

# Sample Surveys Experiments and Observational Studies

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Score: \_\_\_\_\_ / 32

## Q Quick Review

Three big study designs show up in statistics, each answering a different kind of question. Knowing which one was used tells you what conclusions are fair to draw.

**Sample survey.** Ask questions of a random sample to estimate population characteristics (“what fraction of voters support candidate  $X$ ?”). Surveys describe; they don’t establish causation.

**Observational study.** Record what’s already happening without intervening (“do coffee drinkers have higher heart rates?” – you just measure both for people who already drink or don’t drink coffee). Observational studies can show association but cannot rule out *confounding variables* – lurking factors that affect both groups.

**Experiment.** The researcher *assigns* treatments to subjects (“half the people get the new drug, half get a placebo”). Random assignment balances out confounders, so an experiment can establish *causation*.

**Random sampling vs. random assignment.** Random *sampling* (who gets in the study) supports generalizing to the population. Random *assignment* (who gets which treatment) supports causal conclusions. The best experiments have both.

**Sampling methods.** *Simple random sample* – every subset of size  $n$  equally likely. *Stratified* – split population into groups (strata), random sample within each. *Systematic* – pick every  $k$ -th member after a random start. *Cluster* – random sample of groups, then everyone in those groups. *Convenience* – whoever is handy (**prone to bias**).

**Common slips.** Concluding causation from an observational study (the classic “correlation = causation” trap). Calling a convenience sample a random sample. Treating a self-selected online poll as if it were a representative survey. Forgetting that random assignment is what makes experiments special.

## PRACTICE

Identify the study design or sampling method; decide what conclusions are valid.

1. What’s the main feature that distinguishes an experiment from an observational study? \_\_\_\_\_
2. What’s the purpose of random assignment in an experiment? \_\_\_\_\_
3. What’s the purpose of random sampling? \_\_\_\_\_
4. A pollster surveys voters at a shopping mall during business hours. Concern? \_\_\_\_\_
5. The table describes how a survey was conducted. Name the sampling method. \_\_\_\_\_

Step	Action
1	randomly pick 5 of the district’s middle schools
2	survey <i>all</i> 1000 students in those schools

6. The table shows how a researcher drew her sample. Name the sampling method. \_\_\_\_\_

Stratum	Population	Randomly sampled
Male	600	50
Female	600	50

7. Survey every 10th customer entering a store, starting from a random first customer. Method? \_\_\_\_\_
8. Pollster asks the first 50 friends on her contact list. Method? \_\_\_\_\_
9. Observational study finds coffee drinkers score higher on exams. Conclude causation? \_\_\_\_\_



10. The table summarizes a study's design. What type of study is it? \_\_\_\_\_

Group	Assigned by researcher	Treatment
1	yes (random)	new drug
2	yes (random)	placebo

- 11. Online poll on a news website asks visitors to vote. Bias concern? \_\_\_\_\_
- 12. Goal: estimate the proportion of all American adults who exercise weekly. Best design? \_\_\_\_\_
- 13. Goal: test whether a new fertilizer increases crop yield. Best design? \_\_\_\_\_
- 14. Goal: see whether smokers have a higher heart-disease rate than non-smokers (it's unethical to assign smoking). Best design? \_\_\_\_\_
- 15. What's a *placebo*? \_\_\_\_\_
- 16. What's *blinding* in an experiment? \_\_\_\_\_
- 17. True or false: a large convenience sample is just as good as a smaller random sample. \_\_\_\_\_
- 18. What is a *confounding variable*? \_\_\_\_\_
- 19. Can a survey establish causation? \_\_\_\_\_
- 20. A *census* measures \_\_\_\_\_

◆ **Word Problems**

- 21. A school principal wants to know whether students prefer a 4-day or 5-day school week. He posts a poll on the school's social media page and reports that 78% prefer the 4-day option, based on 300 student responses. What's the main methodological problem with his conclusion? \_\_\_\_\_
- 22. A nutrition researcher randomly assigns 200 volunteers to two groups: half eat a Mediterranean diet for six months, half continue their usual diet. After six months, the Mediterranean group has lower average cholesterol. Can the researcher claim the diet *caused* the lower cholesterol? \_\_\_\_\_
- 23. A high school of 1,200 students has 400 freshmen, 300 sophomores, 250 juniors, and 250 seniors. To survey opinions about a new cafeteria menu, the administrator randomly samples 40 freshmen, 30 sophomores, 25 juniors, and 25 seniors. Identify the sampling method and explain its advantage. \_\_\_\_\_
- 24. A study tracks 5,000 adults over 20 years and finds that people who eat breakfast daily have lower rates of heart disease. A headline reads: "Breakfast prevents heart disease!" What kind of study is this, and what's wrong with the headline? \_\_\_\_\_

**Additional Practice**

- 25. Find the mean of 4, 6, 8, 10. \_\_\_\_\_
- 26. Find the median of 3, 9, 4, 10, 7. \_\_\_\_\_
- 27. Find the range of 12, 5, 9, 20. \_\_\_\_\_
- 28. Find the mode of 2, 3, 3, 5, 8. \_\_\_\_\_
- 29. Find  $z$  for  $x = 72$ , mean 60, standard deviation 6. \_\_\_\_\_
- 30. Interpret  $z = -1.5$ . \_\_\_\_\_
- 31. Predicted  $y$  for  $\hat{y} = 2x + 5$  at  $x = 6$ . \_\_\_\_\_
- 32. Residual if actual = 20 and predicted = 17. \_\_\_\_\_



## Answer Keys

- |   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. the researcher assigns treatments</li> <li>2. balance confounders across groups</li> <li>3. ensure the sample represents the population</li> <li>4. sampling bias (not representative)</li> <li>5. cluster sampling</li> <li>6. stratified sampling</li> <li>7. systematic sampling</li> <li>8. convenience sample</li> <li>9. No – confounders possible</li> <li>10. experiment</li> <li>11. voluntary-response (self-selection) bias</li> <li>12. random-sample survey</li> </ol> | <ol style="list-style-type: none"> <li>13. randomized experiment</li> <li>14. observational study</li> <li>15. a fake treatment that looks like the real one</li> <li>16. subjects don't know which treatment</li> <li>17. False</li> <li>18. a lurking variable that affects both groups</li> <li>19. No – only association</li> <li>20. the entire population</li> <li>21. voluntary-response (self-selection) bias</li> <li>22. Yes – this is a randomized experiment</li> <li>23. stratified random sampling</li> <li>24. observational; causation is not justified</li> </ol> |
|---|--|

### Additional Practice Answers

- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>25. 7</li> <li>26. 7</li> <li>27. 15</li> <li>28. 3</li> </ol> | <ol style="list-style-type: none"> <li>29. 2</li> <li>30. 1.5 SD below mean</li> <li>31. 17</li> <li>32. 3</li> </ol> |
|---|---|

**Additional Practice:** Answers for all numbered items, including the added practice, are shown in the grid above.

### Step-by-Step Explanations

1. In an experiment you actively assign people to treatment groups. In an observational study you just watch what happens.
2. Randomly assigning subjects spreads lurking variables evenly across treatment groups, so observed differences are most likely due to the treatment itself.
3. Random sampling gives every population member a fair chance of inclusion, so the sample's characteristics reflect the population's.
4. Mall shoppers at midday aren't a random slice of all voters. The sample skews toward retirees, stay-at-home parents, and the unemployed.
5. A random sample of whole groups (schools), then everyone inside the chosen groups, is cluster sampling – cheap and practical when subjects are naturally clustered.
6. The population is split into strata (here, male and female) and a random sample is drawn *within each* stratum – that's stratified sampling, which guarantees each group is represented.
7. Pick every  $k$ -th individual after a random start. Simple and surprisingly effective if there's no hidden periodicity in the population order.
8. Whoever is easy to reach. Strongly biased – her friends are not a random slice of any larger population.
9. Coffee drinkers might also study more, sleep less, or have demanding schedules. Without random assignment, we can't isolate coffee as the cause.
10. The researcher actively *assigns* treatments (drug vs. placebo) at random  $\Rightarrow$  it's an experiment, and random assignment puts causal conclusions on the table.
11. Only people who care enough to click and vote participate – they're not a random sample of the public. Their opinions are typically more extreme than average.
12. You're estimating a population proportion – that's a survey job. You'd want a random or stratified sample to avoid bias.
13. A causal question (does  $X$  cause  $Y$ ?). Only a randomized experiment can establish causation. Randomly assign plots to fertilizer or no fertilizer.
14. You can't assign smoking, so observation is the only ethical route. The trade-off: you can only claim association, not causation.
15. A dummy treatment used to control for the psychological effect of getting any treatment. Lets you isolate the actual drug effect.
16. Blinding prevents expectation effects from biasing the outcome. Double-blind: neither subjects nor administrators know the assignment.
17. Size doesn't cure bias. A huge convenience sample is still biased; a smaller random sample is unbiased. Better designed beats bigger.
18. A variable correlated with both the treatment and the response. It can fake an apparent treatment effect. Random assignment is the main defense.
19. Surveys describe and estimate. To establish causation, you need an experiment with random assignment.
20. No sampling involved – you collect data from every member of the population. Expensive but no sampling error.
21. The poll captures only students who *choose* to respond – a self-selected group. Students with strong opinions are more likely to vote, and those who prefer the 4-day week have more reason to actively click. The reported 78% probably overstates the school-wide preference. Fix: take a stratified random sample (by grade level) and survey those chosen students directly. Size alone won't fix selection bias.
22. Two key features make causal language appropriate: (1) random *assignment* of treatment (which diet each person eats) balances out confounders like baseline cholesterol, age, exercise, and genetics; (2) the researcher is actively intervening, not just observing. So an observed difference between groups is most reasonably attributed to the diet. (The finding still generalizes only to populations similar to her 200 volunteers – random *sampling* would strengthen that further.)
23. The population is split into strata (grade levels) and a random sample is drawn from each. That's *stratified random sampling*. Its advantage: every grade is guaranteed representation, in correct proportions (10% of each grade). A plain simple random sample of 120 might accidentally under-sample a grade; stratification rules that out. Useful whenever you suspect opinions differ across the strata – and on cafeteria menus, freshmen and seniors very much have different opinions.
24. The researchers didn't assign anyone to eat or skip breakfast – they just followed people and recorded what naturally happened. That makes it an *observational study*. The headline jumps to causation, but observational data can't rule out confounders: daily-breakfast eaters might also exercise more, smoke less, sleep better, or have lower-stress jobs. Any of those could be the real driver. A more honest headline: "Breakfast eaters have lower heart-disease rates" – association, not causation.



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