Review of Part III – Gathering Data

1. The researchers performed a prospective observational study, since the children were identified at birth and examined at ages 8 and 20. There were indications of behavioral differences between the group of "preemies", and the group of full-term babies. The "preemies" were less likely to engage in risky behaviors, like use of drugs and alcohol, teen pregnancy, and conviction of crimes. This may point to a link between premature birth and behavior, but there may be lurking variables involved. Without a controlled, randomized, and replicated experiment, a cause-and-effect relationship cannot be determined.

2. A retrospective observational study was performed. There may be a link between tea drinking and survival after a heart attack. Other variables, like overall health and education might also be involved. Since lurking variables may be involved, a controlled, randomized, and replicated experiment must be performed to determine whether or not a cause-and-effect relationship exists between tea drinking and post heart attack survival.

3. The researchers at the Purina Pet Institute performed an experiment, matched by gender and weight. The experiment had one factor (diet), at two levels (allowing the dogs to eat as much as they want, or restricted diet), resulting in two treatments. One of each pair of similar puppies was randomly assigned to each treatment. The response variable was length of life. The researchers were able to conclude that, on average, dogs with a lower-calorie diet live longer.

4. The officials used a random sample. The population is all homes on the property tax list. The parameter of interest is level of radon contamination. The officials' procedure is not clear, but if they make an effort to get some houses from each area in the city, the sample is stratified by area. If the procedure is followed carefully, the officials can use the results of the sample to make inferences about the radon levels in other houses in the county.

5. It is not apparent whether or not the high folate intake was a randomly imposed treatment. It is likely that the high folate intake was simply an observed trait in the women, so this is a prospective observational study. This study indicates that folate may help in reducing colon cancer for those with family histories of the disease. There may be other variables in the diet and lifestyle of these women that accounted for the decreased risk of colon cancer, so a cause-and-effect relationship cannot be inferred.

6. The research team performed a retrospective observational study. There is evidence that the date of first flowering has generally advanced over the last 47 years, but there may be other variables besides climate change that can account for this. The assertion of the researchers is speculative.

7. The fireworks manufacturers are sampling. No information is given about the sampling procedure, so hopefully the tested fireworks are selected randomly. It would probably be a good idea to test a few of each type of firework, so stratification by type seems likely. The population is all fireworks produced each day, and the parameter of interest is the proportion of duds. With a random sample, the manufacturers can make inferences about

the proportion of duds in the entire day's production, and use this information to decide whether or not the day's production is suitable for sale.

8. This appears to be an experiment, although there are no details in the exercise to confirm this assertion. The statement "exposed some laboratory animals" might imply that there were others not exposed, serving as a control. Also, the statement "heightened incidence of damage" seems to imply that there was a comparison of some sort. There is one factor (exposure to phthalates), at two levels (exposure and none), resulting in two treatments. The response variable is male reproductive damage. There is no mention of random allocation to treatment groups. This experiment shows that exposure to phthalates leads to a higher incidence of male reproductive damage in laboratory animals, but speculation that the same may be true in humans is very risky.

9. The researchers performed a retrospective observational study. The data were gathered from pre-existing medical records. Living near strong electromagnetic fields may be associated with an increase in leukemia rates. Since this is not a controlled, randomized, and replicated experiment, lurking variables may be involved in this increased risk. For example, the neighborhood around the antennas may consist of people of the same socioeconomic status. Perhaps some variable linked with socioeconomic status may be responsible for the higher leukemia rates.

10. The medical researchers performed a retrospective observational study. The data were gathered from pre-existing medical records. The study does not *prove* that there is no long-term risk of prostate cancer associated with having a vasectomy, but it does provide evidence to that effect.

11. This is an experiment, blocked by sex of the rat. There is one factor (type of hormone), with at least two levels (leptin, insulin). There is a possibility that an additional level of no hormone (or placebo injection) was used as a control, although this is not specifically mentioned. This results in at least two treatments, possibly three, if a control was used. There is no specific mention of random allocation. There are two response variables: amount of food consumed and weight lost. Hormones can help suppress appetite, and lead to weight loss, in laboratory rats. The male rats responded best to insulin, and the female rats responded best to leptin.

12. The artisan is performing an experiment. There are 2 factors (glaze type and temperature). The glaze type has 4 levels, and the temperature has 3 levels, resulting in 12 treatments (the different combinations of glazes and temperatures). There is no mention of randomization. The response variable is apparent age of the pottery. Assuming that the evaluator is unbiased, the artisan can make a conclusion about the best combination of glaze and temperature.

13. The researchers performed an experiment. There is one factor (gene therapy), at two levels (gene therapy and no gene therapy), resulting in two treatments. The experiment is completely randomized. The response variable is heart muscle condition. The researchers can conclude that gene therapy is responsible for stabilizing heart muscle in laboratory rats.

14. The researchers performed an observational study that was neither prospective nor retrospective. There appears to be a relationship between eye diameter and time of singing.

15. The orange juice plant depends on sampling to ensure the oranges are suitable for juice. The population is all of the oranges on the truck, and the parameter of interest is the proportion of unsuitable oranges. The procedure used is a random sample, stratified by location in the truck. Using this well-chosen sample, the workers at the plant can estimate the proportion of unsuitable oranges on the truck, and decide whether or not to accept the load.

16. The soft drink manufacture is sampling in order to determine whether or not the machine that caps the bottles is working properly. The population is all of the bottle cap seals. The parameter of interest is the whether or not the bottles are sealing properly. They are using a systematic sample, checking bottles at fixed intervals. If any bottles in the sample are not sealed properly, they can tell that the machine may need adjustment or repair.

17. The researchers performed a prospective observational study, since the subjects were identified ahead of time. Physically fit men may have a lower risk of death from cancer than other men.

18. This statistics professor is performing an experiment, blocked by whether or not the students have taken calculus. However, there is probably no randomization, since students usually select their own courses. Hopefully, the two sections contain similar groups of students. There is one factor (use of software), at two levels (software and no software), resulting in two treatments. The response variable is the final exam score. The experiment incorporates blinding, since the graders do not know which students used software and which did not. The professor can decide if computer software is beneficial, and if so, determine whether or not calculus students perform differently than those who have not had calculus.

19. Point spread.

Answers may vary. Perform a simulation to determine the gambler's expected winnings. A component is one game. To model that component, generate random digits 0 to 9. Since the outcome after the point spread is a tossup, let digits 0-4 represent a loss, and let digits 5-9 represent a win. A run consists of 5 games, so generate 5 random digits at a time. The response variable is the profit the gambler makes, after accounting for the $10 bet. If the outcome of the run is 0, 1, or 2 simulated wins, the profit is −$10. If the outcome is 3, 4, or 5 simulated wins, the profit is $0, $10, or $40, respectively. The total profit divided by the number of runs is the average weekly profit. According to the simulation (80 runs were performed), the gambler is expected to break even. His simulated losses equaled his simulated winnings. (In theory, the gambler is expected to lose about $2.19 per game.)

20. The lottery.

a) Answers may vary. Perform a simulation to determine the number of plays required to win. Pick 3 numbers from 1 to 20. (These don't need to be randomly generated. Players of the lottery aren't required to pick randomly, so there is no reason we should!) Let's use 1, 2, and 3 to keep it simple. A component is the selection of 1 winning number. Simulate the winning number by generating a random pair of digits from 01 to 20. Depending on the

type of lottery you simulate, repeated numbers may have to be ignored. Some lotteries choose the numbers from 5 different sets of numbers, while others choose 5 numbers from a single set of numbers. A run consists of 5 winning numbers, so generate 5 such pairs per run. The response variable is whether or not the numbers 1, 2, and 3 appear in the run. Simply count the number of runs it takes to simulate a win. Just for fun, I performed a couple hundred runs of this simulation, and never got a match for my 3 numbers. You are very unlikely to get a match.

b) With more numbers from which to choose, and more matches required to win, the odds of winning go down dramatically. Winning a state lottery is highly improbable.

21. Everyday randomness.

Answers will vary. Most of the time, events described as "random" are anything but truly random.
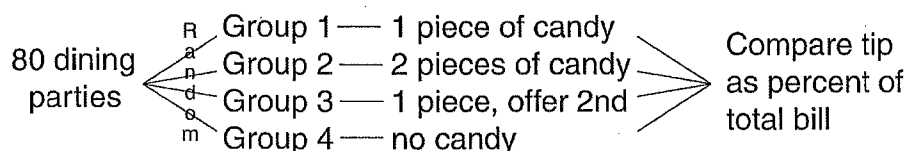
22. Cell phone risks.

a) This is an experiment, since treatments were imposed on randomly assigned groups. There is one factor (radio waves), at three levels (digital cell phone radio waves, analog cell phone radio waves, and no radio waves), resulting in three treatments. The response variable is the incidence of brain tumors.

b) The differences in the incidence of tumors between the groups of rats were not great enough to convince the researchers that the differences were due to anything other than sampling variability.

c) Since the research was funded by Motorola, there may have been bias present. The researchers may have felt pressure to declare cell phones safe, and introduced bias, intended or not, into the experiment.

23. Tips.

a) The waiters performed an experiment, since treatments were imposed on randomly assigned groups. This experiment has one factor (candy), at two levels (candy or no candy), resulting in two treatments. The response variable is the percentage of the bill given as a tip.

b) If the decision whether to give candy or not was made before the people were served, the server may have subconsciously introduced bias by treating the customers better. If the decision was made just before the check was delivered, then it is reasonable to conclude that the candy was the cause of the increase in the percentage of the bill given as a tip.

c) "Statistically significant" means that the difference in the percentage of tips between the candy and no candy groups was more than expected due to sampling variability.

24. Tips, take 2.

a) A diagram of the tipping experiment appears below.

Random
80 dining parties → Group 1 — 1 piece of candy
Group 2 — 2 pieces of candy
Group 3 — 1 piece, offer 2nd
Group 4 — no candy
→ Compare tip as percent of total bill

b) This experiment has 1 factor (candy), at 4 levels (1 piece, 2 pieces, 1 piece with an additional piece offered, and no candy).

c) 1 factor at 4 levels results in 4 treatments.

d) The response variable is the percent of the total bill left as a tip.

e) The diners were not aware that they were part of an experiment, so the experiment was blinded. This experiment did not use double-blinding, but there is probably no way to double blind this experiment, since there is no need to blind the evaluator of the response variable. Biased evaluation of the amount of tip left doesn't seem possible.

f) If the waitress knew which tables were going to receive certain treatments, then she might have treated some tables better than others. The waitress should be unaware of the treatment until after the meal, to avoid the introduction of bias. (Note: This is still only single-blinding. Blinding does not refer to the number of people blinded, but rather the type of blinding employed. If the diners and the waitress are unaware of the assignment of treatments, it is for the same purpose, namely to keep the diners from being systematically influenced.)

25. Cloning.

a) The *USA Weekend* survey suffers from voluntary response bias. Only those who feel strongly will pay for the 900 number phone call.

b) Answers may vary. A strong positive response might be created with the question, "If it would help future generations live longer, healthier lives, would you be in favor of human cloning?"

26. Laundry.

a) Answers may vary. Water (quality and temperature) and material can vary. These confounding variables may influence results. The treatments in the experiment must be in environments that are identical, with the exception of the factor being studied.

b) These conditions are unrealistic. This will not help the experimenters determine how well *Sparklekleen* will work in the conditions for which it was intended.

c) If the swatches are stained at the same time, the stains on the swatches washed later will have more time to "set in", causing bias towards *Sparklekleen*. Also, unforeseen variables, like changes in water temperature or pressure won't be equalized through randomization.

d) The conditions under which the *Sparklekleen* was tested are unknown. There is no way to keep the conditions comparable. Furthermore, the company that produced *Sparklekleen* may not produce reliable data. They have a vested interest in the success of their product.

27. When to stop?

a) Answers may vary. A component in this simulation is rolling 1 die. To simulate this component, generate a random digit 1 to 6. To simulate a run, simulate 4 rolls, stopping if a 6 is rolled. The response variable is the sum of the 4 rolls, or 0 if a 6 is rolled. The average number of points scored is the sum of all rolls divided by the total number of runs. According to the simulation, the average number of points scored will be about 5.8.

b) Answers may vary. A component in this simulation is rolling 1 die. To simulate this component, generate a random digit 1 to 6. To simulate a run, generate random digits until the sum of the digits is at least 12, or until a 6 is rolled. The response variable is the sum of the digits, or 0 if a 6 is rolled. The average number of points scored is the sum of all rolls divided by the total number of runs. According to the simulation, the average number of points scored will be about 5.8, similar to the outcome of the method described in part a).

c) Answers may vary. Be careful when making your decision about the effectiveness of your strategy. If you develop a strategy with a higher simulated average number of points than the other two methods, this is only an indication that you may win in the long run. If the game is played round by round, with the winner of a particular round being declared as the player with the highest roll made during that round, the game is much more variable. For example, if Player B rolls a 12 in a particular game, Player A will always lose that game, provided he or she sticks to the strategy. A better way to get a feel for your chances of winning this type of game might be to simulate several rounds, recording whether each player won or lost the round. Then estimate the percentage of the time that each player is expected to win, according to the simulation.
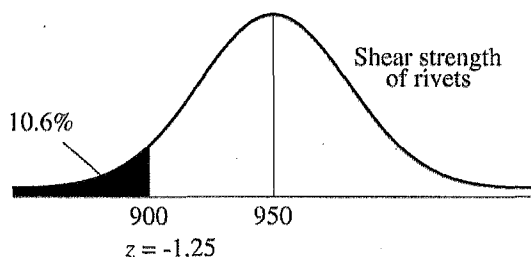
28. Rivets

a)

$$z = \frac{y - \mu}{\sigma}$$

$$z = \frac{900 - 950}{40}$$

$$z = -1.25$$

According to the Normal model, approximately 10.6% of rivets are expected to break when tested under a 900-pound load.

b) Answers may vary. The component being simulated is whether or not a rivet will break under a 900-pound load. To model this component, generate triples of random digits, from 000 to 999. Let digits 001 to 106 represent a broken rivet under a 900-pound load. (001 to 106 represents the 10.6% probability of breaking.) Let other triples of digits represent unbroken rivets under a 900-pound load. To simulate a run, generate a triple of random digits. The response variable is whether or not the rivet will break under a 900-pound load. Count the number of simulated rivets until 3 broken rivets are simulated. According to the simulation, you might need to test about 28 rivets before finding 3 that fail at 900-pounds or below.

29. Homecoming.

a) Since telephone numbers were generated randomly, every number that could possibly occur in that community had an equal chance of being selected. This method is "better" than using the phone book, because unlisted numbers are also possible. Those community members who deliberately do not list their phone numbers might not consider this method "better"!

b) Although this method results in a simple random sample of phone numbers, it does not result in a simple random sample of residences. Residences without a phone are excluded, and residences with more than one phone have a greater chance of being included.

c) No, this is not a SRS of local voters. People who respond to the survey may be of the desired age, but not registered to vote. Additionally, some voters who are contacted may choose not to participate.

d) This method does not guarantee an unbiased sample of households. Households in which someone answered the phone may be more likely to have someone at home when the phone call was generated. The attitude about homecoming of these households might not be the same as the attitudes of the community at large.

30. Youthful appearance.

a) The differences is guessed age were greater than differences that could be explained by natural sampling variability.

b) Dr. Weeks is implying that having sex caused the people to have a more youthful appearance. It seems more plausible that younger-looking people are more sexually active than older-looking people, because of their age.
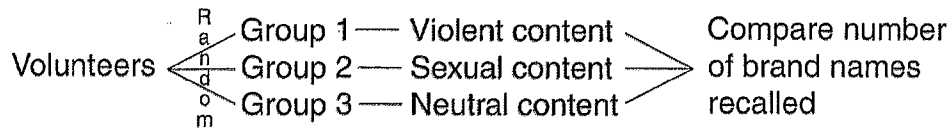
31. Smoking and Alzheimer's.

a) The studies do not prove that smoking offers any protection from Alzheimer's. The studies merely indicate an association. There may be other variables that can account for this association.

b) Alzheimer's usually shows up late in life. Since smoking is known to be harmful, perhaps smokers have died of other causes before Alzheimer's can be seen.

c) The only way to establish a cause-and-effect relationship between smoking and Alzheimer's is to perform a controlled, randomized, and replicated experiment. This is unlikely to ever happen, since the factor being studied, smoking, has already been proven harmful. It would be unethical to impose this treatment on people for the purposes of this experiment. A prospective observational study could be designed in which groups of smokers and nonsmokers are followed for many years and the incidence of Alzheimer's disease is tracked.

32. Antacids.

a) This is a randomized experiment, blocked by gender.

b) Experiments always use volunteers. This is not a problem, since experiments are testing response to a treatment, not attempting to determine an unknown population parameter. The randomization in an experiment is random assignment to treatment groups, not random selection from a population.

c) Since the experiment is studying the effects of an antacid, the placebo may actually confound the experiment, since the introduction of _any_ substance, even a sugar pill, into the digestive system may have an effect on acid reflux. (The use of some sort of placebo is always recommended, but in some cases it may be difficult to find a placebo that truly has no effect, beyond the expected "placebo effect", of course!)

33. Sex and violence.

Volunteers — Random — Group 1 — Violent content — Compare number of brand names recalled
Group 2 — Sexual content
Group 3 — Neutral content

This experiment has one factor (program content), at three levels (violent, sexual, and neutral), resulting in three treatments. The response variable is the number of brand names recalled after watching the program. Numerous subjects will be randomly assigned to see shows with violent, sexual, or neutral content. They will see the same commercials. After the show, they will be interviewed for their recall of brand names in the commercials.

34. Pubs.

a) *Who* – 900 Englishmen. *What* – The researcher was interested in their reasons for going to the pub. *When* – not stated. *Where* – England. *Why* – The producers of Kaliber alcohol-free beer hoped to show that men went to the pub for reasons other than the alcohol. *How* – Researchers surveyed men regarding their reasons for going to the pub.

b) The researcher surveyed believes that the population is all Englishmen.

c) The most important omitted detail is the selection process. How did the researcher acquire the sample of men? Was randomness used? Is the sample representative of the population of Englishmen?

d) Although not stated, it appears that the researcher simply took convenience samples of those in the pubs.

e) The results may be biased. First of all, an alcohol-free beer producer funded the survey. Respondents may have felt subconscious pressure to indicate that alcohol was not the primary reason for going to the pub. Additionally, admitting that you go to the pub merely for the alcohol is a potentially embarrassing admission. The percentage of pub patrons who go for the alcohol may be significantly higher than 10%.
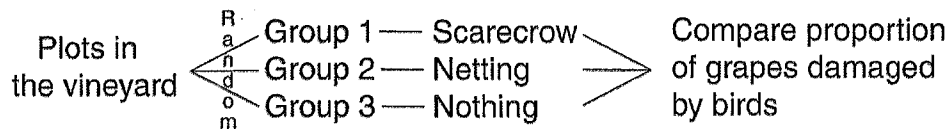
35. Age and party.

a) The number of respondents is roughly the same for each age category. This may indicate a sample stratified by age category, although it may be a simple random sample.

b) 1404 Democrats were surveyed. $\frac{1404}{4002} \approx 35.1\%$ of the people surveyed were Democrats.

c) If this poll is truly representative, this is probably a good estimate of the percentage of voters who are Democrats. However, telephone surveys are likely to systematically exclude those who do not have phones, a group that is likely to be composed of people who cannot afford phones. If socioeconomic status is linked to political affiliation, this might be a problem.

d) The pollsters were probably attempting to determine whether or not political party is associated with age.

36. Bias?

a) Barone claims that nonresponse bias exists in polls, since conservatives are more likely to refuse to participate than other groups. Nonresponse is less of an issue if it is believed that all groups fail to respond at the same rate.

b) The population of interest is all adults in the United States.

c) The column totals do not add up to 100%. There is information missing, and the discrepancies are too large to be attributed to rounding.

d) The differences observed are similar to differences that may have been observed simply due to natural sampling variability. Differences of this size would be probable, even if no bias exists.

37. Save the grapes.

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                    R
         Plots in   a  ⟍Group 1 —— Scarecrow⟍      Compare proportion
                    n  ⟨—Group 2 —— Netting    ⟶   of grapes damaged
        the vineyard d  ⟍Group 3 —— Nothing    ⟋   by birds
                    o
                    m
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This experiment has one factor (bird control device), at three levels (scarecrow, netting, and no device), resulting in three treatments. Randomly assign different plots in the vineyard to the different treatments, making sure to ensure adequate separation of plots, so that the possible effect of the scarecrow will not be confounded with the other treatments. The response variable to be measured at the end of the season is the proportion of bird-damaged grapes in each plot.

38. Bats.

Answers may vary. This experiment has one factor (type of bat), at two levels (wooden and aluminum), resulting in two treatments. The response variable is the difference is distance the ball is hit with each type of bat. Since players vary in their ability to hit the ball, a matched design should be used, with each batter hitting with both types of bats several times in a randomly chosen order. For each batter, calculate the average difference in distance between the aluminum and wooden bats.

39. Knees.

a) In an experiment, all subjects must be treated as alike as possible. If there were no "placebo surgery", subjects would know that they had not received the operation, and might react differently. Of course, all volunteers for the experiment must be aware of the possibility of being randomly assigned to the placebo group.

b) Experiments always use volunteers. This is not a problem, since experiments are testing response to a treatment, not attempting to determine an unknown population parameter. The randomization in an experiment is random assignment to treatment groups, not random selection from a population. Voluntary response is a problem when sampling, but is not an issue in experimentation..

c) There were differences in the amount of pain relief experienced by the two groups, but these differences were small enough that they could be explained by natural sampling variation, even if surgery were not a factor.

40. NBA draft lottery.

Answers will vary. A component in the simulation is drawing one lottery card. To simulate this component, generate random numbers 01 to 66.

Let numbers 01 to 11 represent the team with the worst record, numbers 12 to 21 represent the team with the second worst record, 22 to 30 represent the team with the third worst record (your team), numbers 31 to 38 represent the fourth worst team, numbers 39 to 45 represent the fifth worst team, numbers 46 to 51 representing the sixth worst team, 52 to 56 represent the seventh worst team, 57 to 60 represent the eighth team, 61 to 63 represent the ninth worst team, 64 and 65 represent the tenth worst team, and 66 represent the team with the best record of the teams not making the playoffs.

A run consists of the assignment of one draft pick position to each of the 11 teams. (You can stop after 2 assignments. We are only concerned with whether or not our team gets to pick first or second.) The response variable is whether or not your team receives first or second pick. To simulate a run, generate a random number. If that number is 22 to 30, stop and record a success. If that number is not 22 to 30, note which team received the first pick and generate another random number, ignoring any number that corresponds to the team receiving first pick. If the second number is 22 to 30, record a success. Otherwise record a failure.

The probability that your team gets first or second pick is the total number of successes divided by the number of runs. According to the simulation, your team should get first or second pick approximately 30% of the time.

41. Security.

a) To ensure that passengers from first-class, as well as coach, get searched, select 2 passengers from first-class and 12 from coach. Using this stratified random sample, 10% of the first-class passengers are searched, as are 10% of the coach passengers.

b) Answers will vary. Number the passengers alphabetically, with 2-digit numbers. Bergman = 01, Bowman = 02, and so on, ending with Testut = 20. Read the random digits in pairs, ignoring pairs 21 to 99 and 00, and ignoring repeated pairs.

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65|43|67|11|       27|04|        The passengers selected for search from
XX XX XX Fontana   XX Castillo   first-class are Fontana and Castillo.
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c) Number the passengers alphabetically, with 3 digit numbers, 001 to 120. Use the random number table to generate 3-digit numbers, ignoring numbers 121 to 999 and 000, and ignoring repeated numbers. Search the passengers corresponding to the first 12 valid numbers generated.

42. Profiling?

Answers will vary. A component in this simulation is the selection of a passenger to be searched. To simulate this component, generate pairs of random digits 01 to 20. Let 01 to 04 represent the businessmen from the Middle East, and let numbers 05 to 20 represent other passengers. A run consists of the selection of 2 passengers for search. To simulate a run, generate 2 pairs of random digits, ignoring repeats. The response variable is whether

of not both passengers selected are Middle Eastern businessmen. If both pairs generated are from 01 to 04, record a "success". Otherwise, record a "failure". The total number of successes divided by the total number of runs is the probability that both passengers selected are Middle Eastern businessmen. According to the simulation, this should happen about 3% of the time. Although relatively small, this percentage does not indicate an event that is extremely unlikely. We can't be certain that the Middle Eastern businessmen were not "profiled", but there is little evidence suggesting that they were.

43. Par 4.

Answers may vary. A component in this simulation is a shot. Use pairs of random digits 00 to 99 to represent a shot. The way in which this component is simulated depends on the type of shot.

For the first shot, let pairs of digits 01 to 70 represent hitting the fairway, and let pairs of digits 71 to 99, and 00, represent not hitting the fairway.

If the first simulated shot hits the fairway, let 01 to 80 represent landing on the green on the second shot, and let 81 to 99, and 00, represent not landing on the green on the second shot. If the first simulated shot does not hit the fairway, let 01 to 40 represent landing on the green on the second shot, and let 41 to 99, and 00, represent not landing on the green on the second shot.

If the second simulated shot does not land on the green, let 01 to 90 represent landing on the green, and 91 to 99, and 00, represent not landing on the green. Keep simulating shots until the shot lands on the green.

Once on the green, let 01 to 20 represent sinking the putt on the first putt, and let 21 to 99, and 00, represent not sinking the putt on the first putt. If second putts are required, continue simulating putts until a putt goes in, with 01 to 90 representing making the putt, and 91 to 99, and 00, representing not making the putt.

A run consists of following the guidelines above until the final putt is made. The response variable is the number of shots required until the final putt is made.

The simulated average score on the hole is the total number of shots required divided by the total number of runs. According to 40 runs of this simulation, a pretty good golfer can be expected to average about 4.2 strokes per hole. Your simulation results may vary.

44. The back nine.

a) Answers may vary. A component in this simulation is a shot. Use pairs of random digits 00 to 99 to represent a shot. The way in which this component is simulated depends on the type of shot.

For the first shot, let pairs of digits 01 to 80 represent hitting the fairway, and let pairs of digits 81 to 99, and 00, represent not hitting the fairway.

If the first simulated shot hits the fairway, let 01 to 80 represent landing on the green on the second shot, and let 81 to 99, and 00, represent not landing on the green on the second shot. If the first simulated shot does not hit the fairway, let 01 to 40 represent landing on the green on the second shot, and let 41 to 99, and 00, represent not landing on the green on the second shot.

If the second simulated shot does not land on the green, let 01 to 90 represent landing on the green, and 91 to 99, and 00, represent not landing on the green. Keep simulating shots until the shot lands on the green.

Once on the green, let 01 to 20 represent sinking the putt on the first putt, and let 21 to 99, and 00, represent not sinking the putt on the first putt. If second putts are required, continues simulating putts until a putt goes in, with 01 to 90 representing making the putt, and 91 to 99, and 00, representing not making the putt.

A run consists of following the guidelines above until the final putt is made. The response variable is the number of shots required until the final putt is made.

The simulated average score on the hole is the total number of shots required divided by the total number of runs. According to 20 runs of this simulation, a pretty good golfer can be expected to average about 3.7 strokes per hole. Your simulation results may vary.

b) Answers may vary. The simulation is set up identically to part a), with the exception of the second shot. Now, let 01 to 10 represent hitting the green, and let 11 to 99, and 00, represent not hitting the green.

According to 20 runs of this simulation, a pretty good golfer can be expected to average about 5.3 strokes per hole. Your simulation results may vary.

c) Answers may vary.