Chapter 1

Introduction to the Use of Statistics in Criminal Justice and Criminology

Learning Objectives

- Explain how data collected using scientific methods are different from anecdotes and other nonscientific information.
- List and describe the types of research in criminal justice and criminology.
- Explain the difference between the research methods and statistical analysis.
- Define samples and populations.
- Describe probability sampling.
- List and describe four statistical software packages.

Many criminal justice and criminology students wonder why they are required to take a statistics course. You would not be the first student to suspect nefarious motives on the part of your professor. The question of whether your stats professor might secretly delight in your anguish cannot be answered here, but the question of why you are required to take this class can be.

The basic answer is that stats are everywhere. That might sound trite, since you probably heard the same thing about algebra and now share memes like "Another day gone and I didn't use algebra even once" in mockery of the teacher who lectured you on it. (Fun fact: You will be putting those algebra skills to work in this class, so maybe drop a thank you note in the mail to that teacher.) But really, stats *are* everywhere. Basic descriptive statistics give us information like incarceration rates. More complicated techniques allow us to determine whether drug rehabilitation programs work, how being held in pretrial detention may affect the chances of conviction or imprisonment later, and the factors that predict the severity of police use of force.

Statistical methods are the backbone of criminal justice and criminology as fields of scientific inquiry. Statistics enable the construction and expansion of knowledge. Research is

published in academic journals and books. These works form the basis for most of what we know about criminal offending and the system designed to deal with it. Most of these studies employ quantitative methods, meaning statistics.

Statistics as a class subject can be abstract, so this book uses two techniques to add a realistic, pragmatic dimension. The first technique is the use of examples of statistics in criminal justice and criminology research. These summaries are contained in the Research Example boxes embedded in each chapter. They are meant to offer a glimpse into the types of questions that are asked in this field of research and the ways in which specific statistical techniques are used to seek answers. You will see firsthand how lively and diverse criminal justice and criminology research is. Research Example 1.1 summarizes four studies chosen to illustrate this diversity.

The second tactic is the use of real data from reputable and widely used sources, such as the Bureau of Justice Statistics (BJS). The BJS is housed within the U.S. Department of Justice and is responsible for collecting, maintaining, and analyzing data on various criminal justice topics at the county, state, and national levels. Visit http://bjs.ojp.usdoj.gov/ to familiarize yourself with the BJS. The purpose behind the use of real data is to give you the type of hands-on experience that you cannot get from fictional numbers. You will come away from this book having worked with some of the same data that criminal justice and criminology researchers use. Two sources of data that will be used in upcoming chapters are the Uniform Crime Reports (UCR) and the National Crime Victimization Survey (NCVS). See Data Sources 1.1 and 1.2 for information about these commonly used measures of criminal incidents and victimization, respectively. All the datasets used in this book are publicly available and were downloaded from governmental websites and the archive maintained by the Inter-University Consortium for Political and Social Research at www.icpsr.umich.edu.

Research Example 1.1

What Do Criminal Justice and Criminology Researchers Study?

Criminal justice and criminology researchers examine a wide variety of topics. The following are examples.

1. *Did the rise of Black Lives Matter (BLM) trigger a "war on cops"?* The BLM movement started after the 2012 death of Trayvon Martin in Sanford, Florida, and rocketed to the forefront of public consciousness after a Ferguson, Missouri, police officer killed Michael Brown in 2014. It came to symbolize a massive, long-overdue protest of violence against Black Americans, particularly violence inflicted by police. Critics claim that BLM spreads anti-police messaging that imperils officers' safety. This so-called "war on cops" is alleged to have dramatically increased premeditated, ideology-driven murders of officers. But is there really a "war on cops"? Norris (2024) sought to find out. The Officer Down Memorial Page contains publicly available information detailing the circumstances of officer deaths. Norris narrowed the sample to intentional killings between the years 2008 and 2021. Norris scoured the internet, court records, and other documents to identify the

killers' motives. Findings suggested that 22 percent of the 595 homicides of officers during the study period were premeditated. Approximately 12 percent were ideologically driven; among those, right-wing extremism was the most common motive. There was no post-BLM increase in homicides of officers. Overall, the "war on cops" hypothesis failed to garner empirical support. Most killings of officers were not premeditated or ideological, and among those that were, right-wing extremism was the most prevalent motivation.

2. *Does the presence of a firearms dealer in a community increase the rate of gun violence in that community?* People seeking crime guns obtain them through straw purchases, burglary, theft, and even lawful sales. Licensed firearms dealers include gun stores, general-purpose stores that sell guns (e.g., outdoors and sports stores), and pawn brokers. The existence of a firearms dealer in a neighborhood would presumably increase the prevalence of guns in that same area, thus elevating the rate of gun violence. Semenza et al. (2022) sought to test this proposition. It is well known that gun violence is highly spatially concentrated in "hot spots" where rates are much higher than in surrounding areas. Additionally, these hot spots tend to cluster in socioeconomically disadvantaged neighborhoods. Semenza et al. compiled data on firearms dealers, gun violence, and concentrated disadvantage for neighborhoods in Atlanta, Georgia. Data came from the Atlanta Police Department; the Bureau of Alcohol, Tobacco, and Firearms; and the U.S. Census. Results revealed stark differences by neighborhood type. Shootings in non-disadvantaged areas were fewer and displayed no spatial overlap with the locations of dealers. In disadvantaged neighborhoods, gun violence did spatially correlate with firearms dealers, supporting the notion that firearms dealers increase the availability of crime guns but only in disadvantaged neighborhoods. What is more, shootings within a 2,000-foot buffer surrounding a dealer were disproportionately concentrated among 3 of the 59 total dealers in the city. These findings indicate that firearms dealers are not inevitably "risky facilities" because most do not attract gun violence; however, there are clearly certain dealers that do meet the definition of a risky facility because their negligent or reckless practices contribute to gun crime hot spots. This has direct implications for policy. City officials should include high-risk gun dealers in their strategies for reducing gun violence and figure out how these establishments can be leveraged to improve their practices and help prevent the guns they sell from landing in the wrong hands.
3. *Does footage from body-worn cameras improve misdemeanor case processing?* Body-worn cameras are a popular, widely used tool. Proponents argue these cameras improve police accountability and, by extension, reduce unwarranted uses of force and verbal impropriety. Studies have been mixed as to whether body-worn cameras accomplish the goals of reduced use of force or citizen complaints against officers. However, camera footage could have other benefits. Todak et al. (2024) surmised that footage could act as useful evidence in misdemeanor cases. Evidence is often scant in misdemeanor cases. Physical evidence could improve the speed and accuracy of case processing by more clearly establishing defendants' guilt or innocence. Todak et al. used data from the Tempe Police Department in Arizona. At the time of data collection, the department was implementing body-worn cameras in phases, so some officers had them and some did not. The primary independent variable was whether the responding officer had a camera at the time of the offense. The two dependent variables were (a) whether the case resulted in

a guilty plea or conviction and (b) the elapsed time between the incident date and the date the case was disposed of by the court. The sample consisted of 50,818 misdemeanor cases. Body-worn cameras were present in 54 percent. Analyses predicting the likelihood of conviction revealed that the presence of a camera reduced conviction chances by 10 percent. Likewise, cases in which officers had cameras saw a 4 percent reduction in days to disposition. This effect was uneven across defendant race, with cases involving Black and Hispanic defendants being processed more slowly when cameras were present. The main takeaway is that body-worn cameras do seem to reduce case processing time and conviction likelihood somewhat, but the effect size is small and depends on case type and defendant characteristics. The authors concluded that body-worn camera footage is one of many types of evidence that prosecutors, judges, and juries could consider in their decisions, so the presence or absence of footage is not enough by itself to significantly alter the overall landscape of misdemeanor case processing.

4. *Are there gendered differences among prison inmates who commit serious misconduct?* As with crime in general society, serious misconduct within prisons is perpetrated disproportionately by a small fraction of people. Research has largely supported a concept called "importation," whereby people who consistently behaved in an antisocial manner on the outside continue their disruptive, even violent, conduct within prison. An alternative perspective is the "deprivation" model, which posits that in-prison misbehavior results from the pains of incarceration, independent of whatever risk factors a person may have brought to prison with them. A small handful of studies has uncovered some evidence that women and men experience different barriers during the process of adapting to prison life. Logan et al. (2023) set out to determine whether there were differences between male and female prisoners who commit the highest rates of prison misconduct. Data came from the Ohio Department of Rehabilitation and Correction and included 88,621 individuals housed across 32 state institutions. The authors separated the sample by sex and computed each group's top 1 percent in terms of total misconduct and violent misconduct. The top 1 percent of female offenders accounted for 30 percent of total misconduct and 34 percent of violent misconduct. The top 1 percent of male offenders accounted for 16 percent of total misconduct and 24 percent of violent offenses. Next, the researchers tested for sex differences in predictors of being in the top 1 percent. In other words, they looked for potential differences in the factors that correlate with being a high-rate rule violator. Overall, the predictors were mostly the same for men and women. Consistent with previous research, importation factors emerged as the strongest correlates of high-rate misconduct. As such, appropriate classification may be one way prison officials can proactively assist inmates at elevated risk for chronic rule breaking. For instance, people committed to prison at younger ages were more likely to become part of the top 1 percent, suggesting officials should take extra care to help younger people transition into prison life. Program participation (e.g., going to counseling) was negatively related to high-rate offending, so an adequate supply of programming could help people find prosocial outlets for their frustrations. The authors concluded that their findings support the importation model, but they explained that deprivation can work in conjunction with importation to ensure that those at highest risk for in-prison offending are targeted for proactive intervention.

5. *Do sentencing guidelines restricting judicial discretion increase prosecutorial discretion?* Case processing in criminal courts entails significant discretionary decision making by prosecutors, defense attorneys, and judges. Critics allege that discretion causes problematic outcomes, such as overly lenient or racially discriminatory sentences. However, reducing discretion is not easy. Discretion curtailed at one point in case processing causes it to expand at another point. This phenomenon has been dubbed the hydraulic theory of discretion displacement. Despite the fact that discretion tends to shift rather than disappear when new restrictions are imposed, state legislatures across the country continue enacting such constraints. Vance et al. (2019) tested the impact of sentencing guidelines implemented in 2004 by the District of Columbia governing felony cases in the D.C. Superior Court. Prior to the guidelines' passage, superior court judges had virtually unfettered discretion in their sentencing decisions. The guidelines set forth a matrix to structure sentencing. Their stated purpose was to produce greater consistency in punishment. However, based on what is known about the hydraulic theory of displacement, the guidelines might simply push discretion from judges onto prosecutors. Vance et al. drew a sample of felony cases from 2003 (before the new guidelines; $n = 266$) and 2005 (after; $n = 263$) from the D.C. Superior Court case records. The dependent variable was the difference between the length of prison sentences that would have been imposed based on defendants' initial charges at arraignment and the sentences they ultimately ended up receiving. This difference represents prosecutorial decision making in the form of charge reductions during plea bargaining. Knowing that the guidelines leave little latitude for bargaining over sentences, prosecutors may turn to charge bargaining instead. A before-and-after examination of the impact of charge bargaining on sentences revealed that prior to the guidelines' passage, sentences were 30 percent shorter than expected, while afterward, they were approximately 36 percent shorter. In other words, there was a roughly 6 percentage points rise in the impact of charge bargaining on sentence reductions. This effect size was modest, but it offered some support for the hydraulic theory by indicating that prosecutorial discretion adjusted in response to increased constraints on judicial discretion.

In this book, emphasis is on the production and interpretation of statistics. Every statistical analysis has a producer (the person who runs the analysis) and a consumer (the person to whom an analysis is being presented). Regardless of which role you play in any given situation, you need to be versed in quantitative methods well enough to identify the proper statistical technique and correctly interpret the results. It would be pretty bad if a police chief or prison warden fell for the results of a wrongly conducted statistical test and took away an entirely inaccurate message simply because they were not equipped to see for themselves that the test was untrustworthy. When you are in the consumer role, you must also be ready to question the methods used by the producer so that you can determine for yourself how believable the results are. These are the same skills needed when parsing out real news from fake news or deep fakes generated by artificial intelligence. You look for things that do not seem right, details that do not add up properly, conclusions that are suspiciously surprising or out of line with conventional wisdom. Critical thinking skill is a life skill in general and

an important component of statistics. You are an active agent in your acquisition of knowledge about criminal justice, criminology, and the world overall. Be critical, be skeptical, and never hesitate to ask for more information.

Data Sources 1.1

The National Incident-Based Reporting System

The Federal Bureau of Investigation (FBI) collects annual data on crimes reported to police agencies nationwide and maintains the Uniform Crime Reports (UCR). The UCR program was developed by FBI director J. Edgar Hoover and the International Association of Chiefs of Police. The first UCR bulletin appeared in January of 1930 (Fisher, 2020). Today, the UCR collects and houses data from the National Incident-Based Reporting System (NIBRS), the Law Enforcement Officers Killed and Assaulted (LEOKA) system, and the Hate Crime Statistics Program.

Crimes in NIBRS are sorted into eight index offenses. Violent offences include murder and nonnegligent manslaughter, rape, robbery, and aggravated assault. Property offenses include burglary, larceny-theft, motor vehicle theft, and arson. The 2019 NIBRS report is the most recent available at the time this book was published. These data show 1,203,803 violent crimes occurred this year, for a rate of 366.7 violent crimes per 100,000 residents. There were 6,925,677 property crimes, translating to a rate of 2,109.9 per 100,000.

A limitation of NIBRS is that it collects data only on those crimes that come to the attention of police—crimes that are not reported or otherwise detected by police are not counted. This limitation is important because most crimes are not reported. In 2023, approximately 45 percent of violent victimizations and 30 percent of property crimes were reported to police (Tapp & Coen, 2024). Drug crimes are typically not reported because both parties to the transactions are consensual. Putting it all together, you can see that NIBRS—indeed, any official data source—captures only a small fraction of the total amount of crime that happens.

Data Sources 1.2

The National Crime Victimization Survey

The U.S. Census Bureau conducts the periodic National Crime Victimization Survey (NCVS) under the auspices of the BJS to estimate the number of criminal incidents that transpire each year and to collect information about crime victims. Multistage cluster sampling is used to select a random sample of households, and each member of that household who is 12 years or older is asked to participate in an interview. Those who agree to be interviewed are asked over the phone or in person about any and all criminal victimizations that transpired in the 6 months prior to the interview. The survey

employs a rotating panel design, so respondents are called at 6-month intervals for a total of 3 years, and then new respondents are selected (Inter-University Consortium for Political and Social Research, 2022).

The benefit of the NCVS over the UCR is that NCVS respondents might disclose victimizations to interviewers that they did not report to police, thus making the NCVS a better estimation of the total volume of crime in the United States. Recall from the UCR discussion that more than half of all victimizations are not reported to authorities. The NCVS helps overcome this limitation.

The NCVS, though, does have downsides. It is based entirely on victims' memories and honesty about the timing and circumstances surrounding criminal incidents. It excludes children younger than 12, institutionalized populations (e.g., persons in prisons, nursing homes, and hospitals), unhoused individuals, and active-duty military personnel living on bases. Additionally, since the NCVS is a victim survey, homicide victims are excluded. Overall, then, the NCVS improves over the UCR but still misses a sizeable portion of victims and crime. Despite these limitations, the NCVS is useful because it facilitates research into the characteristics of crime victims. The 2022 wave of the NCVS is the most recent version available as of this writing.

Science: Basic Terms and Concepts

There are a few terms and concepts that you must know before you get into the substance of the book. Statistics are a tool in the larger enterprise of scientific inquiry. **Science** is the process of systematically collecting reliable information and developing knowledge using techniques and procedures that are accepted by other scientists in a discipline. Science is about puzzles. Every scientific theory or observation about the world raises questions and problems. Scientists solving these puzzles across the world and across generations is what creates scientific bodies of knowledge (Kuhn, 1962).

Core to science is the concept of **falsification**. Scientists do not seek to prove that one thing is true; rather, they seek to *disprove* a thing that is opposite. The famous "black swan" (Popper, 1959) is commonly used to illustrate the reasons why scientists seek falsification—rather than confirmation—of theoretical tenets. It would be incorrect to predict that all swans are white and then go down the local pond, note that all the observed swans are white, and conclude that the white-swan hypothesis is correct. Such a procedure falls victim to **confirmation bias**, whereby someone with preconceived notions about what is "true" only seeks out supporting examples. Evidence pointing to a contradictory conclusion is ignored. A person operating under confirmation bias might see a black swan but, because they are too bound to their convictions to see reality objectively, simply assume that the swan must be a duck and therefore no threat to their preconceived beliefs about swan color.

The correct procedure for testing the hypothesis that all swans are white is to look for counterexamples. You go to the local pond and search diligently for black swans. If you find one, the hypothesis is rejected. If you observe only white swans, the hypothesis perseveres for now but still could be rejected upon future tests. A true scientist is always open to the possibility that any

given hypothesis (no matter how well supported at the moment) may be rejected at some point. When we get to hypothesis testing in later chapters, you will see the concept of falsification reflected in what are called the null and alternative hypotheses.

Science is grounded in **methods**—established procedures considered correct by experts in the scientific community. Trustworthy results come about only by using trusted methods. Data collected through nonscientific means lack validity and reliability. Anecdotes are a form of nonscientific information. If you ask one person why he or she committed a crime, that person's response will be an anecdote; it cannot be assumed to be broadly true of other offenders. If you use scientific methods to gather a large sample of offenders that is representative of the population and you survey all of them about their motivations, you will have data that you can analyze using statistics and that can be used to draw general conclusions.

In scientific research, **samples** are drawn from **populations** using scientific techniques designed to ensure that samples are representative of populations. For instance, if the population is 50 percent male, then the sample should also be approximately 50 percent male. A sample that is only 15 percent male is not representative of the population. Classes on research methods teach students about proper sampling procedures.

Statistics classes are about the techniques employed to analyze data once it is collected. Together, proper methods of gathering and analyzing data form the groundwork for scientific inquiry. Science advances only when both the methods and the analysis are sound. Garbage in, garbage out (GIGO) will become your mantra this semester. Data gathered with rigorous methods are worthless if the wrong statistical analysis is applied to them; likewise, the most sophisticated, cutting-edge statistical technique cannot salvage improperly collected data. You cannot fix with a scalpel what was rendered with a sledgehammer. Studies using bad data or flawed stats do not contribute to theory and research or to policy and practice because their findings are unreliable and could be erroneous.

Learning Check 1.1

Identify whether each of the following is a sample or a population:

a. A group of 100 police officers pulled from a department with 300 total officers
b. Fifty prisons selected at random from all prisons nationwide
c. All persons residing in the state of Wisconsin
d. A selection of 10 percent of the defendants processed through a local criminal court in 1 year

Researchers are always obliged to be clear and open about the methods and stats they use. If you become a producer of statistical information, be ready to document and disclose each step along the way. If you are on the consumer side, you should expect detailed reports on the procedures used so that you can evaluate the credibility of the results. When the methods and stats used in a study are scientifically valid, it is not appropriate to question that study's results

on the basis of a moral, emotional, or opinionated objection. We do not get to disregard facts just because we find them uncomfortable or inconvenient. On the other hand, it is entirely correct (indeed, necessary) to question results when methodological or statistical procedures are shoddy. Results produced in untrustworthy manners should be doubted or outright rejected. GIGO!

A key aspect of science is **replication**. No single study ever proves anything or brings a line of questioning to a definitive end. Much testing must be done before firm conclusions can be drawn. Sometimes a study is flawed and needs to be redone or is methodologically sound but needs to be tested on new populations and samples. For example, a correctional treatment program that reduces recidivism rates among adults might not have similar positive results with juveniles, or a program that works for women might be ineffective for men. It would be a mistake to find that it works for one group and then automatically use it on other groups without testing it first. Replicating the evaluation of this program across different groups creates comprehensive knowledge about what works and what does not. The scientific method's requirement that all researchers divulge the steps they took to gather and analyze data allows other researchers and members of the public to examine those steps and, when warranted, to undertake replications.

Types of Scientific Research in Criminal Justice and Criminology

Criminal justice and criminology research is diverse in nature and purpose. Much of it involves theory testing. **Theories** are proposed explanations for certain events. **Hypotheses** are small "pieces" of theories that must be true for the entire theory to hold up. You can think of a theory as a chain and hypotheses as the links forming that chain. Research Example 1.1 discusses Vance et al.'s (2019) test of the hydraulic theory of discretion displacement. This theory conceptualizes the criminal justice system as a series of discretionary decision points and predicts that discretion restricted at one point in the system will cause an expansion of discretion at a different decision point. Vance et al. set up a study to test whether the implementation of new sentencing guidelines curtailing judges' discretion would displace discretion onto prosecutors. This is an example of theory testing.

Evaluation research is also common in criminal justice and criminology. In Research Example 1.1, the article by Todak et al. (2024) is an evaluation. This type of study is undertaken when a new policy, program, or intervention is put into place and researchers want to know whether the intervention accomplished its intended purpose. Todak et al. tested whether body-worn cameras improved the speed and accuracy of misdemeanor case processing. This study sheds light on what police departments and misdemeanor courts can expect as they incorporate camera footage into criminal cases.

Exploratory research occurs when there is limited knowledge about a certain phenomenon; researchers embark into unfamiliar territory when they attempt to study this social event. Norris' (2024) study of BLM's potential impact on homicides of police officers could be classified as exploratory because there was little knowledge at the start of the study as to what the findings might reveal. This study was exploratory because little is known about how ideological motives influence violence against police.

Finally, there is **descriptive research**. None of the studies included in this chapter's Research Example were fully descriptive; however, each one offered descriptive information about the sample. For instance, Logan et al. (2023) explained that the top 1 percent of high-misconduct female prison inmates accounted for 30 percent of total misconduct incidents by female prisoners, and the top 1 percent of male offenders accounted for 16 percent of total misconduct by male offenders. This descriptive finding confirms that, like crime in general society, deviance within prison walls is disproportionately perpetrated by a small fraction of the total incarcerated population.

You probably figured out as you were reading about the four types of research that these categories are not mutually exclusive. Vance et al.'s (2019) study, for instance, tests a theory but also evaluates outcomes of a new policy. Some studies contain elements of two or more research goals.

The ultimate objective in most statistical analyses is to generalize from samples to populations. A generalization is an inference; it is the process of extrapolating an observation recorded in a sample to the population from which the sample was drawn. This is the goal behind **inferential statistics**. A population is the entire set of people, places, or objects that a researcher wishes to study. Populations, though, are usually very large. Consider, for instance, a researcher trying to estimate attitudes about capital punishment in the general U.S. population. That is a population of more than 300 million! It would be impossible to measure everyone directly. Researchers thus draw samples from populations and study the samples instead. **Probability sampling** helps ensure that a sample mirrors the population from which it was drawn so that results found in the sample are generalizable to the population.

Learning Check 1.2

For each of the following scenarios, identify the type of research being conducted.

a. A researcher wants to know more about female serial killers. Very little research has been done on this particular type of killer. He gathers news articles that report on female serial killers and records information about each one's life history and victim type.

b. A researcher wants to know whether a new in-prison treatment program is effective at reducing recidivism. She collects a sample of inmates that participated in the program and a sample that did not. She then gathers recidivism data for each group to see if those who participated had lower recidivism rates than those who did not.

c. The theory of collective efficacy predicts that social ties between neighbors, coupled with neighbors' willingness to intervene when a disorderly or criminal event occurs in the area, protect the area from violent crime. A researcher gathers a sample of neighborhoods and records the level of collective efficacy and violent crime in each one to determine whether those with higher collective efficacy have lower crime rates.

d. A research team notes that relatively little research has been conducted on the possible effects of military service on later crime commission. They collect a sample of people who served in the military and a sample of people who did not and compare them to determine whether the military group differs from the nonmilitary group in terms of the numbers or types of crimes committed.

Software Packages for Statistical Analysis

Hand computations are the foundation of this book because seeing the numbers and working with the formulas facilitates an understanding of statistical analyses. In the real world, however, statistical analysis is generally conducted using a software program. Microsoft Excel contains some rudimentary statistical functions and is commonly used in situations requiring only basic descriptive analyses; however, this program's usefulness is exhausted quickly because researchers usually want far more than descriptives. Many statistical packages are available. Programs common in criminal justice and criminology research are SPSS, Stata, SAS, and R. Each of these packages has strengths and weaknesses. Simplicity and ease of use make SPSS a good place to start for people new to statistical analysis. Stata is a powerful program excellent for many types of statistical modeling. The SAS package is useful for extremely large datasets and is popular in industry. A fourth option is the R program. R is free and open source, but it is code driven and, therefore, its accessibility depends on a user's skill level.

This book incorporates SPSS into each chapter. This allows you to get a sense of what data look like when displayed in their raw format and permits you to run analyses and read and interpret program output. Where relevant, the chapters offer SPSS practice problems and accompanying datasets that are available for download from collegepublishing.sagepub.com. This offers a practical, hands-on lesson about the way that criminal justice and criminology researchers use statistics.

Organization of the Book

This book is divided into three parts. Part I (Chapters 1 through 5) covers descriptive statistics. Chapter 2 provides a basic overview of types of variables and levels of measurement. Chapter 3 delves into charts and graphs as means of graphically displaying data. Measures of central tendency are the topic of Chapter 4. These descriptive statistics let you get a feel for where the data are clustered. Chapter 5 discusses measures of dispersion. Measures of dispersion complement measures of central tendency by offering information about whether the data tend to cluster tightly around the center or, conversely, whether they are very spread out.

Part II (Chapters 6 through 8) describes the theoretical basis for statistics in criminal justice and criminology: probability and probability distributions. Part I of the book can be thought of as the nuts-and-bolts of the mathematical concepts used in statistics, and Part II can be seen as the theory behind the math. Chapter 6 introduces probability theory. Binomial and continuous probability distributions are discussed. In Chapter 7, you will learn about population, sample,

and sampling distributions. Chapter 8 provides the book's first introduction to inferential statistics in the form of point estimates and confidence intervals. The introduction of inferential statistics at this juncture is designed to help ease you into Part III.

Part III (Chapters 9 through 14) of the book merges concepts from Parts I and II to form the discussion on inferential hypothesis testing. Chapter 9 offers a conceptual introduction to this framework, including a description of the five steps of hypothesis testing that will be used in every proceeding chapter. In Chapter 10, you will encounter your first bivariate statistical technique: chi-square. Chapter 11 describes two-population *t* tests and tests for differences between proportions. Chapter 12 covers analysis of variance, which is an extension of the two-population *t* test that can accommodate more than two groups. In Chapter 13, you will learn about correlations. Chapter 14 wraps up the book with an introduction to regression.

A solid background in algebra is an indispensable prerequisite to this course. You must be comfortable with basic techniques such as adding, subtracting, multiplying, and dividing. You need to understand the difference between positive and negative numbers. You will be plugging numbers into equations and solving those equations. Appendix A offers an overview of the basic mathematical techniques you will need to know, so look those over and make sure that you are ready to take this course.

Statistics are cumulative in that concepts you learn at the beginning form the building blocks for more complex techniques that you will learn about as the course progresses. For instance, you will learn about means and proportions in Part I, then in later chapters use means and proportions to calculate inferential tests. You must, therefore, learn these fundamental calculations well, and you must remember them. This is not a situation where you can briefly memorize a few facts, pass a test, then toss those facts to the wayside and move on.

Repetition is key to learning statistics. Practice, practice, practice! There is no substitute for doing and redoing the end-of-chapter review problems and any other problems your instructor might provide. You can also use the in-text examples as problems if you copy down the numbers and do the calculations on your own without looking at the book. Remember, even the most advanced statisticians started off knowing nothing about stats. Everyone goes through the learning process. You will complete this process successfully as long as you put in the necessary time and effort.

Thinking Critically

1. Media outlets and other agencies frequently conduct opinion polls to try to capture information about the public's thoughts on contemporary events, controversies, or political candidates. Poll data are faster and easier to collect than survey data are because they do not require adherence to scientific sampling methods and questionnaire design. Agencies conducting polls often do not have the time or resources to engage in full-scale survey projects. Debate the merits of poll data from a policy standpoint. Is having low-quality information better than having none at all? Or is there no place in public discussions for data that fall short of scientific standards? Explain your answer.

2. Suppose you tell a friend that you are taking a statistics course, and your friend reacts with surprise that a criminal justice or criminology degree program would require

students to take a stats class. Your friend argues that this area of knowledge is not useful for people with practitioner jobs, such as police and corrections officers. Construct a response to this assertion. Identify ways in which people in practical settings benefit from knowing about research methods and statistical analyses.

3. Throughout the generations, there have been moral panics over various trends. The 1980s and into the 1990s saw the so-called "Satanic panic," a mass hysteria driven by the popularity of heavy metal music and goth styles of dress. When graphic video games hit the market, a wave of fear swept the nation over the potential for video game violence to inspire actual violent behavior by glorifying blood and money. Similar claims have been advanced about rap songs featuring aggressive lyrics. Suppose someone tries to convince you of the truth of such claims. This person offers examples of people who committed violence and were later discovered to have been a fan of metal or rap or claimed to worship Satan. What is your response? Are these examples proof that certain types of music or belief systems cause people to become violent? Explain.

Review Problems

1. Define science and explain the role of methods in the production of scientific knowledge.
2. What is a population? Why are researchers usually unable to study populations directly?
3. What is a sample? Why do researchers draw samples?
4. Explain the role of replication in science.
5. List and briefly describe the different types of research in criminal justice and criminology.
6. Identify three theories that you have encountered in your criminal justice or criminology classes. For each one, write one hypothesis for which you could collect data in order to test that hypothesis.
7. Think of three types of programs or policies you have heard about or read about in your criminal justice or criminology classes. For each one, suggest a possible way to evaluate that program's or policy's effectiveness.
8. If a researcher were conducting a study on a topic about which very little is known and the researcher does not have theory or prior evidence to make predictions about what she will find in her study, what kind of research would she be doing? Explain your answer.
9. If a researcher were solely interested in finding out more about a particular phenomenon and focused entirely on a sample without trying to make an inference to a population, what kind of research would he be doing? Explain your answer.
10. What does GIGO stand for? What does this cautionary concept mean in the context of statistical analyses?

Key Terms

Confirmation bias
Descriptive research
Evaluation research
Exploratory research
Falsification
Hypothesis
Inferential statistics
Methods
Population
Probability sampling
Replication
Sample
Science
Theory

Chapter 2

Types of Variables and Levels of Measurement

Learning Objectives

- Define variables and constants.
- Define unit of analysis and be able to identify the unit of analysis in any given study.
- Define independent and dependent variables and be able to identify each in a study.
- Explain the difference between empirical associations and causation.
- List and describe the four levels of measurement, including similarities and differences between them, and be able to identify the level of measurement of different variables.

Let's talk **variables**. A variable is, quite literally, something that varies. It is a coding scheme measuring a particular characteristic of interest. For instance, asking your statistics classmates, "What color is your hair?" would yield many different answers. This would be a variable. Variables sit in contrast to **constants**, which are characteristics that assume only one value in a sample. It would be pointless for you to ask all your classmates whether they are taking statistics this term because the answer they would all provide is "yes." The core goal in most statistical analyses is to explain variation. Why did one person commit a crime while another did not? Why did a police officer make an arrest in one situation but not in another? Why did a judge sentence one defendant to jail and another to probation? All these behaviors differ and, therefore, contain variation. You would not get very far in a study of judicial sentencing decisions if the judge sentenced everyone to jail or everyone to probation. No variation, no stats.

Units and Levels of Analysis

Samples are made of things. These things can be objects or entities, such as rocks, molecules, prosecutors, or prisons. This is called the **unit of analysis**, and it is, essentially, whatever the sample consists of. In criminal justice and criminology research, individual people are often the

units of analysis. These individuals might be probationers, police officers, criminal defendants, or judges. Prisons, police departments, criminal incidents, or court records can also be units of analysis.

Related to units of analysis are what is called **levels of analysis**. There are three levels of analysis: micro, meso, and macro. These levels are not fixed or absolute; rather, they are relative to one another and can be different across studies. In a study of students in classrooms, the students would be micro-level units and the classrooms would be the macro-level units. In a study of students in classrooms in school districts, students would be micro, classrooms meso, and districts macro.

Research Example 2.1 describes the methodological setup of a selection of criminal justice and criminology studies, each of which employed a different unit of analysis.

Independent Variables and Dependent Variables

Researchers in criminal justice and criminology typically seek to examine relationships between two or more variables. Observed or **empirical** phenomena give rise to questions about the underlying forces driving them. For instance, certain cities across the United States have higher homicide rates than others. This is interesting in its own right, but what we really want to know is *why* this is so. What criminogenic factors are present in high-crime communities? What protective factors are present in low-crime communities? This is where independent variables come in.

Research Example 2.1

Units and Levels of Analysis

1. *Did anti-AAPI hate crimes rise during the Covid-19 pandemic?* The novel coronavirus labeled Covid-19 started as a small outbreak in the Wuhan province of China in late 2019. It spread rapidly, eventually ripping across the world and turning life upside down, resulting in lockdowns, closures, job losses, and illness. As of 2024, the virus has consumed more than 7 million lives worldwide. The United States has a sordid history of blaming Asian immigrants and Asian Americans for disease. This despicable racial trope traces back to at least the 1800s when Chinese immigrants garnered resentment from White laborers who saw them as competition for jobs, even though immigrants were typically exploited, abused, and did backbreaking labor that caused untold injuries and deaths. Having started in China, Covid-19 was inevitably going to fuel animosity toward persons of Asian, Asian American, and Pacific Islander (AAPI) descent. Prominent politicians using racist nicknames for the virus like "Wuhan flu" and "China virus" fanned the flames of anti-AAPI hate. Han et al. (2023) set out to determine whether anti-AAPI hate crimes rose as a result of all this. The researchers collected hate-crime reports from the police departments in New York, New York; San Francisco, California; Seattle, Washington; and Washington, D.C. The unit of analysis in this study was

the hate-crime incident and the question was whether the number of incidents would increase upon the advent of Covid. The data included anti-AAPI hate crimes and hate crimes against other groups, too, because it was necessary to determine whether any observed rise in anti-AAPI hate crimes were unique to this group or part of a broader upward trend in hate crime. Results revealed that hate crimes against other groups dropped between 31 percent and 36 percent between 2019 and 2020, except in San Francisco, where they rose by 63 percent. By contrast, anti-AAPI hate crimes rose an astonishing 3200 percent in New York and 129 percent in Seattle. San Francisco saw a 12 percent increase, and Washington, D.C.'s numbers fell 83 percent. Longitudinal analyses indicated that this abrupt spike did not translate into a higher level sustained over the long term. However, official hate-crime data suffers severe shortcomings. The vast majority of victims do not go to the police, and many hate incidents are heinous but not technically criminal (e.g., directing racial epithets at Asian people), so they are not captured in police data. Lantz and Wenger (2023) conducted a study that may overcome this limitation by collecting self-report data from a sample of people who identified as AAPI. Asking people directly about their experiences can reveal the information that gets lost from official police data. In this study, the unit of analysis is the individual/person. Results revealed that nearly 34 percent of AAPI respondents reported experiencing some form of bias-based victimization. This included 31 percent reporting non-criminal victimization (e.g., being refused a service because of their race) and 17 percent experiencing criminal victimization (e.g., assaulted, threatened, or spat on). The cross-sectional study design did not allow for a determination of whether these hate crimes and hate incidents were linked to the pandemic; however, the data were collected during May of 2020, a few months into the wave of panic sweeping the nation, so it can be inferred that at least some of the incidents were linked to Covid. Together, Han et al.'s study using official reports and Lantz and Wenger's study using self-reports confirm that anti-AAPI hate and hate crimes are all too prevalent in this country.

2. *Do neighborhood-level changes in concentrated disadvantage lead to changes in crime rates?* Dating back to the famous Chicago school of criminology, researchers have invested considerable effort into investigating the link between macro-level concentrated disadvantage (e.g., poverty, joblessness, low education) and crime. Many studies have confirmed the relationship between disadvantage and crime. It is theorized that concentrated disadvantage disrupts social networks and blocks opportunities for people living in these conditions, thus simultaneously promoting crime and dismantling protective social safety nets. This is social disorganization theory. Despite consistently supporting social disorganization theory, most studies are cross-sectional, meaning they gather data at only one time point. As such, causation cannot be established; disadvantage and crime overlapping spatially is not proof that disadvantage causes crime. Wenger (2023) addressed this gap in the literature. The author collected data from multiple sources and combined datasets to create a file containing socioeconomic and sociodemographic information as well as crime counts measured at two points in time. What would the units of analysis be? Recall that levels of analysis are relative, not absolute. You have to consider the nature of the clustering. Census tracts are clustered within cities, suggesting that tracts would be the micro units and cities the macro ones. But remember that this study is longitudinal, meaning there is another level of

analysis that might not be immediately obvious: time! The researcher analyzed the data using a three-level hierarchical linear regression model because time (micro) was nested within tracts (meso), which in turn were nested in cities (macro). Results supported social disorganization theory—not only was concentrated disadvantage related to robbery and burglary, but *changes in* concentrated disadvantage produced changes in these crimes. Increases in disadvantage over time significantly worsened the prevalence of robberies and burglaries. This study adds to the criminological literature by supplying a longitudinal test of social disorganization theory.

Researchers undertaking quantitative studies must specify **dependent variables** and **independent variables**. Dependent variables are the empirical events that a researcher is attempting to explain. Homicide rates, recidivism among recently released prisoners, police use of force, and judicial sentencing decisions are examples of dependent variables. Researchers seek to identify independent variables that help predict or explain these events. Independent variables are factors a researcher believes might affect dependent variables. It might be predicted, for instance, that people returning to the community after serving prison time who are given little support during the reentry process will recidivate more frequently than those who receive transitional housing and assistance. In this case, "support" is the independent variable, and "recidivism" is the dependent variable.

Correlation Versus Causation

"Independent" and "dependent" are not synonymous with "cause" and "effect," respectively. A particular independent variable might be related to a certain dependent variable, but this is far from definitive proof that the former is the cause of the latter. You are probably familiar with the phrase "correlation does not mean causation," and that is precisely what we are talking about here. An observed empirical association cannot, by itself, be taken as proof of causality. Recall the Wenger (2023) study from Research Example 2.1. Wenger explained that although numerous studies confirmed the relationship between concentrated disadvantage and crime, most were cross-sectional, thus limiting their ability to establish causation. Therefore, the author designed a longitudinal study to address this limitation.

The first causality requirement is that there be an **empirical relationship** between the independent variable and the dependent variable. An empirical relationship is an observed connection (covariation) between variables. This is a basic necessity—it does not make sense to try to delve into the nuances of a nonexistent connection. For example, if a researcher predicts that people living in high-crime areas are more likely to own handguns for self-protection but then finds no relationship between neighborhood-level crime rates and handgun ownership, the study cannot proceed to the stage of finding out why handgun ownership is patterned by neighborhood because this patterning does not exist.

Second is **temporal ordering**. Once an empirical association has been observed, the next question is whether the independent variable came first. It would be illogical, for instance, to predict that adolescents' participation in delinquency will impact their gender; clearly, if there is a relationship between gender and delinquency, gender is the independent variable and delinquency is the dependent variable. Often, though, temporal ordering is not this obvious, such as with concentrated disadvantage and crime at the neighborhood level. Wenger (2023) built temporal ordering into the analysis by collecting data on neighborhood disadvantage at one time point and crime at a later time point.

The third requirement is **nonspuriousness**. That is, alternative explanations for the relationship between the independent variable and dependent variable must be ruled out. For example, finding that men are often sentenced more harshly than women might seem like a disturbing empirical finding; however, controlling for offense severity may eliminate the gender effect. It might simply be that men's crimes are worse, on average, and therefore their sentences are more severe. This criterion is often hard to meet in social sciences because human behavior is complicated, and each action a person engages in has multiple causes and multiple effects. Disentangling these causal factors can be difficult or impossible.

When an important variable is erroneously left out of a statistical analysis, **omitted variable bias** may invalidate the results. This is the classic example of ice cream sales and crime. Looking solely at empirical data, one might be befuddled as to why a spike in ice cream sales would seem to cause crime to rise. Entitled brats (including of the adult variety) lashing out when told their favorite flavor is sold out? People beset by severe brain freezes slipping into temporary insanity, losing sight of right from wrong in their agony? Obviously, we all know that the connection between ice cream and crime is spurious. The omitted variable is ambient temperature. Crime rates and ice cream sales both rise during the warm months of the year. Add temperature or season to the model, and the empirical relationship between ice cream and crime disappears.

A final caution with respect to causality is that statistical analyses are examinations of aggregate trends. Uncovering an association between an independent variable and a dependent variable means only that the presence or absence of the independent variable has the *tendency* to be related to either an increase or a reduction in the dependent variable. For instance, children who experience the loss of a parent to incarceration are more likely to one day be incarcerated themselves. This association is about risk factors, though, not fate. Many people who experience parental incarceration never end up in prison. Be smart when interpreting the directions and implications of relationships. Learning Check 2.1 takes you through some critical thinking exercises.

Learning Check 2.1

1. A state governor is pushing for harsher sentences for juvenile offenders. He points to a recent study finding that most adults who commit serious crimes later in life were involved in minor deviance as juveniles. He claims this proves a crackdown on youthful offending is needed to prevent serious crimes in the future. Tell the governor why his argument is wrong.

2. Researchers have struggled to pinpoint the effects of prison solitary confinement on people subjected to this punishment. Most of the people penalized with solitary confinement suffer this penalty because of significantly disruptive behavior. Explain why it would be hard to figure out what psychological or emotional impacts solitary confinement might have on people.

Levels of Measurement

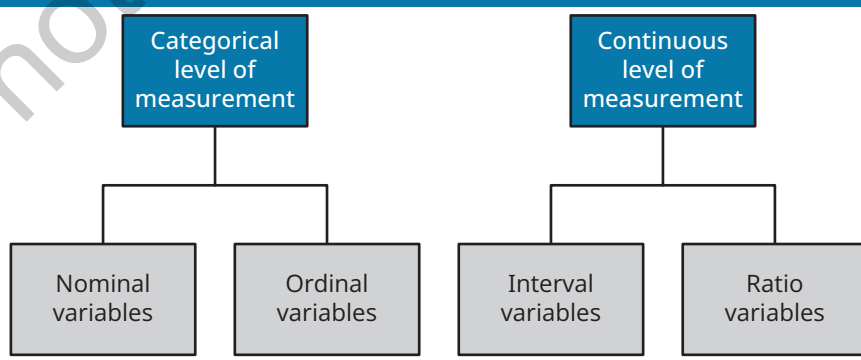
Every variable possesses a **level of measurement**. Levels of measurement describe or classify variables based on how quantitatively honed they are. Level of measurement is not the same as level of analysis; do not confuse the two. There are two overarching types of variables: *categorical* and *continuous*. **Categorical variables** consist of labels rather than meaningful numbers, whereas **continuous variables** are made of numbers that measure the relative presence of some type of characteristic. Each of these types contains two subtypes. This two-tiered classification system is diagrammed in Figure 2.1 and discussed in the following sections.

The Categorical Level of Measurement: Nominal and Ordinal Variables

Categorical variables represent ways of divvying up people and objects according to some characteristic. Categorical variables are subdivided into two types: *nominal* and *ordinal*. A **nominal variable** is the most rudimentary type. Nominal variables group people, objects, or characteristics. See Tables 2.1 and 2.2 for examples of nominal variables (see also Data Sources 2.1 for a description of the dataset used in these tables). Data in both are from the 2020 Police–Public Contact Survey (PPCS).

The variable in Table 2.1 comes from a question on the survey asking respondents who reported having had contact with police officers within the past 12 months what time of day

Figure 2.1 ▪ Levels of Measurement



or night that encounter took place. This is a nominal variable because it is simply a list of time periods; no information is conveyed about facets of the encounters like how long they lasted, whether they were positive or negative, or what the outcomes were. The question is simply "What time was it?" and time was grouped into categories.

Table 2.1 ▪ Time of Contact

What Time of Day or Night Was Your Contact With an Officer?	Frequency
After 6 a.m. to 12 p.m.	4,317
After 12 p.m. to 6 p.m.	8,165
After 6 p.m. to 12 a.m.	4,454
After 12 a.m. to 6 a.m.	1,220
	Total = 18,156

Data Sources 2.1

The Police–Public Contact Survey

The Bureau of Justice Statistics (BJS; see Data Sources 2.3) conducts the Police–Public Contact Survey (PPCS) periodically as a supplement to the National Crime Victimization Survey (NCVS; see Data Sources 1.2). Interviews are conducted in English only. NCVS respondents aged 16 and older are asked about recent experiences they might have had with police. Variables include respondent demographics, the reason for respondents' most recent contact with police, whether the police used or threatened force against the respondents, the number of officers present at the scene, whether the police asked to search respondents' vehicles, and so on. This dataset is used to estimate the number of police–citizen contacts that take place each year and to study characteristics of these contacts. The 2020 wave of the PPCS is the most current one available at this time.

Table 2.2 displays data from a question asking people who reported having had a recent experience with a police officer whether they thought the officer displayed proper behavior during the encounter. You can see that, overwhelmingly, respondents felt officers' behavior was appropriate. Table 2.3 shows the racial breakdown of people who reported a crime to police within the past 12 months of the survey. Race is a nominal variable because it is a series of categories that conveys no information about quantity or quality; it is just a list.

Table 2.2 ▪ Perceptions of Police Behavior

Did the Police Officer Behave Properly?	Frequency
Yes	17,599
No	1,005
	Total = 18,604

Table 2.3 ▪ Race of People Who Reported a Crime in the Past 12 Months

Race	Frequency
Black	446
Hispanic	596
Asian	176
White	4,294
Other	159
	Total = 5,671

Much information is missing from the nominal variables in Tables 2.1 through 2.3. This is why the nominal level of measurement is lowest in terms of descriptiveness and utility. These classifications represent only *differences*; there is no way to arrange the categories in any meaningful rank or order. Nobody in one racial group can be said to have "more race" or "less race" than someone in another category.

Two requirements for nominal variables are that they be **mutually exclusive** and **exhaustive**. Being mutually exclusive means each unit in the dataset (person, place, and so on) sits in only one category. Notice in Table 2.1 the use of the word "after" to make the categories mutually exclusive. Absent the word "after," a person whose encounter with police took place at 6 a.m., 12 p.m., 6 p.m., or 12 a.m. could be put into two different categories, which would violate the rule of mutual exclusion.

The requirement that they be exhaustive means all units in the sample must have a category that applies to them. Omitting a racial category or failing to offer an "other" option in the race variable would be problematic because survey respondents who do not fall into the race options that are available would have no applicable category for themselves. When a variable is exhaustive and mutually exclusive, everyone filling out the survey has one, and only one, answer option.

Ordinal variables are one step up from nominal ones in terms of descriptiveness because they can be ranked according to the quantity of a characteristic possessed by each person or

object in a sample. University students' class level is an ordinal variable because freshmen, sophomores, juniors, and seniors can be rank ordered. Numbers can also be represented as ordinal classifications when the numbers have been grouped into ranges like those in Table 2.4 showing the income categories of PPCS respondents who had called the police to report a crime in the past year. Table 2.5 displays the length of contact for those who reported crimes.

Learning Check 2.2

In a study of people incarcerated in prison, the variable "offense type" captures the crime that each person was convicted of. This variable could be coded as either nominal or ordinal. Explain why this is. Give an example of each type of measurement approach.

Table 2.4 ▪ Household Income of Respondents Who Reported Crimes

Household Income	Frequency
$49,999 or less	2,168
$50,000–$74,999	1,015
$75,000 or more	2,488
	Total = 5,671

Table 2.5 ▪ Length of Contact for Respondents Who Reported a Crime

Minutes	Frequency
1–5	2,559
6–10	1,078
11–15	631
16–20	393
21–30	429
31–45	180
46–60	178
61 or more	132
	Total = 5,580

The categories in Tables 2.4 and 2.5 can be rank ordered, unlike the variables in the tables displaying nominal variables. "More than" and "less than" conclusions can be drawn from them. However, do not let their use of numbers fool you: They are still categorical! You cannot do math such as addition or subtraction. Grab your calculator and look for the "$50,000 to $74,999" button or the "61 or more button." Can't find them? That is because they are not real numbers. Be wise to the difference between an ordinal variable made of numbers and a truly numeric variable.

The Continuous Level of Measurement: Interval and Ratio Variables

Continuous variables differ from categorical ones in that the former are represented not by categories but rather by numbers. **Interval variables** are numerical scales with equal distances between all adjacent points on those scales. Ambient temperature is a classic example of an interval variable. This scale is measured using numbers representing degrees, and every point on the scale is exactly one degree away from the nearest points on each side. Twenty degrees Fahrenheit, for instance, is 1 degree cooler than 21 degrees and 4 degrees warmer than 16 degrees. Importantly, interval variables do not contain true zero points. Temperature scales have zeroes, but they are placeholders. A zero on the Fahrenheit or Celsius scale does not indicate that there is no temperature.

None of the datasets we have been working with contain interval variables, and interval variables do not lend themselves to tidy displays in tables the way categorical variables do, so let us turn to a research article for examples of interval variables. Worley et al. (2023) examined the relationship between job demands and depressive symptoms among correctional officers. Data came from self-report surveys of correctional officers in the Texas Department of Criminal Justice. Job demands included work stress and boundary violations. There were five items on the survey asking respondents about different facets of the stress they feel at work and six items asking them about boundary violations. Work stress items included statements such as, "When I am at work, I often feel tense or uptight" and "A lot of times, my job makes me very frustrated or angry." Boundary violations items included statements like, "Some employees let inmates do their jobs for them" and "Some employees let inmates break the rules." Respondents were given a scale for each item to rate how much they agreed or disagreed with it. The scale was 1 = *strongly disagree*; 2 = *disagree*; 3 = *neutral/middle*; 4 = *agree*; and 5 = *strongly agree*. These variables are interval because they are numeric and continuous but lack true zeroes. The five stress items and the six boundary items were each summed to create scales. The stress scale ranged from 5 to 25, and the boundary violation scale ranged from 6 to 30.

Ratio variables are the other subtype within the continuous level of measurement. The ratio level resembles the interval level in that ratio, too, is numerical and has equal and known distance between adjacent points. Ratio variables, though, contain true zeroes. The amount of money someone makes per year, the number of children they have, and the number of times they visited the grocery store last month are all ratio variables because they can all take on the value of zero to mean a genuine absence. A person can make zero dollars, have zero children, and grocery shop zero times.

Because they have true zero points, ratio variables can be multiplied and divided in ways interval variables cannot be. For instance, it does not make sense to say that 80 degrees is twice the temperature as 40 degrees; however, since a parked car travels 0 miles per hour, we can say that 80 miles per hour is twice as fast as 40 miles per hour.

Table 2.6 contains examples of ratio variables. Like interval variables, ratio variables do not look good listed out in tables because most contain too many numbers for a clean, easy-to-read display. Instead, the minimum and maximum values are shown. These numbers are from the Annual Survey of Jails (ASJ) conducted by the Bureau of Justice Statistics.

Table 2.6 ▪ Inmates in Local Jails

Characteristic	Minimum and Maximum
Total confined population	0–13,232
Adult males	0–11,894
Adult females	0–1,338
Convicted	0–7,067
Not convicted	0–7,535

You can see from Table 2.6 why a table displaying a frequency distribution like those used for categorical variables would be impossible to create and interpret. The table for "total confined population" would have more than 13,000 rows. Even a graph or chart would be unwieldy and pretty useless. We will see in Chapter 3 how graphs and charts can be used to display continuous data.

For the sake of getting one ratio variable we can display, let us put a couple of arbitrary parameters on the ASJ data to shrink the sub-sample down to a usable number. It is important for you to see this type of display here in Chapter 2 because subsequent chapters will have you performing calculations on tables like this. For this illustration, we will examine the prevalence of female correctional staff in Illinois jails. Table 2.7 displays the results.

Table 2.7 ▪ Female Correctional Staff Members in Illinois Jails

Number of Female Correctional Officers	Frequency
0	1
1	1
2	3
4	1

(*Continued*)

Table 2.7 ▪ Female Correctional Staff Members in Illinois Jails (*Continued*)

Number of Female Correctional Officers	Frequency
5	1
9	2
10	1
11	2
14	1
17	2
20	1
22	1
27	1
33	1
38	1
666	1
	Total = 21

This table is interpreted the same way as tables displaying categorical variables, but it can be a tad more confusing because the left column contains numbers rather than categories. Try to think of it as being the same basic premise, though. The number of female staff members across the 21 Illinois jails ranges from 0 to 666 (Cook County jail being the culprit of this devilish number). The frequency column represents the number of jails employing the number of female staff listed in the left column. For instance, 1 jail reported having 0 female staff members, and 3 jails reported having 2 female officers. The "total" row is applicable only for the *right* (i.e., frequency) column because this sums the number of jails in the sample.

Data Sources 2.2

Annual Survey of Jails

Each year, the Bureau of Justice Statistics surveys a stratified random sample of jails from all 50 states. Federal detention facilities and jails on tribal lands are excluded. There are approximately 2,850 jails nationwide, and roughly 900 of these are selected for the survey each year. The survey captures data on characteristics like jail population, number of juveniles held, whether the jail has a weekend program, and so on. The most recent wave of the ASJ is 2022.

Learning Check 2.3

Zip codes are five-digit sequences that numerically identify certain locations. What is the level of measurement of zip codes? Explain your answer.

In the real world of statistical analysis, interval and ratio variables are often used similarly. Most of the same day-to-day analyses like those we will be discussing can be applied to both of them. If you eventually go on to take advanced stats courses, you will see where the distinctions matter, but for our purposes, the two variable types are largely interchangeable. The categorical-versus-continuous distinction really matters, though. Later in the book, you will learn the skill of selecting the correct statistical procedure to analyze data based on the level(s) of measurement of your variables. Misidentifying level of measurement will lead you to choose the wrong analysis. Be sure you are fully versed in level of measurement before closing this chapter and moving on in the book.

If you ever find yourself collecting data, the rule to abide by is to always use the highest level of measurement possible. Some variables are inherently categorical but researchers often have choices. For instance, the question "How many speeding tickets have you received in your life?" will yield much more valuable data than the question "Have you ever received a speeding ticket?" The second option gives you "yes/no" (categorical) data. The first one, though, allows you to dig deeper into respondents' answers. Maybe there are a few respondents who have received extraordinarily high numbers of tickets. If you have another variable capturing deviant behavior, you could find out if people who receive a lot of tickets also commit other forms of legal violations. Table 2.8 summarizes the basic characteristics that define each level and distinguish it from the others.

Table 2.8 ▪ Characteristics of Each Level of Measurement

Level of Measurement	Variable Characteristic			
	Mutually exclusive and exhaustive	Rank-orderable	Equal intervals	True zero
Nominal	✓			
Ordinal	✓	✓		
Interval	✓	✓	✓	
Ratio	✓	✓	✓	✓

Chapter Summary

In this chapter, you read about units and levels of analysis, independent variables, dependent variables, and the three requirements for causality. Levels of analysis are the units that comprise a sample. Dependent variables are phenomena researchers seek to explain, and independent variables are factors predicted to influence dependent variables. The chapter also described levels of measurement. Categorical variables are qualitative groupings or classifications into which people or objects are placed on the basis of some characteristic. The two subtypes of categorical variables are nominal and ordinal. These two kinds of variables are quite similar in appearance, with the distinguishing feature being that nominal variables cannot be rank-ordered, whereas ordinal variables can be. Continuous variables are quantitative measurements of the presence or absence of a certain characteristic in a group of people or objects. Interval and ratio variables are both continuous. The difference between them is that ratio-level variables possess true zero points and interval-level variables do not.

You must be able to identify the level of measurement of any given variable because, in statistics, the level at which a variable is measured is one of the most important determinants of the analytic techniques that can be employed. Using the wrong statistical procedure can produce wildly inaccurate results and conclusions. Be sure you are familiar with the four types before moving on from this chapter.

Thinking Critically

1. Many researchers have tried to determine whether incarceration deters violent crime. Suppose a report has been published showing a negative relationship between prison rates and crime rates. The authors claim their findings confirm that incarceration works: More prison, less crime. Do you think this conclusion is trustworthy? What additional information is needed before causal claims can be made?

2. The impact that immigration may have on crime is a hotly debated topic in political and social circles. Researchers have weighed in with empirical analyses, but these studies have produced mixed results. Studies suggest that immigrants themselves are less likely than people born in the United States to commit crime. At the same time, though, some studies indicate that communities with large proportions of immigrants sometimes have higher crime rates than those with smaller proportions. How could these phenomena both be true at the same time?

3. Many studies and polls over time have asked samples of United States residents about their attitudes toward capital punishment. Survey items are often worded "Do you support the use of capital punishment in cases of first-degree murder?" and offer respondents a "yes/no" answer option. Results typically indicate a majority opinion in favor of capital punishment. Other studies have employed alternative items, such as "What do you think is the most appropriate punishment for someone convicted of

first-degree murder?" and allowing them to select from "death penalty, life in prison without the possibility of parole, life in prison with the possibility of parole." Results from surveys utilizing this phrasing show substantially smaller levels of support for capital punishment. Why do you think that is?

Review Problems

1. A researcher testing the hypothesis that education levels affect the likelihood that people will commit crime gathers a sample of people aged 25 and older.
   a. What is the independent variable?
   b. What is the dependent variable?
   c. What is the unit of analysis?

2. A researcher testing the hypothesis that arrest deters future law breaking gathers a sample of people who have been arrested.
   a. What is the independent variable?
   b. What is the dependent variable?
   c. What is the unit of analysis?

3. A researcher testing the hypothesis that concentrated disadvantage affects victimization gathers a random sample of neighborhoods and then surveys a random sample of residents of each neighborhood about their experiences with crime.
   a. What is the independent variable?
   b. What is the dependent variable?
   c. What is the unit(s) of analysis?

4. A researcher testing the hypothesis that prison architectural design affects the number of inmate-on-inmate assaults that take place inside a facility gathers a sample of prisons.
   a. What is the independent variable?
   b. What is the dependent variable?
   c. What is the unit of analysis?

5. A researcher testing the hypothesis that the amount of money a state spends on education, health, and welfare affects the level of violent crime in cities within that state gathers a random sample of states and a random sample of cities within each selected state.
   a. What is the independent variable?
   b. What is the dependent variable?
   c. What is the unit(s) of analysis?

6. A researcher testing the hypothesis that correctional officers' job satisfaction affects the length of time they stay in their jobs gathers a sample of correctional officers.
   a. What is the independent variable?
   b. What is the dependent variable?
   c. What is the unit of analysis?

7. A researcher testing the hypothesis that the location of a police department in either a rural or an urban area affects starting pay for entry-level police officers gathers a sample of police departments.
   a. What is the independent variable?
   b. What is the dependent variable?
   c. What is the unit of analysis?

8. A researcher testing the hypothesis that the level of urbanization in a city or town affects residents' social cohesion gathers a sample of municipal jurisdictions (cities and towns).
   a. What is the independent variable?
   b. What is the dependent variable?
   c. What is the unit of analysis?

9. Suppose that in a random sample of adults, a researcher found a statistical relationship between parental drug addiction and people's own involvement in crime or addiction. Does this mean that every person whose parent struggled with drug addiction ended up criminally involved? Explain your answer.

10. Identify the level of measurement of each of the following variables:
    a. Suspects' race measured as *Latinx, Black, Asian, White, other*
    b. The age at which an offender was arrested for the first time
    c. The sentences received by convicted defendants, measured as *jail, prison, probation, fine*, and *other*
    d. Correctional officers' job satisfaction, measured on a 1–5 scale
    e. The amount of money, in dollars, that a police department collects annually from drug asset forfeitures
    f. Prison security level, measured as *minimum, medium*, and *maximum*
    g. Trial judges' gender

11. Identify the level of measurement of each of the following variables:
    a. The number of times someone has shoplifted, measured as the number that survey respondents write in
    b. The number of times someone has shoplifted, measured as *0–2, 3–5*, or *6 or more*
    c. People's attitudes toward the police, measured as *like a lot; like somewhat; do not like much; do not like at all*
    d. The type of attorney a criminal defendant has at trial, measured as *privately retained* or *publicly funded*
    e. In a sample of juvenile delinquents, whether or not those juveniles have substance abuse disorders
    f. Prosecutors' charging decisions, measured as *filed charges* and *did not file charges*

12. If a researcher is conducting a survey and wants to ask respondents about their self-reported involvement in shoplifting, there are a few different ways he could phrase this question. Use the possible phrasings to do two things:

a. Identify the level of measurement that each type of phrasing would produce.
b. Explain which of the three possible phrasings would be the best one to choose and why this is.

Possible phrasing 1: *How many times have you taken small items from stores without paying for those items?*

Please write in: _____

Possible phrasing 2: *How many times have you taken small items from stores without paying for those items? Please circle one of the following:*

Never, 1–2 times, 3–4 times, 5+ times

Possible phrasing 3: *Have you ever taken small items from stores without paying for those items? Please circle one of the following:*

Yes No

13. A researcher is conducting a survey and wants to ask respondents about the number of times they have been arrested. Write down three ways the question could be worded to produce three different levels of measurement.

14. Table 2.9 contains BJS data on the number of prisoners under sentence of death, by region.

Table 2.9 ▪ Number of Prisoners Under Sentence of Death in State Prisons at Year-End 2021 (Snell, 2023)

Region	Frequency
Northeast	118
Midwest	187
South	1,179
West	926
	Total = 2,410

a. Identify the level of measurement of the variable *region*.
b. Identify the level of measurement of *number of prisoners under sentence of death*.

15. Table 2.10 contains data from the same BJS report on capital punishment (Snell 2023). The table displays age ranges and the number of people under sentence of death in 2021 in each age range.

Table 2.10 ▪ Ages of Prisoners Under Sentence of Death in State and Federal Prisons at Year-End 2021 (Snell, 2023)

Age	Frequency
18–24	0
25–34	109
35–44	457
45–54	800
55 and older	1,016
	Total = 2,382

a. Identify the level of measurement of the variable *age*.
b. Identify the level of measurement of the variable *number of prisoners*.

16. A researcher is studying whether providing victim advocates to domestic violence survivors makes it more likely those survivors will pursue criminal cases against their abusers. The researcher collects a sample of survivors who did not have advocates and a sample who did, and for each one codes whether the victim showed up in court to testify against the defendant.
a. Identify the independent variable in this study.
b. Identify the level of measurement of the independent variable.
c. Identify the dependent variable in this study.
d. Identify the level of measurement of the dependent variable.
e. Identify the unit of analysis.

17. Some researchers posit that people will be more cooperative with police when they feel the police treat them fairly. A research team is studying body-worn camera footage from arrest incidents. They code each officer's behavior toward the suspect (1 = *polite and fair*; 2 = *neutral*; 3 = *impolite and unfair*) and the suspects' behavior toward the officers (1 = *cooperative*; 2 = *slightly uncooperative*; 3 = *resistive*; 4 = *assaultive*).
a. Identify the independent variable in this study.
b. Identify the level of measurement of the independent variable.
c. Identify the dependent variable in this study.
d. Identify the level of measurement of the dependent variable.
e. Identify the unit of analysis.

18. Deterrence theory holds that people are less likely to commit crime when they perceive the risk of punishment as being high. A researcher surveys a group of adults. The survey asks, "If you stole an item from a store, what do you think is the chance the police would arrest you?" and instructs them to write in a percentage. The survey also asks, "How many times have you stolen an item from a store?" and gives them the answer options "0–2 times; 3–5 times; 6+ times."

- **a.** Identify the independent variable used in this study.
- **b.** Identify the level of measurement of the independent variable.
- **c.** Identify the dependent variable in this study.
- **d.** Identify the level of measurement of the dependent variable.
- **e.** Identify the unit of analysis.

19. A researcher studying parole board decision making wants to know if prisoners' race affects their chances of being paroled. The researcher gathers parole board records and notes each incarcerated person's race and the number of times that person applied for parole and was denied.

- **a.** Identify the independent variable used in this study.
- **b.** Identify the level of measurement of the independent variable.
- **c.** Identify the dependent variable in this study.
- **d.** Identify the level of measurement of the dependent variable.
- **e.** Identify the unit of analysis.

Key Terms

Categorical variable
Constant
Continuous variable
Dependent variable
Empirical
Empirical relationship
Exhaustive
Independent variable
Interval variable
Level of analysis
Level of measurement
Mutually exclusive
Nominal variable
Nonspuriousness
Omitted variable bias
Ordinal variable
Ratio variable
Temporal ordering
Unit of analysis
Variable