STATISTICS FOR CRIMINOLOGY AND CRIMINAL JUSTICE

Third Edition

JACINTA M. GAU

Statistics for Criminology and Criminal Justice

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Preface to the Third Edition

In 2002, James Comey, the newly appointed U.S. attorney for the Southern District of New York who would later become the director of the Federal Bureau of Investigation, entered a room filled with high-powered criminal prosecutors. He asked the members of the group to raise their hands if they had never lost a case. Proud, eager prosecutors across the room threw their hands into the air, expecting a pat on the back. Comey's response befuddled them. Instead of praising them, he called them chickens (that is not quite the term he used, but close enough) and told them the only reason they had never lost is that the cases they selected to prosecute were too easy.[1] The group was startled at the rebuke, but they really should not have been. Numbers can take on various meanings and interpretations and are sometimes used in ways that conceal useful information rather than revealing it.

This book enters its third edition at a time when the demand for an educated, knowledgeable workforce has never been greater. This is as true in criminal justice and criminology as in any other university major and occupational field. Education is the hallmark of a professional. Education is not just about knowing facts, though—it is about thinking critically and treating incoming information with a healthy dose of skepticism. All information must pass certain tests before being treated as true. Even if it passes those tests, the possibility remains that additional information exists that, if discovered, would alter our understanding of the world. People who critically examine the trustworthiness of information and are open to new knowledge that challenges their preexisting notions about what is true and false are actively *using* their education, rather than merely possessing it.

At first glance, statistics seems like a topic of dubious relevance to everyday life. Convincing criminology and criminal justice students that they should care about statistics is no small task. Most students approach the class with apprehension because math is daunting, but many also express frustration and impatience. The thought, "But I'm going to be a [police officer, lawyer, federal agent, etc.], so what do I need *this* class for?" is on many students' minds as they walk through the door or log in to the learning management system on the first day. The answer is surprisingly simple: Statistics form a fundamental part of what we know about the world. Practitioners in the criminal justice field rely on statistics. A police chief who alters a department's deployment plan so as to allocate resources to crime hot spots trusts that the researchers who analyzed the spatial distribution of crime did so correctly. A prison warden seeking to classify inmates according to the risk they pose to staff and other inmates needs assessment instruments that accurately predict each person's likelihood of engaging in behavior that threatens institutional security. A chief prosecutor must recognize that a high conviction rate might not be testament to assistant prosecutors' skill level but, rather, evidence that they only try simple cases and never take on challenges.

Statistics matter because what unites all practitioners in the criminology and criminal justice occupations and professions is the need for valid, reliable data and the ability

[1]Eisinger, J. (2017). *The chickens**t club: Why the Justice Department fails to prosecute executives.* New York: Simon & Schuster.

to critically examine numbers that are set before them. Students with aspirations for graduate school have to understand statistical concepts because they will be expected to produce knowledge using these techniques. Those planning to enter the workforce as practitioners must be equipped with the background necessary to appraise incoming information and evaluate its accuracy and usefulness. Statistics, therefore, is just as important to information consumers as it is to producers.

The third edition of *Statistics for Criminology and Criminal Justice*, like its two predecessors, balances quantity and complexity with user-friendliness. A book that skimps on information can be as confusing as one overloaded with it. The sacrificed details frequently pertain to the underlying theory and logic that drive statistical analyses. The pedagogical techniques employed in this text draw from the scholarship of teaching and learning, wherein researchers have demonstrated that students learn best when they understand logical connections within and across concepts, rather than merely memorizing key terms or steps to solving equations. In statistics, students are at an advantage if they first understand the overarching goal of the techniques they are learning before they begin working with formulas and numbers.

This book also emphasizes the application of new knowledge. Students can follow along in the step-by-step instructions that illustrate plugging numbers into formulas and solving them. Additional practice examples are embedded within the chapters, and chapter review problems allow students to test themselves (the answers to the odd-numbered problems are located in the back of the book), as well as offering instructors convenient homework templates using the even-numbered questions.

Real data and research also further the goal of encouraging students to apply concepts and showing them the relevance of statistics to practical problems in the criminal justice and criminology fields. Chapters contain *Data Sources* boxes that describe some common, publicly available data sets such as the Uniform Crime Reports, National Crime Victimization Survey, General Social Survey, and others. Most in-text examples and end-of-chapter review problems use data drawn from the sources highlighted in the book. The goal is to lend a practical, tangible bent to this often-abstract topic. Students get to work with the data their professors use. They get to see how elegant statistics can be at times and how messy they can be at others, how analyses can sometimes lead to clear conclusions and other times to ambiguity.

The *Research Example* boxes embedded throughout the chapters illustrate criminal justice and criminology research in action and are meant to stimulate students' interest. They highlight that even though the math might not be exciting, the act of scientific inquiry most definitely is, and the results have important implications for policy and practice. In the third edition, the examples have been expanded to include additional contemporary criminal justice and criminology studies. Most of the examples contained in the first and second editions were retained in order to enhance diversity and allow students to see firsthand the rich variety of research that has been taking place over time. The full texts of all articles are available on the SAGE companion site (http://www.sagepub.com/gau) and can be downloaded online by users with institutional access to the SAGE journals in which the articles appear.

This edition retains the *Learning Check* boxes. These are scattered throughout the text and function as mini-quizzes that test students' comprehension of certain concepts. They are short so that students can complete them without disrupting their learning process. Students can use each *Learning Check* to make sure they are on the right track in their understanding of the material, and instructors can use them for in-class discussion. The answer key is in the back of the book.

Where relevant to the subject matter, chapters end with a section on IBM® SPSS® Statistics[2] and come with one or more shortened versions of a major data set in SPSS file format. Students can download these data sets to answer the review questions presented at the end of the chapter. The full data sets are all available from the Inter-University Consortium for Political and Social Research at www.icpsr.umich.edu/icpsrweb/ICPSR/ and other websites as reported in the text. If desired, instructors can download the original data sets to create supplementary examples and practice problems for hand calculations or SPSS analyses.

The third edition features the debut of *Thinking Critically* sections. These two-question sections appear at the end of each chapter. The questions are open-ended and designed to inspire students to think about the nuances of science and statistics. Instructors can assign them as homework problems or use them to initiate class debates.

The book is presented in three parts. Part I covers descriptive statistics. It starts with the basics of levels of measurement and moves on to frequency distributions, graphs and charts, and proportions and percentages. Students learn how to select the correct type(s) of data display based on a variable's level of measurement and then construct that diagram or table. They then learn about measures of central tendency and measures of dispersion and variability. These chapters also introduce the normal curve.

Part II focuses on probability theory and sampling distributions. This part lays out the logic that forms the basis of hypothesis testing. It emphasizes the variability in sample statistics that precludes direct inference to population parameters. Part II ends with confidence intervals, which is students' first foray into inferential statistics.

Part III begins with an introduction to bivariate hypothesis testing. The intention is to ease students into inferential tests by explaining what these tests do and what they are for. This helps transition students from the theoretical concepts covered in Part II to the application of those logical principles. The remaining chapters include chi-square tests, *t* tests and tests for differences between proportions, analysis of variance (ANOVA), correlation, and ordinary least squares (OLS) regression. The sequence is designed such that some topics flow logically into others. Chi-square tests are presented first because they are the only nonparametric test type covered here. Two-population *t* tests then segue into ANOVA. Correlation, likewise, supplies the groundwork for regression. Bivariate regression advances from correlation and transitions into the multivariate framework. The book ends with the fundamentals of interpreting OLS regression models.

This book provides the foundation for a successful statistics course that combines theory, research, and practical application for a holistic, effective approach to teaching and learning. Students will exit the course ready to put their education into action as they prepare to enter their chosen occupation, be that in academia, law, or the field. Learning statistics is not a painless process, but the hardest classes are the ones with the greatest potential to leave lasting impressions. Students will meet obstacles, struggle with them, and ultimately surmount them so that in the end, they will look back and say that the challenge was worth it.

[2]SPSS is a registered trademark of International Business Machines Corporation.

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The third edition of this book came about with input and assistance from multiple people. With regard to the development and preparation of this manuscript, I wish to thank Jessica Miller and the staff at SAGE for their support and encouragement, as well as Alison Hope for her excellent copyediting assistance. You guys are the best! I owe gratitude to my family and friends who graciously tolerate me when I am in “stats mode” and a tad antisocial. Numerous reviewers supplied advice, recommendations, and critiques that helped shape this book. Reviewers for the third edition are listed in alphabetical order here. Of course, any errors contained in this text are mine alone.

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Jacinta M. Gau, Ph.D., is an associate professor in the Department of Criminal Justice at the University of Central Florida. She received her Ph.D. from Washington State University. Her primary areas of research are policing and criminal justice policy, and she has a strong quantitative background. Dr. Gau's work has appeared in journals such as *Justice Quarterly*, *British Journal of Criminology*, *Criminal Justice and Behavior, Crime & Delinquency, Criminology & Public Policy*, *Police Quarterly*, *Policing: An International Journal of Police Strategies & Management*, and the *Journal of Criminal Justice Education*. In addition to *Statistics for Criminology and Criminal Justice*, she is author of *Criminal Justice Policy: Origins and Effectiveness* (Oxford University Press) and coauthor of *Key Ideas in Criminology and Criminal Justice* (SAGE). Additionally, she coedits *Race and Justice: An International Journal*, published by SAGE.

PART I

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 the three major statistics software packages.

You might be thinking, "What do statistics have to do with criminal justice or criminology?" It is reasonable for you to question the requirement that you spend an entire term poring over a book about statistics instead of one about policing, courts, corrections, or criminological theory. Many criminology and criminal justice undergraduates wonder, "Why am I here?" In this context, the question is not so much existential as it is practical. Luckily, the answer is equally practical.

You are "here" (in a statistics course) because the answer to the question of what statistics have to do with criminal justice and criminology is "Everything!" Statistical methods are the backbone of criminal justice and criminology as fields of scientific inquiry. Statistics enable the construction and expansion of knowledge about criminality and the criminal justice system. Research that tests theories or examines criminal justice phenomena and is published in academic journals and books is the basis for most of what we know about criminal offending and the system that has been designed to deal with it. The majority of this research would not be possible without statistics.

Statistics can be abstract, so this book uses two techniques to add a realistic, pragmatic dimension to the subject. 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 give you 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 answer those questions. You will see firsthand how lively and diverse criminal justice and criminology research is. Research Example 1.1 summarizes seven studies. Take a moment now to read through them.

The second technique to add a realistic, pragmatic dimension to the subject of this book 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 gathering, maintaining, and analyzing data on various criminal justice topics at the county, state, and national levels. Visit http://bjs.ojp.usdoj.gov/ to familiarize

Research Example 1.1

Researchers in the field of criminology and criminal justice examine a wide variety of issues pertaining to the criminal justice system and theories of offending. Included are topics such as prosecutorial charging decisions, racial and gender disparities in sentencing, police use of force, drug and domestic violence courts, and recidivism. The following are examples of studies that have been conducted and published. You can find the full text of each of these articles and of all those presented in the following chapters at ( ).

Can an anticrime strategy that has been effective at reducing certain types of violence also be used to combat open-air drug markets? The "pulling levers" approach involves deterring repeat offenders from crime by targeting them for enhanced prosecution while also encouraging them to change their behavior by offering them access to social services. This strategy has been shown to hold promise with gang members and others at risk for committing violence. The Rockford (Illinois) Police Department (RPD) decided to find out if they could use a pulling levers approach to tackle open-air drug markets and the crime problems caused by these nuisance areas. After the RPD implemented the pulling levers intervention, Corsaro, Brunson, and McGarrell (2013) used official crime data from before and after the intervention to determine whether this approach had been effective. They found that although there was no reduction in violent crime, nonviolent crime (e.g., drug offenses, vandalism, and disorderly conduct) declined noticeably after the intervention. This indicated that the RPD's efforts had worked, because drug and disorder offenses were exactly what the police were trying to reduce.

Are prisoners with low self-control at heightened risk of victimizing, or being victimized by, other inmates? Research has consistently shown that low self-control is related to criminal offending. Some studies have also indicated that this trait is a risk factor for victimization, in that people with low self-control might place themselves in dangerous situations. One of the central tenets of this theory is that self-control is stable and acts in a uniform manner regardless of context. Kerley, Hochstetler, and Copes (2009) tested this theory by examining whether the link between self-control and both offending and victimization held true within the prison environment. Using data gathered from surveys of prison inmates, the researchers discovered that low self-control was only slightly related to in-prison offending and victimization. This result could challenge the assumption that low self-control operates uniformly in all contexts. To the contrary, something about prisoners themselves, the prison environment, or the interaction between the two might change the dynamics of low self-control.

Does school racial composition affect how severely schools punish black and Latino students relative to white ones? Debates about the so-called school-to-prison pipeline emphasize the long-term effects of school disciplinary actions such as suspension, expulsion, and arrest or court referral. Youth who experience these negative outcomes are at elevated risk for dropping out of school and getting involved in delinquency and, eventually, crime. Hughes, Warren, Stewart, Tomaskovic-Devey, and Mears (2017) set out to discover whether schools' and school boards' racial composition affects the treatment of black, Latino, and white students. The researchers drew from two theoretical perspectives: The racial threat perspective argues that minorities are at higher risk for punitive sanctions when minority populations are higher, because whites could perceive minority groups as a threat to their place in society. On the other hand, the intergroup contact perspective suggests that racial and ethnic diversity reduces the harshness of sanctions for minorities, because having contact with members of other racial and ethnic groups diminishes prejudice. Hughes and colleagues used data from the Florida Department of Education, the U.S. Census Bureau, and the Uniform Crime Reports. Statistical results provided support for both perspectives. Increases in the size of the black and Hispanic student populations led to higher rates of suspension for students of these groups. On the other hand, intergroup contact among school board members of different races reduced suspensions for all students. The researchers concluded that interracial contact among school board members equalized disciplinary practices and reduced discriminatory disciplinary practices.

What factors influence police agencies' ability to identify and investigate human trafficking? Human trafficking has been recognized as a transnational crisis. Frequently, local police are the first ones who encounter victims or notice signs suggesting the presence of trafficking. In the United States, however, many local police agencies do not devote systematic attention to methods that would enable them to detect and investigate suspected traffickers. Farrell (2014) sought to learn more about U.S. police agencies' antitrafficking efforts. Using data from two national surveys of medium-to-large municipal police departments, Farrell found that 40% of departments trained their personnel on human trafficking, 17% had written policies pertaining to this crime, and 13% dedicated personnel to it. Twenty-eight percent had investigated at least one trafficking incident in the previous six years. Larger departments were more likely to have formalized responses (training, policies, and dedicated personnel), and departments that instituted these responses were more likely to have engaged in trafficking investigations. These results show a need for departments to continue improving their antitrafficking efforts. Departments that are more responsive to local problems and more open to change will be more effective at combating this crime.

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How safe and effective are conducted energy devices as used by police officers? Conducted energy devices (CEDs) have proliferated in recent years. Their widespread use and the occasional high-profile instances of misuse have generated controversy over whether these devices are safe for suspects and officers alike. Paoline, Terrill, and Ingram (2012) collected use-of-force data from six police agencies nationwide and attempted to determine whether officers who deployed CEDs against suspects were more or less likely to sustain injuries themselves. The authors' statistical analysis suggested a lower probability of officer injury when only CEDs were used. When CEDs were used in combination with other forms of force, however, the probability of officer injury increased. The results suggest that CEDs can enhance officer safety, but they are not a panacea that uniformly protects officers in all situations.

How prevalent is victim precipitation in intimate partner violence? A substantial number of violent crimes are initiated by the person who ultimately becomes the victim in an incident. Muftić, Bouffard, and Bouffard (2007) explored the role of victim precipitation in instances of intimate partner violence (IPV). They gleaned data from IPV arrest reports and found that victim precipitation was present in cases of both male and female arrestees but that it was slightly more common in instances where the woman was the one arrested. This suggests that some women (and, indeed, some men) arrested for IPV might be responding to violence initiated by their partners rather than themselves being the original aggressors. The researchers also discovered that victim precipitation was a large driving force behind dual arrests (cases in which both parties are arrested), because police could either see clearly that both parties were at fault or, alternatively, were unable to determine which party was the primary aggressor. Victim precipitation and the use of dual arrests, then, could be contributing factors behind the recent rise in the number of women arrested for IPV against male partners.

What are the risk factors in a confrontational arrest that are most commonly associated with the death of the suspect? There have been several high-profile instances of suspects dying during physical confrontations with police wherein the officers deployed CEDs against these suspects. White and colleagues (2013) collected data on arrest-related deaths (ARDs) that involved CEDs and gained media attention. The researchers triangulated the data using information from medical-examiner reports. They found that in ARDs, suspects were often intoxicated and extremely physically combative with police. Officers, for their part, had used several other types of force before or after trying to solve the situation using CEDs. Medical examiners most frequently attributed these deaths to drugs, heart problems, and excited delirium. These results suggest that police departments should craft policies to guide officers' use of CEDs against suspects who are physically and mentally incapacitated.

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 data sets 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.

In this book, emphasis is placed on both the production and interpretation of statistics. Every statistical analysis has a producer (someone who runs the analysis) and a consumer (someone to whom an analysis is being presented). Regardless of which role you play in any given situation, it is vital for you to be sufficiently versed in quantitative methods that you can identify the proper statistical technique and correctly interpret the results. 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 trustworthy the results are. Critical thinking skills are an enormous component of statistics. You are not a blank slate standing idly by, waiting to be written on—you are an active agent in your acquisition of knowledge about criminal justice, criminology, and the world in general. Be critical, be skeptical, and never hesitate to ask for more information.

Data Sources 1.1

The Federal Bureau of Investigation (FBI) collects annual data on crimes reported to police agencies nationwide and maintains the UCR. Crimes are sorted into eight index offenses: homicide, rape, robbery, aggravated assault, burglary, larceny-theft, motor vehicle theft, and arson. An important aspect of this data set is that it includes only those crimes that come to the attention of police—crimes that are not reported or otherwise detected by police are not counted. The UCR also conforms to the hierarchy rule, which mandates that in multiple-crime incidents only the most serious offense ends up in the UCR. If, for example, someone breaks into a residence with intent to commit a crime inside the dwelling and while there, kills the homeowner and then sets fire to the structure to hide the crime, he has committed burglary, murder, and arson. Because of the hierarchy rule, though, only the murder would be reported to the FBI—it would be as if the burglary and arson had never occurred. Because of underreporting by victims and the hierarchy rule, the UCR undercounts the amount of crime in the United States. It nonetheless offers valuable information and is widely used. You can explore this data source at www.fbi.gov/about-us/cjis/ucr/ucr.

Data Sources 1.2

The U.S. Census Bureau conducts the periodic 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 (BJS, 2006). 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. The NCVS, though, suffers from the weakness of being based entirely on victims' memory and honesty about the timing and circumstances surrounding criminal incidents. The NCVS also excludes children younger than 12 years, institutionalized populations (e.g., persons in prisons, nursing homes, and hospitals), and the homeless. Despite these problems, the NCVS is useful because it facilitates research into the characteristics of crime victims. The 2015 wave of the NCVS is the most recent version available as of this writing.

Science: Basic Terms and Concepts

Science: The process of gathering and analyzing data in a systematic and controlled way using procedures that are generally accepted by others in the discipline.

Methods: The procedures used to gather and analyze scientific data.

Sample: A subset pulled from a population with the goal of ultimately using the people, objects, or places in the sample as a way to generalize to the population.

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 grounded in **methods**—research results are trustworthy only when the procedures used to arrive at them are considered correct by experts in the scientific community. Nonscientific information is that which is collected informally or without regard for correct methods. 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 group of offenders 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% male, then the sample should also be approximately 50% male. A sample that is only 15% male is not representative of the population. Research-methods courses instruct students on the proper ways to gather representative samples. In a statistics course, the focus is on techniques used to analyze the data to look for patterns and test for relationships. Together, proper methods of gathering and analyzing data form the groundwork for scientific inquiry. If there is a flaw in either the gathering or the analyzing of data, then the results might not be trustworthy. Garbage in, garbage out (GIGO) is the mantra of statistics. Data gathered with the best of methods can be rendered worthless if the wrong statistical analysis is applied to them; likewise, the most sophisticated, cutting-edge statistical technique cannot salvage improperly collected data. When the data or the statistics are defective, the results are likewise deficient and cannot be trusted. Studies using unscientific data or flawed statistical analyses do not contribute to theory and research or to policy and practice because their findings are unreliable and could be erroneous.

Population: The universe of people, objects, or locations that researchers wish to study. These groups are often very large.

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% of the defendants processed through a local criminal court in 1 year

Everybody who conducts a study has an obligation to be clear and open about the methods they used. You should expect detailed reports on the procedures used so that you can evaluate whether they followed proper scientific methods. When the methods used to collect and analyze data are sound, it is not appropriate to question scientific results on the basis of a moral, emotional, or opinionated objection to them. On the other hand, it is entirely correct (and is necessary, in fact) to question results when methodological or statistical procedures are shoddy or inadequate. Remember GIGO!

A key aspect of science is the importance of **replication**. No single study ever proves something definitively; quite to the contrary, much testing must be done before firm conclusions can be drawn. Replication is important because there are times when a study is flawed and needs to be redone or when the original study 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 or might not have similar positive results with juveniles. Replicating the treatment and evaluation with a sample of juvenile offenders would provide information about whether the program is helpful to both adults and juveniles or is only appropriate for adults. 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.

Replication: The repetition of a particular study that is conducted for purposes of determining whether the original study's results hold when new samples or measures are employed.

Types of Scientific Research in Criminal Justice and Criminology

Theory: A set of proposed and testable explanations about reality that are bound together by logic and evidence.

Hypothesis: A single proposition, deduced from a theory, that must hold true in order for the theory itself to be considered valid.

Evaluation research: Studies intended to assess the results of programs or interventions for purposes of discovering whether those programs or interventions appear to be effective.

Exploratory research: Studies that address issues that have not been examined much or at all in prior research and that therefore might lack firm theoretical and empirical grounding.

Descriptive research: Studies done solely for the purpose of describing a particular phenomenon as it occurs in a sample.

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 in order 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 a test of the general theory of crime conducted by Kerley et al. (2009). The general theory holds that low self-control is a static predictor of offending and victimization, regardless of context. From this proposition, the researchers deduced the hypothesis that the relationship between low self-control and both offending and victimization must hold true in the prison environment. Their results showed an overall lack of support for the hypothesis that low self-control operates uniformly in all contexts, thus calling that aspect of the general theory of crime into question. This is an example of a study designed to test a theory.

Evaluation research is also common in criminal justice and criminology. In Research Example 1.1, the article by Corsaro et al. (2013) is an example of evaluation research. 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. In this study, the RPD implemented a pulling levers approach to combat drug and nuisance offending. After the program had been put into place, the researchers analyzed crime data to find out whether the approach was effective.

Exploratory research occurs when there is limited knowledge about a certain phenomenon; researchers essentially embark into unfamiliar territory when they attempt to study this social event. The study by Muftić et al. (2007) in Research Example 1.1 was exploratory in nature because so little is known about victim precipitation, particularly in the realm of IPV. It is often dangerous to venture into new areas of study when the theoretical guidance is spotty; however, exploratory studies have the potential to open new areas of research that have been neglected but that provide rich information that expands the overall body of knowledge.

Finally, some research is **descriptive** in nature. White et al.'s (2013) analysis of CED-involved deaths illustrates a descriptive study. White and colleagues did not set out to test a theory or to explore a new area of research—they merely offered basic descriptive information about the suspects, officers, and situations involved in instances where CED use was associated with a suspect's death. In descriptive research, no generalizations are made to larger groups; the conclusions drawn from these studies are specific to the objects, events, or people being analyzed. This type of research can be very informative when knowledge about a particular phenomenon is scant.

With the exception of purely descriptive research, the ultimate goal in most statistical analyses is to generalize from a sample to a population. 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 (e.g., a

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. He gathers news articles that report on female serial killers and records information about each killer's life history and the type of victim she preyed on.

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 go through the program. 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 researcher notes that relatively little research has been conducted on the possible effects of military service on later crime commission. She collects a sample of people who served in the military and a sample of people that did not and compares them to determine whether the military group differs from the nonmilitary group in terms of the numbers or types of crimes committed.

Probability sampling: A sampling technique in which all people, objects, or areas in a population have a known chance of being selected into the sample.

sample of people should contain a breakdown of race, gender, and age similar to that found in the population). Samples are smaller than populations, and researchers are therefore able to measure and analyze them. The results found in the sample are then generalized to the population.

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. The most common in criminal justice and criminology research are SPSS, Stata, and SAS. Each of these packages has strengths and weaknesses.

Simplicity and ease of use makes SPSS a good place to start for people new to statistical analysis. Stata is a powerful program excellent for regression modeling. The SAS package is the best one for extremely large data sets.

This book incorporates SPSS into each chapter. This allows you to get a sense for what data look like when displayed in their raw format and permits you to run particular analyses and read and interpret program output. Where relevant, the chapters offer SPSS practice problems and accompanying data sets that are available for download from **www.sagepub.com/gau**. 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. Some of this material will be review for students who have taken a methods course. Chapter 3 delves into charts and graphs as means of graphically displaying data. Measures of central tendency are the topic of Chapter 4. These are descriptive statistics that 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 with its coverage 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 the concepts learned in 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. In Chapter 13, you will learn about correlations. Finally, Chapter 14 wraps up the book with an introduction to bivariate and multiple regression.

The prerequisite that is indispensable to success in this course is a solid background in algebra. You absolutely must be comfortable with basic techniques such as adding, subtracting, multiplying, and dividing. You also need to understand the difference between positive and negative numbers. You will be required to plug numbers into equations and solve those equations. You should not have a problem with this as long as you remember the lessons you learned in your high school and college algebra courses.

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. If necessary, use them to brush up on your skills.

Statistics are cumulative in that many of the concepts you learn at the beginning form the building blocks for more-complex techniques that you will learn about as the course progresses. Means, proportions, and standard deviations, for instance, are concepts you will learn about in Part I, but they will remain relevant throughout the remainder of the book. You must, therefore, learn these fundamental calculations well and you must remember them.

Repetition is the 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 just 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 statistics. Everyone has to go through the learning process. You will complete this process successfully as long as you have basic algebra skills and are willing to put in the time and effort it takes to succeed.

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.

Suppose you tell a friend that you are taking a statistics course, and your friend reacts with surprise that a criminology or criminal justice degree program would require students to take this class. Your friend argues that although it is necessary for people whose careers are dedicated to research to have a good understanding of statistics, 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 possessing an understanding of statistical concepts and techniques.

Define science and explain the role of methods in the production of scientific knowledge.

What is a population? Why are researchers usually unable to study populations directly?

What is a sample? Why do researchers draw samples?

Explain the role of replication in science.

List and briefly describe the different types of research in criminal justice and criminology.

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.

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.

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.

If a researcher were solely interested in finding out more about a particular phenomenon and focused entirely on a sample without trying to make inference to a population, what kind of research would he be doing? Explain your answer.

What does GIGO stand for? What does this cautionary concept mean in the context of statistical analyses?

CHAPTER

2

Types of Variables and Levels of Measurement

The first thing you must be familiar with in statistics is the concept of a **variable**. A variable is, quite simply, something that varies. It is a coding scheme used to measure a particular characteristic of interest. For instance, asking all of your statistics classmates, "How many classes are you taking this term?" 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 of course the answer they would all provide is "yes."

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.

Units of Analysis

It seems rather self-evident, but nonetheless bears explicit mention, that every scientific study contains *something* that the researcher conducting the study gathers and examines. These "somethings" can be objects or entities such as rocks, people, molecules, or prisons. This is called the **unit of analysis**, and it is, essentially, whatever the sample under study 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. Larger units are also popular; for example, many studies focus on census tracks, block groups, cities, states, or even countries. Research Example 2.2 describes the methodological setup of a selection of criminal justice studies, each of which employed a different unit of analysis.

Variable: A characteristic that describes people, objects, or places and takes on multiple values in a sample or population.

Constant: A characteristic that describes people, objects, or places and takes on only one value in a sample or population.

Unit of analysis: The object or target of a research study.

Independent Variables and Dependent Variables

Researchers in criminal justice and criminology typically seek to examine relationships between two or more variables.

Research Example 2.1

Conducted energy devices (CEDs) such as the Taser have garnered national—indeed, international—attention in the past few years. Police practitioners contend that CEDs are invaluable tools that minimize injuries to both officers and suspects during contentious confrontations, whereas critics argue that police sometimes use CEDs in situations where such a high level of force is not warranted. Do police seem to be using CEDs appropriately? Gau, Mosher, and Pratt (2010) addressed this question. They sought to determine whether suspects' race or ethnicity influenced the likelihood that police officers would deploy or threaten to deploy CEDs against those suspects. In an analysis of this sort, it is important to account for other variables that might be related to police use of CEDs or other types of force; therefore, the researchers included suspects' age, sex, and resistance level. They also measured officers' age, sex, and race. Finally, they included a variable indicating whether it was light or dark outside at the time of the encounter. The researchers found that police use of CEDs was driven primarily by the type and intensity of suspect resistance but that even controlling for resistance, Latino suspects faced an elevated probability of having CEDs either drawn or deployed against them.

Research Example 2.2

Each of the following studies used a different unit of analysis.

Do prison inmates incarcerated in facilities far from their homes commit more misconduct than those housed in facilities closer to home? Lindsey, Mears, Cochran, Bales, and Stults (2017) used data from the Florida Department of Corrections to find out whether distally placed inmates (i.e., those sent to facilities far from their homes) engaged in more in-prison misbehavior, and, if so, whether this effect was particularly pronounced for younger inmates. Individual prisoners were the units of analysis in this study. The findings revealed a curvilinear relationship between distance and misconduct: Prisoners' misconduct increased along with distance up to approximately 350 miles, but then the relationship inverted such that further increases in distance were associated with less misconduct. As predicted, this pattern was strongest among younger inmates. Visitation helped offset the negative impact of distance but did not eliminate it. The researchers concluded that family visitation might have mixed effects on inmates.

Inmates might be less inclined to commit misconduct if they fear losing visitation privileges, but receiving visits might induce embarrassment and shame when their family sees them confined in the prison environment. This strain, in turn, could prompt them to act out. Those who do not see their families much or at all do not experience this unpleasant emotional reaction.

Is the individual choice to keep a firearm in the home affected by local levels of crime and police strength? Kleck and Kovandzic (2009), using individual-level data from the General Social Survey (GSS) and city-level data from the FBI, set out to determine whether city-level homicide rates and the number of police per 100,000 city residents affected GSS respondents' likelihood of owning a firearm. There were two units of analysis in this study: individuals and cities. The statistical models indicated that high homicide rates and low police levels both modestly increased the likelihood that a given person would own a handgun; however, the relationship between city homicide rate and individual gun ownership decreased markedly when the authors controlled for whites' and other nonblacks' racist attitudes toward African Americans. It thus appeared that the homicide–gun ownership relationship was explained in part by the fact that those who harbored racist sentiments against blacks were more likely to own firearms regardless of the local homicide rate.

How consistent are use-of-force policies across police agencies? The U.S. Supreme Court case *Graham v. Connor* (1989) requires that police officers use only the amount of force necessary to subdue a resistant suspect; force exceeding that minimum is considered excessive. The Court left it up to police agencies to establish force policies to guide officers' use of physical coercion. Terrill and Paoline (2013) sought to determine what these policies look like and how consistent they are across agencies. The researchers mailed surveys to a sample of 1,083 municipal police departments and county sheriff offices nationwide, making the agency the unit of analysis. Results showed that 80% of agencies used a force continuum as part of their written use-of-force policies, suggesting some predictability in the way in which agencies organize their policies. However, there was substantial variation in policy restrictiveness and the placement of different techniques and weapons. Most agencies placed officer presence and verbal commands at the lowest end, and deadly force at the highest, but between those extremes there was variability in the placement of soft and hard hand tactics, chemical sprays, impact weapons, CEDs, and other methods commonly used to subdue noncompliant suspects. These findings show how localized force policies are, and how inconsistent they are across agencies.

Does gentrification reduce gang homicide? Gentrification is the process by which distressed inner-city areas are transformed by an influx of new businesses or higher-income residents. Gentrification advocates argue that the economic boost will revitalize the area, provide new opportunities, and reduce crime.

(Continued)

(Continued)

Is this assertion true? Smith (2014) collected data from 1994 to 2005 on all 342 neighborhoods in Chicago with the intention of determining whether gentrification over time reduces gang-motivated homicide. Smith measured gentrification in three ways: Recent increases in neighborhood residents' socioeconomic statuses, increases in coffee shops, and demolition of public housing. The author predicted that the first two would suppress gang homicide and that the last one would increase it; even though public-housing demolition is supposed to reduce crime, it can also create turmoil, residential displacement, and conflict among former public-housing residents and residents of surrounding properties. Smith found support for all three hypotheses. Socioeconomic-status increases were strongly related to reductions in gang-motivated homicides, coffee-shop presence was weakly related to reductions, and public-housing demolition was robustly associated with increases. These results suggest that certain forms of gentrification might be beneficial to troubled inner-city neighborhoods but that demolishing public housing might cause more problems than it solves, at least in the short term.

Empirical: Having the qualities of being measurable, observable, or tangible. Empirical phenomena are detectable with senses such as sight, hearing, or touch.

Dependent variable: The phenomenon that a researcher wishes to study, explain, or predict.

Independent variable: A factor or characteristic that is used to try to explain or predict a dependent variable.

Observed or **empirical** phenomena give rise to questions about the underlying forces driving them. Take homicide as an example. Homicide events and city-level rates are empirical phenomena. It is worthy of note that Washington, D.C., has a higher homicide rate than Portland, Oregon. Researchers usually want to do more than merely note empirical findings, however—they want to know *why* things are the way they are. They might, then, attempt to identify the criminogenic (crime-producing) factors that are present in Washington but absent in Portland or, conversely, the protective factors possessed by Portland and lacked by Washington.

Researchers undertaking quantitative studies must specify **dependent variables** (DVs) and **independent variables** (IVs). Dependent variables are the empirical events that a researcher is attempting to explain. Homicide rates, property crime rates, recidivism among recently released prisoners, and judicial sentencing decisions are examples of DVs. Researchers seek to identify variables that help predict or explain these events. Independent variables are factors a researcher believes might affect the DV. It might be predicted, for instance, that prisoners released into economically and socially distressed neighborhoods and given little support during the reentry process will recidivate more frequently than those who receive transitional housing and employment assistance. Different variables—crime rates, for instance—can be used as both IVs and DVs across different studies. The designation of a certain phenomenon as an IV or a DV depends on the nature of the research study.

Relationships Between Variables: A Cautionary Note

It is vital to understand that *independent* and *dependent* are not synonymous with *cause* and *effect*, respectively. A particular IV might be related to a certain DV, but this is far from definitive proof that the former is the cause of the latter. To establish causality, researchers must demonstrate that their studies meet three criteria. First is **temporal ordering**, meaning that the IV must occur prior to the DV. It would be illogical, for instance, to predict that adolescents' participation in delinquency will impact their gender; conversely, it does make sense to predict that adolescents' gender affects the likelihood they will commit delinquent acts. The second causality requirement is that there be an **empirical relationship** between the IV and the DV. This is a basic necessity—it does not make sense to try to delve into the nuances of a nonexistent connection between two variables. 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.

The last requirement is that the relationship between the IV and the DV be **nonspurious**. This third criterion is frequently the hardest to overcome in criminology and criminal justice research (indeed, all social sciences) because human behavior is complicated, and each action a person engages in has multiple causes. Disentangling these causal factors can be difficult or impossible.

The reason spuriousness is a problem is that there could be a third variable that explains the DV as well as, or even better than, the IV does. This third variable might partially or fully account for the relationship between the IV and DV. The inadvertent exclusion of one or more important variables can result in erroneous conclusions because the researcher might mistakenly believe that the IV strongly predicts the DV when, in fact, the relationship is actually partially or entirely due to intervening factors. Another term for this problem is **omitted variable bias**. When omitted variable bias (i.e., spuriousness) is present in an IV–DV relationship but erroneously goes unrecognized, people can reach the wrong conclusion about a phenomenon. Research Example 2.3 offers examples of the problem of omitted variables.

A final caution with respect to causality is that statistical analyses are examinations of aggregate trends. Uncovering an association between an IV and a DV means only that the presence of the IV has the *tendency* to be related to either an increase or a reduction in the DV in the sample as a whole—it is not an indication that the IV–DV link inevitably holds true for every single person or object in the sample. For example, victims of early childhood trauma are more likely than nonvictims to develop substance abuse disorders later in life (see Dass-Brailsford & Myrick, 2010). Does this mean that every person who was victimized as a child has substance abuse problems as an adult? Certainly not! Many people who suffer childhood abuse do not become addicted to alcohol or other drugs. Early trauma is a risk factor that elevates the risk of substance abuse, but it is not a guarantee of this outcome. Associations present in a large group are not uniformly true of all members of that group.

Temporal ordering: The causality requirement holding that an independent variable must precede a dependent variable.

Empirical relationship: The causality requirement holding that the independent and dependent variables possess an observed relationship with one another.

Nonspuriousness: The causality requirement holding that the relationship between the independent variable and dependent variable not be the product of a third variable that has been erroneously omitted from the analysis.

Omitted variable bias: An error that occurs as a result of unrecognized spuriousness and a failure to include important third variables in an analysis, leading to incorrect conclusions about the relationship between the independent and dependent variables.

Research Example 2.3

In the 1980s and 1990s a media and political frenzy propelled the "crack baby" panic to the top of the national conversation. The allegations were that "crack mothers" were abusing the drug while pregnant and were doing irreparable damage to their unborn children. Stories of low-birth-weight, neurologically impaired newborns abounded. What often got overlooked, though, was the fact that women who use crack cocaine while pregnant are also likely to use drugs such as tobacco and alcohol, which are known to harm fetuses. These women also frequently have little or no access to prenatal nutrition and medical care. Finally, if a woman abuses crack—or any other drug—while pregnant, she could also be at risk for mistreating her child after its birth (see Logan, 1999, for a review). She might be socially isolated, as well, and have no support from her partner or family. There are many factors that affect fetal and neonatal development, some under mothers' control and some not; trying to tie children's outcomes definitively to a single drug consumed during mothers' pregnancies is inherently problematic.

In the 1980s, policymakers and the public became increasingly concerned about domestic violence. This type of violence had historically been treated as a private affair, and police tended to take a hands-off approach that left victims stranded and vulnerable. The widely publicized results of the Minneapolis Domestic Violence Experiment suggested that arrest effectively deterred abusers, leading to lower rates of recidivism. Even though the study's authors said that more research was needed, states scrambled to enact mandatory arrest laws requiring officers to make arrests in all substantiated cases of domestic violence. Subsequent experiments and more detailed analyses of the Minneapolis data, however, called the effectiveness of arrest into question. It turns out that arrest has no effect on some offenders and even increases recidivism among certain groups. Offenders' employment status, in particular, emerged as an important predictor of whether arrest deterred future offending. Additionally, the initial reduction in violence following arrest frequently wore off over time, putting victims back at risk. Pervasive problems collecting valid, reliable data also hampered researchers' ability to reach trustworthy conclusions about the true impact of arrest (see Schmidt & Sherman, 1993, for a review). The causes of domestic violence are numerous and varied, so it is unwise to assume that arrest will be uniformly advantageous.

In sum, you should always be cautious when interpreting IV–DV relationships. It is better to think of IVs as *predictors* and DVs as *outcomes* rather than to view them as causes and effects. As the adage goes, correlation does not mean causation. Variables of all kinds are related to each other, but it is important not to leap carelessly to causal conclusions on the basis of statistical associations.

Levels of Measurement

Every variable possesses a **level of measurement**. Levels of measurement are ways of classifying or describing variable types. There are two overarching classes of variables: **categorical** (also sometimes called *qualitative*) and **continuous** (also sometimes referred to as *quantitative*). Categorical variables comprise groups or classifications that are represented with labels, whereas continuous variables are made of numbers that measure how much of a particular characteristic a person or object possesses. Each of these variable types contains two subtypes. This two-tiered classification system is diagrammed in Figure 2.1 and discussed in the following sections.

Level of measurement: A variable's specific type or classification. There are four types: *nominal, ordinal, interval,* and *ratio.*

Categorical variable: A variable that classifies people or objects into groups. There are two types: *nominal* and *ordinal.*

Continuous variable: A variable that numerically measures the presence of a particular characteristic. There are two types: *interval* and *ratio.*

The Categorical Level of Measurement: Nominal and Ordinal Variables

Categorical variables are made up of categories. They represent ways of divvying up people and objects according to some characteristic. Categorical variables are subdivided into two types: *nominal* and *ordinal*. The **nominal** level of measurement is the most rudimentary of all the levels. It is the least descriptive and sometimes the least informative. Race is an example of a nominal-level variable. See Tables 2.1 and 2.2 for examples of nominal variables (see also Data Sources 2.1 for a description of the data set used in these tables). The variable in Table 2.1 comes from a question on the survey asking respondents whether or not they personally know a police officer assigned to their neighborhood. This variable is nominal because respondents said "yes" or "no" in response and so can be grouped accordingly. In Table 2.2, the variable representing the races of stopped drivers is nominal because races are groups into which people are placed. The labels offer descriptive information about the people or objects within each category. Data are from the Police–Public Contact Survey (PPCS).

Nominal variable: A classification that places people or objects into different groups according to a particular characteristic that cannot be ranked in terms of quantity.

Figure 2.1 Levels of Measurement

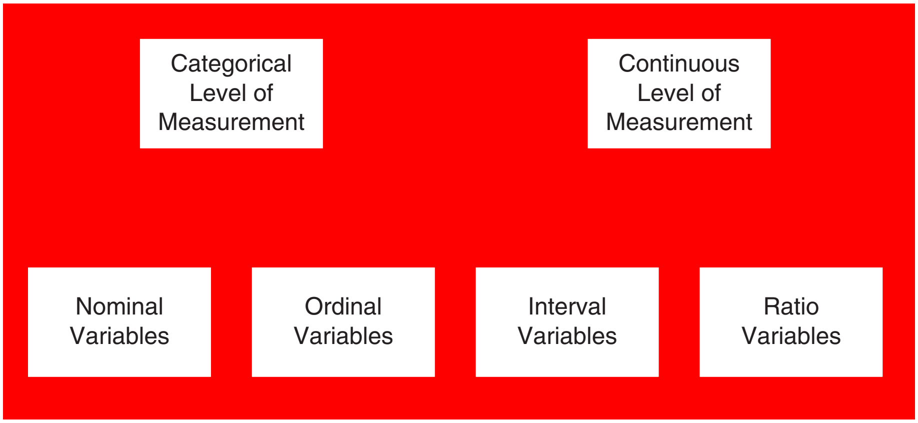

Table 2.1 Knowledge of Police in the Neighborhood (PPCS)	
Do you know any police officers that work in your neighborhood by name or by sight?	***Frequency***
Yes	9,246
No	32,263
	Total = 41,509

Table 2.2 Race of Stopped Drivers (PPCS)	
Driver Race	***Frequency***
White	416
Black	63
Asian	14
Other, including multiracial	26
	Total = 519

Data Sources 2.1

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 (BJS, 2011). This data set is used by BJS statisticians to estimate the number of police–citizen contacts that take place each year and is used by researchers to study suspect, officer, and situational characteristics of police–public contacts. The 2011 wave of the PPCS is the most current one available at this time.

Gender is another example of a nominal variable. Table 2.3 displays the gender breakdown among people who reported that they had sought help from the police within the past year.

Table 2.3 Gender of People Who Sought Help From Police (PPCS)

Gender	Frequency
Male	1,511
Female	1,904
	Total = 3,415

Much information is missing from the nominal variables in Tables 2.1 through 2.3. For instance, the question about knowing a local police officer does not tell us how often respondents talk to the officers they know or whether they provide these officers with information about the area. Similarly, the race variable provides fairly basic information. 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—they are merely of different races. The same applies to gender. Most people identify as being either female or male, but members of one gender group do not have more or less gender relative to members of the other group.

One property that nominal variables possess (and share with other levels) is that the categories within any given variable are **mutually exclusive** and **exhaustive**. They are mutually exclusive because each unit in the data set (person, place, and so on) can fall into only one category. They are exhaustive because all units have a category that applies to them. For example, a variable measuring survey respondents' criminal histories that asks them if they have been arrested "0–1 time" or "1–2 times" would not be mutually exclusive because a respondent who has been arrested once could circle both answer options. This variable would also violate the principle of exhaustiveness because someone who has been arrested three or more times cannot circle any available option because neither is applicable. To correct these problems, the answer options could be changed to, for instance, "no arrests," "1–2 arrests," and "3 or more arrests." Everyone filling out the survey would have one, and only one, answer option that accurately reflected their experiences.

Ordinal variables are one step up from nominal variables 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 according to how many credits they have earned. Numbers can also be represented as ordinal classifications when the numbers have been grouped into ranges like those in Table 2.3, where the income categories of respondents to the General Social Survey (GSS; see Data Sources 2.2) are shown. Table 2.4 displays another variable from the PPCS. This survey question queried respondents about how often they drive. Respondents were offered categories and selected the one that most accurately described them.

Mutually exclusive: A property of all levels of measurement whereby there is no overlap between the categories within a variable.

Exhaustive: A property of all levels of measurement whereby the categories or range within a variable capture all possible values.

Ordinal variable: A classification that places people or objects into different groups according to a particular characteristic that can be ranked in terms of quantity.

Ordinal variables are useful because they allow people or objects to be ranked in a meaningful order. Ordinal variables are limited, though, by the fact that no algebraic techniques can be applied to them. This includes ordinal variables made from numbers such as those in Table 2.3. It is impossible, for instance, to subtract *<$1,000* from *$15,000–$19,999*. This eliminates the ability to determine exactly how far apart two respondents are in their income levels. The difference between someone in the *$20,000–$24,999* group and the *≥$25,000* group might only be $1 if the former makes $24,999 and the latter makes $25,000. The difference could be enormous, however, if the person in the *≥$25,000* group has an annual family income of $500,000 per year. There is no way to figure this out from an assortment of categories like those in Table 2.3. The same limitation applies to the variable in Table 2.4. A glance at the table reveals general information about the frequency of driving, but there is no way to add, subtract, multiply, or divide the categories to obtain a specific measurement of how more or less one person in the sample drives relative to another.

Learning Check 2.1

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

Table 2.4 Annual Family Income (GSS)

Family Income	*Frequency*
<$1,000	40
$1,000–$2,999	32
$3,000–$3,999	19
$4,000–$4,999	14
$5,000–$5,999	20
$6,000–$6,999	18
$7,000–$7,999	16
$8,000–$9,999	50
$10,000–$14,999	150
$15,000–$19,999	114
$20,000–$24,999	157
≥$25,000	1,684
	Total = 2,314

Table 2.5 Driving Habits (PPCS)

How often do you drive?	*Frequency*
Every day or almost every day	29,442
A few days a week	5,833
A few days a month	1,235
A few times a year	395
Never	4,623
	Total = 41,528

Data Sources 2.2

The National Opinion Research Center has conducted the GSS annually or every 2 years since 1972. Respondents are selected using a multistage clustering sample design. First, cities and counties are randomly selected. Second, block groups or districts are selected from those cities and counties. Trained researchers then canvass each block group or district on foot and interview people in person. Interviews are offered in both English and Spanish. The GSS contains a large number of variables. Some of these variables are asked in every wave of the survey, whereas others are asked only once. The variables include respondents' attitudes about religion, politics, abortion, the death penalty, gays and lesbians, persons of racial groups other than respondents' own, free speech, marijuana legalization, and a host of other topics (Davis & Smith, 2009). The most current wave of the GSS available at this time is the one conducted in 2014.

Table 2.6 contains another example of an ordinal variable. This comes from the GSS and measures female respondents' educational attainment. You can see that this variable is categorical and ranked. Someone who has attended junior college has a higher educational attainment than someone who did not complete high school. As before, though, no math is possible. Someone whose highest education level is junior college might be in her first semester or quarter, putting her barely above someone in the high-school-only category, or she might be on the verge of completing her associate's degree, which places her nearly two years above.

Table 2.6 Female Respondents' Educational Levels (GSS)

Highest Schooling Completed	*Frequency*
Less than High School	198
High School	673
Associate's Degree	122
Bachelor's Degree	257
Graduate Degree	147
	Total = 1,397

The Continuous Level of Measurement: Interval and Ratio Variables

Interval variable: A quantitative variable that numerically measures the extent to which a particular characteristic is present or absent and does not have a true zero point.

Continuous variables differ from categorical ones in that the former are represented not by categories but rather by numbers. **Interval variables** are numerical scales in which there are 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 exactly 1 degree cooler than 21 degrees and exactly 4 degrees warmer than 16 degrees.

An example of an interval-level variable is the GSS's scoring of respondents' occupational prestige. The GSS uses a ranking system to assign each person a number representing how prestigious his or her occupation is. Figure 2.2 displays the results. The scores range from 16 to 80 and so are presented as a chart rather than a table.

As can be seen in Figure 2.2, the prestige scores are numerical. This sets them apart from the categories seen in nominal and ordinal variables. The scores can be subtracted from one another; for instance, a respondent with a prestige score of 47 has 9 points fewer than someone whose score is 56. Importantly, however, the scores cannot be multiplied or divided. It does not make sense to say that someone with a score of 60 has twice the occupational prestige as someone with a 30. This is because interval data, such as this scale, do not have a true zero point. The numbers, although useful and informative, are ultimately arbitrary. An occupational prestige score of 30, for instance, could have been any other number if a different coding system had been employed.

Table 2.7 contains another interval variable. This one measures GSS respondents' political views. The scale ranges from 1 (extremely liberal) to 7 (extremely conservative). This variable in Table 2.7 is interval because it is a scale (as opposed to distinctly separate categories), but lacks a zero point and therefore is an arbitrary numbering system. The 1-to-7 numbering system could be replaced by any other 7-point consecutive sequence without affecting the meaning of the scale. These are the hallmark identifiers of interval-level data.

Figure 2.2 Respondents' Occupational Prestige Scores (GSS)

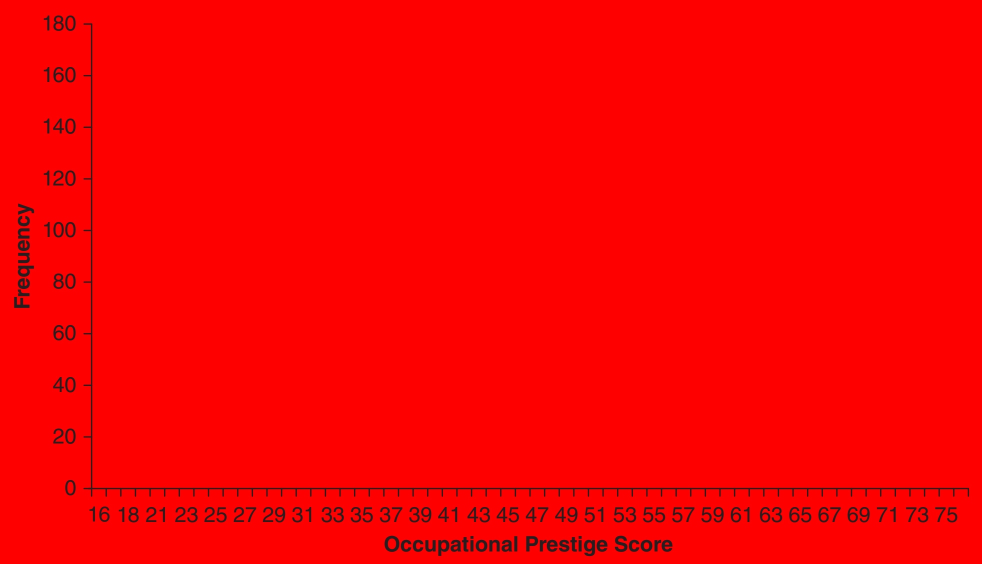

Table 2.7 Respondents' Political Views (GSS)

Political Views	*Frequency*
1 (extremely liberal)	94
2	304
3	263
4	989
5	334
6	358
7 (extremely conservative)	107
	Total = 2,449

Another attitudinal variable measured at the interval level is shown in Table 2.8. This is a scale tapping into how punitive GSS respondents feel toward people convicted of crimes. The scale ranges from the lower range of punitiveness to the upper range. The idea behind attitudinal scores being interval (as opposed to categorical) is that attitudes are best viewed as a continuum. There is a lot of gray area that prevents attitudes from

Table 2.8 Punitiveness Scores (GSS)

Political Views	*Frequency*
1 (least punitive)	191
2	358
3	643
4 (most punitive)	1,002
	Total = 2,194

being accurately portrayed as ordinal; chunking attitudes up into categories introduces artificial separation between the people falling into adjacent positions on the scale.

Ratio variable: A quantitative variable that numerically measures the extent to which a particular characteristic is present or absent and has a true zero point.

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. The difference is that ratio-level scales, unlike interval ones, have meaningful zero points that represent the absence of a given characteristic. Temperature, for instance, is not ratio level because the zeros in the various temperature scales are just placeholders. Zero does not signify an *absence* of temperature. Likewise, the data presented in Figure 2.2 and Tables 2.7 and 2.8, as discussed previously, do not have meaningful zero points and therefore cannot be multiplied or divided. You could not, for instance, say that someone who scores a 4 on the punitiveness scale is twice as punitive as a person with a 2 on this measure. Ratio-level data permit this higher level of detail.

Criminal justice and criminology researchers deal with many ratio-level variables. Age is one example. Although it is strange to think of someone as having zero age, age can be traced close enough to zero to make analytically reasonable to think of this variable as ratio. A 40-year-old person is twice as old as someone who is 20.

Table 2.9 displays the number of state prisoners who were executed in 2013. These data come from the BJS (Snell, 2014; see Data Sources 2.3). The left-hand column of the table displays the number of people executed per state, and the right-hand column shows the frequency with which each of those state-level numbers occurred (note that the frequency column sums to 50 to represent all of the states in the country). Can you explain why *number of persons executed* is a ratio-level variable?

In Table 2.10, the number of children GSS respondents report having is shown. Since the zero is meaningful here, this qualifies as ratio level.

Learning Check 2.2

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

Table 2.9 Number of Persons Executed, 2013

Number Executed	*Frequency*
0	41
1	3
2	2
3	1
6	1
7	1
16	1
	Total = 50

Another example of the ratio level of measurement is offered in Figure 2.3. These data come from a question on the PPCS asking respondents who had been the subject of a traffic or pedestrian stop in the past 12 months the number of minutes the stop lasted. Time is ratio level because, in theory, it can be reduced down to zero, even if nobody in the sample actually reported zero as their answer.

Figure 2.3 Length of Stop, in Minutes (PPCS)

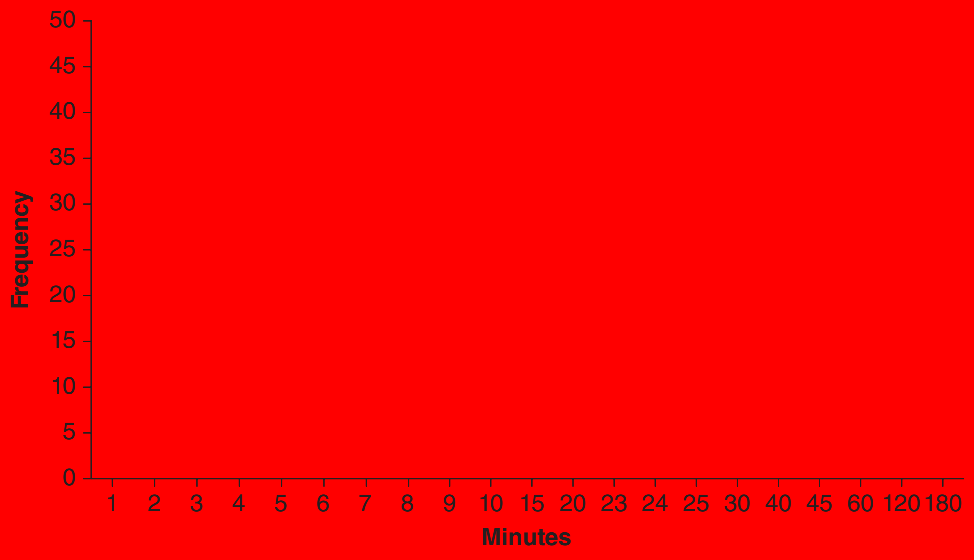

Table 2.10 Number of Children (GSS)

Children	Frequency
0	704
1	419
2	658
3	394
4	198
5	88
6	40
7	14
8	15
	Total = 2,530

Data Sources 2.3

The BJS is the U.S. Department of Justice's repository for statistical information on criminal justice–related topics. The BJS offers downloadable data and periodic reports on various topics that summarize the data and present them in a user-friendly format. Researchers, practitioners, and students all rely on the BJS for accurate, timely information about crime, victims, sentences, prisoners, and more. Visit http://bjs.ojp.usdoj.gov/ and explore this valuable information source.

In the real world of statistical analysis, the terms *interval* and *ratio variables* are often used interchangeably. It is the overarching categorical-versus-continuous distinction that usually matters most when it comes to statistical analyses. When a researcher is collecting data and has a choice about level of measurement, the best strategy is to always use the highest level possible. A continuous variable can always be made categorical later, but a categorical variable can never be made continuous.

Level of measurement is a very important concept. It might be difficult to grasp if this is the first time you have been exposed to this idea; however, it is imperative that you gain a firm understanding because level of measurement determines what analyses can and cannot be conducted. This fundamental point will form an underlying theme of this entire book, so be sure you understand it. Do not proceed with the book until you can readily identify a given variable's level of measurement. Table 2.11 summarizes the basic characteristics that define each level and distinguish it from the others.

Table 2.11 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	✓	✓	✓	✓

This chapter discussed the concept of a variable. You also read about units of analysis, independent variables, dependent variables, and about the importance of not drawing strict causal conclusions about statistical relationships. It is important to consider whether meaningful variables have been left out and to keep in mind that empirical associations do not imply that one variable causes the other.

This chapter also described the two overarching levels of measurement: categorical and continuous. 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 understand this concept and 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 graphing and analytic techniques that can be employed. In other words, each type of graph or statistical analysis can be used with some levels of measurement and cannot be used with others. Using the wrong statistical procedure can produce wildly inaccurate results and conclusions. You must therefore possess an understanding of level of measurement before leaving this chapter.

Suppose you have been contacted by a reporter from the local newspaper who came across data showing that men tend to be sentenced more harshly than women (e.g., more likely to be sent to prison, given longer sentence lengths). The reporter believes this to be a clear case of discrimination and asks you for comment. What is your response? Do you agree that gender discrimination has been demonstrated here, or do you need more information? If the latter, what additional data would you need before you could arrive at a conclusion?

Many researchers have tried to determine whether capital punishment deters murder. Suppose a new study has been published analyzing how death-sentence rates in one year relate to murder rates the following year. The researchers who conducted this study included only the 32 states that authorize the death penalty, and excluded the remaining states. Do you think this is a justifiable approach to studying the possible deterrent effects of the death penalty? Would you trust the results of the analysis and the conclusions the researchers reach on the basis of those results? Explain your answer.

A researcher wishes to test the hypothesis that low education affects crime. She gathers a sample of people aged 25 and older.

What is the independent variable?

What is the dependent variable?

What is the unit of analysis?

A researcher wishes to test the hypothesis that arrest deters recidivism. She gathers a sample of people who have been arrested.

What is the independent variable?

What is the dependent variable?

What is the unit of analysis?

A researcher wishes to test the hypothesis that poverty affects violent crime. He gathers a sample of neighborhoods.

What is the independent variable?

What is the dependent variable?

What is the unit of analysis?

A researcher wishes to test the hypothesis that prison architectural design affects the number of inmate-on-inmate assaults that take place inside a facility. He gathers a sample of prisons.

What is the independent variable?

What is the dependent variable?

What is the unit of analysis?

A researcher wishes to test the hypothesis that the amount of money a country spends on education, health, and welfare affects the level of violent crime in that country. She gathers a sample of countries.

What is the independent variable?

What is the dependent variable?

What is the unit of analysis?

A researcher wishes to test the hypothesis that police officers' job satisfaction affects the length of time they stay in their jobs. He gathers a sample of police officers.

What is the independent variable?

What is the dependent variable?

What is the unit of analysis?

A researcher wishes to test the hypothesis that the location of a police department in either a rural or an urban area affects starting pay for