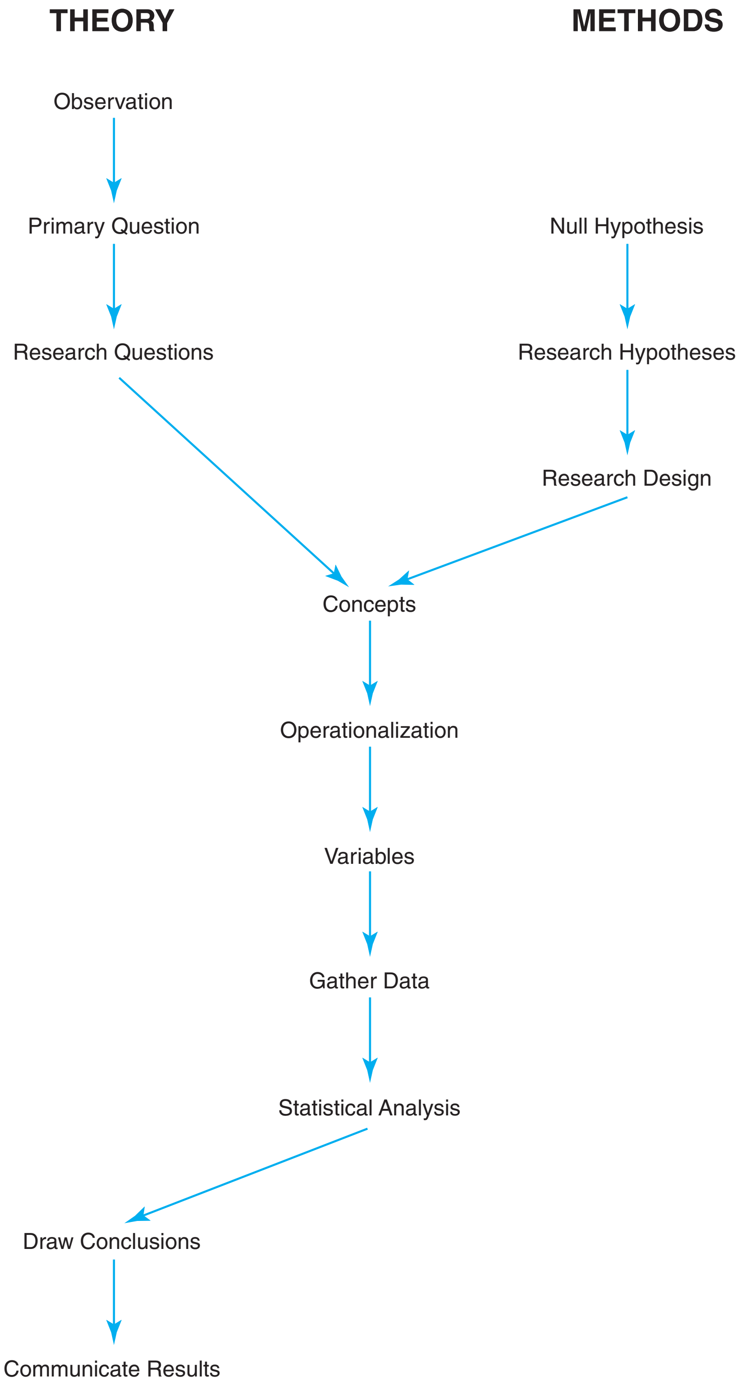
THEORY
METHODS
Observation
Primary Question
Null Hypothesis
Research Questions
Research Hypotheses
Research Design
Concepts
Operationalization
Variables
Gather Data
Statistical Analysis
Draw Conclusions
Communicate Results

Chapter 1

The Logic of Comparisons and Analysis

Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.

—H. G. Wells

Learning Objectives

- Understand the difference between statistics and math.
- Explain the role of statistics in the process of scientific inquiry.
- Discuss the relationship among theory, research methods, and statistics.
- Identify the steps in the research process.
- Understand the relationship among primary questions, research questions, null hypotheses, and research hypotheses.

1-1 Introduction: Why Analyze Data?

Discovery and innovation may be the distinguishing characteristics between modern human activity and that of our ancestors. The Renaissance period brought forth an emphasis on learning and advancing our way of doing things that has prevailed to the present. Scientists, inventors, and others involved in the process of scientific inquiry have often been held in awe for their works. Galileo, Einstein, Madam Curie, and others are singled out in grade school books for their works and discoveries. As you will learn, so too should be people such as Pearson, Kendall, and Yule.

Statistical analysis is all about **discovery**. The process of **scientific inquiry** provides a method of examining things that interest us in a systematic manner. This process generally requires evidence to support an argument. One of the clearest methods of establishing evidence is by examining numbers associated with the objects being studied. That examination takes place through statistical analysis. As such, statistical analysis is the linchpin of discovery, and mastery of it draws us closer to Einstein and Galileo.

1-2 Some Statistical History

The earliest form of what is now considered **statistical analysis** was developed by Pythagoras in the 6th century BC. This was the forerunner of **descriptive statistics** (what would eventually be known as the *mean*, or what is commonly known as an *average*). The other type of statistical analysis **(inferential statistics)** is thought to have first developed in the Orient around 200 BC (Dudycha and Dudycha, 1972). This was a form of probability analysis used in assessing whether an expected child was likely to be male or female. Probability theory, as it would come to be known, continued in the form of gambling mathematics in the works of Blaise Pascal (1623–1662) and Lord Christianus Huygens (1629–1695) (David, 1962). Many of the other descriptive statistics were developed in the late 1800s and early 1900s by mathematicians and scientists such as Galton (1883) and Pearson (1895).

Statistics moved beyond gambling and purely mathematical concepts through what was called *political arithmetic,* a term coined because of its close association with those studying political topics, including economics. (This probably began the close association between political lying and statistical lying.) The first known use of this political arithmetic was by John Graunt (1662), who used what is now called descriptive statistics to study London's death rates. Although there is fierce debate concerning the original use of the term **statistics** (Yule, 1905), the position with the greatest support is that it was coined by Eberhard August Wilhelm von Zimmerman in the preface of *A Political Survey of the Present State of Europe* (1787). Modern use of the term *statistics* (as opposed to *mathematics*) is often attributed to R. A. Fisher and his work *Statistical Methods for Research Workers* (1925), wherein he stated that "a statistic is a value calculated from an observed sample with a view to characterizing the population from which it is drawn." Since that time, statisticians have added to the techniques available to analyze data, many adding their names to the procedures; and the addition of statistical techniques continues today. Analysis procedures have been added to the statistical repertoire in the past few years that have greatly increased the ability of researchers in sociology, criminology, and other fields to examine the relationship between variables more accurately.

A single death is a tragedy, a million deaths is a statistic.

—Joseph Stalin

1-3 Uses of Statistics

The term *statistics* is often misunderstood because there are actually two practical applications of it. The first, reflecting the history of the term, is a collection of data—often expressed in summary form—that is collected and preserved. The best example of these are census statistics or mortality statistics, which depict the characteristics of the living or the causes of death, respectively. The second application is the subject of this text: a method of analyzing data.

Statistics as you will come to know them are methods used to examine data collected in the process of scientific inquiry. These methods allow researchers to think logically about the data and to do one of two things: to come to some succinct and meaningful conclusions about the data *(descriptive statistics)*, or to determine—or infer—characteristics of large groups based on the data collected on small parts (samples) of the group *(inferential statistics)*. For example, data could be gathered on all correctional officers in Arkansas for a research project to determine the sex and race breakdown of the officers. This would be a descriptive analysis that could be used to examine the employment patterns for the Arkansas Department of Correction. Alternatively, a sample of correctional officers from each state could be collected and the data from the sample used to make statements about all correctional officers in the nation. This would be drawing conclusions (inferences) about a large group based on information about a sample of the group.

Statistical analysis is the workhorse of discovery and knowledge. The scientific process, using research to test theory, requires that empirical evidence (data) drawn from the research subjects be examined systematically. The use of mathematics in general and statistical analysis in particular allows researchers to make these comparisons and to discover new information that will provide a better understanding of their subject.

In the scientific process, the purpose is usually to discover something that was previously unknown or to prove something true or false that was previously thought to be true but was never supported by hard evidence. The way to obtain that evidence is by gathering information (data) and subjecting it to statistical analysis.

1-4 Theory Construction at a Glance

Three elements in social science research, or any research for that matter, are essential to sound investigation: theory, research methods, and statistical analysis. Although these elements are intimately linked, there is debate—even among those most supportive of the research process—on their ordering, importance, and what should be included from each element in a textbook. It is not possible to cover all of these elements adequately in one course or in one textbook, so it becomes an issue of how much of each element should be included in a discussion of the other. In this book, theory is covered primarily in this chapter, research spans this chapter and several that follow, and statistical analysis prevails thereafter.

What Is Theory?

At the most basic level, **theory** consists of statements concerning the relationship or association among *social phenomena* such as events and characteristics of people or things. For example, in criminology, there are theories addressing how people learn to be criminal. In these theories, statements are constructed dealing with the role of peers in a person's learning criminal behavior, how the rewards from a crime can influence behavior, and what influence punishment can have on the decision to commit a crime.

The goal of these statements is to develop explanations of why things are as they appear and to try to explain their meaning. From an early age, humans have ideas about the causes of events and why things work the way that they do. The problem with these explanations, however, is that they are often too simplistic to be of any real value. Theory attempts to provide a stronger foundation for these ideas by asking questions about them, such as:

- What is the point of all of this?
- What does it mean?
- Why are things this way?

Without theory, there is often only conjecture and war stories. With theory, we may begin to develop statements or ideas that are based on sound observation and thought.

Theory and Research

Theory may be developed in several ways. Researchers may look at the world around them, find the **social phenomena** that pique their interest, and begin to develop statements concerning why these phenomena work the way they do. This is called **induction**. An example could be a researcher who follows crime trends in a city for a number of years. She may begin to see that the crimes follow a definite pattern of movement in the city, moving from east to west across the city. From this, she might set out to determine what the cause of this movement could be, ultimately developing a theory of crime movement in urban areas. This is a process of moving from data to theory and attempting to make sense of the data with the theory.

Alternatively, researchers may become curious about something and set out to develop statements and then to test them. This is called **deduction**. The process of deduction begins with an idea and an attempt to test the idea with data and analysis. For example, a researcher might believe that increased supervision of probationers would prevent them from becoming involved in subsequent crimes. This researcher might create an experiment where a random sample of probationers are put under intensive supervision while another random sample receives a normal amount of supervision. The results of this experiment could either support or refute the researcher's initial beliefs. This is a process of moving from theory to data, where the data tests the theory. It should be noted that Sherlock Holmes was not exactly correct in his understanding of the difference between induction and deduction. When Holmes made his famous statement, "brilliant deduction, Watson!", he should actually have been commending Watson on his inductive reasoning. Watson was drawing conclusions based on what he had observed, not testing previously developed conclusions.

Finally, and probably most often the case, a researcher may start with either induction or deduction, but by the time a project is finished, he or she has used both induction and deduction. This is called **retroduction**. With this process, the researcher investigating supervision of probationers might conduct the intensive supervision experiment as a deductive process. After examining the data, however, it might be obvious that the experiment could be done better or that there was something in the data that needed further explanation. For example, those probationers who received the most supervision were successful, whereas those who received intensive, but less than the most intensive, supervision were not successful. The researcher might then rethink part of the theory and set out to retest it. This process might continue until the theory was supported or disproven. This is a process of moving from theory to data to theory and so on; or data to theory to data and so on. The key here is that it is an alternating process between induction and deduction.

1-5 The Process of Scientific Inquiry

The process of scientific inquiry (using a deductive method) is shown in **Figure 1-1**. As shown in this diagram, theory is at the starting point of the process. Theory is driven by observations and leads researchers to initiate the research process through primary questions and research questions. It is from this process of theory building that researchers follow the process from developing a null hypothesis to communicating results. The process of scientific inquiry and its individual parts are discussed further in the remainder of the chapter.

Observation and Inquisitiveness

The first steps in the process of scientific inquiry, and among the most important, are often overlooked: **observation** and *inquisitiveness*. Many research projects are never begun because the researcher was not aware of his or her surroundings or did not recognize something as a topic worthy of research.

It is often theory that stimulates observation and scientific inquiry. As you go through school and read research and material you find interesting, you will sometimes think that you have a better way to do something, or what you read may stimulate you in other areas. By using a structured scientific process to evaluate your observations and formulate statements of why these phenomena are behaving the way they are, you are developing theory.

An example of inductive theory development can be shown in Robert Burgess's Zonal Hypothesis. Students at the University of Chicago were making maps of Chicago showing different characteristics of neighborhoods, such as welfare, infant

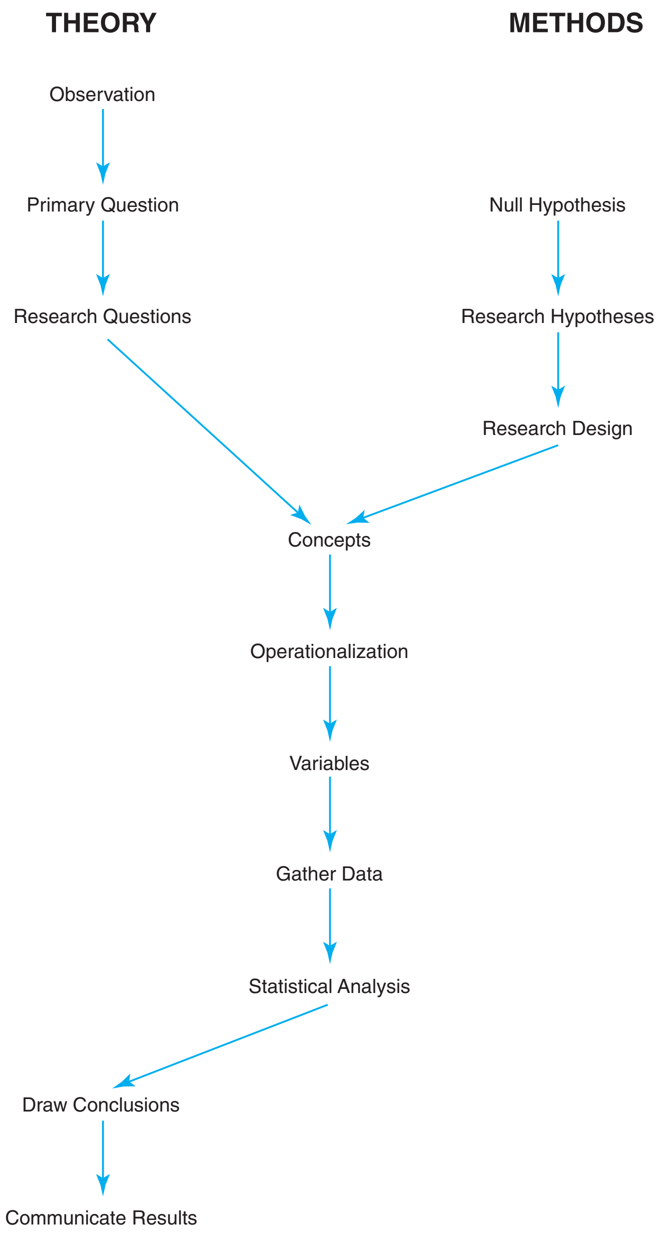

Figure 1-1 Process of Scientific Inquiry: Theory, Research Methods, and Statistical Analysis

mortality, and housing. Burgess observed that these maps followed very similar patterns throughout the city. His observations led him to develop a theory about how cities grow and change. The theory he developed from these maps proposed that cities grow in rings similar to when a rock is thrown into the water. In this configuration, the rings closest to the center of the city will be the most run down, have the highest level of infant mortality, and be characterized by other social ills that are not present in the outer rings. All of this was developed simply by examining students' maps and by using inductive theory building.

Primary Questions

A **primary question** is the one driving thought behind a research project. It should represent the entire reason for the study. Primary questions are important because how well a researcher meets the goals of the primary question will often be the criteria by which the research will be evaluated. The primary question should be a carefully worded phrase that states exactly the focus of the study. For example, in research on police use of deadly force, a possible primary question might be: What factors most influence police use of deadly force?[1] This question is very broad and somewhat vague, but it can easily represent the goal of a research project.

Research Questions

Often, the primary question will be theoretical, vague, and quite possibly not directly addressable through research. **Research questions** break down the primary question into subproblems that are more manageable and make the primary question testable through research. If the primary question establishes the goal of the research, the research questions suggest ways of achieving that goal.

In our earlier example concerning police use of deadly force, some possible research questions might include the following:

- What is the relationship between an officer's shift and the likelihood that an officer will use deadly force?
- What is the relationship between the violent crime rate of an area and the likelihood that an officer will use deadly force?
- What is the relationship between an officer's level of education and the likelihood that an officer will use deadly force?

These research questions break down the primary question into smaller parts that can be examined more easily. The answers to these questions are derived from the research process and statistical analysis and allow the researcher to answer the primary question.

Doing research is like defusing a bomb. When you begin, you are all excited and focused on the end result. If you have a good plan, know the layout, and work the plan, you will typically get the results you sought. If you run in and start cutting without a plan, it is likely to blow up in your face.

1-6 Research: Movement from Theory to Data and Back

Theory cannot stand alone; nor can research or statistics. Theory without research and statistical analyses to back it up is little more than fable. Research without theory is like building a house without plans, and research without statistical analysis is like building a house without nails: it is possible and it is done, but it would be more effective with them. Statistical analysis without theory and research methodology to guide the research is like having your own intercontinental ballistic missile: nice to have and may impress your neighbors, but not really useful.

Whatever the technique of developing theory, **research** is the method used to test and validate the theory. In its purest form research is a scientific, systematic study undertaken to discover new information or to test the validity of theories developed previously. The primary goal of research is discovery. Depending on whether an inductive or a deductive process is used, research is a systematic way of turning observation and statistical analysis into theory (induction) or testing theory through statistical analysis (deduction).

Although there are no exact steps that must be followed in conducting a research project, there are some general guidelines that should be followed to ensure nothing is left out of the study. These steps are included in this chapter and provide a kind of map of where research and statistics fit into the overall process of scientific inquiry.

Formulating Hypotheses

Once the research questions have been developed, you must decide what the research is attempting to determine. Hypotheses are questions or statements whose answers will support or refute the theoretical propositions of the research. Hypotheses are generally broken down into research hypotheses and null hypotheses. Although these are covered in more detail in Chapters 11 through 14, a brief definition is provided here.

A **research hypothesis** is a statement, similar to a research question, that indicates the expected outcome of a part of a research project. If a research question in a project asked "What is the relationship between an officer's shift and the likelihood that he or she will use deadly force?", the research hypothesis might be: "There is a statistically significant correlation between an officer's shift and the likelihood that he or she will use deadly force." In using research hypotheses, the researcher turns the relatively abstract wording of theory development into a more concrete, testable form appropriate for statistical analysis.

One of the often difficult to understand but vital elements of statistical analysis and hypothesis testing is that research alone cannot prove anything. Even when researchers find a great deal of support for an association between two variables, it may be that these results are occurring because information is missing or the model is somehow flawed. Other researchers may very well be able to disprove these findings by conducting additional research. If research cannot prove anything, what can it do? It can be used to disprove something or eliminate alternatives. For example, even though research cannot prove that officers on night shifts use deadly force more than their daytime counterparts, it may disprove that there is no relationship between shift and the use of deadly force. This is accomplished with a **null hypothesis**, which generally takes the form of one of the following examples:

- There is no statistically significant difference between the groups being compared.
- There is no statistically significant difference between a group being studied and the general population.
- The differences between the groups are due to random errors.

An example of a null hypothesis is: "There is no statistically significant difference between an officer's shift and the likelihood that he or she will use deadly force." This null hypothesis contains several important components. The first is the phrase *statistically significant*. This is a specific type of relationship between the shift of duty and deadly force. The null hypothesis is not stating that there is no difference at all, just that there is no statistically significant difference. How will you know if there is no statistically significant difference? A test of the null hypothesis (test of significance) will determine statistical significance. This is discussed further in Chapter 8, "Measures of Existence and Statistical Significance." The wording here is chosen carefully and should be followed carefully. Stating that "there is no difference between the shifts" is very different from stating that "there is no statistically significant difference." There probably is a difference in the use of deadly force between the shifts. However, as discussed in Chapter 8, "Measures of Existence and Statistical Significance," this difference may not be sufficient to make a statistical or theoretical stand. There is also a small but tangible difference between the statements "there is no statistical difference" and "there is no statistically significant difference." It is possible to have a statistical difference (a difference in means, a difference in standard deviations, a difference in the epsilon) and not have a statistically significant difference (a difference between the variables at a particular level of confidence based on Chi-square, *t*-test, or another measure of statistical significance).

Another important part of the null hypothesis consists of the **variables** or items being compared. Most null hypotheses will contain two groups that are being examined (night shift, day shift, and mid shift in this example) and will contain what is being measured (deadly force). If these items are absent from the null hypothesis, it makes it difficult to determine exactly what is being compared.

These examples show that proper wording is important in the null hypothesis. Although this phrasing does not have to be followed verbatim, it is a good example of the proper language for a null hypothesis, and any hypothesis presented should generally follow this format.

The goal of a null hypothesis is to disprove it. Disproving that there is no relationship (disproving the null hypothesis) helps support a conclusion that there is some relationship between the phenomena being studied.

Constructing the Research Design

Once a decision is made of exactly what will be studied, planning the actual research may begin. As a researcher, you should be cautious not to jump ahead of this step to other steps in the research process. You would not start building a house without first looking at other houses and thinking about what you want your house to look like; why would you start a research project without thorough consideration of what you want to do and find?

Activities in this step include determining the method to be used (experiment, survey, or other method) and generally how to approach the research. If the researcher has to collect the data, decisions must be made concerning how to collect it, what group it will be collected from, and other parameters. The decisions made here will drive the rest of the project, so they should be made carefully. This step in the research process is also dictated by the type of data gathered, which in turn dictates the statistical analyses that will be used.

Conceptualization

Once research questions and hypotheses have been developed, they must be broken down into more manageable parts. This is accomplished by drawing out the concepts from the questions and hypotheses. **Concepts** are terms that are generally agreed upon as representing a characteristic, a phenomenon, or a group of interrelated phenomena. Concepts can be very abstract or they can be fairly concrete. In the abstract, concepts can be labels used to identify properties or they can be symbolic representations of reality that are difficult to describe. For example, poverty and prejudice are fairly abstract concepts. You know immediately what each of these means, but it would probably be difficult for you to write a concise description of what they mean and even more difficult to get a consensus among the class members of what they mean. The use of concepts allows researchers to break down questions and hypotheses but retain the flexibility, for now, of not having to describe specifically what is being studied. In the example above concerning the use of force by police, the concepts to be addressed are fairly straightforward: police officer, shift of duty, violent crime, educational level, and deadly force. Although these will require more definition, it is fairly easy to get a consensus about their meaning. In general, the more theoretical the research, the more abstract the concepts, the more policy oriented the research, the more concrete the concepts will be.

Operationalization

To be able to address concepts in terms of statistical analysis, they must be placed in a form that can be analyzed mathematically. This is accomplished through **operationalization**. This is a process of translating a concept, which is abstract and verbal, into a variable, which can be seen and tested, by describing how the concept can be measured. Operationalization was introduced by the physicist Percy Bridgman in 1927.

The process of converting the abstract to the concrete can best be seen in the example of poverty used in the preceding section. As discussed, poverty itself is an abstract term; it is difficult to come to a consensus about its meaning without defining it further. This process of operationalization is a specific form of defining concepts so they may be converted to data. For example, poverty can be operationalized by deciding that income will be used to measure a person's relative level of poverty. Income cutoffs can then be used to establish the income level that will be considered poverty status. In this case, poverty is a concept; it must be operationalized to reach a point where data can be gathered on it. Income, on the other hand, has data attached to it and does not need further measurement.

In the example of police use of deadly force, the distinction between the concepts and variables is much less clear. In cases like this, the difference between a concept and a variable may be determined by asking if the word is specific enough to be able to find data on it. *Police officer* is a fairly clear term, but for the purposes of research it is still a concept that needs to be operationalized. Questions to be answered include the following:

- Will all police officers be used, or just municipal officers?
- Will detectives or patrol officers be used?
- Will staff officers in patrol be included?

The answers to these questions and others will operationalize the somewhat vague concept of a police officer into someone who can be classified as an object of the research.

The process of transforming concepts into variables demonstrates a critical point in operationalization: operationalized definitions used in research are the researcher's definitions and do not have to match the definitions others might use or definitions the same researcher might use in other research. For example, in this research project, the term *police officer* might be operationalized as only municipal patrol officers. Certainly, others could define the term *police officer* differently by including detectives and other police. Furthermore, a different research project might very well include detectives in an operationalized definition of police officer. For this particular research, however, *police officer* will be defined, or operationalized, specifically as a municipal patrol officer.

Gathering the Data

Gathering the data is the step in the research process where most people want to begin—and nearly the last place they should begin. Returning to the example of building a house, beginning by gathering data would be like deciding to build a house and, without developing any plans, ordering a truckload of 2 × 4s, 1000 pounds of nails, and 5 bags of concrete, and going to work. You might actually get the house built this way, especially if you are an expert, but it would be better to begin with carefully developed plans.

At this point, all decisions concerning the research should have been made. The researcher should have a well-thought-out theoretical model and a clear and complete research design detailing how the data will be collected and analyzed. The concepts should already be operationalized into variables that can be measured accurately. The only thing left to do is gather the data according to the research design, analyze it according to that design, and report the results.

The research process concerning police use of deadly force is shown in **Figure 1-2**. This exhibit shows each of the steps in a deductive process. The researcher established a research plan, working through the steps in the research process from theory to data and analysis to publication of conclusions. This scientific process is applicable whether conducting academic or practical research. Note that between the concepts and drawing the conclusions is the portion of the process that directly involves statistical analysis. This is the part of the process with which this text is most concerned.

Figure 1-3, an example taken from the strain theory of criminology, provides another illustration of the process of scientific inquiry. This is what might be expected in an academic research process. Although all of the steps are not included, the figure shows the flow of activity and the difference between theory and research. It also shows the types of work products that might be achieved at each step.

In this example, the observation is that poverty causes crime. The primary question or null hypothesis is the goal that drives the research: the relationship between poverty and crime. The research questions and hypotheses put the abstract primary

Observation

- What makes police officers use deadly force?

Primary Question

- What factors most influence police use of deadly force?

Null Hypothesis

- There is no statistically significant difference between officers who use deadly force and those who do not.

Research Questions

- What is the relationship between an officer's shift and the likelihood that an officer will use deadly force?
- What is the relationship between the violent crime rate of an area and the likelihood that an officer will use deadly force?
- What is the relationship between an officer's level of education and the likelihood that an officer will use deadly force?

Research Hypotheses

- Officers on night shift have a greater likelihood of using deadly force than those on day shift.
- Officers are more likely to use deadly force in high-crime areas than in low-crime areas.
- College-educated officers are less likely to use deadly force than are non-college-educated officers.

Concepts

- Police officer, deadly force, shift of duty, violent crime rate, college education.

Variables

- Number of patrol officers, deadly force incidents, number of officers by shift of duty, violent crime rate, college education of officers.

Data

- Data from the police department for each of the variables listed above would be obtained.

Statistical Analysis

- Because the variables here are interval level or can be dummy coded, correlation or regression may be appropriate for analysis.

Draw Conclusions

- Based on the analysis, there were no differences between officers using deadly force and those who did not.

Communicate Results

- A formal report on the result of the study might be presented to the police chief and/or city council.

Figure 1-2 Research Process: Use of Deadly Force

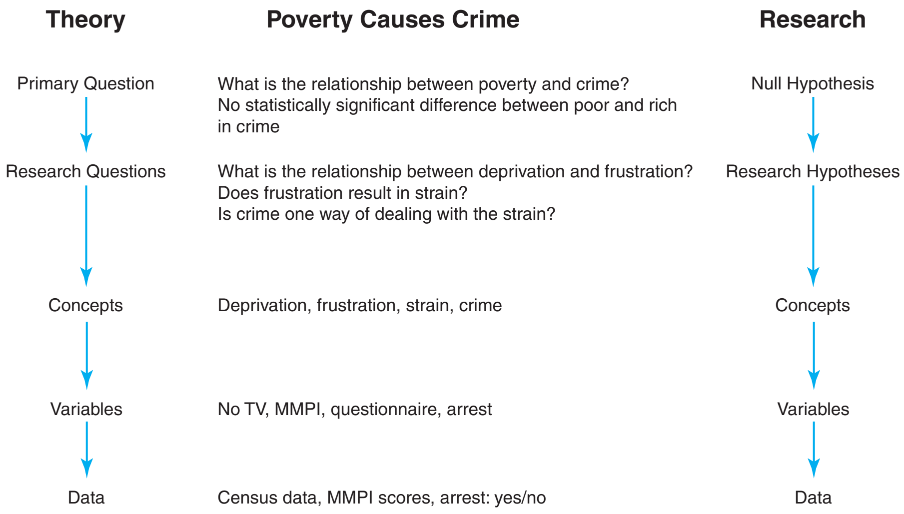

Figure 1-3 Process of Scientific Inquiry: Example from Theory to Data

question into testable statements. The concepts break the research questions and hypotheses down further into key elements that must be measured. The variables that are operationalized from the concepts are those elements from which the data will be drawn. Finally, the data represents the numbers and other information that can be examined in the process of statistical analysis. It is this statistical analysis to which the discussion now turns.

A minor but important point should be made here. Most statistics and research methods books approach a discussion of the research process as if original data were to be gathered (you were going to develop a questionnaire and survey people). It is very common, however, especially for students, to use existing data sets for research (called *secondary research*), such as data taken from a police department or data from a repository such as the Inter-university Consortium of Political and Social Research (ICPSR). When conducting original research, the typical methodology is to move from the primary question to the data, as discussed in this text. When conducting secondary research, however, it is more common to determine the primary question and perhaps a draft of research questions and then examine the data to see if data is available to support the concepts the researcher wants to use. If the data seems to support the required concepts, the researcher can return, establish the research questions, draw out the concepts, and operationalize them into variables supported by the data. If the data does not support one or more concepts, the researcher may be required to reconceptualize parts of the research questions or even drop certain portions of the research.

1-7 Statistical Analysis: The Art of Making Comparisons

A key element of research is statistical analysis. Statistical analysis is the nuts and bolts work that gives researchers the information needed to determine the success or failure of the research and the validity or fallacy of a theory. Statistical analysis deals specifically with the art of making valid comparisons.

Foundations of Valid Comparisons

The art of making valid comparisons starts with the assumption that there is some relationship between the variables to be studied. This assumption is necessary because if there is no relationship between two variables, one cannot be the cause of the other, and the purpose of the research may be invalidated.

Several different types of comparisons are made in statistical analysis, depending on the goal of the research. Variables may be compared against themselves and what the researcher expects from them (**univariate statistics**), two variables may be compared to each other (**bivariate statistics**), or several variables may be compared to each other (**multivariate statistics**).

To make valid comparisons, there are some requirements that must be understood and followed. These are general requirements for making valid comparisons and are in addition to any requirements that individual methods of analysis may impose.

Comparing Appropriate Phenomena

It is easy to distort the presentation of findings, either consciously or unconsciously, when making comparisons. Take, for example, the following newspaper headline: "Murder rate jumps 100% in Polk County." This seems very dramatic until you discover that the number of murders only rose from two to four. Yes, this is technically a 100% increase, but a rise of two murders can be just an aberration that may last only one year. A more accurate comparison would have been to compare numbers or rates for Polk County to counties around it or to compare this year's increase to a 10-year average.

Although this headline is not necessarily the result of a research project gone astray, it is far too common that research produces results that can be manipulated to achieve a desired outcome. Thoughtful theory building and careful research design planning will usually prevent any unconscious distortion of comparisons. If a researcher truly works through the process of developing quality primary and research questions, it may become clear early in the research process that the comparisons to be made might be distorted. Even if it does not become clear during the theory-building process, work in developing concepts and operationalizing them should show any distortions.

Using Comparable Measures

Two levels of data may be collected: individual and aggregate. **Individual-level data** consists of one record that contains all the information to be used for each person or element. For each individual, the researcher could determine, from one data set or from several data sets in which each individual can be identified, such information as his or her age, income, number of arrests, and other data that is to be used in the research.

Aggregate-level data, on the other hand, consists of one or more data sets whose data cannot tie one person to all variables. Census data is an example of aggregate-level information. There is data on the number of persons living in houses, average income, age, and so on. A researcher could not, however, determine any information about any one person or family in the data set.

Comparisons must be based on the level of data available. For example, with individual-level data, a researcher can make comparisons based on individual-level analyses, and the same can be said for all aggregate-level analyses. If a data set contains some individual-level data and some aggregate-level data, however, the individual-level data should not be used at the individual level. The individual-level data should be combined to the same level as the aggregate data. For example, if some of the data is obtained on individual residents and some on a square-mile area, the residents' data should be aggregated to square-mile areas so the data is comparable. Although it is possible to aggregate individual-level data, you should not take the characteristics of aggregate-level data and attempt to apply them to an individual. This is called an *ecological fallacy* and should be avoided in any research.

Choosing Analysis Methods That Best Summarize the Data

Always strive to use graphs, tables, and statistical analyses that most clearly demonstrate the findings of the analysis. You have probably read articles from which you could not make sense of the statistical analysis, and it may not have been from an inability to understand the procedure. Often, results are presented such that they are almost uninterpretable—not necessarily because of their complexity but perhaps because the author did not use statistical analyses that best summarized the data. The goal of statistical analysis is to use methods that make sense of complex data and clearly support conclusions drawn.

It is a general rule of statistical analysis that it is best to use the highest-order statistics possible.[2] If the data will support it, analysis procedures designed for interval or ratio level data (covered in Chapter 2) generally provide the greatest explanatory power. Using higher-order analyses with lower levels of data can render the analysis unsound; alternatively, using lower-level analyses with higher levels of data is not taking full advantage of the data and information the data can reveal.

This is not as easy as it sounds, however. As discussed in "Variables and Measurement" (Chapter 2) and beyond, it is generally necessary to use the statistical analysis method appropriate for the variable(s) with the lowest level of measurement. For example, to study the age of juvenile delinquents, with juvenile delinquency coded as yes / no / potentially delinquent, an analysis procedure appropriate for nominal-level data should be used because even though age could be analyzed using higher-order statistics, juvenile delinquency is nominal level; therefore, nominal-level statistical analyses should be used. There are, of course, exceptions to this rule, discussed later, but the general rule is to use analyses that are appropriate for the lowest level of data available.

Drawing Conclusions

Mistakenly, many people believe that the process of statistical analysis, and even scientific inquiry, stops at the end of the analysis. Nothing could be further from the truth. Statisticians and researchers distinguish themselves in the interpretation of analyses and in the conclusions that can be drawn. This is also generally the most difficult part of statistical analysis. This step involves determining if the results of the statistical analysis support the hypotheses developed at the beginning of the research process.

At this step, the research process leaves statistical analysis and methodological issues and returns to theory. If the researcher is using a deductive process, this is the point at which the theory outlined in the first steps is compared to the results and a decision is made concerning whether the theory is supported or refuted. In an inductive process, this is the point at which the researcher makes initial conclusions about what he or she has seen. As evident from this discussion, theory never really leaves the research process, just as methodological issues and statistical issues are important in every step, from setting up the theory to drawing conclusions.

Moving from being a student to being a practitioner in terms of statistical analysis means sharpening your skills at interpreting analyses. It is one thing to be able to work problems or to coax a computer to provide an answer to a particular analysis; it is quite another to be able to take that analysis, return it to the process of scientific inquiry, and interpret what you have found in a way that brings new insights to the topic being studied.

Communicating the Results

The final step in the process of scientific inquiry is to communicate the results of the research. This step is also often overlooked. Many people believe that unless the findings support the hypotheses and are a monumental discovery, they are not worthy of communication. Although it is true that many of the more prestigious journals shy away from publishing negative results, it does not mean that they should not be communicated. It is important to people in the field that results, even negative results, be communicated. This will often prevent people from making the same mistakes or expending time on ground already covered. It can also aid in the process of scientific inquiry, as mentioned at the beginning of the chapter, by stimulating others to undertake research. This final, and vital, portion of the research process may be accomplished in a number of ways. Typically, the most desirable way is to publish the results in an academic journal or a book. The results can also be communicated in practitioner publications such as *Police Chief* or *Federal Probation*, in paper presentations at professional conferences, and through the release of technical bulletins.

1-8 Data and Purposes of This Text

Throughout this text, examples are taken from research conducted in criminal justice and criminology. This research does not always allow presentation of perfect tables or results of analysis. It is more important to be exposed to the reality of research and statistical analysis through actual works rather than to emphasize repetitious homework exercises and formulas using computational routines and shortcuts on small, error-free, fictitious data sets. This text features actual data in all of its noncooperative messiness and complexity that cannot be replicated outside the real world of research. **Figure 1-4** shows symbols and notations used in the text.

Most of the examples used in the text are drawn from data sets that were used in actual research projects undertaken by the authors. The first data set, LR_COP, is a survey of citizens in Little Rock, Arkansas, concerning their attitudes toward community policing. This data set contains a number of scale questions that represent lower-level data. This data was used in a number of technical reports and presentations to the Little Rock Police Department and the city council. The second data set, CENSUS, is taken from the U.S. census of 1990, and is combined with crime data from Little Rock, Arkansas. This data was used in a replication of Shaw and McKay's (1942) work examining social disorganization in Chicago and was published in *Varieties of Criminology* (Walker, 1993). The third data set, GANG, was a survey administered to juveniles appearing in the Little Rock Municipal Court. This data, published in the *Journal of Gang Research* (Walker, Watt, and White, 1994), addressed mundane, potentially delinquent, and delinquent activities of these juveniles.

The final two data sets are used for examples in the chapters dealing with multivariate statistics, primarily in relation to Chapters 16 and 17 on multiple regression techniques. The first data set (AR_Sentencing) contains variables associated with sentencing outcomes in Arkansas. This data set is concerned with exploring the number of months in prison an offender receives. The final data set (gang_mem) comes from an ICPSR study on gang membership (Esbensen, 2003). This data set is concerned with trying to predict what factors influence a youth's decision to join a gang in several metropolitan areas. While both of these data sets are used with higher-level statistical analyses, univariate and bivariate techniques can be used on these data as well.

Generally, formulas are presented and explained for each of the statistical procedures covered. These are presented primarily to demonstrate how each procedure works and to show how data behaves under certain circumstances. Some instructors will require students to work problems by hand to get a better feel for how the formulas work; others will not. Whatever the case, it is important that you understand the underlying concepts and mathematical derivatives behind each procedure, and you should strive to understand how the formulas work, even if you will never use them. In this text, computational formulas are generally replaced with formulas that, although sometimes more difficult, are more descriptive. This is done to enhance understanding the analysis rather than to make computations easier. The following symbols are used in the formulas.

N	The sample size or total number of cases.
X_i	A single score or case, where *i* is the score's location in the distribution. In grouped data this will be the midpoint of the class.
f_i	The frequency of the *i*th category.
$\sum$	This is a summation operator. It requires you to add data, columns, or other material (or shows that something has been added).
$\sum_{i=1}^{N}$	This tells exactly what to add. The starting point is shown on the bottom (where the lower limit is 1); numbers are added until the number on the top (*N*) is reached. If it is obvious that you are to add all of the numbers, cases, or other data, the upper and lower limits may be omitted.
$\sum f_i$	Add the frequencies of all of the valid categories.
$\sum_{i=1}^{N} X_i$	Add all the raw scores, starting with one and ending when all numbers have been added.

Figure 1-4 Symbols and Notation Used in This Text

The primary advantage of these data sets is that they are small. This will make it easier for students to work problems by hand as well as to allow the use of student versions of statistical software, which are often limited in the number of variables and cases. The data sets have also been cleaned of errors and are provided in dBase, Excel, and SPSS (the statistical package used in examples in this text) formats, which will allow use of the data in practically any statistical analysis program used in courses. Also, because the examples provided are, with few exceptions, taken directly from the data sets, they can be replicated, modified, or extended using the data sets provided. Finally, the variables included give students and instructors the opportunity to use a variety of demographic, criminological, and other variables of interest.

Included in Appendix D is a list of the variables used in each of these data sets, along with a short description (the SPSS Value Label) of each. This will assist in understanding what variables are included in examples used in the text, and should help in deciding variables to be used in homework.

The focus of the text is on statistical reasoning and interpretation of analysis. To accomplish this goal, the data is presented both in formulas and in computer output. This allows you to focus on the proper identification of data (level of measurement, abnormalities, and the application of statistical analyses) and the interpretation of results. It is recognized that initially, the tables and output may be somewhat difficult to read, but this is the actual output from SPSS. It is certainly possible to place the output in cleaner and more understandable tables such as those that appear in academic journals, but this would not help you understand the output you would receive when conducting actual research. It is important, therefore, that you be able to read statistical output as it is presented in the real world. Once this is accomplished, reading other tables and output will be that much easier.

Also included for each chapter is a flowchart of the decision process included in the discussion of that chapter. Sometimes this flowchart will be replicated, either in part or entirely, in the text. This assists in understanding a particular part of the discussion. You are encouraged, however, to always look first at the flowchart for the chapter and to refer to it as you read, work through the examples, and complete the homework.

Many students approach a statistics course with great trepidation. Typical responses range from "I have never been good at math; I just barely made it through high school," to "I have a mental block with math," to "I haven't had a math course in 10 years." Learning statistics is not easy, primarily because you have to learn a new language, much like learning a foreign language. There is a review and practice test in Appendix A that may help determine how much math you remember. This review and practice test will also show that there is not a great deal of advanced math needed to study statistical analysis. If you can add, subtract, multiply, and divide, you will be able to work any formulas and undertake any statistical analyses in this text. After finishing the text, you should have the foundation needed to produce original research from statistical analysis and to be a consumer of statistical findings; that is, you should be able to read the tables and findings in journal articles and books rather than skipping over them. With the foundation of the process of scientific inquiry behind us, it is now time to move to the world of statistical analysis—hold on and have fun.

1-9 Key Terms

aggregate-level data
bivariate statistics
concept
deduction
descriptive statistics
discovery
individual-level data
induction
inferential statistics
multivariate statistics
null hypothesis
observation
operationalization
primary question
research
research hypothesis
research question
retroduction
scientific inquiry
statistical analysis
statistics
theory
univariate statistics
variable

1-10 Exercises

1. What is the difference between a null hypothesis and a research hypothesis?
2. What is the difference between a research hypothesis and a research question?
3. Using the list of variables for one of the data sets in Appendix D, develop a primary question, research questions, null hypothesis, and research hypotheses for a research project.
4. What is the difference between a concept and a variable? Provide examples of concepts and then operationalize them into variables. What data might match the variables chosen?
5. What are some of the concepts that would be associated with the variables you have chosen in Exercise 3?
6. Think about and write out a research design you think might be used to carry out your research.
7. Select a journal in criminal justice or criminology. See if you can determine the following from an article:
   a. The primary question
   b. The research questions
   c. The null hypothesis (you may have to develop this from the primary question)
   d. The research hypotheses
   e. Concepts
   f. Methods used to operationalize the concepts
   g. Variables

1-11 References

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1-12 For Further Reading

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1-13 Notes

1. This example is used throughout the discussion to show the research process using a single example in each stage.
2. As discussed in "The Form of a Distribution" (Chapter 6) and beyond, higher-order statistics are those used with interval- and ratio-level data; lower-level statistics are generally used with nominal- and ordinal-level data.

Criminal Justice on the Web

Visit http://criminaljustice.jbpub.com/Stats4e to make full use of today's teaching and technology! Our interactive Companion Website has been designed to specifically complement *Statistics in Criminology and Criminal Justice: Analysis and Interpretation, 4th Edition*. The resources available include a Glossary, Flashcards, Crossword Puzzles, Practice Quizzes, Weblinks, and Student Data Sets. Test yourself today!