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Populations and Sampling

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The Rationale of Sampling

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In Chapter One, we established the fact that inductive reasoning is an essential part of the scientific process. Recall that inductive reasoning moves from individual observations to general principles. If a researcher can observe a characteristic of interest in all members of a population, he can with confidence base conclusions about the population on these observations. This is perfect induction. If he, on the other hand, observes the characteristic of interest in some members of the population, he can do no more than infer that these observations will be true of the whole. This is imperfect induction, and is the basis for sampling.[1] The population of interest is usually too large or too scattered geographically to study directly. By correctly drawing a sample from a specific population, a researcher can analyze the sample and make inferences about population characteristics.

The Population

A "population" consists of all the subjects you want to study. "Southern Baptist missionaries" is a population. So is "ministers of youth in SBC churches in Texas." So is "Christian school children in grades 3 and 4." A population comprises all the possible cases (persons, objects, events) that constitute a known whole.[2]

Sampling

Sampling is the process of selecting a group of subjects for a study in such a way that the individuals represent the larger group from which they were selected.[3] This representative portion of a population is called a sample.[4]

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[1]Donald Ary, Lucy Cheser Jacobs, and Asghar Razavieh, Introduction to Research in Education, (New York: Holt, Rinehart and Winston, Inc., 1972), 160

[2]Ibid., p. 125

[3]L. R. Gay, Educational Research: Competencies for Analysis and Application, 3rd ed., (Columbus, Ohio: Merrill Publishing Company, 1987), 101.

[4]Ary et. al., 125

Biased Samples

It is important that samples provide a representative cross-section of the population they supposedly represent. The sample should be a "microcosm" — a miniature model — of the population from which it was drawn. Otherwise, the results from the sample will be misleading when applied to the population as a whole. If I select "Southern Baptist ministers" as the population for my study and select Southern Baptist pastors in Fort Worth as my sample, I will have a biased sample. "Fort Worth pastors" may not reflect the same characteristics as ministers (including staff members) across the nation. Selecting people for a study because they are within convenient reach —members of my church, students in a nearby school, co-workers in the surrounding region — yields biased samples. Biased samples do not represent the populations from which they are drawn.

Randomization

The key to building representative samples is **randomization**. "Randomization" is the process of randomly selecting population members for a given sample, or randomly assigning subjects to one of several experimental groups, or randomly assigning experimental treatments to groups. In the context of this chapter, it is selecting subjects for a sample in such a way that every member of the population has an equal chance at being selected. By randomly selecting subjects from a population, you statistically equalize all variables simultaneously.

Steps in Sampling

Target Population
Accessible Population
Size of Sample
Select

Regardless of the specific type of sampling used, the steps in sampling are essentially the same: identify the target population, identify the accessible population, determine the size of the sample, and select the sample.

Identify the Target Population

The first step is the identification of the target population. In a study concerning professors in Southern Baptist seminaries, the target population would be all professors in all Southern Baptist seminaries. In a study of job satisfaction of local church staff ministers, the target population is all staff ministers in all churches.

Identify the Accessible Population

Since it is usually not possible to reach all the members of a target population, one must identify that portion of the population which is accessible. The nature of the accessible population depends on the time and resources of the researcher. Given the target population of "Southern Baptist professors," the accessible population might be "Southwestern Seminary professors." Given the target population of "local church staff ministers," the accessible population might be "Southern Baptist ministers of education in Texas."

Notice that specifying the accessible populations reduces the scope of the two examples in the preceding paragraph. In most cases this is helpful because beginning researchers tend to include too much in their study.

Determine the Size of the Sample

Student researchers often ask "How big should my sample be?" The first answer is "use as large a sample as possible."[5] The reason is obvious: the larger the sample, the better it represents the population. But if the sample size is too large, then the value of sampling — reducing time and cost of the study — is negligible.

The more common problem, however, is having too few subjects, not too many.[6] So the more important question is, "What's the minimum number of subjects I need?" The question is still difficult to answer. Here are some of the factors which relate to proper sample size.

Accuracy

In every measurement, there are two components: the true measure of the variable and error. The error comes from incidental extraneous sources within each subject: degree of motivation, interest, mood, recent events, future expectations. All of these cause variations in test results. In all statistical analysis, the objective is to minimize error and maximize the true measure. As the sample size increases, the random extraneous errors tend to cancel each other out, leaving a better picture of the true measure of the population.

Cost

An increasing sample size translates directly into increasing costs: not only of money, but time as well. Just think of the difference in printing, mailing, receiving, processing, tabulating, and analyzing questionnaires for 100 subjects, and then for 1000 subjects.

The dilemma of realistically balancing "accuracy" (increase sample size) with "cost" (decrease sample size) confronts every researcher. Inaccurate data is useless, but a study which cannot be completed due to lack of funds is not any better.

"Cost per subject" is directly related to the kind of study being done. Interviews are expensive in time, effort and money. Mailing out questionnaires is much less expensive per subject. Therefore, one can plan to have a larger sample with questionnaires than with interviews for the same cost.

The Homogeneity of the Population

"Homogeneous" [from *homo-genos*, "like-kind"] means "of the same kind or nature; consisting of similar parts, or of elements of the like nature" (Webster, s.v. "homogeneous"). Homogeneity in a population means that the members of the population are similar on the characteristic under study. We can take a sample of two drops of water from a 10 gallon drum, and have a good representative sample of the ten gallons. This is because the water in a 10 gallon drum is an homogeneous solution (if we mix it up well before sampling). But if we take two people out of a group of 500, we will not have a good representative sample of the 500. "People" are much less homogeneous than a water solution!

But even populations of people vary in homogeneity. The population "Texas Baptists" would have less variability on the issue of gambling than the more general population of "Texans." The greater the variability in the population, the larger the sample needs to be.

[5] Ary et. al., 167 [6] Gay, 114

Other Considerations

Borg and Gall list several additional factors which influence the decision to increase the sample size (See pp. 257-261). These are

1. When uncontrolled variables are present.
2. When you plan to break samples into subgroups.
3. When you expect high attrition of subjects.
4. When you require a high level of statistical power (see Chapter 17) .

So, what is a good rule of thumb for setting sample size in a research proposal? Here are two suggestions

Sample Size Rule of Thumb

Size of Population	Sampling Percent
0-100	100%
101-1,000	10%
1,001-5,000	5%
5,001-10,000	3%
10,000+	1%

Dr. John Curry, Professor of Educational Research, North Texas State University (now retired), provided his research students (fall, 1984) with the "rule of thumb" on sample size (see right). Using this rule, an adequate sample of Southern Baptists' 36,000 pastors would be a random sample of 1%, or 360 pastors.

L. R. Gay suggests 10% of large populations and 20% of small populations as minimums.[7] Using Gay's suggestion, our sample of pastors would include 3,600. It is left to the student to weigh the factors of accuracy, cost, homogeneity of the accessible population, type of sampling and kind of study, and determine the best sample size for his study.

Select the Sample

The final step is to actually select a sample of predetermined size from the accessible population.

Types of Sampling

Simple
Systematic
Stratified
Cluster

There are several ways of doing this. We will look at four major types here: simple random, systematic, stratified, and cluster sampling. The basic characteristic of random sampling is that all members of the population have an equal and independent chance of being included in the sample.[8]

Simple Random Sampling

The most common method of sampling is known as simple random sampling: "Pick a number out of a hat!" Gay provides a good example of this type of sampling.[9]

A superintendent of schools wants to select a sample of teachers so that their attitudes toward unions can be determined. Here is how he did it:

1. The population is 5,000 teachers in the system.

2. The desired sample size is 10%, or 500 teachers.

3. The superintendent has a directory which lists all 5,000 teachers alphabetically. He assigns numbers

[7]Gay, 114-115 [8]Ary, 162 [9]Gay, 105-7

from 0000 to 4999 to the teachers.

4. *A table of random numbers is entered at an arbitrarily selected number such as the one underlined below:*

59058 11859 <u>53634</u> 48708 71710

5. *Since his population has only 5000 members, he is interested only in the last 4 digits of the number, 3634.*
6. *The teacher assigned #3634 is selected for the sample.*
7. *The next number in the column is 48708. The last four digits are 8708. No teacher is assigned #8708 since there are only 5000. Skip this number.*
8. *Applying these steps to the remaining numbers shown in the column, teachers 1710, 3942, and 3278 would be added to the sample.*
9. *This procedure continues down this column and succeeding columns until 500 teachers have been selected.*

This random sample could well be expected to represent the population from which it was drawn. But it is not guaranteed. The probable does not always happen. For example, if 55% of the 5000 teachers were female and 45% male, we would expect about the same percentages in our random sample of 500. Just by chance, however, the sample might contain 30% females and 70% males.

If the superintendent believed teaching level (elementary, junior high, senior high) might be a significant variable in attitude toward unions, he would not want to leave representation of these three sub-groups to chance. He would probably choose to do a stratified random sample.

Systematic Sampling

A systematic sample is one in which every Kth subject on a list is selected for inclusion in the sample.[10] The "K" refers to the sampling interval, and may be every 3rd (K=3) or 10th (K=10) subject. The value of K is determined by dividing the population size by the sample size. Let's say that you have a list of 10,000 persons. You decide to use a sample of size 1000. K = 10000/1000 = 10. If you choose every 10th name, you will get a sample of size 1000. The superintendent in our example would employ systematic sampling as follows:

1. *The population is 5,000 teachers.*
2. *The sample size is 10%, or 500 teachers.*
3. *The superintendent has a directory which lists all 5,000 teachers in alphabetical order.*
4. *The sampling interval (K) is determined by dividing the population (5000) by the desired sample size (500). K = 5000/500 = 10.*
5. *A random number between 0 and 9 is selected as a starting point. Suppose the number selected is "3".*
6. *Beginning with the 3rd name, every 10th name is selected throughout the population of 5000 names. Thus, teacher 3, 13, 23, 33 ... 993 would be chosen for the sample (Gay, pp. 113-114).*

Writers disagree on the usefulness of systematic sampling. Ary and Gay discount systematic sampling as "not as good as" random sampling because each selection is not independent of the others.[11] Once the beginning point is established, all other choices are determined. Both writers give as an example a population which includes various nationalities. Since certain nationalities have distinctive last names that tend to group together under certain letters of the alphabet, systematic sampling can skip over

[10] Gay, 112 [11] Ary, 116 and Gay, 114

whole nationalities at a time.

Babbie on the other hand, states that "systematic sampling is virtually identical to simple random sampling" when one chooses a random starting point.[12] Sax reports that systematic sampling "usually leads to the same results as simple random sampling."[13] There is a module on your tutorial disk that directly compares systematic sampling with simple random sampling. Use that to compare the results of sampling for yourself.

There is one major danger with systematic sampling on which all authors agree. If there is some natural periodicity — repetition — within the list, the systematic sample will produce estimates which are seriously in error.[14] If this condition exists, the researcher can do one of two things. He can use simple random sampling on the list as it exists, or he can randomly order the list and then use systematic sampling.

Stratified Sampling

Stratified sampling permits the researcher to identify sub-groups within a population and create a sample which mirrors these sub-groups by randomly choosing subjects from each stratum. Such a sample is more representative of the population across these sub-groups than a simple random sample would be.[15] Subgroups in the sample can either be of equal size or proportional to the population in size. Equal size sample subgroups are formed by randomly selecting the same number of subjects from each population subgroup. Proportional subgroups are formed by selecting subjects so that the subgroup percentages in the population are reflected in the sample. The following example is a proportionally stratified sample.

The superintendent would follow these steps to create a stratified sample of his 5,000 teachers.[16]

1. *The population is 5,000 teachers.*
2. *The desired sample size is 10%, or 500 teachers.*
3. *The variable of interest is teaching level. There are three subgroups: elementary, junior high, and senior high.*
4. *Classify the 5,000 teachers into the subgroups. In this case, 65% or 3,250 are elementary teachers, 20% or 1,000 are junior high teachers, and 15% or 750 are senior high teachers.*
5. *The superintendent wants 500 teachers in the sample. So 65% of the sample (325 teachers) should be elementary, 20% (100) should be junior high teachers, and 15% (75) should be senior high teachers. This is a proportionally stratified sample. (A non-proportionally stratified sample would randomly select 167 subjects from each of the three groups.)*
6. *The superintendent now has a sample of 500 (325+100+75) teachers, which is representative of the 5,000 and which reflects proportionally each teaching level.*

Cluster sampling

Cluster sampling involves randomly selecting groups, not individuals. It is often impossible to obtain a list of individuals which make up a target population. Suppose

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[12]Earl Babbie, *The Practice of Social Research*, 3rd. (Belmont, CA: Wadsworth Publishing Company, 1983), 163

[13]Gilbert Sax, *Foundations of Educational Research* (Englewood Cliffs, NJ: Prentice-Hall, 1979), 191

[14]Gilbert Churchill, *Marketing Research: Methodological Foundations*, 2nd (Hinsdale, IL: The Dryden Press, 1979), 328

[15]Ary and others, 164; Babbie, 164-165; Borg and Gall, 248-249; Sax, 185-190

[16]Gay, pp. 107-109

a researcher is interested in surveying the residents of Fort Worth. Through cluster sampling, he would randomly select a number of city blocks and then survey every person in the selected blocks. Or, another researcher wants to study social skills of Southern Baptist church staff members. No list exists which contains the names of all church staff members. But he could randomly select churches in the Convention, and use all the staff members of the selected churches.

Any intact group with similar characteristics is a cluster. Other examples of clusters include classrooms, schools, hospitals, and counseling centers. Let's apply this approach to the superintendent's study.

1. The population is 5,000 teachers.
2. The sample size is 10%, or 500 teachers.
3. The logical cluster is the school.
4. The superintendent has a list of 100 schools in the district.
5. Although the clusters vary in size, there are an average of 50 teachers per school.
6. The required number of clusters is obtained by dividing the sample size (500) by the average size of cluster (50). Thus, the number of clusters needed is 500/50 = 10 schools.
7. The superintendent randomly selects 10 schools out of the 100.
8. Every teacher in the selected schools is included in the sample.

In this way, the interviewer can conduct interviews with all the teachers in ten locations, and save traveling to as many as 100 schools in the district.[17]

There are drawbacks to cluster sampling. First, a sample made up of clusters may be less representative than one selected through random sampling.[18] Only ten schools out of 100 are used in our example. These ten may well be different from the other ninety. Using a larger sample size, say, 25 schools rather than 10, reduces this problem.

A second drawback is that commonly used inferential statistics are not appropriate for analyzing data from a study using cluster sampling.[19] The statistical procedures we will be studying require random sampling.[20]

Inferential Statistics: A Quick Look Ahead

The field of inferential statistics allows researchers to study samples and infer the characteristics of populations. We have already noted the two basic components of every piece of collected data: the true measurement and error. Suppose you have a population of 1000 test scores. The average of the entire 1000 scores is 75. You would expect the average of a random sample of 100 scores to also be 75. So you draw your first sample of 100 and compute the average. You get 73.8. You draw another 100 and find the average to be 76.2. Another hundred: 77.7. Yet another: 71.5. The central tendency in 1000 scores is not exactly duplicated in a sample of 100.

The differences among sample averages is due to sampling error. Inferential statistics provides a way to estimate true population parameters from sample statistics through the use of the laws of probability. Each of the sample means is different from the population mean. But is the difference great enough to be considered significant? We will master some of the most popular techniques for inferring population characteristics from sample measurements a little later in the course.

[17]Gay, 110-112 [18]Ibid., 111 [19]Ibid, 112
[20]See Babbie 167-171 his discussion of statistical analysis and cluster sampling.

The Case Study Approach

Not all research is geared to sampling subjects out of large populations. The case study is a kind of descriptive research in which an in-depth investigation of an individual, group, event, community or institution is conducted. The strength of the case study approach is its depth, rather than its breadth. The investigator tries to discover all the variables that are important in the history or development of his subject.[1]

The weakness of the case study is its lack of breadth. "The dynamics of one individual or social unit may bear little relationship to the dynamics of others. Most case studies arise out of counseling or remedial efforts and therefore provide information on exceptional rather than representative individuals."[2] Because of this, it is more difficult to write an acceptable dissertation which employs a case study approach.

The objective of graduate research is to concentrate on areas which have high generalizability. In most cases, this involves sampling from specified populations. The case study approach involves finding atypical subjects that exemplify some relevant trait. Random sampling methods are therefore inappropriate.[3] Borg and Gall cite several areas where the case study approach is used:[4]

Historical Case Studies of Organizations

An historical case study of an organization involves the analytical observation of an organization, by way of records, documents and personal interviews of members and leaders, from its inception to the present. An example of this kind of case study would be "The Development of the School of Educational Ministries, Southwestern Baptist Theological Seminary, Fort Worth, Texas."

Observational Case Studies

An observational case study involves the in-depth observation of a specific individual or group over a period of time. An example of this type of study would be "Living with the Children of God: New Testament Community or New Age Cult?"

Oral Histories

Oral histories involve extensive first-person interviewing of a single individual. Dissertations have been written on the lives of J. M. Price and Joe Davis Heacock, former deans of the School of Religious Education, using this approach.

Situational Analysis

An event is studied from the perspective of the participants involved. For example, a staff member is summarily fired from a church staff by the pastor. Interviews with the staff member and family, staff colleagues, pastor, church leaders and selected church members would be conducted. When all the views are synthesized, an in-depth understanding of the event can be produced.

Clinical case study

A particular problem is studied through in-depth analysis of a single individual

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[1]Ary, p. 286. See the following for guidance in proposing a case study approach: Borg and Gall, 488-490; Gay, 207; Sax, 106.

[2]Ibid., 287 [3]Sax, 106 [4]Headings from Borg and Gall, 489

suffering from the problem. "Depression in the Ministry: A Case Study of Twenty Ministers of Eeducation."

Summary

In this chapter you have learned about sampling techniques that allow you to select and study a small representative group of subjects (the sample) and infer findings to the larger group (the population). You have been given a rationale for sampling, the place of randomization in sampling, the steps of sampling, four types of sampling, and a look at the case study approach.

Vocabulary

accessible population	subjects available for sampling (e.g. mailing list)
attrition	loss of subjects during a study
biased sample	subjects selected in non-random manner (e.g. 3rd grade classes at school)
case study approach	in-depth study of individual subject or institution
Cluster sampling	selecting subjects by **randomly choosing groups** (e.g. city blocks or churches)
error	difference between the measurement of a variable and its true value
estimated parameters	mean and standard deviation of population **computed from sample statistics**
population parameters	mean and standard deviation of population **measured directly**
randomization	selecting subjects so that each population member has equal chance of being selected
sample	a (smaller) group of subjects which represents a (larger) population
sample size	the number of subjects in a sample (symbolized by N or n)
sample statistics	mean and standard deviation of a sample (not useful in themselves)
sampling error	source of the discrepancy between sample statistics and population parameters
Sampling	process of selecting a representative sample from a population
Simple random sampling	drawing **subjects by random number** (e.g. names out of a hat)
statistical power	the probability that a statistic will declare a difference `significant'
Stratified sampling	selecting subjects at **random from population strata** (e.g., male, female)
systematic sampling	selecting every **k^{th} subject** from a list. (e.g., every 10th person in 1000 = 100 subjects)
target population	population of interest to your study (e.g. single adults)
true measure	the true value of a variable (no error)

Study Questions

1. Define “target population,” “accessible population,” and “sample.”
2. Explain why sampling is an important part of research.
3. List and describe four types of sampling.
4. Explain why randomization is important in sampling.
5. You want to study “Youth ministers’ attitudes toward small group Bible study.” You have identified 4,573 youth ministers. Using the “rules of thumb” estimate for sampling, how many youth ministers should you select for your study?

Sample Test Questions

1. Sampling is based on the principles of
    a. intuition
    b. trial and error
    c. inductive reasoning
    d. deductive reasoning

2. The key to producing a good representative sample is
    a. random selection of subjects
    b. using volunteers for the sample
    c. narrowly defining the target population
    d. using the minimum number of subjects in the sample

3. "Southern Baptist single adults" would be considered a(n)
    a. accessible population
    b. target population
    c. stratified sample
    d. cluster sample

4. One would increase sample size if he expected
    a. high attrition of subjects during the study
    b. a high cost per subject
    c. high homogeneity of the population
    d. few uncontrolled variables in the population