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THE CHICAGO GUIDE TO WRITING ABOUT Numbers

SECOND EDITION

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To my parents,

for nurturing my

love of numbers

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SEVEN BASIC PRINCIPLES

In this chapter, I introduce seven basic principles to increase the precision and power of your quantitative writing. I begin with the simplest, most general principles, several of which are equally applicable to other types of writing: setting the context; choosing simple, plausible examples; and defining your terms. Next, I introduce principles for choosing among prose, tables, and charts. Last, I cover several principles that are more specific to quantitative tasks: reporting and interpreting numbers, specifying direction and magnitude of associations, and summarizing patterns. I accompany each of these principles with illustrations of how to write (and how not to write) about numbers.

ESTABLISHING THE CONTEXT FOR YOUR FACTS

"The W's"

Context is essential for all types of writing. Few stories are told without somehow conveying "who, what, when, and where," or what journalists call "the W's." Without them your audience cannot interpret your numbers and will probably assume that your data describe everyone in the current time and place (e.g., the entire population of the United States in 2014). This unspoken convention may seem convenient. However, if your numbers are read later or in a different situation without information about their source, they can be misinterpreted. Don't expect your readers to keep track of when a report was issued to establish the date to which the facts pertain. Even using such tricks, all they can determine is that the information predated publication, which leaves a lot of room for error. If you encounter data

BOX 2.1. NAMED PERIODS AND COHORTS

Some time periods or cohorts are referred to by names such as "the Great Depression," "the post-war baby boom," or "Generation X," the dates varying from source to source. Generation X is loosely defined as the generation following the baby boom, but has been variously interpreted as "those born between 1965 and 1980," "those raised in the 1970s and 1980s," or even "those born since the mid-1960s" (scary, since it is lacking an end date, unless you look at when the article was published) (Jochim 1997). When reporting numbers about a "named" period for general background purposes, varying definitions probably don't matter very much. However, if your readers need precise comparisons, specify the range of dates. If you directly compare statistics from several sources, point out any variation in the definitions.

without the W's attached, either track down the associated contextual information and report it, or don't use those facts.

To include all of the W's, some beginners write separate sentences for each one, or write them in a stilted list: "The year was 2014. The place was the United States. The numbers reported include everyone of all ages, racial groups, and both sexes. [Then a sentence reporting the pertinent numbers]." Setting the context doesn't have to be lengthy or rote. In practice, each of the W's requires only a few words or a short phrase that can be easily incorporated into the sentence with the numbers. Suppose you want to include some mortality statistics in the introductory section of a paper about the Black Plague in fourteenth-century Europe.

Poor: "There were 25 million deaths."

This statement lacks information about when and where these deaths occurred, or who was affected (e.g., certain age groups or occupations). It also fails to mention whether these deaths were from the Black Plague alone or whether other causes also contributed to that figure.

Better: "During the fourteenth century, 25 million people died in Europe."

Although this statement specifies the time and place, it still does not clarify whether the deaths were from all causes or from the plague alone.

Best: "When the Black Plague hit Europe in the latter half of the fourteenth century, it took the lives of 25 million people, young and old, city dwellers and those living in the countryside. The disease killed about one-quarter of Europe's total population at the time (Mack, n.d.)."

This sentence clearly conveys the time, place, and attributes of the people affected by the plague, and provides information to convey the scale of that figure.

Despite the importance of specifying context, it is possible to take this principle too far: in an effort to make sure there is absolutely no confusion about context, some authors repeat the W's for every numeric fact. I have read papers that mention the date, place, and group literally in every sentence pertaining to numbers—a truly mind-numbing experience for both writer and reader. Ultimately, this obscures the meaning of the numbers because those endless W's clutter up the writing. To avert this problem, specify the context for the first number in a paragraph, then mention it again in that paragraph only if one or more aspects of the context change.

"When the Black Plague hit Europe in the latter half of the fourteenth century, it took the lives of 25 million people. The disease killed about one-quarter of Europe's total population at the time." [*Add*] "Smaller epidemics occurred from 1300 to 1600."

The last sentence mentions new dates but does not repeat the place or cause of death, implying that those aspects of the context remain the same as in the preceding sentences.

If you are writing a description of numeric patterns that spans several paragraphs, occasionally mention the W's again. For longer descriptions, this will occur naturally as the comparisons you make vary from one paragraph to the next. In a detailed analysis of the plague, you might compare mortality from the plague to mortality from other causes in the same time and place, mortality from the plague in other places or other times, and a benchmark statistic to help people relate to the magnitude of the plague's impact. Discuss each of these points in separate sentences or paragraphs, with introductory topic phrases or sentences stating the purpose and context of the comparison. Then incorporate the pertinent W's into the introductory sentence or the sentence reporting and comparing the numbers.

Units

An important aspect of "what" you are reporting is the units in which it was measured. There are different systems of measurement for virtually everything we quantify—distance, weight, volume, temperature, monetary value, and calendar time, to name a few. Although most Americans continue to be brought up with the British system of measurement (distance in feet and inches; weight in pounds and ounces; liquid volume in cups, pints, and gallons; temperature in degrees Fahrenheit), most other countries use the metric system (meters, grams, liters, and degrees Celsius, respectively). Different cultural and religious groups use many different monetary and calendar systems.

Scale of measurement also varies, so that population statistics may be reported in hundreds, thousands, millions, or even billions of people, according to whether one is discussing local, national, or international figures. Because of these variations, if the units of measurement are not reported along with a fact, a number alone is virtually useless, as you will see in some amusing examples in chapter 4, where I discuss this important principle in depth.

PICKING SIMPLE, PLAUSIBLE EXAMPLES

As accomplished speakers know, one strong intuitive example or analogy can go a long way toward helping your audience grasp quantitative concepts. If you can relate calories burned in a recommended exercise to how many extra cookies someone could eat, or translate a tax reduction into how many dollars a typical family would save, you will have given your readers a familiar basis of comparison for the numbers you report.

Most people don't routinely carry scales, measuring cups, or radar guns with them, so if you refer to dimensions such as weight, volume, or speed, provide visual or other analogies to explain particular values. In a presentation about estimating the number of people attending the 1995 Million Man March, Joel Best held up a newspaper page to portray the estimated area occupied by each person (3.6 square feet).[1] This device was especially effective because he was standing behind the page as he explained the concept, making it easy for his audience literally to see whether it was a reasonable approximation of the space he—an average-size adult—occupied.

The choice of a fitting example or analogy is often elusive. Finding one depends on both the audience and the specific objective of your example.

Objectives of Examples

Most examples are used to provide background information that establishes the importance of the topic, to compare findings with earlier ones, or to illustrate the implications of results. Your objectives will determine the choice of an example. For introductory information, a couple of numeric facts gleaned from another source usually will do. In the results section of a detailed scientific report, examples often come from your own analyses, and appropriate contrasts within your own data or comparisons with findings from other sources become critical issues. Below I outline a set of criteria to get you started thinking about how to choose effective examples for your own work.

The logic behind choosing numeric illustrations is similar to that for selecting excerpts of prose in an analysis of a literary work or case examples in a policy brief. Some examples are chosen to be representative of a broad theme, others to illustrate deviations or exceptions from a pattern. Make it clear whether an example you are writing about is typical or atypical, normative or extreme. Consider the following ways to describe annual temperature:

> *Poor:* "In 2001, the average temperature in the New York City area was 56.3 degrees Fahrenheit."
> *From this sentence, you cannot tell whether 2001 was a typical year, unusually warm, or unusually cool.*

Better: "In 2001, the average temperature in the New York City area was 56.3 degrees Fahrenheit, 1.5 degrees above normal."

This version clarifies that 2001 was a warm year, as well as reporting the average temperature.

Best: "In 2001, the average temperature in the New York City area was 56.3 degrees Fahrenheit, 1.5 degrees above normal, making it the seventh warmest year on record for the area."

This version points out not only that temperatures for 2001 were above average, but also just how unusual that departure was.

Principles for Choosing Examples

The two most important criteria for choosing effective examples are simplicity and plausibility.

SIMPLICITY

The oft-repeated mnemonic KISS—"Keep It Simple, Stupid"—applies to both the choice and explication of examples and analogies. Although the definition of "simple" will vary by audience and length of the work, your job is to design and explain examples that are straightforward, concrete, and familiar (Willingham 2009). The fewer terms you have to define along the way, and the fewer logical or arithmetic steps you have to walk your readers through, the easier it will be for them to understand the example and its purpose. The immensity of the Twin Towers was really driven home by equating the volume of concrete used in those buildings to the amount needed to build a sidewalk from New York City to Washington, DC (Glanz and Lipton 2002)—especially to a reader who had recently completed the three-hour train ride between those cities.

PLAUSIBILITY

A comparison example must be plausible: the differences between groups or changes across time must be feasible biologically, behaviorally, politically, or in whatever arena your topic fits. If you calculate the beneficial effects of a 20-pound weight loss on chances of a heart attack but the average dieter loses only 10 pounds, your projection will not apply to most cases. If voters are unlikely to approve more

than a 0.7% increase in local property taxes, projecting the effects of a 1.0% increase will overestimate potential revenue.

This is an aspect of choosing examples that is ripe for abuse: advocates can artificially inflate apparent benefits (or understate liabilities) by using unrealistically large or small differences in their examples. For instance, sea salt aficionados tout the extra minerals it provides in comparison to those found in regular ol' supermarket salt (sodium chloride). Although sea salt does contain trace amounts of several minerals, closer examination reveals that you'd have to eat about a quarter pound of it to obtain the amount of iron found in a single grape (Wolke 2002). The fact that two pounds of sodium chloride can be fatal provides additional perspective on just how problematic a source of iron sea salt would be.

Other factors to consider include relevance, comparability, target audience, and how your examples are likely to be used, as well as a host of measurement issues. Because the choice of examples has many subtle nuances, I devote the whole of chapter 8 to additional guidelines.

SELECTING THE RIGHT TOOL FOR THE JOB

The main tools for presenting quantitative information—prose, tables, and charts—have different, albeit sometimes overlapping, advantages and disadvantages. Your choice of tools depends on several things, including how many numbers are to be presented, the amount of time your audience has to digest the information, the importance of precise versus approximate numeric values, and, as always, the nature of your audience. Chapters 6 and 7 provide detailed guidelines and examples. For now, a few basics.

How Many Numbers?

Some tools work best when only a few numbers are involved, others can handle and organize massive amounts of data. Suppose you are writing about how unemployment has varied by age group and region of the country in recent years. If you are reporting a few numbers to give a sense of the general pattern of unemployment for a short piece or an introduction to a longer work, a table or chart would probably be overkill. Instead, use a sentence or two:

> "In February 2012, the unemployment rate for the United States was 8.3%, down from 9.0% a year earlier. Unemployment rates in each of the four major census regions also showed a minor decrease over that period (US Bureau of Labor Statistics 2012)."

If you need to include 10 years' worth of unemployment data on three age groups for each of four census regions, a table or chart is efficient and effective.

How Much Time?

When a presentation or memo must be brief, a chart, simple table, or series of bulleted phrases is often the quickest way of helping your audience understand your information. Avoid large, complicated tables: your audience won't grasp them in the limited time. For a memo or executive summary, write one bullet for each point in lieu of tables or charts.

Are Precise Values Important?

If in-depth analysis of specific numeric values is the point of your work, a detailed table is appropriate. For instance, if your readers need to see the fine detail of variation in unemployment rates over a decade or more, a table reporting those rates to the nearest tenth of a percentage point would be an appropriate choice. On the other hand, if your main objective is to show the general pattern of unemployment over that period, a chart would work better: all those numbers (and extra digits) in a table can distract and confuse.

"A chart is worth a thousand words," to play on the cliché. It can capture vast amounts of information far more succinctly than prose, and illustrate the size of a difference or the direction of a trend more powerfully than a sentence or a table. There is a tradeoff, however: it is difficult to ascertain exact values from a chart; avoid them if that is your objective.

Mixing Tools

In most situations, you will use a combination of tables, charts, and prose. Suppose you are writing a scholarly paper on unemployment patterns. You might include a few statistics on current unemployment rates in your introduction, a table to show how current unemployment varies by age group and region, and some charts to illustrate 10-year trends in unemployment by age group and region. To explain patterns in the tables or charts and relate them to the main purpose of the paper, describe those patterns in prose. For oral presentations, chartbooks, or automated slide shows, use bulleted phrases next to each chart or table to summarize the key points. Examples of these formats appear in later chapters.

As a general rule, don't duplicate information in both a table and a chart; you will only waste space and test your readers' patience. For instance, if I were to see both a table and a chart presenting unemployment rates for the same three age groups, four regions, and 10-year period, I would wonder whether I had missed some important point that one but not the other vehicle was trying to make. And I certainly wouldn't want to read the explanation of the same patterns twice—once for the table and again for the chart.

There are exceptions to every rule, and here are two. First, if both a quick sense of a general pattern *and* access to the full set of exact numbers matter, you might include a chart in the text, and a table in an appendix to report the detailed numbers from which the chart is constructed. Second, if you are presenting the same information to different audiences or in different formats, make both table and chart versions of the same data. You might use a table of unemployment statistics in a detailed academic journal article but show the chart in a presentation to your church's fund-raising committee for the homeless.

DEFINING YOUR TERMS (AND WATCHING FOR JARGON)

Why Define Terms?

Quantitative writing often uses technical language. To make sure your audience comprehends your information, define your terms, acronyms, and symbols.

UNFAMILIAR TERMS

Don't use phrases such as "opportunity cost" or "standardized mortality ratio" with readers who are unfamiliar with those terms. Ditto with abbreviations such as SES, LBW, or PSA. If you use technical

BOX 2.2. NAMES FOR NUMBERS

In addition to some of the more obvious jargon, other numeric terminology can confuse your audience. You might want to spice up your writing by using phrases such as "a century" instead of "100 years" or "the age of majority" instead of "age 18." Some of those phrases are widely understood, others a part of cultural literacy that depends on what culture you are from. That "a dozen" equals 12 is common knowledge in the United States, but the idea that "a baker's dozen" equals 13 is less universal. Writing for a modern American audience, I would hesitate to use terms such as "a fortnight" (14 nights or two weeks), "a stone" (14 pounds), or "a score" (20) without defining them. A British author or a historian could probably use them with less concern. Think carefully about using terms that require a pause (even a parenthetical pause) to define them, as it can interrupt the rhythm of your writing.

language without defining it first, you run the risk of intimidating an applied or lay audience and losing them from the outset. Or, if they try to figure out the meaning of new words or acronyms while you are speaking, they will miss what you are saying. If you don't define terms in written work, you either leave your readers in the dark, send them scurrying for a textbook or a dictionary, or encourage them to disregard your work.

TERMS THAT HAVE MORE THAN ONE MEANING

A more subtle problem occurs with words or abbreviations that have different meanings in other contexts. If you use a term that is defined differently in lay usage or in other fields, people may *think* they know what you are referring to when they actually have the wrong concept.

- To most people, a "significant difference" means a large one, rather than a difference that meets certain criteria for inferential statistical tests.[2] Because of the potential for confusion about the meaning of "significant," restrict its use to the statistical sense when describing statistical results. Many other adjectives such as "considerable," "appreciable," or even "big" can fill in ably to describe large differences between values.
- Depending on the academic discipline and type of analysis, the Greek symbol α (alpha) may denote the probability of Type I error, inter-item reliability, or the intercept in a regression model—three completely different concepts (Agresti and Finlay 1997).
- "Regression analysis" could mean an investigation into why Johnny started sucking his thumb again. Among statisticians, it refers to a technique for estimating the net effects of several variables on some outcome of interest, such as how diet affects child growth when illness and exercise are taken into account.
- The acronym PSA means "public service announcement" to people in communications, "prostate specific antigen" to health professionals, "professional services automation" in the business world, among more than 80 other definitions according to an online acronym finder.

These examples probably seem obvious now, but can catch you unaware. Often people become so familiar with how a term or symbol is used in a particular context that they forget that it could be confused with other meanings. Even relative newcomers to a field can become so immersed in their work that they no longer recognize certain terms as ones they would not have understood a few months before.

DIFFERENT TERMS FOR THE SAME CONCEPT

People from different fields of study sometimes use different terms for the same quantitative concept. For example, the term "scale" is sometimes referred to as "order of magnitude," and what some people call an "interaction" is known to others as "effect modification." Even with a quantitatively sophisticated audience, don't assume that people will know the equivalent vocabulary used in other fields. In 2002, the journal *Medical Care* published an article whose sole purpose was to compare statistical terminology across various disciplines involved in health services research, so that researchers could understand one another (Maciejewski et al. 2002). After you define the term you plan to use, mention the synonyms from other fields represented in your audience to make sure they can relate your methods and findings to those from other disciplines.

To avoid confusion about terminology, scan your work for jargon before your audience sees it. Step back and put yourself in your readers' shoes, thinking carefully about whether they will be familiar with the quantitative terms, concepts, abbreviations, and notation. Show a draft of your work to someone who fits the profile of one of your future readers in terms of education, interest level, and likely use of the numbers, and ask them to flag anything they are unsure about. Then evaluate whether those potentially troublesome terms are necessary for the audience and objectives.

Do You Need Technical Terms?

One of the first decisions is whether quantitative terminology or mathematical symbols are appropriate for a particular audience and objective. For all but the most technical situations, *you* need to know the name and operation of the tools you are using to present numeric concepts, but your readers might not. When a carpenter builds a deck for your house, she doesn't need to name or explain to you how each of her tools works as long as she knows which tools suit the task and is adept at using them. You use the results of her work but don't need to understand the technical details of how it was accomplished.

To demonstrate their proficiency, some writers, particularly novices to scientific or other technical fields, are tempted to use only complex quantitative terms. However, some of the most brilliant and effective writers are so brilliant and effective precisely because they can make a complicated idea easy to grasp. Even for a quantitatively adept audience, a well-conceived restatement of a complex numeric relation underscores your familiarity with the concepts and enlightens those in the audience who are too embarrassed to ask for clarification.

WHEN TO AVOID JARGON ALTOGETHER

For nonscientific audiences or short pieces where a term would be used only once, avoid jargon altogether. There is little benefit to introducing new vocabulary or notation if you will not be using it again. And for nonstatisticians, equations full of Greek symbols, subscripts, and superscripts are more likely to reawaken math anxiety than to promote effective communication. The same logic applies to introductory or concluding sections of scientific papers: using a new word means that you must define it, which takes attention away from your main point. If you will not be using that term again, find other ways to describe numeric facts or patterns. Replace complex or unfamiliar words, acronyms, or mathematical symbols with their colloquial equivalents, and rephrase complicated concepts into more intuitive ones.

As an illustration, suppose an engineering firm has been asked to design a bridge between Littletown and Midville. To evaluate which materials last the longest, they use a statistical technique called failure time analysis. They are to present their recommendations to local officials, few of whom have technical or statistical training.

> *Poor*: "The relative hazard of failure for material C was 0.78."
>
> *The key question—which material will last longer—is not answered in ways that the audience will understand. Also, it is not clear which material is the basis of comparison.*
>
> *Better*: "Under simulated conditions, the best-performing material (material C) lasted 1.28 times as long as the next best choice (material B)."
>
> *This version presents the information in terms the audience can comprehend: how much longer the best-performing material will last. Scientific jargon that hints at a complicated statistical method has been translated into common, everyday language.*
>
> *Best*: "In conditions that mimic the weather and volume and weight of traffic in Littletown and Midville, the best-performing material (material C) has an average expected lifetime of 64 years, compared with 50 years for the next best choice (material B)."
>
> *In addition to avoiding statistical terminology related to failure time analysis, this version gives specific estimates of how long the materials can be expected to last, rather than just reporting*

the comparison as a ratio. It also replaces "simulated conditions" with the particular issues involved—ideas that the audience can relate to.

WHEN TO USE AND PARAPHRASE JARGON

Many situations call for one or more scientific terms for numeric ideas. You might refer repeatedly to unfamiliar terminology. You might use a word or symbol that has several different meanings. You might refer to a concept that has different names in different disciplines. Finally, you might have tried to "explain around" the jargon, but discovered that explaining it in nontechnical language was too convoluted or confusing. In those instances, use the new term, then define or rephrase it in other, more commonly used language to clarify its meaning and interpretation. Suppose a journalist for a daily newspaper is asked to write an article about international variation in mortality.

Poor: "In 2009, the crude death rate (CDR) for Sweden was 10 deaths per 1,000 people and the CDR for Ghana was 8 deaths per 1,000 people (World Bank 2012). You would think that Sweden—one of the most highly industrialized countries—would have lower mortality than Ghana—a less developed country. The reason is differences in the age structure, so I calculated life expectancy for each of the two countries. To calculate life expectancy, you apply age-specific death rates for every age group to a cohort of ... [You get the idea ...]. Calculated life expectancies for Sweden and Ghana were 81 years and 63 years."

This explanation includes a lot of background information and jargon that the average reader does not need, and the main point gets lost among all the details. Using many separate sentences, each with one fact or definition or calculation, also makes the presentation less effective.

Better (For a nontechnical audience): "In 2009, people in Ghana could expect to live until age 63 years, on average, compared to age 81 in Sweden. These life expectancies reflect much lower mortality rates in Sweden (World Bank 2012)."

This version conveys the main point about differences in mortality rates without the distracting detail about age distributions and how to calculate life expectancy.

Better (For a longer, more technical article): "In 2009, the crude death rate (CDR) for Sweden was 10 deaths per 1,000 people and the CDR for Ghana was 8 deaths per 1,000, giving the appearance of slightly more favorable survival chances in Ghana (World Bank 2012). However, Sweden has a much higher share of its population in the older age groups (18% aged 65 and older, compared to only 4% in Ghana), and older people have higher death rates. This difference pulls up the average death rate for Sweden. Life expectancy—a measure of mortality that corrects for differences in the age distribution—shows that in fact survival chances are much better in Sweden, where the average person can expect to live for 81 years, than in Ghana (63 years)."

This version conveys the main point about why life expectancy is the preferred measure and rephrases it in ways that introduce the underlying concepts: that older people have higher mortality, and that Sweden has a higher share of older people.

WHEN TO RELY ON TECHNICAL LANGUAGE

Although jargon can obscure quantitative information, equations and scientific phrasing are often useful, even necessary. When tradesmen talk to one another, using the specific technical names of their tools, supplies, and methods makes their communication more precise and efficient, which is the reason such terms exist. Being familiar with a "grade 8 hex cap bolt," they know immediately what supplies they need. A general term such as "a bolt" would omit important information. Likewise, if author and audience are proficient in the same field, the terminology of that discipline facilitates communication. If you are defending your doctoral dissertation in economics, using the salient terminology demonstrates that you are qualified to earn your PhD. And an equation with conventional symbols and abbreviations provides convenient shorthand for communicating statistical relationships, model specifications, and findings to audiences that are conversant with the pertinent notation.

Even for quantitatively sophisticated audiences, define what you mean by a given term, acronym, or symbol to avoid confusion among different possible definitions. I also suggest paraphrasing technical language in the introductory and concluding sections of a talk or paper, saving the heavy-duty jargon for the methodological and analytic portions. This approach reminds the audience of the purpose of the analyses, and places the findings back in a real-world context—both important parts of telling your story with numbers.

REPORTING *AND* INTERPRETING

Why Interpret?

Reporting the numbers you work with is an important first step toward effective writing about numbers. By including the numbers in the text, table, or chart, you give your readers the raw materials with which to make their own assessments. After reporting the raw numbers, interpret them. An isolated number that has not been introduced or explained leaves its explication entirely to your readers. Those who are not familiar with your topic are unlikely to know which comparisons to make or to have the information for those comparisons immediately at hand. To help them grasp the meaning of the numbers you report, provide the relevant data and explain the comparisons. Consider an introduction to a report on health care costs in the United States, where you want to illustrate why these expenditures are of concern.

Poor: "In 2011, total expenditures on health care in the United States were estimated to be more than $2.7 trillion (Centers for Medicare and Medicaid Services 2013)."

From this sentence, it is difficult to assess whether total US expenditures on health care are high or low, stable or changing quickly. To most people, $2.7 trillion sounds like a lot of money, but a key question is "compared to what?" If they knew the total national budget, they could do a benchmark calculation, but you will make the point more directly if you do that calculation for them.

Better: "In 2011, total expenditures on health care in the United States were estimated to be more than $2.7 trillion, equivalent to $8,658 for every man, woman, and child in the nation (Centers for Medicare and Medicaid Services 2013)."

This simple translation of total expenditures into a per capita figure takes a large number that is difficult for many people to fathom and converts it into something that they can relate to. Readers can compare that figure with their own bank balance or what they have spent on health care recently to assess the scale of national health care expenditures.

Best (To emphasize trend): "Between 2000 and 2011, the total costs of health care in the United States nearly doubled, from $1,377 billion to $2,693 billion (Centers for Medicare and Medicaid Services 2013; table 1). Over that same period, the share of gross domestic product (GDP) spent for health care increased from 13.7% to 17.7% (Organisation for Economic Co-operation and Development [OECD] 2013, figure 7.2.2)."

By discussing how health care expenditures have changed across time, this version points out that the expenditures have risen markedly in recent years. The sentence on share of GDP spent on health care shows that these expenditures comprise a substantial portion of the national budget—another useful benchmark.

Best (To put the United States in an international context): "In the United States, per capita health expenditures averaged $8,658 in 2011, equivalent to 17.7% of gross domestic product (GDP). The percentage of GDP spent on health care in the United States was 50% higher than the next highest country (the Netherlands, 11.9% of its GDP), and 90% higher than the OECD average of 9.3% (OECD 2013; figure 7.2.1)."

This description reveals that health care expenditures in the United States were the highest of any country, and reports how much higher compared to the next highest country and the average for a widely used international benchmark (the OECD). By using percentage of GDP as the measure, this comparison avoids the issue that countries with smaller populations would be expected to spend fewer total dollars but could still have higher per capita or percentage of GDP expenditures on health.

Why Report the Raw Numbers?

Although it is important to interpret quantitative information, it is also essential to report the numbers. If you *only* describe a ratio or percentage change, for example, you will have painted an incomplete picture. Suppose that a report by the local department of wildlife states that the density of the deer population in your town is 30% greater than it was five years ago but does not report the density for either year. A 30% difference is consistent with many possible combinations: 0.010 and 0.013 deer per square mile, or 5.0 and 6.5, or 1,000 and 1,300, for example. The first pair of numbers suggests a very sparse deer population, the last pair an extremely high concentration. Unless the densities themselves are mentioned, you can't determine whether the species has narrowly missed extinction or faces an overpopulation problem. Furthermore, you can't compare density figures from other times or places.

SPECIFYING DIRECTION AND MAGNITUDE OF AN ASSOCIATION

Writing about numbers often involves describing relationships between two or more variables. To interpret an association, explain both its shape and size rather than simply stating whether the variables are correlated.[3] Suppose an educational consulting firm is asked to compare the academic and physical development of students in two school districts, one of which offers a free breakfast program. If the consultants do their job well, they will report *which* district's students are bigger, faster, and smarter, as well as *how much* bigger, faster, and smarter.

Direction of Association

Variables can have a *positive* or *direct* association (as the value of one variable increases, the value of the other variable also increases) or a *negative* or *inverse* association (as one variable increases, the other decreases). Physical gas laws state that as the temperature of a confined gas rises, so does pressure; hence temperature and pressure are positively related. Conversely, as the price of a pair of jeans rises, the demand for jeans falls, so price and demand are inversely related.

For nominal variables such as gender, race, or religion that are classified into categories that have no inherent order, describe direction of association by specifying which category has the highest or lowest value (see chapter 4 for more about nominal variables, chapter 9 for more on prose descriptions of associations). "Religious group is negatively associated with smoking" cannot be interpreted. Instead, write "Mormons were least likely to smoke," and mention how other religious groups compare.

Size of Association

An association can be large (a given change in one variable is associated with a big change in the other variable) or small (a given change in one variable is associated with a small change in the other). A 15-minute daily increase in exercise might reduce body weight by five pounds per month or only one pound per month, depending on type of exercise, dietary intake, and other factors. If several factors each affect weight loss, knowing which make a big difference can help people decide how best to lose weight.

To see how these points improve a description of a pattern, consider the following variants of a description of the association between age and mortality. Note that describing direction and magnitude can be accomplished with short sentences and straightforward vocabulary.

Poor: "Mortality and age are correlated."
This sentence doesn't say whether age and mortality are positively or negatively related or how much mortality differs by age.

Better: "As age increases, mortality increases."
Although this version specifies the direction of the association, the size of the mortality difference by age is still unclear.

Best: "Among the elderly, mortality roughly doubles for each successive five-year age group."
This version explains both the direction and the magnitude of the age/mortality association.

Specifying direction of an association can also strengthen statements of hypotheses: state which group is expected to have the more favorable outcome, not just that the characteristic and the outcome are expected to be related. "Persons receiving Medication A are expected to have fewer symptoms than those receiving a placebo" is more informative than "symptoms are expected to differ in the treatment and control groups." Typically, hypotheses do not include precise predictions about the size of differences between groups.

SUMMARIZING PATTERNS

The numbers you present, whether in text, tables, or charts, are meant to provide evidence about some issue or question. However, if you provide only a table or chart, you leave it to your readers to figure out for themselves what that evidence says. Instead, digest the patterns to help readers see the general relationship in the table or chart; in other words, answer the word problem.

When asked to summarize a table or chart, inexperienced writers often make one of two opposite mistakes: (1) they report every single number from the table or chart in the text, or (2) they pick a few arbitrary numbers to contrast in sentence form without considering whether those numbers represent an underlying general pattern. Neither approach adds much to the information presented in the table or chart, and both can confuse or mislead the audience. Paint the big picture, rather than reiterating all of the little details. If readers are interested in specific values within the pattern you describe, they can look them up in the accompanying table or chart.

Why Summarize?

Summarize to relate the evidence back to the substantive topic: Do housing prices change across time as would be expected based on changing economic conditions? Are there appreciable differences in housing prices across regions? Summarize broad patterns with a few simple statements instead of writing piecemeal about individual numbers or comparing many pairs of numbers. For example, when describing the pattern in figure 2.1, answering a question such as "are housing prices rising, falling, or remaining stable?" is much more instructive than responding to "what were housing prices in 1980, 1981, 1982 . . . 1999, 2000 in the Northeast?" or "how much did housing prices in the Northeast change between 1980 and 1981? Between 1981 and 1982? . . ."

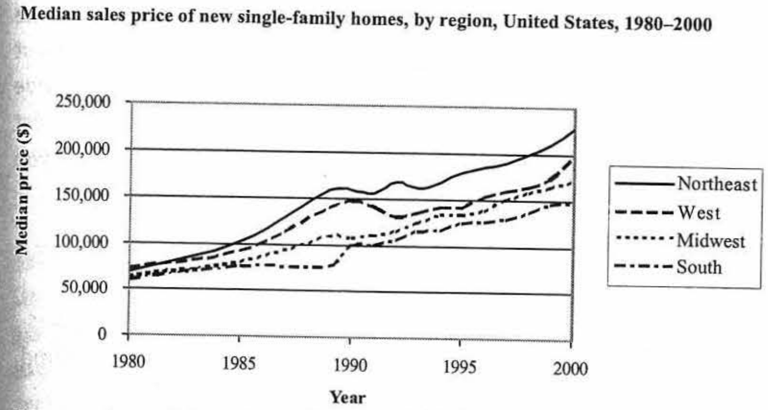

Figure 2.1. Generalizing patterns from a multiple-line trend chart
Source: US Census Bureau 2001a.

Generalization, Example, Exceptions—An Approach to Summarizing Numeric Patterns

Here is a mantra I devised to help guide you through the steps of writing an effective description of a pattern involving three or more numbers or series of numbers: "generalization, example, exceptions," or GEE for short. The idea is to identify and describe a pattern in general terms, give a representative example to illustrate that pattern, and then explain and illustrate any exceptions. This approach can also be used to compare results across different subgroups, time periods, or outcome variables (see "'Generalization, Example, Exceptions' Revisited" in chapter 9), or to synthesize findings or theories in previous literature (see "Literature Review" in chapter 11).

GENERALIZATION

For a generalization, come up with a description that characterizes a relationship among most, if not all, of the numbers. In figure 2.1, is the general trend in most regions rising, falling, or stable? Does one region consistently have the highest housing prices over the years? Start by describing one such pattern (e.g., trends in housing prices in the Northeast), then consider whether that pattern applies to the other regions as well. Or figure out which region had the highest housing prices in 1980 and see whether it is also the most expensive region in 1990 and 2000. If the pattern fits most of the time and most places, it is a generalization. For the few situations it doesn't fit, you have an *exception* (see below).

> "As shown in figure 2.1, the median price of a new single-family home followed a general upward trend in each of the four major census regions between 1980 and 2000. This trend was interrupted by a leveling off or even a decline in prices around 1990, after which prices resumed their upward trajectory. Throughout most of the period shown, the highest housing prices were found in the Northeast, followed by the West, Midwest, and South (US Census Bureau 2001a)."
>
> *This description depicts the approximate shape of the trend in housing prices (first two sentences), then explains how the four regions compare to one another in terms of relative price (last sentence). There are two generalizations: the first about how prices changed across time, the second about regional rank in terms of price. Readers are referred to the accompanying chart, which depicts the relationships, but no precise numbers have been reported yet.*

EXAMPLE

Having described your generalizable pattern in intuitive language, illustrate it with numbers from your table or chart. This step anchors your generalization to the specific numbers upon which it is based. It ties the prose and table or chart together. By reporting a few illustrative numbers, you implicitly show your readers where in the table or chart those numbers came from as well as the comparison involved. They can then test whether the pattern applies to other times, groups, or places using other data from the table or chart. Having written the above generalizations about figure 2.1, include sentences that incorporate examples from the chart into the description.

> (To follow the trend generalization): "For example, in the Northeast region, the median price of a new single-family

> home rose from $69,500 in 1980 to $227,400 in 2000, more than a three-fold increase in price."
>
> (To follow the across-region generalization): "In 2000, the median prices of new single-family homes were $227,400 in the Northeast, $196,400 in the West, $169,700 in the Midwest, and $148,000 in the South."

EXCEPTIONS

Life is complicated: rarely will anything be so consistent that a single general description will capture all relevant variation in your data. Tiny blips can usually be ignored, but if some parts of a table or chart depart substantially from your generalization, describe those departures. When portraying an exception, explain its overall shape and how it differs from the generalization you have described and illustrated in your preceding sentences. Is it higher or lower? By how much? If a trend, is it moving toward or away from the pattern you are contrasting it against? In other words, describe both direction and magnitude of the change or difference between the generalization and the exception. Finally, provide numeric examples from the table or chart to illustrate the exception.

> "In three of the four regions, housing prices rose throughout the 1980s. In the South, however, housing prices did not begin to rise until 1990, after which they rose at approximately the same rate as in each of the other regions."
>
> *The first sentence describes a general pattern that characterizes most of the regions. The second sentence describes the exception and identifies the region to which it applies. Specific numeric examples to illustrate both the generalization and the exception could be added to this description.*

Other types of exceptions include instances where prices in all four regions were rising but at a slower rate in some regions, or where prices rose over a sustained period in some regions but fell appreciably in others. In other words, an exception can occur in terms of magnitude (e.g., small versus large change over time) as well as in direction (e.g., rising versus falling, or higher versus lower) (see chapter 9). Because learning to identify and describe generalizations and exceptions can be difficult, in appendix A you will find additional pointers about recognizing and portraying patterns and organizing the ideas for a GEE into paragraphs, with step-by-step illustrations for several different tables and charts.

CHECKLIST FOR THE SEVEN BASIC PRINCIPLES

- Set the context for the numbers you present by specifying the W's: who, what, when, and where the data pertain to.
- Choose effective examples and analogies.
  - Use simple, familiar examples that your audience will be able to understand and relate to.
  - Select contrasts that are plausible under real-world circumstances.
- Choose vocabulary to suit your readers.
  - Define terms and mention synonyms from related fields for statistical audiences.
  - Replace jargon and mathematical symbols with colloquial language for nontechnical audiences.
- Decide whether to present numbers in text, tables, or figures.
  - Determine how many numbers you need to report.
  - Estimate how much time your audience has to grasp your data.
  - Assess whether your readers need exact values.
- Report and interpret numbers in the text.
  - Report them and specify their purpose.
  - Interpret and relate them back to your main topic.
- Specify both the direction and size of an association between variables.
  - If a trend, is it rising or falling, and how steeply?
  - If a difference across groups or places, which has the higher value, and by how much?
- To describe a pattern involving many numbers, summarize the overall pattern rather than repeating all the numbers.
  - Find a generalization that fits most of the data.
  - Report a few illustrative numbers from the associated table or chart.
  - Describe exceptions to the general pattern.

1 2 **3** 4 5 6 7 8 9 10 11 12 13

CAUSALITY, STATISTICAL SIGNIFICANCE, AND SUBSTANTIVE SIGNIFICANCE

A common task when writing about numbers is describing a relationship between two or more variables, such as the association between math curriculum and student performance, or the associations among diet, exercise, and heart attack risk. After portraying the shape and size of the association, interpret the relationship, assessing whether it is "significant" or "important."

Although many people initially believe that importance is based only on the size of an association—the bigger the difference across groups, the more important the association—in practice, this appraisal involves more thought. There are three key questions to consider. First, is the association merely a spurious correlation, or is there an underlying *causal* relationship between the variables? Second, is that association *statistically* significant? And third, is it *substantively* significant or meaningful? Only if all three criteria are satisfied does it make sense to base programs or policy on that association, seeking to improve student performance by changing math curriculums, for example. To provide a common basis for understanding these principles, below I review some needed statistical terms and concepts of study design, and provide references that treat these concepts in greater depth.

CAUSALITY

Many policy issues and applied scientific topics address questions such as, If we were to change x, would y get better? Will a new curriculum improve math comprehension and skills? Are e-cigarettes a