

Chapter 1

Introduction to Statistics

1-2 Statistical Thinking

1. A voluntary response sample, also called a self-selected sample, is one in which the subjects themselves decide whether or not to participate in the study.
2. A voluntary response sample is generally not suitable for a statistical study because its results are not likely to be representative of the entire population under study. Those who make the effort to respond voluntarily are typically those with strong feelings or opinions (either favorable or unfavorable) regarding the topic under consideration.
3. Statistical significance occurs when the sample data indicate that a particular conclusion is mathematically justified. Practical significance occurs when the sample data lead to a conclusion that is meaningful and useful. A conclusion may be mathematically justified (i.e., statistically significant) but of no meaningful or useful value (i.e., of no practical significance). For example, the data may lead to the conclusion that a gasoline additive improves mileage – but if the estimated improvement is only 0.1 mpg, common sense dictates that using the additive is not worth the time or the money. That would be an example of a case where there is statistical significance but not practical significance.
4. The context of the data determines the type of statistical analysis that should be used. In lists of male and female ages on marriage licenses, for example, it makes a difference whether the ages were collected for each gender at random or paired according to who was marrying whom.
5. Determining whether or not the weight loss is statistically significant properly requires applying the techniques presented in future chapters. But even if one can conclude that the program is effective (i.e., that the 3.0 lb weight loss is statistically significant), such a weight loss does not have practical significance. Most people would not be willing to subject themselves for one full year to a regimen that produced such a small weight loss.
6. Yes. The sample is a voluntary response sample because the subjects themselves decided whether or not to be included in the sample.
7. (b) Possible, but very unlikely. Possible because there are no physical constraints or rules of the game that would prohibit such scores.
8. (b) Possible, but very unlikely. Possible if he were driving a race car that could attain such a speed.
9. (c) Possible and likely. Likely in the sense of “not unusual enough to raise suspicion,” not likely in the sense of “more probable to happen than not to happen.”
10. (a) Impossible. In the United States, Thanksgiving Day always falls on a Thursday.
11. (b) Possible, but very unlikely. This would be either an amazing coincidence or the result of specific planning.
12. (c) Possible and likely.

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13. (a) Impossible. The highest possible total on a normal pair of dice is $6+6 = 12$.
14. (b) Possible, but very unlikely. This would be either an amazing run of luck or the result of a broken machine.
15. There is nothing in the presentation of the data to suggest that the x and y values are matched. If the x and y values are not matched as presented, it does not make sense to calculate the differences between the x and y values – moving the x values around, for example, would yield a different set of differences.
16. Yes. Since the Federal Trade Commission receives no financial or other benefit from a particular set of results, there is no reason for the data or the data selected to be biased.
17. The data can address the issue of whether or not the two types of cigarette (menthol and king-size) contain the same amounts of nicotine.
18. If the results are as stated, we can conclude that the first type of cigarette is less dangerous (with regard to nicotine content) than the second – but not that it is safe. Crossing a busy highway with your legs tied together may be less dangerous than crossing that highway blindfolded, but neither activity is a safe one.
19. The presentation of the data suggests that the weight and mpg values are matched, each pair of values referring to a particular car. Even though the x (lbs) and y (mpg) values are matched, it does not make sense to calculate their differences. In general, quantities must have the same units in order to be added or subtracted – and then the resulting sum or difference will also have those same units. No meaningful units or interpretation can be assigned to “pounds minus mpg.”
20. Given that the x (lbs) and y (mpg) values are paired, the data can address the issues of whether or not there is a relationship between a car’s weight and its fuel consumption as measured in miles per gallon.
21. If car manufacturers supplied the information, there is reason to suspect that the data might be biased. Since the industry profits from increased sales, and since consumers tend to look for cars with high mpg ratings, the individual manufacturers might tend to supply information only for their better models (i.e., the one with the highest mpg values).
22. No. An association between two variables does not imply that there is a cause and effect. It could be that both weight and mpg are determined by a third factor. [Perhaps vehicles that are designed for hauling are deliberately made heavier and equipped with engines designed for power rather than efficiency; and once the design is complete, adding weight will not further affect the mpg.] Or if there is a cause and effect between two variables, the statistics alone cannot identify which is the cause and which is the effect. [From a purely statistical viewpoint, saying that adding weight causes increased consumption of fuel is no more justified than saying using more fuel causes the car to gain weight.]
23. The weight loss program has statistical significance (i.e., one can conclude that the program produces a weight loss) because it is very unlikely (only 3 chances in 1000) that such a weight loss could have occurred by chance alone. The program does not have practical significance because the amount of lost weight (3.3 lbs) is so small.
24. Determining whether or not the difference between Mendel’s actual results (26%) and the results predicted by his theory (25%) is statistically significant properly requires applying the techniques presented in future chapters. Common sense suggests the 1% difference is of no practical difference. Considering the sample size, the actual difference between the observed

and expected results is $152 - 145 = 7$. Common sense suggests that a discrepancy of 7 (relative to an expected result of 145 plants from a total sample of 580 plants) is within the natural fluctuation inherent in normal biological processes, and that the difference is not statistically significant.

25. Determining whether or not the difference between the survey results (85%) and the statement of the industry representative (50%) is statistically significant properly requires applying the techniques presented in future chapters. But common sense suggests that this is statistically significant evidence against the representative's claim because (1) the observed result of 85% is so much greater than the stated claim of the 50% and (2) the sample of 1038 randomly selected adults appears to be properly chosen and large enough to provide reliable data.
26.
 - a. Yes. If success rate is the determining factor, we should conclude that surgery is a better treatment than splints. In practice, however, one should also consider other factors such as side effects and cost.
 - b. Yes. Because there is only about 1 chance in 1000 of obtaining such a difference (92% vs. 72%) by chance alone whenever the treatments are the same, it appears that the result is statistically significant and represents a real difference between the treatments.
 - c. Yes. The 92% success rate for surgery appears to be substantially better than the 72% success rates for splints.
 - d. Yes. Based on the substantially higher success rate, it appears that surgery should be the recommended treatment – however, other factors (side effects, costs, etc.) should also be considered.
27.
 - a. Yes. In every case the highway amount is substantially greater than the city amount. If there were no difference, we would expect the highway and city amounts to be approximately equal – and when they were not, we would expect the highway amount to be larger about half the time and the city amount to be larger about half the time.
 - b. Yes. The differences appear to be substantial – generally ranging from 6 to 10 mpg higher for the highway amounts.
 - c. One practical implication of the difference is the increased cost of city driving compared to highway driving. Given a choice between two otherwise equal routes, financial considerations would suggest choosing the highway route over the city one.
28. The important value that was not included was the amount of ATV usage. If the $(704 - 617) / 617 = 14.1\%$ increase in fatalities was accompanied by a 25% in ATV usage, for example, then the death rate is actually going down and ATV usage is becoming less life-threatening.

1-3 Types of Data

1. A parameter is a numerical value that describes a population, while a statistic is a numerical value that describes a sample.
2. Quantitative data are numbers representing counts or measurements, while categorical data are names or labels that identify without measuring.
3. Discrete data are limited to certain finite or countable number of values, while continuous data can assume any value within a specified range.
4. The 45% value is a statistic, since it was determined from the 877 executives in the sample and not from the entire population. The population consists of all executives. The practical

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implication of this result is that one should carefully proofread his job applications before they are submitted.

5. Statistic, since it was determined from a sample of households.
6. Parameter, since it is based on the population of all Senators.
7. Parameter, since it was determined from the population of all 2223 passengers.
8. Parameter, since it was determined by testing the population of all 3250 walk buttons.
9. Parameter, since it was determined from the population of all 50 states.
10. Parameter, since it was determined from the population of all elements in the periodic table.
11. Statistic, since it was determined from a sample of 40 days.
12. Statistic, since it was determined from a sample of 35 movies.
13. Discrete, since the value must be one of the integers 0,1,2,...3249,3250.
14. Discrete, since the number of votes received must be a whole number.
15. Continuous, since the amount of nicotine could be any value on a continuum – even though it is reported to the nearest 0.1 mg.
16. Continuous, since the volume could be any value on a continuum – even though it is reported to the nearest 0.1 oz.
17. Discrete, since the number of baby girls must be one of the integers 0,1,2,...,725,726.
18. Continuous, since the systolic pressure could be any value on a continuum – even though it is reported to the nearest mm Hg.
19. Continuous, since the weight could be any value on a continuum – even though it is reported to the nearest 0.1 kg.
20. Discrete, since the number of cylinders must be a positive integer.
21. Ratio, since differences are meaningful and there is a meaningful zero.
22. Nominal, since the data give category names only and there is no natural ordering.
23. Ordinal, since the categories have a natural ordering but the differences between the categories are not necessarily uniform.
24. Interval, since differences between temperatures are meaningful but there is no meaningful zero.
25. Nominal, since the data give category names only and there is no natural ordering.
26. Ratio, since differences are meaningful and there is a meaningful zero.
27. Interval, since differences between years are meaningful but there is no meaningful zero.
28. Ordinal, since the ranks have a natural ordering but the differences between the ranks are not necessarily uniform.

IMPORTANT NOTE for exercises 29-32: The population and sample are determined by the intent of the researcher, which must be clearly defined at the outset of any project. Unfortunately these exercises state only what the researcher did, and do not specifically identify the intent of the researcher. Consequently there may be differences of interpretation in some of the exercises, but

some general principles apply. (1) The sample is a subset of the population of interest and must have the same units as the population. If the population of interest is all households, for example, then the sample must be a selection of households and not a selection of adults – as households with more adults would have a higher chance of being included in the study, thus creating a bias. (2) The problem of nonresponse must be addressed. If 500 persons are randomly selected and asked a personal question, for example, but only 400 choose to answer the question, what is the sample? Depending on the situation, the sample could be either the 500 people randomly selected (and the 100 “no response” answers be reported as part of the sample data) or the just 400 people who actually gave data in the form of a specific answer.

29. a. The sample is the readers who completed and returned the survey.
 b. The population is all people who read *USA Today*.
 c. No, since the sample is self-selected it is not likely to be representative of the population. Only those with special interest in health matters are likely to return the survey.
30. a. The sample is the 1012 randomly selected adults.
 b. The population is all adults. This should probably be understood to be all adults living in the United States.
 c. Yes. Since the adults were selected at random by an organization with experience in polling and with no vested interest in the results, the sample is likely to be representative of the population.
31. a. The sample is the people who responded to the request.
 b. The intended population is likely all persons over 18. The actual population is actually all persons over 18 who have opportunity to receive the request. If the request went out over the Internet, for example, the population would be all Internet users over 18. If the request went out over several radio and/or TV stations, the population would be all persons over 18 who tune in to those stations. And so on.
 c. No, since the sample is self-selected it is not likely to be representative of the population. Only those with special interest in abortion issues are likely to spend the time and money to respond to the survey.
32. a. The sample is the 33,160 persons who responded.
 b. The population is all AOL subscribers.
 c. No, since the sample is self-selected it is not likely to be representative of the population. Only those with any interest in the survey, and with time on their hands, are likely to respond.
33. Temperature ratios are not meaningful because a temperature of 0° does not represent the absence of temperature in the same sense that \$0 represents the absence of money. The zero temperature in the exercise (whether Fahrenheit or Centigrade) was determined by a criterion other than “the absence of temperature.”
34. That value has no meaning.
 NOTE: When there are only two categories coded 0 and 1, the average gives the proportion of the cases falling in the category coded 1. When there are more than two categories, such calculations with nominal data have no meaning.
35. This is an example of ordinal data. It is not interval data because differences are not meaningful – i.e., the difference between the ratings +4 and +5 does not necessarily represent the same differential in the quality of food as the difference between 0 and +1.

1-4 Critical Thinking

1. A voluntary response sample is one in which the subjects themselves choose whether or not to participate. This is generally unsuitable for statistical purposes because it is persons with strong feelings and/or a personal interest in the topic that tend to respond – and the opinions of such people are not necessarily representative of the entire population.
2.
 - a. No. While voluntary response samples generally fail to be representative of the entire population, such is not necessarily the case. Depending on the topic and the situation, it may be possible for a voluntary response sample to be representative of the population.
 - b. No. There are other kinds of sampling that fail to be representative of the entire population – such as sampling only friends or relatives, or sampling only those who happen to be convenient.
3.
 - a. No. An association between two variables does not imply that there is a cause and effect. Even if there is a cause and effect between two variables, the statistics alone cannot identify which is the cause and which is the effect – saying that an increase in the number of registered weapons caused an increase in the murder rate is no more justified than saying it was an increase in the murder rate that caused the increase in the number of registered weapons.
 - b. No. Since there is not necessarily a cause and effect relationship, a decrease in the number of registered weapons will not necessarily result in a reduced murder rate.
4. No. Since she used a voluntary response sample, the responses that she received are likely to be from those with strong feelings on the topic and not representative of the entire population. Even if she had not used a voluntary response sample, the results would apply only to women who were members of the different women's groups that she surveyed – and not to the general population of all women.
5. College graduates tend to earn more money than non-graduates, and people who have more money are able to purchase better health care. Having more money (whether or not it resulted from having a college degree) and not studying more is the primary contributing factor toward longer life.
6. In general, radio stations provide the programming that will attract the highest number of listeners – and thus command the highest advertising rates. In order to please their listeners, it is reasonable to believe that radio stations play most often the songs that were the most popular – i.e., that were being purchased the most often. When it comes to the success of a new song, the radio is more of a lagging indicator than a leading indicator.
7. If the population of Orange County includes significantly more minority drivers than white drivers, one would expect more speeding tickets to be issued to minorities than to whites – even if the percentage of white drivers who violated the speed limit was greater than the percentage of minority drivers who did so. It is also possible that police tend to target minority drivers – so that the numbers of tickets issued to the various racial/ethnic groups does not correspond to the actual amount of speed limit violations occurring. The fact that more speeding tickets are given to minorities does not warrant the conclusion that minority persons are more likely to speed.
8. It could be that the exam is a fair instrument to measure the aptitude for the job, but that larger percentages of the members of the minority group fail the test for reasons other than the test being biased. There may be fewer opportunities for the minorities, causing a larger number of them (including those who are less qualified) to unrealistically attempt the exam.

9. Self-reporting is not always a reliable method of gathering information. People tend to answer questions in a manner that will reflect well on them; they tend to give the answer they wish were true, or that they wish others to believe about them, rather than the true answer. The 82% rate is more likely to be accurate because it was based on objective observation rather than self-reporting.
10. No. Since the 66% figure is based on a voluntary response sample, it might reflect only the views of those with strong feelings and not the views of the general population. In addition, the views of those using the Internet are not necessarily representative of the views of the general population, particularly in matters involving tradition and technology.
11. The fact that the study was financed by groups with vested interests in the outcome might have influenced the conducting and/or reporting to concentrate on aspects of the study favorable to chocolate. The fact that a product contains one ingredient associated with positive health benefits may not outweigh other negative aspects of the product that were not reported.
12. The headline suggests a level of precision that is not warranted. While the national census attempts to be complete, various types of undercounts are known to occur. In addition, the data are collected over a period of time – during which people are constantly dying and being born. Even if the data collected were 100% correct, no single figure could claim to be the exact population at a specific given moment.
13. There are at least two reasons why the results cannot be used to reach any conclusion about how the general population feels about keeping the United Nations in the United States. First, only viewers of the ABC “Nightline” program, which are not necessarily representative of the general population, were aware of the poll. Secondly, the 186,000 persons who responded (and there is always the possibility that some people called more than once in order to give their opinion more weight) are a voluntary response sample – which means that the responses will include an over representation of those with strong feelings and/or a personal interest in the survey.
14. The question appears to be designed to influence opinion in favor of Sweeney’s opponent rather than to gather information for a legitimate “national opinion research poll.”
15. People who were killed in motorcycle crashes, when a helmet may have saved their lives, were not present to testify.
16. Persons will be reluctant to give their financial advisor a poor rating for fear that he will treat them poorly and/or make their investments less of a priority in the future. At the very least, it would create an awkward working relationship. The company should forward comments to the individual financial advisors without revealing which customers made which comments.
17. No, this is not likely to be a good estimate of the average per capita income for all individuals in the United States. States with small populations but high wages (due to the cost of living) like Alaska and Hawaii, for example, contribute $2/50 = 4\%$ of the average for the 50 states – but since they do not contain 4% of the US wage earners, they inflate the estimate to make it higher than the true average of all US wage earners. In general, the average of averages does not give the overall average.

NOTE: Imagine a hypothetical country of two states: one where all 4 persons earned a total of \$400,000 (for a per capita income of $\$400,000/4 = \$100,000$), and one where all 96 persons earned a total of \$4,800,000 (for a per capita income of $\$4,800,000/96 = \$50,000$). The true per capita income for the country is $(400,000 + 4,800,000)/100 = 5,200,000/100 = \$52,000$, but the average of the state averages is $(100,000 + 50,000)/2 = 150,000/2 = \$75,000$.

18. One problem would be in obtaining the correct value: some people may not know their exact heights, some people may think they know their heights but be mistaken, and some people may deliberately exaggerate their heights. Another problem would be in recording the correct value: some people may record 6'2" and have it misread as 62", some people who are not mathematical and/or not used to speaking in terms of inches only may mistakenly convert 6'2" into 62", and some people of other cultures who know their exact height in another system may not be familiar with inches – can you give your height in centimeters?
19. Nothing. Because the information comes from a voluntary response sample, the opinions expressed are more likely to be representative of those with strong feelings on the topic than of the general population. Even if the information had not come from a voluntary response sample, the conclusion would apply only to women who read *Good Housekeeping* magazine and not to “all women.”
20. As medical knowledge and treatment improve, we expect death rates from most causes – including SIDS – to decrease. The fact that the death rate decreased while the supine position was being advised may be just a coincidence, as it might have decreased regardless of the position being advised.
21. a. $5/8 = 0.625 = (0.625)(100\%) = 62.5\%$
 b. $23.4\% = 23.4/100 = 0.234$
 c. $(37\%)(500) = (37/100)(500) = 185$
 d. $0.127 = (0.127)(100\%) = 12.7\%$
22. a. $(5\%)(5020) = (5/100)(5020) = 251$
 b. $83\% = 83/100 = 0.83$
 c. $0.045 = (0.045)(100\%) = 4.5\%$
 d. $227/773 = 0.294 = (0.294)(100\%) = 29.4\%$
23. a. $(49\%)(734) = (49/100)(734) = 360$
 b. $323/734 = 0.440 = (0.440)(100\%) = 44.0\%$
24. a. $68/976 = 0.070 = (0.070)(100\%) = 7.0\%$
 b. $(32\%)(976) = (32/100)(976) = 312$
25. a. $(5\%)(38410) = (5/100)(38410) = 1920.5$
 While either 1920 or 1921 seem like reasonable answers, it is not possible to give an exact answer; any number between 1729 and 2112 rounds to 5%.
 b. $18053/38410 = 0.470 = (0.470)(100\%) = 47.9\%$
 c. No. Because the information comes from a voluntary response sample, the opinions expressed are more likely to be representative of those with strong feelings on the topic than of the general population. Even if the information had not come from a voluntary response sample, the conclusion would apply only to those with AOL Internet access and not to the “general population.”
26. When plaque is reduced by 100%, there is none remaining. To reduce plaque by 300% would be to eliminate 3 times as much plaque as there is to begin with – which is not physically possible.
27. If something falls 100%, there is none remaining. For foreign investment to fall 500% it would have to decline by an amount equal to 5 times as much as it started with – which is not possible.

28. To reduce something by 100% is to eliminate all of it. When the odds of the occurrence of some event are reduced by 100%, the event becomes impossible. No further reduction is possible. The ad may have intended to say that “The Club makes car theft one-fourth as likely.”
29. If the researcher started with 20 mice in each of the six groups, and none of the mice dropped out of the experiment for any reason, then the proportions of success could only be fractions like $0/20$, $1/20$, $2/20$, etc. – and the success rates in percents could only be multiples of 5 like 0%, 5%, 10%, etc. A success rate of 53%, for example, would not be possible.
NOTE: This appears to be a case of miscommunication rather than falsifying data. If the 120 mice had not been divided evenly among the 6 groups, the following fractions would account for all the $19+19+19+24+21+18 = 120$ mice and give the 6 reported success rates:
 $10/19 = 53%$, $11/19 = 58%$, $12/19 = 63%$, $11/24 = 46%$, $10/21 = 48%$, $12/18 = 67%$.
30. The following are reasons why the report should not be taken as a good representation of public opinion.
- (1) Only people who read that particular newspaper were included in the survey. The survey did not reach the general public.
 - (2) Those who responded constituted a voluntary response sample, which would not necessarily be representative of the population..
 - (3) The question was worded in a biased way that would tend to elicit a negative response.
 - (4) If 20 readers responded, the percent of those responding “no” would have to be a multiple of 5 – since $0/20 = 0%$, $1/20 = 5%$, $2/20 = 10%$, etc.
 - (5) The sample size of 20 is probably too small to represent the population.

1-5 Collecting Sample Data

1. In a random sample, every individual member has an equal chance of being selected; while in a simple random sample of size n , every possible sample of size n has an equal chance of being selected.
2. In an observational study, measurements are taken from subjects as they are and without any attempt to modify them; while in an experiment, measurements are taken from subjects at least some of which have been modified in order to assess the effects of the modification.
3. No. A random sample is likely to be representative of the population from which it is selected. The stated sample is likely to be representative of the student’s friends, but not necessarily of the general population.
4. In general, convenience samples are not likely to be representative of the general population because there is no guarantee that the subjects which happen to be readily available are a true cross section of the population. Assuming there is nothing about left-handedness or right-handedness that relates to being in the author’s classes, however, this particular convenience sample is likely to produce results typical of the population. This particular convenience sample would not be valid only if there were some otherwise unknown relationship involved (e.g., if there were racial or gender differences in left-handedness and the author’s students were not racially or gender inclusive).
5. Observational study, since the researcher (Emily) merely measured whether the therapist could identify the chosen hand and did nothing to modify the therapist.
6. Observational study, since the poll involves collecting data from unmodified subjects.

7. Experiment, since the effect of an applied treatment (in this case a zero dose of the appropriate medicine) was measured.
NOTE: There is room for disagreement – some might argue that this is an observational study, since the intent was to learn about the effects of the disease on untreated men and specific characteristics were measured on unmodified subjects. But since the patients were given a placebo and/or were part of a larger formal study in which other persons received the proper medicine, then the given statement describes an experiment. Even if there were no such larger formal study, the spirit of the statement is that the subjects were selected and monitored for the purposes of seeing what particular effect their “treatment” had and/or comparing this effect to known results when the proper treatment was given.
8. Experiment, since the effect of an applied treatment was measured.
9. Convenience, since the sample is those who happened to be in the student’s family.
10. Random, since each infection had an equal chance of being selected for the Echinacea group.
11. Cluster, since all the voters at randomly selected polling stations were surveyed.
12. Systematic, since every 5th driver was stopped.
13. Stratified, since the population of wines was subdivided into 5 different subgroups (wineries), and then samples were drawn from each subgroup.
14. Cluster, since all the prisoners at five randomly selected prisons were surveyed.
15. Systematic, since every 100th spark plug is tested.
16. Convenience, since the sample is those who happen to be students of the author.
17. Random, since every person who filed a return had an equal chance of being selected..
18. Stratified, since the population was subdivided into 3 different subgroups, and then samples were drawn from each subgroup. The population of interest appears to be only communications, business and history majors – most likely because the programs being studied involved only those majors.
19. Cluster, since all the members of six randomly selected health plans were interviewed.
20. Random, since each adult has an equal chance of being selected.
NOTE: This is a complex situation. The above answer ignores the fact that there is not a 1 to 1 correspondence between adults and phone numbers. An adult with more than one number will have a higher chance of being selected. An adult who shares a phone number with other adults will have a lower chance of being selected. And, of course, adults with no phone numbers have no chance of being selected at all.
21. Yes, it is a random sample because each pill has an equal chance of being selected.
Yes, it is a simple random sample because each sample of size 30 has an equal chance of being selected.
22. Whether the sample is a random sample depends on how the first selection is made. If the engineer chooses the first one at random from 1 to 10,000 and every 10,000th one thereafter, then every M&M has an equal chance of being selected (namely 1 in 10,000) and the sample is a random sample. If the engineer determines to start with #1 and choose every 10,000th one thereafter, then some M&M’s have no chance of being selected (e.g., #2) and the sample is not a random sample.
No, no matter how the first selection is made the sample will not be a simple random sample of

size n . All possible groupings of size n are not possible – any grouping containing #1 and #2, for example, could not occur.

23. Yes, it is a random sample because each voter has an equal chance of being selected – and that probability is the number of precincts selected divided by the total number of precincts.
No it is not a simple random sample because some samples of a given size are not possible – e.g., a sample with at least voter from every precinct is not possible.
24. Yes, this is a random sample since each adult has an equal chance of being selected (when one assumes there is an equal number of each gender in the population).
No, this is not a simple random sample of size 1000 since samples with unequal numbers of each gender are not possible.
25. No, this is not a random sample of all New Yorkers because persons who did not visit the location had not chance of being selected.
No it is not a simple random sample because it is not a random sample.
26. Yes, this results in a random sample because each student has an equal chance of being selected.
Yes, this results in a simple random sample of size 6 because each possible grouping of size 6 has an equal chance to occur.
27. Retrospective. The researchers identified groups with a common characteristic (those with and without present respiratory problems) and gathered data by going backward in time (to see how they were involved in the events of 9/11).
28. Prospective. The researchers identified a group with a common characteristic (9/11 responders) and will gather data by going forward in time (to see what happens to them in the future).
29. Cross-sectional. The data examined refer to a single point in time.
30. Retrospective. The researchers identified a group experiencing a common event (drivers who were in a crash and who owned a cell phone at the time of the crash) and examined data describing the group before that common event (whether the drivers were using the cell phone at the time of the crash).
31. Blinding occurs when either the subject or the evaluator doesn't know if the subject received a valid treatment or a placebo. Double-blinding occurs when neither the subject nor the evaluator knows whether a treatment or a treatment was received. Blinding is important in experiments in which there is subjectivity involved in measuring the response. In this experiment, knowledge of whether a treatment or a placebo was received might influence the subject's or evaluator's assessment of whether the "treatment" was effective in dealing with the cold.
32. Assume that survey covers the last Y years, which includes a total on N graduates, and that you want a sample of size n .
 - a. Random. Obtain a list of all N graduates and number them from 1 to N . Choose n random numbers from 1 to N , and select the graduate that corresponds to each number chosen.. In this manner every student has the same chance of being selected. In fact every possible grouping of n students has the same chance of being selected, and the sample is also a simple random sample.

- b. Systematic. Place the N graduates in a list. Choose a random number between 1 and (N/n) to determine a starting selection. Select that graduate and every $(N/n)^{\text{th}}$ graduate thereafter.
 - c. Convenience. Randomly (or conveniently) select and survey 100 students from your school.
 - d. Stratified. Divide the N graduates into Y categories according to their years of graduation. For each year randomly select and survey (n/Y) graduates.
 - e. Cluster. Select one of the Y years at random and survey all the graduates. Repeat as necessary until the desired sample of n graduates is reached.
33. To see which of two statistics textbooks results in better student understanding, have Professor A use one text in all his classes and Professor B use the other text in all her classes. At the end of the semester give all the students a common exam. Confounding will occur because it will not be possible to tell if any difference between the two groups is due to the textbook or to the professor.
34. The study may be described as
- a. prospective because the data are to be collected in the future, after the patients are assigned to different treatment groups.
 - b. randomized because the patients were assigned to one of the three treatment groups at random.
 - c. double-blind because neither the patient nor the evaluating physician knew which treatment had been administered.
 - d. placebo-controlled because there was a treatment with no drug that allowed the researchers to distinguish between real effects of the drugs in question and (1) the psychological effects of being “treated” and/or (2) the effects (e.g., natural improvement over time) of not receiving any drug

Statistical Literacy and Critical Thinking

1. No. Since the responders constituted a voluntary response sample, they likely represented only those with strong feelings for or against one candidate or the other and were not necessarily representative of the entire population.
2. a. Quantitative, because the data consist of numbers representing measurements
 b. Continuous, since length can be any value on a continuum – even though the values are recorded in whole minutes.
 c. Observational study, since the data were collected without involving any treatments or modifications.
 d. Nominal, since the data give names only and do not measure or rank the films.
 e. Ratio, since differences are meaningful and there is a meaningful zero.
3. The subjects must be selected so that all samples of the same size have the same chance of being selected.
4. No, this is the average travel time to work for all individuals in the United States. States with larger populations (which would likely have the greater travel times) should be given more weight.

NOTE: Imagine a hypothetical country of two states: one where all 4 persons had an average travel time of 10 minutes, and one where all 96 persons had an average travel time of 30 minutes. The true average travel time for the country is $[(4)(10) + (96)(30)]/100 = [2900]/100 = 29$ minutes, but the average of the state averages is $[10 + 30]/2 = [40]/2 = 20$ minutes.

Chapter Quick Quiz

1. True. That is a possible complete set from which one might wish to take a sample.
2. Continuous. They may take on any value within a continuum.
3. False. Every combination of n names is not possible – e.g., no combination of names containing two adjacent names is possible.
4. False. A numerical value describing a characteristic of a sample is a statistic, not a parameter.
5. Experiment. The application of a treatment makes the study an experiment.
6. False. There is no natural ordering of the colors.
7. Population. For a sample, the numerical value that describes some characteristic is a statistic.
8. Categorical. The data consist of names or labels, and they are not numbers representing counts or measurements. Since there is a natural ordering to the ratings, they are categorical data at the ordinal level of measurement.
9. Nominal. The book categories are names only, and no natural ordering scheme applies.
10. No. Since the people were randomly selected, the responders constitute a random sample of the population. The typical voluntary response sample results from those choosing to respond to surveys that are sent out (whether by print media, the Internet, on the phone, etc.) indiscriminately to broad audiences. If some of the 500 people in this particular survey refused to reply, it would still be a random sample – but the response “no reply” should be used to bring the total number of responses up to 500 in order to account for all the subjects in the survey.

Review Exercises

1.
 - a. Since the survey was based on a voluntary response sample, its results might not be representative of the population. It could be that people who respond to such surveys tend to have characteristics (e.g., being conscientious) that would affect how they squeeze their toothpaste tubes.
 - b. As stated to apply to the population of all Americans, the 72% is a parameter. In truth, the figure is based on a sample and is properly a statistic. While it may be used to estimate the value in the population, it is accurate only for the sample. It is a statistic that is used to estimate the parameter, and the article should have stated that “it is estimated that 72% of Americans squeeze their toothpaste tube from the top.”
 - c. Observational study, since there was no attempt to modify the behavior being observed.
2. No, results based only those who agree to respond may not be representative of the entire population. Those who refuse to respond may be fundamentally different from their more cooperative peers and may possess opinions that would become under-represented in the sample. One possible strategy for dealing with those who refuse to respond would be to call back (perhaps using a different pollster with an especially agreeable manner) and hope to find them in a more cooperative mood.
3.
 - a. Ratio, since differences are meaningful and there is a meaningful zero.
 - b. Nominal, since gender is only a category with no natural ordering.
 - c. Interval, since differences between temperatures are meaningful but there is no meaningful

zero.

- d. Ordinal, since the categories have a natural ordering but the differences between the categories are not necessarily uniform.
4.
 - a. Nominal, since color is only a category with no natural ordering.
 - b. Ratio, since differences are meaningful and there is a meaningful zero.
 - c. Ordinal, since the categories have a natural ordering but the differences between the categories are not uniform.
 - d. Interval, since differences between temperatures are meaningful but there is no meaningful zero.
 5.
 - a. Discrete. While it may be possible to own $\frac{1}{2}$ shares, the number of shares cannot be any value on a continuum – e.g., a person cannot own π shares.
 - b. Ratio. Differences are meaningful and there is a meaningful zero.
 - c. Stratified. The population has been divided into subgroups, and subjects are selected from each subgroup.
 - d. Statistic. While it may be used to estimate the true value in the population (i.e., the parameter), the average in the sample is a statistic.
 - e. That would be a voluntary response sample and would likely be representative only of those stockholders with strong opinions and not of the general population of stockholders.
 6. NOTE: The second part of the problem involves deciding “whether the sampling scheme is likely to result in a sample that is representative of the population.” This is subjective, since the term “representative” has not been well-defined. Mathematically, any random sample is representative in the sense that there is no bias and a series of such samples can be expected to average out to the true population values – even though any one particular sample may not be representative. And so we expect a random sample of size $n=50$ to be representative. But how about a random sample of size $n=2$? It has all the mathematical properties of a random sample of size $n=50$, but common sense suggests that any one sample of size $n=2$ is not necessarily likely to be representative of the population.
 - a. Systematic, since the selections were made at regular intervals. Yes, there is no reason why every 500th stockholder should have some characteristic that would introduce a bias.
 - b. Convenience, since those selected were the ones who happened to attend. No, those who attend would tend to be the more interested and/or more well-off stockholders.
 - c. Cluster, since the stockholders were organized into groups (by stockbroker) and all the stockholders in the selected groups were surveyed. Yes, since every stockholder has the same chance of being included in the sample (assuming each stockholder works through a single stockbroker), the sample will be a random sample – and considering the large number of stockbrokers involved (see the NOTE at the beginning of the problem), it is reasonable to expect the sample to be representative of the population.
 - d. Random, since each stockholder has the same chance of being selected. Yes, since every stockholder has the same chance of being included in the sample, the scheme is likely to result in a representative sample.
 - e. Stratified, since the stockholders were divided into subpopulations (zip codes) from which the actual sampling was done. No, since all the zip codes were given equal weights (5 stockholders from each) – because “significant” zip codes (with large numbers of stockholders) are counted equal with “insignificant” zip codes (with small numbers of small stockholders), stockholders from “insignificant” zip codes have a greater chance of being included and the types of stockholders that live in “significant” zip codes will be under-represented.

7. a. $12/35 = 0.343 = (0.343)(100\%) = 34.3\%$
 b. $(18\%)(4544) = (18/100)(4544) = 818$
8. a. Parameter, since it was calculated from the entire population.
 b. Discrete, since the numbers of votes must be whole numbers.
 c. $(49.72\%)(68,838,000) = (49.72/100)(68,838,000) = 34,226,000$ (rounded to agree with the accuracy used for the size of the population)
9. a. To contain 100% less fat would be to contain no fat at all – 100% of the fat has been removed. It is not physically possible to contain 125% less fat.
 b. $(58\%)(1182) = (58/100)(1182) = 686$
 c. $331/1182 = 0.280 = (0.280)(100\%) = 28.0\%$
10. The Gallup poll used randomly selected respondents, while the AOL respondents were a voluntary response sample. In addition, those with Internet access to participate in the AOL poll would include more affluent and well-educated persons (who tended to support Obama) and fewer blue-collar workers (who tended to support Clinton). The Gallup poll is more likely to reflect the true opinions of American voters.

Cumulative Review Exercises

NOTE: Throughout the text intermediate mathematical steps will be shown to aid those who may be having difficulty with the calculations. In practice, most of the work can be done continuously on calculators and the intermediate values are unnecessary. Even when the calculations cannot be done continuously, DO NOT WRITE AN INTERMEDIATE VALUE ON YOUR PAPER AND THEN RE-ENTER IT IN THE CALCULATOR. That practice can introduce round-off and copying errors. Store any intermediate values in the calculator so that you can recall them with greater accuracy and without copying errors. In general, the degree of accuracy appropriate depends upon the particular problem – and guidelines for this will be given as needed in subsequent chapters. Unless there is reason to otherwise, answers in this section are given with 3 decimal accuracy.

$$1. \frac{1.1+1.7+1.7+1.1+\dots+1.1}{25} = \frac{31.4}{25} = 1.256 \text{ mg}$$

$$2. \frac{110+96+170+125+\dots+119}{35} = \frac{4196}{35} = 119.9 \text{ min}$$

$$3. \frac{85-80}{3.3} = \frac{5}{3.3} = 1.52$$

$$4. \frac{12.13-12.00}{0.12/\sqrt{24}} = \frac{0.13}{0.0245} = 5.31$$

$$5. \left[\frac{(1.96)(0.25)}{0.01} \right]^2 = [49]^2 = 2401$$

$$6. \frac{(491-513.174)^2}{513.174} = \frac{(-22.174)^2}{513.174} = \frac{491.6863}{513.174} = 0.9581$$

$$7. \frac{(98.0-98.4)^2+(98.6-98.4)^2+(98.6-98.4)^2}{3-1} \\ = \frac{(-0.4)^2+(0.2)^2+(0.2)^2}{2} = \frac{0.16+0.04+0.04}{2} = \frac{0.24}{2} = 0.12$$

$$8. \sqrt{\frac{(98.0-98.4)^2+(98.6-98.4)^2+(98.6-98.4)^2}{3-1}} \\ = \sqrt{\frac{(-0.4)^2+(0.2)^2+(0.2)^2}{2}} = \sqrt{\frac{0.16+0.04+0.04}{2}} = \sqrt{\frac{0.24}{2}} = \sqrt{0.12} = 0.346$$

NOTE FOR EXERCISES 9-12: Many calculators have a display that is limited to 8 or 10 characters, and they will not display as many digits as are shown in the following solutions. Answers with fewer significant digits are acceptable.

$$9. (0.4)^{12} = 1.6777216\text{E-}05 = 0.000016777216$$

$$10. 5^{15} = 3.0517578125\text{E}10 = 30,517,578,125$$

$$11. 9^{11} = 3.1381059609\text{E}10 = 31,381,059,609$$

$$12. (0.25)^6 = 2.44140625\text{E-}04 = 0.000244140625$$