NHANES)[76] surveys a large national random sample of Americans about a wide variety of health related topics. Among many questions, the 2009–2010 survey included a question about eating organic ("In the past 30 days, did you buy any food that had the word 'organic' on the package?"), and also a question about self-reported health status ("Would you say your health in general is Excellent, Very good, Good, Fair, or Poor?"). For the 5060 people who answered both questions, 46% of the people who had bought organic food reported their health as very good or excellent, as opposed to only 33% of the people who had not bought organic food. Remember that there are three possible explanations for this observed difference:

(i) Causal association; buying (and then, presumably eating) organic food improves general health status.

(ii) Association due to confounding; the groups (people who buy organic and those who don't) differed to begin with.

(iii) No actual association; just random chance.

Also recall that evaluating evidence *for* the causal explanation, (i), requires evaluating evidence *against* the alternative explanations, (ii) and (iii). In Chapter 6 we rule out explanation (iii). What about explanation (ii)?

(a) Does this study provide evidence against confounding and groups differing to begin with? Why or why not?

(b) If your answer to part (a) was no, name a potential confounding variable or a way in which the groups may differ to begin with.

(c) Based on your answer to part (a), does this study provide convincing evidence that buying organic food improves general health status? Why or why not?

1.113 Does Eating Organic Food Make Fruit Flies Live Longer? For a high school science project, a 16-year-old girl randomly divided fruit flies into two groups, and fed one group organic food and the other group conventional (non-organic) food.[77] The flies fed organic food lived an average of 3.25 days longer than the flies fed conventional food (which is a long time in the lifespan of a fruit fly!). Remember that there are three possible explanations for this observed difference:

(i) Causal association; eating organic food causes fruit flies to live longer.

(ii) Association due to confounding; the groups (organic fed and conventional fed fruit flies) differed to begin with.

(iii) No actual association; just random chance.

Also recall that evaluating evidence *for* the causal explanation, (i), requires evaluating evidence *against* the alternative explanations, (ii) and (iii). In Chapter 5 we rule out explanation (iii). What about explanation (ii)?

(a) Does this study provide evidence against confounding and groups differing to begin with? Why or why not?

(b) If your answer to part (a) was no, name a potential confounding variable or a way in which the groups may differ to begin with.

(c) Based on your answer to part (a), does this study provide convincing evidence that eating organic food causes fruit flies to live longer? Why or why not?

1.114 Goldilocks Effect: Read to Your Kids! (Part 2) Exercise 1.13 introduces a study in which 27 four-year-old children are presented with stories three different ways: audio only, illustrated, and animated. Every child was presented with all three formats while an MRI machine measured their brain connectivity. The researchers found a "Goldilocks effect," in which both audio (too cold) and animation (too hot) showed low brain connectivity, while the illustrated format (similar to reading a book to a child) showed the highest connectivity (just right!).

[76] https://www.cdc.gov/nchs/nhanes/index.htm

[77] Chhabra R, Kolli S, Bauer JH (2013) Organically Grown Food Provides Health Benefits to Drosophila melanogaster. PLoS ONE 8(1): e52988.

(a) Is this an observational study, a randomized controlled experiment or a matched pairs type experiment?

(b) Can we conclude that reading to a child increases connectivity in their brain more than listening to a story or watching a movie does?

(c) How should randomization be used in the design of this study?

1.115 Sleep and Recognition of Facial Expressions The ability to recognize and interpret facial expressions is key to successful human interaction. Could this ability be compromised by sleep deprivation? A study[78] took 18 healthy young adult volunteers and exposed them to 70 images of facial expressions, ranging from friendly to threatening. They were each shown images both after a full night of sleep and after sleep deprivation (24 hours of being awake), and whether each individual got a full night of sleep or was kept awake first was randomly determined. The study found that people were much worse at recognizing facial expressions after they had been kept awake.

(a) What are the explanatory and response variables?

(b) Is this an observational study or a randomized experiment? If it is a randomized experiment, is it a randomized comparative experiment or a matched pairs experiment?

(c) Can we conclude that missing a night of sleep hinders the ability to recognize facial expressions? Why or why not?

(d) In addition, for the people who had slept, the study found a strong positive association between quality of Rapid Eye Movement (REM) sleep and ability to recognize facial expressions. Can we conclude that better quality of REM sleep improves ability to recognize facial expressions? Why or why not? (*Hint:* What is the explanatory variable in this case? Was it randomly assigned?)

1.116 Diet Cola and Weight Gain in Humans A study[79] found that American senior citizens who report drinking diet soda regularly experience a greater increase in weight and waist circumference than those who do not drink diet soda regularly.

(a) From these results, can we conclude that drinking diet soda causes weight gain? Explain why or why not.

(b) Consider the results of this study on senior citizens, and the randomized experiment on rats introduced in Exercise 1.70 on page 30, which showed a similar association. Discuss what these two studies together might imply about the likelihood that diet cola causes weight gain in humans.

1.117 Urban Brains and Rural Brains A study published in 2010 showed that city dwellers have a 21% higher risk of developing anxiety disorders and a 39% higher risk of developing mood disorders than those who live in the country. A follow-up study published in 2011 used brain scans of city dwellers and country dwellers as they took a difficult math test.[80] To increase the stress of the participants, those conducting the study tried to humiliate the participants by telling them how poorly they were doing on the test. The brain scans showed very different levels of activity in stress centers of the brain, with the urban dwellers having greater brain activity than rural dwellers in areas that react to stress.

(a) Is the 2010 study an experiment or an observational study?

(b) Can we conclude from the 2010 study that living in a city increases a person's likelihood of developing an anxiety disorder or mood disorder?

(c) Is the 2011 study an experiment or an observational study?

(d) In the 2011 study, what is the explanatory variable and what is the response variable? Indicate whether each is categorical or quantitative.

(e) Can we conclude from the 2011 study that living in a city increases activity in stress centers of the brain when a person is under stress?

1.118 Split the Bill? When the time comes for a group of people eating together at a restaurant to pay their bill, sometimes they might agree to split the costs equally and other times will pay individually. If this decision were made in advance, would it affect what they order? Suppose that you'd like to do an experiment to address this question. The variables you will record are the type of *payment*

[78] Goldstein-Piekarski, A., et al., "Sleep Deprivation Impairs the Human Central and Peripheral Nervous System Discrimination of Social Threat," *The Journal of Neuroscience*, July 15, 2015; 35(28): 10135–10145; doi: 10.1523/JNEUROSCI.5254-14.2015

[79] Fowler, S.P., Williams, K., and Hazuda, H.P. "Diet Soda Intake Is Associated with LongTerm Increases in Waist Circumference in a Bioethnic Cohort of Older Adults: The San Antonio Longitudinal Study of Aging." *Journal of the American Geriatrics Society*, 2015; 63(4), 708–715.

[80] "A New York state of mind," *The Economist*, June 25, 2011, p. 94.

(split or individual), *sex* of each person, number of *items* ordered, and the *cost* of each person's order. Identify which of these variables should be treated as *explanatory* and which as *response*. For each explanatory variable, indicate whether or not it should be randomly assigned.

1.119 Be Sure to Get Your Beauty Sleep! New research[81] supports the idea that people who get a good night's sleep look more attractive. In the study, 23 subjects ages 18 to 31 were photographed twice, once after a good night's sleep and once after being kept awake for 31 hours. Hair, make-up, clothing, and lighting were the same for both photographs. Observers then rated the photographs for attractiveness, and the average rating under the two conditions was compared. The researchers report in the *British Medical Journal* that "Our findings show that sleep-deprived people appear less attractive compared with when they are well rested."

(a) What is the explanatory variable? What is the response variable?

(b) Is this an experiment or an observational study? If it is an experiment, is it a randomized comparative design or a matched pairs design?

(c) Can we conclude that sleep deprivation *causes* people to look less attractive? Why or why not?

1.120 Do Antidepressants Work? Following the steps given, design a randomized comparative experiment to test whether fluoxetine (the active ingredient in Prozac pills) is effective at reducing depression. The participants are 50 people suffering from depression and the response variable is the change on a standard questionnaire measuring level of depression.

(a) Describe how randomization will be used in the design.

(b) Describe how a placebo will be used.

(c) Describe how to make the experiment double-blind.

[81]Stein, R., "Beauty sleep no myth, study finds," *Washington Post, washingtonpost.com*, Accessed December 15, 2010.

1.121 Do Children Need Sleep to Grow? About 60% of a child's growth hormone is secreted during sleep, so it is believed that a lack of sleep in children might stunt growth.[82]

(a) What is the explanatory variable and what is the response variable in this association?

(b) Describe a randomized comparative experiment to test this association.

(c) Explain why it is difficult (and unethical) to get objective verification of this possible causal relationship.

1.122 Carbo Loading It is commonly accepted that athletes should "carbo load," that is, eat lots of carbohydrates, the day before an event requiring physical endurance. Is there any truth to this? Suppose you want to design an experiment to find out for yourself: "Does carbo loading actually improve athletic performance the following day?" You recruit 50 athletes to participate in your study.

(a) How would you design a randomized comparative experiment?

(b) How would you design a matched pairs experiment?

(c) Which design do you think is better for this situation? Why?

1.123 Alcohol and Reaction Time Does alcohol increase reaction time? Design a randomized experiment to address this question using the method described in each case. Assume the participants are 40 college seniors and the response variable is time to react to an image on a screen after drinking either alcohol or water. Be sure to explain how randomization is used in each case.

(a) A randomized comparative experiment with two groups getting two separate treatments

(b) A matched pairs experiment

1.124 Causation and Confounding Causation does not necessarily mean that there is no confounding variable. Give an example of an association between two variables that have a causal relationship AND have a confounding variable.

[82]Rochman, B., "Please, Please, Go to Sleep," *Time Magazine*, March 26, 2012, p. 46.

Mean, median, standard deviation, range, IQR
Statistics by group or difference in means
Frequency or relative frequency table, proportion

A.7 What is the current public opinion on capital punishment? Do more people support or oppose it?

A.8 Is there an association between the diameter of the plate used and how much food is consumed?

A.9 Do people who take a multivitamin live longer than those who don't?

A.10 How many hours do college students sleep each night?

A.11 Are males or females more likely to be homosexual?

A.12 Do college graduates who take a statistics course in college earn more at age 40 than those who don't take statistics?

A.13 How far away are stars in the Milky Way Galaxy?

A.14 What percentage of first dates yield second dates?

A.15 Is there an association between how long a child is breastfed and the weight of the child at age 2?

A.16 Is there an association between the color of a car and whether that car has been pulled over for speeding?

A.17 Does Eye Black Work for Athletes? Athletes routinely swipe black grease under their eyes to help cut down on glare on sunny days. Recently, some athletes have switched from grease to patches of black tape. Does either method work? Which is best? A study[3] helped to answer these questions. A sample of 46 subjects were tested using the Pelli-Robson contrast chart, which gives a numerical rating for ability to discern contrast against a sunlit background. Subjects were then randomly assigned to one of three groups and tested again. One group used black grease, one used black tape patches, and one used clear petroleum jelly. The group wearing the black grease was the only group to show significant improvement in discerning contrast in sunlight.

(a) Is this an experiment or an observational
Explain.

(b) Why is this study not double-blind (o
single-blind)?

(c) What is the sample in this study? Give a r
able intended population.

(d) What are the variables in the study? Id
each as either categorical or quantitative.

(e) What sort of graph would you use to displ
results of the study?

A.18 Penguin Tags May Do Harm In Data
page 10, we describe a 10-year study in whic
entists investigated the effect of tagging pen
with either a metal strip or an electronic ta
the study, a sample of 100 penguins were rand
assigned to one of the two groups and then foll
for 10 years. The study found that, overall, pen
banded using a metal strip had fewer chicks
a lower survival rate (percent to survive ove
decade), and on average took significantly long
foraging trips than penguins who were tagged
an electronic tag.[4]

(a) What are the cases in this study? What ar
variables? Identify each variable as catego
or quantitative.

(b) The description above indicates that the
entists found a strong association between
type of tag and various measures, with
metal-tagged penguins having less success.
we conclude that the metal tag is causing
problems?

(c) To investigate a relationship between eac
the following two variables, what graph or t
might we use? What statistics might we comp
or use?

i. Type of tag and number of chicks
ii. Type of tag and survival
iii. Type of tag and foraging time
iv. Foraging time and number of chicks
v. Foraging time and survival

**A.19 What Webpages Do Students Visit dur
Class?** In a study[5] investigating how stude
use their laptop computers in class, research
recruited 45 students at one university in

[3]DeBroff, B. and Pahk, P., "The Ability of Periorbitally Applied Antiglare Products to Improve Contrast Sensitivity in Conditions of Sunlight Exposure," *Archives of Ophthalmology*, July 2003; 121: 997–1001.

[4]Saraux, C., et. al., "Reliability of flipper-banded penguins indicators of climate change," *Nature*, 13 January 2011; 4 203–206.

[5]Kraushaar, J. and Novak, D., "Examining the Affects of S dent Multitasking with Laptops during the Lecture," *Jour of Information Systems Education*, 2010; 21(2): 241–251.

SECTION LEARNING GOALS

You should now have the understanding and skills to:

- Use a description of a study to evaluate the method of data collection and to identify relevant variables
- Use the method of data collection to determine what inferences might be possible
- Recognize which graphs and statistics are relevant in different situations
- Examine individual variables and relationships between variables in a dataset

Exercises for UNIT A: Essential Synthesis

RANDOM SAMPLING AND RANDOM ASSIGNMENT

We have seen that random sampling allows us to generalize to a broader population and that random assignment to groups allows us to conclude causation. A study may include either one of these, or both, or neither. For each of the questions in Exercises A.1 to A.6:

(a) Does the study appear to use random sampling? (Yes or No)

(b) Does the study appear to use random assignment? (Yes or No)

A.1 To predict the outcome of an election, 2500 likely voters are randomly selected to take a survey.

A.2 The students in an Introductory Statistics class are asked to complete a survey about study habits.

A.3 In the oncology unit of a hospital, half the breast cancer patients are randomly selected to receive a new drug while the rest will receive a placebo.

A.4 At a large university, 100 students are randomly selected to take part in a marketing study. Half of these students will be randomly assigned to view one advertising campaign while the other half will watch a different advertising campaign.

A.5 Students in a Psychology class are shown a scary movie while eating popcorn, to examine the impact of fear on appetite.

A.6 In a study examining the reaction of mice to alcohol, all 50 mice in a lab will be randomly assigned to either have alcohol mixed in with their water or to have non-alcoholic liquid of similar taste and caloric content mixed in with their water.

WHICH GRAPH AND STATISTIC?

For the each of the questions in Exercises A.7 to A.16:

(a) From the following list, choose the type(s) of variable(s) that the question pertains to.

One categorical variable
One quantitative variable
One categorical variable and one quantitative variable
Two categorical variables
Two quantitative variables

(b) From the following list, choose the appropriate type(s) of graph(s) that could be used to visualize data corresponding to the question.

Segmented or side-by-side bar charts
Side-by-side boxplots, dotplots, or histograms
Bar chart or pie chart
Scatterplot
Histogram, dotplot, or boxplot

(c) From the following list, choose the appropriate type(s) of statistic(s) that could be used to summarize data corresponding to the question.

Correlation or slope from regression
Two-way table or difference in proportions