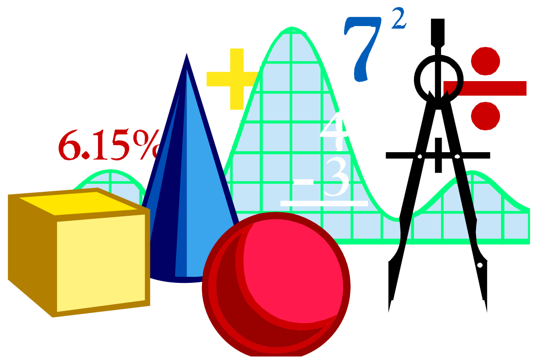

STATISTICAL LITERACY 2021B

Seeing the Story Behind the Statistics

Milo Schield

STATISTICAL LITERACY 2021B:

Seeing the Story behind the Statistics

Eighth Edition

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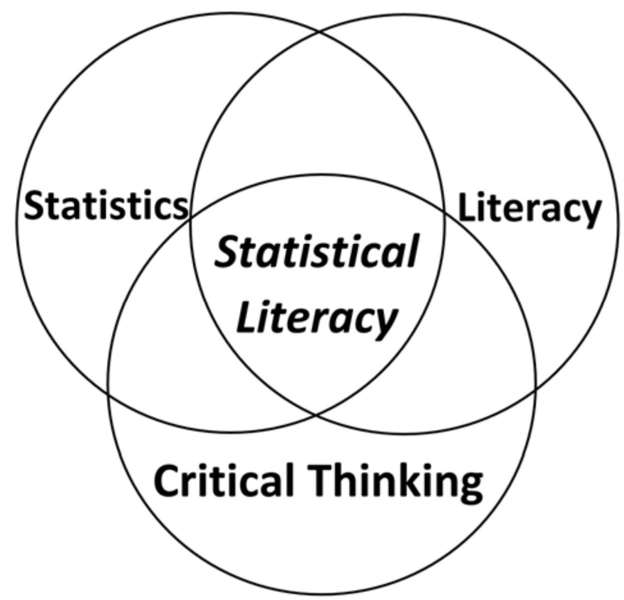
228 figures, 129 tables, 34 stories, 11 equations,
210 glossary terms, 420 index entries,



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Typography: Bold indicates a term that is being defined. Any word or phrase in bold should be found in the Glossary. Italics indicate an important concept, point or claim. In part-whole ratios, underscoring indicates a part while small caps indicates a whole.

DEDICATION

To[1]

Florence Nightingale, Jerome Cornfield,
Dennis Haack, Victor Cohn
and Joel Best

GOAL

To help decision makers
make better decisions using statistics as evidence

[1] Florence Nightingale (1820-1910)—the "Lady with the Lamp", the founder of modern nursing and the first female member of the Royal Statistical Society—used observational statistics to argue the need for nurses in the military. Dr. Jerome Cornfield, (1912-1979)—the creator of the Odds Ratio, Relative Risk and the Cornfield conditions, and a Fellow and President of the American Statistical Society—used observational statistics to argue that the association between smoking and cancer was "so great" that it cannot be due to any known confounder. Dr. Dennis Haack's 1979 textbook, "*Statistical Literacy*" was the first book to use that phrase. He argued that statistical literacy is more about words (doublespeak) than about mathematics. Victor Cohn (1920-2000)—a former Science editor for the Washington Post and author of *News and Numbers*—argued that students need to read the story behind the story when statistics are involved as evidence. Dr. Joel Best—Professor of Sociology and author of *Damned Lies and Statistics* and of *More Damned Lies and Statistics*—noted that "All statistics are social products, the results of people's efforts." He argued that understanding this fact is most essential in evaluating statistics as evidence in arguments. He also noted that "Statistics can become weapons in political struggles over social problems and social policy."

Preface

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Preface

Students: See the story behind the statistics

You may be very interested in social issues such as social justice or individual rights. Most of these involve statistics: social statistics. Figuring out whether the statistics provide strong evidence is not easy. This course is dedicated to helping you read, interpret and evaluate social statistics. Social statistics are very different from numbers. Usually there is a story behind the statistics. That story is important; it deserves to be told, studied and understood.

Social statistics may involve sensitive subjects. If you are an adult and some social statistics trigger strong feelings, then your job is to deal with your feelings. If you are having difficulties, talk to your instructor or counselor. Ultimately, you are responsible for controlling your mind. If you can't, then you are vulnerable to being controlled by others who may not have your best interests at heart.

Not all statistics are your friends. Some statistics are false, while others are ambiguous, ill-defined, misleading or spurious. As Mark Twain said, "There are three kinds of lies: lies, damned lies and statistics."

As a reader you have three choices: (1) be naïve: treat every statistic as a fact, (2) be a cynic: ignore every statistic since it might be an error or an opportunistic misrepresentation, or (3) be a critical thinker: learn how to distinguish good and bad statistics. You may get overwhelmed or feel trapped when you see a statistic. If you accept the statistic as strong evidence, you may be fooled. If you reject a statistic as evidence, you may be wrong and make a bad choice.

The primary goal of statistical literacy is to help you evaluate the credibility of a statistic (not just the source) — to go beyond reading statistics in the everyday news to reading 'between the lines'— to see the story behind the statistics.

It takes training and practice to read people or to see the theme of a movie or the direction of play in a sport. It takes training and practice to untangle an argument. It takes more training and practice to untangle an argument that uses statistics as evidence. A goal of this book is to give you that training and practice.

Statistical literacy is the ability to read and interpret statistics in the everyday media. Statistical literacy is critical thinking about statistics as evidence in arguments.

Statistical literacy is closer to critical thinking than to mathematics. Mathematics is deduction: true or false, right or wrong. Critical thinking involves induction: shades of grey, strength of evidence supporting a conclusion. Think of statistical literacy as quantitative rhetoric[2].

Journalists are also helping to make statistical literacy a necessity for citizens in a democracy. While statisticians thrive on numbers; journalists thrive on words. While statisticians try to avoid controversy and ambiguity; journalists live on controversy and ambiguity.

Statistical literacy—the ability to read and interpret social statistics—is a requirement to understanding issues and making intelligent decisions in modern society where anyone can find a statistic to support their view.

Statistical Literacy is a new discipline. Welcome aboard.

Secondary Goal

Communicating is the secondary goal of this book. This involves two activities. First to help people communicate their evaluation of statistical claims as presented in graphs, tables and statements. Second, to help people present statistical claims in their papers at school and at work, and in their presentations.

Communicating involves writing and speaking, both of which are more demanding than reading – especially for those with weak English skills. This text has a strong focus on the English grammar required to read and communicate arithmetic comparisons, ratios (using percentage, rate and change grammar) and comparisons of ratios (using likely grammar).

Teachers: Statistical literacy solves a problem

Traditional introductory statistics has a problem. Most students see less value in statistics after that course that they did before taking the course.

[2] Schmit, John (2010) Teaching Statistical Literacy as a Quantitative Rhetoric Course. *Proceedings of Section on Statistical Education*. www.statlit.org/pdf/2010SchmitASA.pdf

The traditional inference course is designed for Producers: those who major or minor in statistics and those who may conduct or read statistical studies.

Most college graduates are Consumers. They will never conduct or read the results of a study. They will see statistics in the everyday media that they need to read and interpret. Many will make de7cisions based on statistics.

Students see value in statistical literacy. Most agree that statistical literacy should be required for graduation by all students.

Statistical literacy is different:

- Different audience: Statistical literacy is for those who need to read and interpret the statistics they encounter in the everyday media.
- Different content: Traditional statistics focuses on randomness; statistical literacy focuses more on confounding.
- Different focus: The world has changed. In the past, small surveys and clinical trials were more common. Today, large surveys, big data, quasi-experiments, and observational studies are much more common.
- Different approach: Statistical inference is deductive: if the premises are true, then the conclusion must be true. In random sampling, 95% of all the 95% confidence intervals must include the population parameter. Statistical literacy is inductive: how strong is the evidence in supporting a disputable claim or conclusion?
- Different thinking: Traditional statistics involves mathematical thinking: Statistical literacy involves hypothetical thinking. What should have been controlled for? How could things have been defined, counted and measured differently? What was omitted or overlooked? What difference would these differences make?
- Different mission: The mission of statistical literacy is to improve critical thinking about statistics as evidence in arguments. With the advent of big data, statistics are everywhere. Most social arguments involve social statistics as evidence. Students need to read and evaluate these statistics.

Students see that studying statistical literacy helps them deal with today's big issues. Statistical literacy helps them understand and evaluate the statistics presented in statements, tables and graphs. Students learn how to describe and compare these statistics using ordinary English.

As one college senior said, "Statistical literacy is the hardest course I've taken, but I think it will be the most valuable."

If you teach the traditional introductory statistics course, but want more of your students to see value in studying statistics, give statistical literacy a try.

Teachers: Is this Statistics?

How can statistical literacy be statistics if statistical literacy has less than a 30% overlap with the traditional statistical-inference course?

Statistics studies variation. Variation is classified as random or systematic. Traditionally, the first statistics course focuses on random; the second focuses on systematic. The problem is that most students never take the second.

Statistical literacy studies variation – systematic and random – with a stronger emphasis on systematic. It includes topics from both the first and second statistics courses, and from epidemiology.

Audience for this book

This book is designed for consumers and decision makers. Decision makers include those who access, assemble, prepare and disseminate the statistics.

Decision makers make decisions involving large structured groups; consumers make decisions involving themselves or small informal groups. At college, decision makers are mainly those in non-science quantitative majors (the professions and the social sciences) or in political science, communications or journalism. Those in non-quantitative majors are typically consumers.

Design and Use of this book

By limiting the topics, this book allows instructors free time to experiment and do what they want: analyze news stories, investigate journal articles or run a project. Learning to think critically about statistics takes time and lots of practice. This book allows instructors the time to help students reach that goal.

This book is suitable for two-year and four-year colleges and in schools as an alternative to AP statistics. It has been used in an on-line class. This text can be used in a bridging course for those who will take statistical inference.

This book can be used as a companion text or as a text for a full course. A Moodle test-bank is available on Classroom Revolution.

Statistical Literacy and GAISE

This textbook is compliant with the first three recommendations of the ASA GAISE 2005 College Report: introductory statistics courses should "strive to (1) emphasize statistical literacy and develop statistical thinking, (2) use real data and (3) stress conceptual understanding rather than mere knowledge of procedures. This report suggested assessing statistical literacy by students "interpreting or critiquing articles in the news and graphs in media." *This textbook is compliant with the GAISE 2016* recommendation for more focus on multivariate thinking and confounding.[3]

[3] Schield, Milo (2017). GAISE 2016 Promotes Statistical Literacy.

Ways to use this textbook

This textbook has less than a 30% overlap with the topics in a traditional statistical inference course. As such it provides a unique alternative to traditional statistics.

As a separate course, start by using just the first three chapters. They have the main ideas. This allows plenty of time to focus on reading news stories. Plan A (Inference emphasis): add the last two chapters. Plan B (confounder emphasis): Cover Ch 1-4 and 7; skip 5, 6 and 8. Add skipped chapters later.

In a traditional statistics course, use the last three weeks to introduce confounding in chapters three and seven and show how controlling for confounding can influence statistical significance in observational studies as shown in chapter eight.

For those who are averse to teaching English grammar and strength of evidence, focus on chapters three, seven and eight where problems have right-wrong answers.

Here are some of the unique topics in this textbook:

Ch 1: Statistics are Numbers in context. Take CARE: four kinds of influence.

Ch 2: Comparison: Arithmetic and Grammar (includes 'times less') [ESL]
Study designs including quasi-experiments (along with letter grades)
Randomness: Law of Very Large Numbers

Ch 3: Standardization of measures (algebraic and graphical)
Cornfield's conditions for nullifying or reversing an association

Ch 4: Describing part-whole ratios using percent and percentage grammar [ESL]
Reading 100% tables, half tables and two-way half tables.

Ch 5: Describing part-whole ratios using rate and chance grammar [ESL]

Ch 6: Comparing part-whole ratios using percentage and likely grammar [ESL]

Ch 7: Diabolical denominators. Interpreting part-whole ratios: medical tests.
Standardization of percentages. Cornfield conditions.

Ch 8: Statistical significance influenced by confounding, assembly and bias.
Sampling designs (along with letter grades)

Recommended Supplements

- 2020: *Calling Bullshit: The Art of Skepticism …* by Bergstrom and West
- 2019: *Critical Statistics* by Robert de Vries
- 2019: *Guided Worksheets for Thinking Quantitatively* by Eric Gaze
- 2015: *Thinking Quantitatively: Communicating with Numbers*, Eric Gaze
- 2012: *Just Plain Data Analysis* by Gary Klass
- 2010: *Case Studies for Quantitative Reasoning* by Bernie Madison, et al.

Statistical Literacy: Descriptions and Comments

"What is statistical literacy? What every educated person should know."[4]
David Moore, past-President of the American Statistical Association.

"Statistical literacy goes beyond numeracy by focusing on reading and communicating those topics studied in numeracy."[5] Peter Holmes, Royal Statistical Society: Centre for Statistical Education.

"I see statistical literacy as standing in relation to traditional statistics as quantitative literacy is related to mathematics: they serve different purposes, but in each case the former is typically more useful than the latter for citizens and decision-makers."[5] Lynn Steen, past-President of the MAA.

"There are few tasks in education today as urgent as improving the quality of statistical literacy. It is not necessary that every student learn the techniques of a professional statistician, but it is important that every student know enough to become an intelligent and critical consumer of statistical information."[5] Dr. David Kelley, author of *The Art of Reasoning*.

"Many universities now have statistical or numerical literacy courses in addition to the traditional introductory statistics course. One lecture explaining the difference between an observational study and a randomized experiment, and the role of confounding variables in the interpretation of observational studies would do more to prepare students for reading the news than a dozen lectures on statistical inference procedures." Jessica Utts (2003)

"From my perspective, this teaching of causal inference is the most interesting topic today in statistical education, certainly so at the undergraduate level" [5]
Dr. Donald Rubin, Professor of Statistics, Harvard University.

"Misuse of the language of statistics is statistical doublespeak." Dennis Haack, author of *Statistical Literacy: A Guide to Interpretation*.

"Widespread statistical illiteracy among the gifted is cause for immediate concern..." Charles Murray, *Real Education*, p. 118.

I hope that...statistical literacy will...rise to the top of your advocacy list. Ruth Carver, 2012 ATOMPAV Presidential Address[6]

"Statistical literacy should be part of every citizen's tool kit" Nicholas Kristof[7]

Statistical literacy has risen to the top of my advocacy list, right alongside numeracy, and perhaps even ahead of "algebra for all." Michael Shaughnessy[8], Past-President of the NCTM. USCOTS 2015 Lifetime Achievement award.

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[4] http://www.statlit.org/Moore.htm
[5] Private communication (2001)
[6] http://www.statlit.org/pdf/2012-Carver-Presidents-Message-Statistical-Literacy.pdf
[7] http://www.statlit.org/pdf/2015-Kristof-NY-Times-0425.pdf
[8] http://www.statlit.org/pdf/2010Shaughnessy-StatisticsForAll-NCTM.pdf

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Learning Outcomes

Critical thinking outcomes:

- Distinguish association from causation using an ABC classification.

Statistical literacy outcomes:

- Learn that statistics are numbers in context: they can be influenced.
- Learn that statistics are socially constructed by people with motives and values
- Learn that "take care" is the best advice when dealing with statistics.
- Learn how all influences on statistics can be grouped into four categories.
- Learn CARE categories: Confounding, Assembly, Randomness and Error
- See how each influence can change the size and direction of an association.
- Use Take CARE to analyze statistics in the everyday media

Introduction

The goal of statistical literacy is for you to be able to read, interpret and evaluate the social statistics you encounter in the everyday media.

Consider two news stories published in the same month:

- An article in the British Medical Journal claims "There is overwhelming evidence that excessive consumption [of salt] causes high blood pressure... "
- An article in the Journal of the American Medical Association concludes that "Dietary salt intake has little effect on blood pressure..."

How can these opposite claims be published at the same time? To address that question, you need statistical literacy, the subject of this text. **Statistical literacy** studies statistics in everyday usage. Statistically literate people think critically about the statistics behind claims like these.

Let's see what statistical literacy means in thinking critically about this story:

Story 1: Fruits, Veggies Cut Risk of Breast cancer

Fruits, Veggies Cut Breast Cancer Risk
Four or more daily servings reduces chances of disease by half

FRIDAY, Oct. 31 (HealthDayNews) -- A diet rich in fruits and veggies can help protect against breast cancer.

A study by Oregon Health and Science University researchers found women who eat at least four servings of fruits and vegetables have a 50 percent lower risk of breast cancer than women who consume no more than two such servings each day.

They reached that conclusion after examining the diets of 378 women with breast cancer and the diets of 1,070 cancer-free women. All the women, living in Shanghai, China, filled out questionnaires that asked about their intake of 108 individual food items, fried and restaurant food, dietary changes, and the use of nutrient supplements and Chinese herbal medicines.

First we must decide what the point of the story is. You can see it from the first sentence: *Eating lots of fruits and veggies can help protect against breast cancer*. The article would have had a different point if it had said *Breast cancer was less prevalent among women who ate lots of fruits and veggies than among those who ate little or none*. The latter point reports a factual matter; the point actually made claims that there's a cause. Causation is also implied by the action words used in the story: *cut* and *reduces.* One aspect of statistical literacy is distinguishing claims of association from claims of causation.

Another aspect of statistical literacy is thinking about the statistics themselves. Statistics are numbers describing data. But they're not pure numbers; they're numbers that measure or count real things. Therefore they can be shaped by

Chapter 2. Comparisons and CARE Solutions

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Learning Outcomes

Recognize associations as possible indications of causation

- Analyze associations: two-group vs. two-factor
- Study two-group comparisons: non-arithmetic (ordinal) vs. arithmetic.
- Distinguish four kinds of arithmetic associations and exceptions.

Recognize three techniques that deal with confounding

- Distinguish different kinds of experiments and observational studies
- Recognize how different study designs control different confounders.
- Know that a controlled study is "any study involving a control group"
- Distinguish 'control of' and 'control for'.

Study techniques that deal with randomness and bias

- Use overlapping confidence intervals to test for statistical significance
- Recognize bias-control methods: placebo, single and double blind.

Review

Chapter 1 focused on problems: the influences on a statistic. It contained a lot of new material. Here are a few of the highlights.

- showed that statistics are typically used as evidence in arguments.
- introduced statistics as numbers in context, so they can be influenced.
- admonished students to "Take Care" when dealing with statistics.
- used CARE to indicate the four kinds of influence on a statistic.

Review the chapter summary at the end of chapter 1. Review each figure. Identify what is being stated. Understand why the information in the figure is important.

Become familiar with the key words and phrases in the new word list. Becoming statistically literate is like learning a new language. It takes time and repetition.

This chapter introduces some of the solutions to some of the problems in chapter 1. It introduces some things to look for in analyzing the use of statistics as evidence.

Association

As noted in chapter 1, there are two kinds of association: two group comparisons and two-factor co-variation. Both are examined in more detail.

Two-Group Comparisons

The most common form of an association is a two-group comparison. There are three types of two group comparisons[72]: raw comparisons, ordered comparisons and arithmetic comparisons. **Raw comparisons** just present the values to be compared. Raw comparisons provide the underlying data, but the user must figure out the order and the size of the comparison. Ordered comparison provide order, but lack precision. Arithmetic comparison provide order and precision.

Ordered Comparisons

Ordered comparisons compare two values without mentioning their size or the size of the comparison. "Seniors are older than Juniors," Ordered comparisons are common in headlines and advertisements.

Table 3 presents counts of accidental deaths.

[72] Others. Ordered raw: Male height (69") is greater than female height (65"). Arithmetic raw: Male height (69") is 4" more than female height (65"). Raw obscures the comparison.

To see this, study the above worksheet[151]. There are 28 people at a table: seven on each side. That gives 49 combinations (7*7) between adjacent sides (top and right; top and left; bottom and right; bottom and left) and opposite sides (top-bottom and left-right). There are four sets of adjacent sides and two sets of opposite sides. This gives a total of 294 pairs given six sets at 49 per set. Finally, there are 21 pairs (6+5+4+3+2+1) for two matches within each of the four sides for a total of 84 pairs (4*21) giving a grand total of 378 pairs (294+84).[123]

With 378 possible pairs hidden inside these 28 people, we can expect one match given one chance in 360 of a match. At least one match is more likely than not.

[151] Assumes 30 days for each month. www.statlit.org/Excel/2012Schield-Bday.xls

Chapter 3. Understanding measurements

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Learning Outcomes

Understand ranks and percentiles.

Recognize the order of mean, median and mode in skewed distributions.

- Compare means, medians or modes using ordinary English.
- Distinguish percent, "percentage points" and "percentile points".
- See how assembly can influence the size of a comparison.

See how shift from totals to ratios can change size & direction of a comparison.

- Compute weighted average from subgroup averages.

Calculate the influence of a binary confounder on a comparison of two means.

- Standardize using arithmetic mix-matching or a graphical technique
- Use Cornfield conditions to see if nullification or reversal is possible.

c. Subject is the group. The measure is inside the verb. The determiners are in trailing prepositional phrases

Means: Adults in 2000 are 10 cm taller on average than in 1920.
Modes Adults in 1920 are typically 10 cm taller than in 1920.
Median: Do not use

===

#3: Compare two measures (measure1 and measure2) involving one group at one time and place. Assume all involve US families in 2018.

a. Subject is measure1. Measure2 is in the predicate. Group possessing the measure is in a prepositional phrase.
Long: The average income of families was 25% greater than the median income of families.
Short: Average family income was 25% greater than median income

*b. Subject is a phrase involving the group (a possessive adjective) and measure1 (a noun). Sentence predicate is a phrase involving a possessive adjective (groups') and a noun (measure2)**
Long: Families' mean income was 25% more than families' median income.
Medium: Families' mean income was 25% more than *their* median income.

c. Subject is the group; measure1 is in the predicate. Comparison is in relative clause modifying measure1.
Short: Families have an average income that is 25% greater than their median income.

Discussion:
It is tempting to say "the average adult male" has a height of 5' 10" instead of saying "The average height of adult males is 5'10". . That usage can be problematic with qualities: The average adult has one testicle and one breast. It is somewhat problematic with discrete quantities: "The average person has less than two legs." Although it is not problematic when describing a continuous quantity, it can be problematic in comparing such a measure for two groups: "The average city in California is bigger than that in Iowa". We don't know the measure. Is it population or area? We don't know. It seems better to connect the measure of center (average, median or modal) with the measure it modifies in a single adjective-noun phrase.

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Learning Outcomes

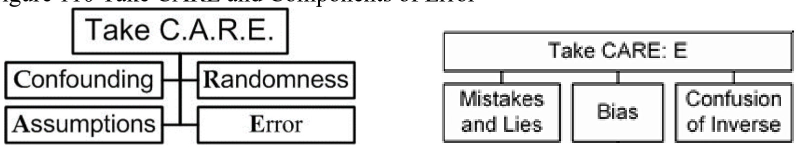
Learning outcomes include:

- Identify part and whole in named ratio grammar statements and questions.
- Learn named-ratio grammars: percent and percentage grammar
- Distinguish percent and percentage grammar.
- Translate part-whole statements between percent and percentage grammar.
- Describe percentages ratios in 100% tables and in half-tables.
- Describe percentages in tables with missing margins.
- Recognize the importance of selection and the confusion of the inverse.

Review

In chapter 1, we noted that statistics – unlike numbers – can be influenced. These influences were classified into four groups as the left side of Figure 110 reminds us. The right side points out the confusion of the inverse as a source of Error.

Figure 110 Take CARE and Components of Error



Confounding provides an alternate explanation for an association. Assembly includes how things are created, selected, defined, measured and presented.

In chapter 2, we studied four ways to form a two-group comparison. Of these, three involved ratios. Confounders can be controlled physically or mentally as shown on left side of and right side of Figure 111 respectively.

Figure 111 Controlling Confounders: Control Of and Control For

CONTROL OF CONFOUNDERS			
Physical Control (Grade = Quality)			
Experiment		Observational Study	
A+	Scientific	C	Longitudinal
A-	Random Assign	D	Cross-sectional
B	Quasi-Exper	F	Anecdotal story

CONTROLLING FOR CONFOUNDERS			
Take into account (mental)			
Can do by hand		*Calculator/Computer*	
1	Select/Stratify	4	Linear Regression
2	Form Ratios	5	Logistic Regression
3	Standardize	6	Multivariate Regress

Chapter 3 studied measurements. We studied three easy ways to control for measurement-related confounders: selection, ratios and standardization. The ratios were averages: sum of measures divided by their count.

Ratios are a natural way to control for the influence of a proportionally-related factors such as the size of a group. That may be why ratios are the most common statistic in everyday life. Ratios are the workhorse in the statistical literacy stable.

This chapter studies ratios of counts where the numerator is typically a part of the denominator. Mathematically, this is no big deal. But describing these ratios is a very big deal. It seems fairly simple, but it is not.

Part-Whole Ratios

To be statistically literate, one must be able to read and interpret part-whole ratios in text, tables and graphs.

The simplest way involves prepositions. Third-graders are introduced to count-based ratios using common prepositions such as *out of* (four out of five doctors recommend Crest) or just *of* (four *of* the six slices of pizza had peperroni). Adults may use a less-common preposition: *per*. Less than one infant *per* hundred dies from a Covid19 infection.

Prepositions are words that identify specific relationships: spatial (in, out), temporal (before, after), logical (if, then) or quantitative (out of, per).

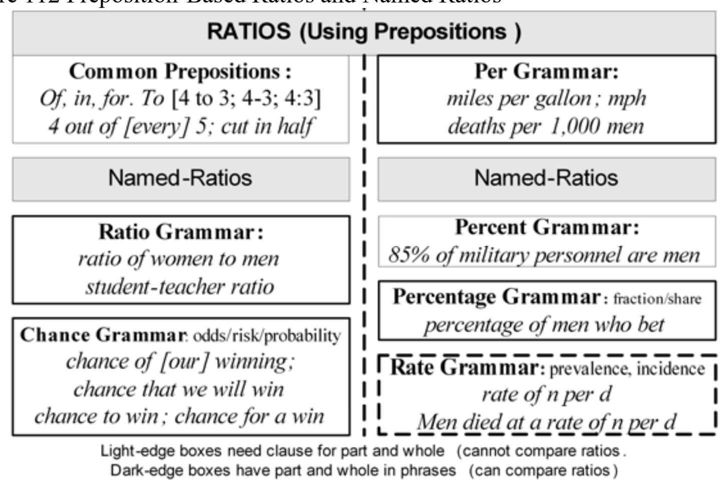
Part-whole ratios can be expressed using just prepositions. But it is difficult to form comparison of these ratios. By giving some of these ratios names, we can describe and compare ratios more effectively.

In English, there are certain nouns that indicate a particular type of ratio and do so with a unique grammar. In this book, these are called named ratios.[192]

Named ratios are words that indicate the presence of a ratio: nouns such as *rate*, *percentage* or *chance*, or adverbs such as *likely* or *prevalent* in comparisons.

Named ratios can be classifed into families that share a common grammar. The five main families are named the *percent*, *percentage*, *rate*, *chance* and *ratio* families. These five-named ratio families are grouped in two columns in Figure 112 depending on whether they involve 'per'.

Figure 112 Preposition-Based Ratios and Named Ratios



The 'per' statistics are arguably the most common ratios.[193] These appear in *percent*, *percentage* and *rate* grammar. Of these three named-ratio families, *percent* and *percentage* are the two that are the most error-prone. So, this chapter studies *percent* and *percentage* grammar. The next chapter studies the other three.

Treat each named ratio grammar as a new language. You will discover how small changes in syntax (grammar) can produce big differences in semantics (meaning).

Percent signifies per 100. Per 100 can be written in two ways: *percent* (in the US) and *per cent* (in the UK). This text uses the US style.

[192] www.statlit.org/pdf/2000SchieldASA.pdf
[193] Allan Tarp (2000) introduced the 'per' ratios. ICME-9. Tokyo.

Convert questions between Percent and Percentage grammar.

When used in a question, the keyword *percentage* is used with percent grammar. What percentage of men who run are seniors? This questions is really percent grammar. The whole and part are in the subject and predicate respectively, so seniors is the part. We don't ask, "What percent….?" That would be like asking "What pounds are you?" instead of "What weight are you?"

The keyword percentage can be used in a question with percentage grammar. What is the percentage of men who run? The presence of *the* before *percentage* indicates percentage grammar, so *runner* is the part.

1. To convert questions from percentage to percent grammar simply drop "is the" in "What is the percentage" and convert the relative clause to a main verb. For example, convert "What is the percentage of men who smoke?" to "What percentage of men are smokers?"
2. Converting questions from percent to percentage grammar is straightforward when there is no relative clauses. Change "What percentage" to "What is the percentage". Change the predicate into a relative clause. For example, convert "What percentage of men are smokers" to "What is the percentage of men who are smokers?"
3. In percent-grammar questions with one or two relative clauses, review the options given in converting percent statements to percentage. Convert "What percentage of <whole1> who are <whole2) are <part1> who are <part2>? Form the complete part as a single phrase without a trailing relative clause by moving the trailing adjective to a leading adjective. "Among <whole1> who are <whole2>, what is the percentage who are <part2><part1>?"

Convert these questions from percent to percentage grammar:
1. What percentage of college students are smokers?
2. What percentage of college students who are 18-25 are women?
3. What percentage of college students are women who smoke?
4. What percentage of college students who are 18-25 are women who smoke?

Warning: Students may get overloaded with the details of percentage grammar. To skip these details, use these two rules for percentage statements: "The percentage who" always introduces a part. "The percentage of" always introduces a part unless followed by a relative pronoun such as *who*, *what* or *that*.

Chapter 5. Describing Ratios: Rate, Chance and Ratio

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Learning Objectives

1. Rate grammar is most common in dealing with very small ratios.
2. The rate family includes prevalence and incidence
3. The keyword *rate* is equivocal. It have four forms. It can be a frequency (# events per unit time), a growth rate (% increase per unit time), a prevalence (# of unemployed per 100 members of the civilian labor force) or an incidence (# of births per year per 100,000 women ages 15-44).
4. Rate grammar has both a phrase form and a clause form.
5. The *chance* family of grammars includes odds, risk, likelihood and probability.
6. Chance grammars has both a phrase form and a clause form.
7. Chance grammars are common but may often leave the whole unstated.
8. The ratio family can easily be involved in the confusion of the inverse.

9. Graphs: recall that a quintile is one-fifth, quartile is fourth and decile is a tenth.
10. Ratios are easily influenced by the choice of the denominator.

Review

In chapter 1, we noted that statistics are numbers in context. Statistics can be influenced. The influences were classified into four groups: Confounding, Assembly, Randomness and Error/Bias. "Take CARE" reminds us of these.

Chapter 3 identified three easy ways to mentally control for confounding: the influence of a related factor. See Figure 135.

Figure 135: Controlling confounding: Control of vs control for

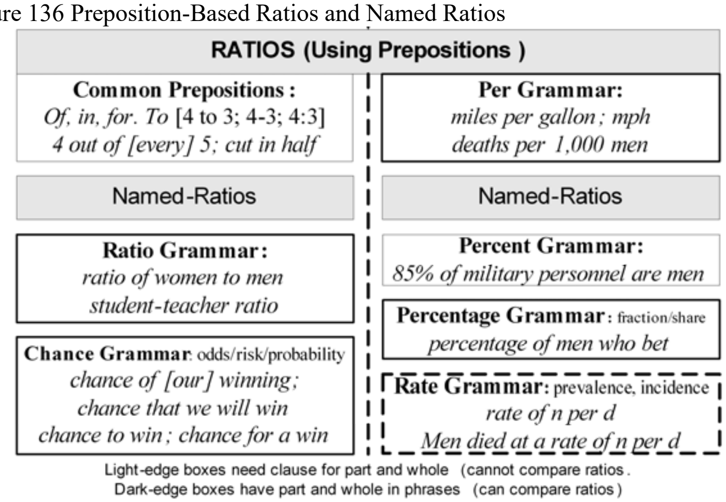
CONFOUNDING

Control of	Control for
Experiments	Selection, ratios
Observ. studies	Standardize

Comparisons, selection, ratios and standardization all involve assembly. Compared to what? Selected what? Out of what? Standardized by what?

Ratios are the workhorse in the statistical literacy stable. Chapters 4 introduced part-whole ratios using *percent* and *percentage* grammar. *Among* always indicated a whole, while *of* sometimes introduced a whole. Figure 136 classifies the ratios by the prepositions involved and introduces the five named ratios.

Figure 136 Preposition-Based Ratios and Named Ratios



Percent and percentage grammar are extremely susceptible to the confusion of the inverse. Describing percentages in tables and graphs can be tricky.

This chapter studies the three remaining named ratios: rate, chance and ratio.

Chapter 6. Comparing Ratios using Named-Ratios or Likely

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Learning Outcomes

1. Calculate the percentage and counts that are attributable to group membership.
2. Distinguish common-part and distinct-part comparisons
3. Write ordinal and arithmetic comparisons involving named-ratio grammar.
4. Compare ratios in ordinary English using percentage, rate or chance grammar.
5. Compare part-whole ratios using "Likely" grammar.

Review

In chapter 1, we noted that statistics are numbers in context. Statistics can be influenced. The influences were classified into four groups: Confounding, Assembly, Randomness and Error/Bias. "Take CARE" reminds us of these.

In chapter 2, we formed comparisons. Review the arithmetic and the wording.

Table 79 Arithmetic Comparisons

ARITHMETIC COMPARISONS	
Difference	Test is (T-B) more|less than Base
Ratio	Test is (T/B) times as much as Base
% difference	Test is [(T-B)/B]*100% more|less than Base
Times difference	Test is [(T-B)/B] times more|less than Base

Chapter 3 identified three easy ways to mentally control for confounding: the influence of a related factor. They were selection, ratios and standardization.

Ratios are the workhorse in the statistical literacy stable. Chapter 4 introduced *percent* and *percentage*. Chapter 5 introduced *rate* and *chance*. Review these.

Table 80 Named Ratio Grammars

CHAPTER 4 NAMED RATIO GRAMMARS		CHAPTER 5 NAMED RATIO GRAMMARS	
Percent	X% of <Whole> are <Part>	Rate (phrase)	The <Part> rate is n per N <Whole>
	Among <Whole>, X% are <Part>		The rate of <Part> is n per N <Whole>
Percentage	The percentage of W who are P is X%	Chance	The chance of <Process><Result> is X%
	Among W, the percentage who are P is X%		<Process's> chance of <Results> is X%.
	Among W, the percentage of P is X%		The chance that <Process> will <Result> is X%

You need to be very familiar with comparisons and named ratios in this chapter.

Introduction to Comparisons of Ratios

This chapter introduces new arithmetic (the 'attributable to' comparisons) and another named ratio grammar: *likely to*. To repeat: small differences in syntax (grammar) can create big differences in semantics (meaning).

After this chapter, you should understand the difference between these claims:

"216,000 deaths *attributed to* obesity" versus "216,000 deaths *caused by* obesity".

"Among NFL players, blacks *charged with more* crimes than whites" versus "Among NFL players, blacks *less likely to be charged with* crimes than whites."

Chapter 7. Interpreting Confusing Ratios

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Learning Outcomes

1. Identify and evaluate inverse ratio claims (the confusion of the inverse)
2. Distinguish different kinds of accuracy and error in medical tests.
3. Calculate predictive accuracy given test accuracy and disease prevalence.
4. Distinguish different kinds of statements involving social statistics.
5. Understand the Cornfield conditions: the necessary conditions to nullify or reverse an association.
6. Understand Simpson's paradox
7. Standardize percentages by mix-matching: algebraic and graphical

Review

In chapter 1, we noted that statistics – unlike numbers – can be influenced. In CARE, recall that Error included 'wrong order'. See Figure 198. For ratios, this is known as the confusion of the inverse.

Figure 198: CARE: Classifying Error

CARE: ERROR

Wrong Order	Bias	Lies
Subtract, Divide	Subject	Mistakes
Comparisons	Measurement	Prevarication
Ratios	Sampling	Weasel words

In chapter 2, we studied two group comparisons. We learned that study design (experiments) can protect statistics from various types of confounders.

Figure 199: Control Confounding: Control Of and Control For

CONTROL OF CONFOUNDERS	
Physical Control (Grade = Quality)	
Experiment	Observational Study
A+ Scientific	C Longitudinal
A- Random Assign	D Cross-sectional
B Quasi-Exper	F Anecdotal story

CONTROLLING FOR CONFOUNDERS	
Take into account (mental)	
Can do by hand	*Calculator/Computer*
1 Select/Stratify	4 Linear Regression
2 Form Ratios	5 Logistic Regression
3 Standardize	6 Multivariate Regress

In chapter 3 we studied some of the easier mental ways to control for confounders. Selection and forming ratios are the simplest.

In chapters 4 and 5, we studied ratios of counts using the named ratios. We recognized that the confusion of the inverse is a major problem. In chapter 6 we studied comparisons of ratios.

All of this is background to this chapter. Chapters 3-6 are like calisthenics. This chapter and the next are the payoff! It's time to apply what you've learned.

Diabolical Denominators

Mathematically, a denominator is just another number. School students work problems changing the units of denominator: from inches to centimeters or from pounds to kilograms. But linguistically, the denominator is much more important. It may seem innocent or trivial, but as you will see, it is almost diabolical.

Diabolical denominator: Changing the denominator can change the direction of an association between two ratios. See Table 85:

Table 85: Annual Expenses per Household (HH) and per HH Reporting

Microwave/year	1980	1987	Chg
per household:HH	$14	$20	43%
Percent reporting	2.9%	8%	176%
per HH reporting	$483	$250	-48%
www.bls.gov/opub/mlr/1992/05/art3full.pdf			Table 1

Babysitting / year	1986	1987	Chg
per household:HH	$76	$75	-1%
Percent reporting	6.8%	6.4%	-6%
per HH reporting	$1,118	$1,172	5%
www.bls.gov/opub/mlr/1992/05/art3full.pdf			Table 3

Chapter 8. Randomness

"If there is a 50-50 chance that something can go wrong, then 9 times out of 10 it will." Paul Harvey News, Fall 1979.

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Learning Outcomes

1. Understand the good and bad of statistical significance

2. See when statistical significance can be influenced – transformed from significance to insignificance or vice versa – by confounding, assembly and bias

3. Calculate confidence intervals given the margin of error for subgroups
   - Calculate the margin of error for subgroups
   - Determine if a difference in subgroup means is statistically significant

4. Distinguish polls from surveys. Polls predict; surveys summarize.

5. Analyze statistical significance impact on clinical trials

6. Identify some common misunderstanding involving chance

Review and Background

Chapter 1 showed how randomness can influence statistics in three areas: extremes, big data and small samples.

1. Extreme outcomes are often just coincidence and can't be replicated.
2. Big data makes it more likely that unlikely outcomes will occur.
3. Small samples make it easier for random variation to influence the results.

Chapter 2 introduced three quantitative ideas involving randomness:

#1: Law of Very Large Numbers. Qualitatively: The unlikely is almost certain given enough tries. Quantitatively: If an event has one chance in N and there are N tries, then one event is expected: the chance of at least one event is more likely than not.

#2: The margin of error is the expected error in random sampling. To form a confidence interval, add and subtract the margin of error to the sample statistic.

#3: A sufficient condition for statistical significance between the means or proportions of two samples is the lack of overlap in their confidence intervals.

Statistically significant describes an outcome that is very unlikely if due just to chance. Statistical significance is evidence for: 1) treating a sample association as real (not spurious) in the population, and 2) treating the difference in a randomly controlled trial as caused by the treatment.

Idea of Statistical Significance

One measure of randomness in the everyday media is the phrase 'statistical significance' or 'statistically significant'. Yes, we don't encounter it very often, but there are times when it is extremely important. Approving new vaccines requires that the results be statistically significant. So this chapter begins with that idea.

Statistical significance is a very abstract idea. It deals with situations that are unlikely. This combination makes it difficult to understand. Let’s think about the idea outside of statistics.

Suppose you are in a relationship. You’ve left a call and three texts with no answer. Normally, you get quick replies. An hour passes, then three hours, then ten. At some point you begin to think. Has something happened? Was there an accident? Is the relationship over? At some point the time delay becomes ‘significant’. It is very unlikely: beyond what is normal, abnormal.

Suppose you are a manager. You’ve learned through experience, that you can’t afford to deal with every problem that crosses your desk. You’ve learned ‘management by exception’: a "policy by which management devotes time to investigating only those situations in which actual results differ significantly from planned results. " This idea was propounded by Frederick Winslow Taylor.

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[325] Schield named ASA Fellow: www.StatLit.org/pdf/2018-Schield-ASA-Fellow.pdf

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Table of Equations

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Glossary

100% Sum Rule	100% Sum Rule: If a margin value is a 100% sum, then the group is whole and each component is a part. P. 171
Accuracy: Confirmation	Confirmation accuracy in a medical test is the percentage of diseased cases that test positive; the percentage of disease-free that test negative. P. 278
Accuracy: Prediction	Prediction accuracy in a medical test is the percentage of positive outcomes that involve the disease (fraction of negatives that are disease free). P. 278
Alternate explanation	An alternate explanation for an association can be provided by a confounder but never by a mechanism. P. 55
Ambiguous	Ambiguous means vague on essentials. P. 19
Anecdotal evidence	Anecdotal evidence involves a study or story about an individual or a small group based on limited experience. P. 72
Apples+oranges comparison	See crude comparison or mixed-fruit comparison
Arbitrary evidence	Arbitrary evidence is evidence that is purely hypothetical or is weakly related to the argument. P. 26
Argument: sound	A sound argument is one that is valid and has true premises. P. 105
Argument strong	A strong argument is one where the premises give strong support for the conclusion.105
Argument: valid	A valid argument is one where the conclusion must true given that the premises are true. P. 105.
Argument: weak	A weak argument is one where the premises give weak support for the conclusion. P. 105
Arithmetic comparison	Arithmetic comparisons compare two values by showing the direction and size of the comparison. Arithmetic two-group comparisons are of four kinds: difference, times ratio, percent difference and times difference. P. 62
Assembly	Assembly involves all the choices that influence a statistic and are not covered elsewhere under CARE. P. 32
Assembly solutions	Assembly solutions involve maturity and critical thinking: close-reading, hypothetical thinking, estimating the impact and asking questions. P. 85
Association	Association (statistical) is a quantitative connection between groups or characteristics. P. 16

Association: crude	A crude association is one that fails to take into account plausible confounders. Also known as a mixed-fruit association or an apples and oranges association. P. 87
Association: flimsy	A flimsy association is one that is readily influenced. P. 105
Association: solid	A solid association is one that is resistant to being influenced (not readily influenced). P. 105
Association words	Association words assert association explicitly or describe associations involving fixed conditions or unrepeatable events. P. 19 See also Causation words and Between words.
Availability bias	Availability bias: A judgement about an event or statistic that is influenced by how readily one recalls examples. P. 99
Average	Average: See Mean.
Bar chart	A bar chart is a chart that uses bar lengths or heights for the amounts. The bars can be vertical (column chart) or horizontal (row charts). The bars can be separated or touching. P. 116
Base part	A base-part is a base in a comparison and a part in a part-whole ratio. P. 246
Base whole	A base-whole is a base in a comparison and a whole in a part-whole ratio. P. 246
Bayes comparison	A Bayes comparison is a common-part ratio comparison in a group versus the entire population. It allows an exchange of the part with the test whole with no change in the numerical strength of the ratio comparison. P. 269
Between words	Between words are words whose meanings are 'between' association and causation. They describe an association but suggest causation. P. 20
Bias	Bias is systematic error: a "systematic deviation of results or inferences from the truth." See Respondent bias, sampling bias and measurement bias. P. 43
Big data	Big data (statistically) is any data set that is so big that all the associations are statistically significant. P. 92
Causation words	Causation words assert causation, state sufficiency or state a contra-factual.. P. 20
Cause	A cause is an event or condition whose level or presence makes (or can make) a difference in something else. P. 18
Cases attributable	Cases attributable to exposure are those deaths in the exposed group that are attributable to being in the exposure group. P. 243

Centers rule	Three centers rule: The three measures of center have a natural order in most skewed distributions. It is alphabetic in English: mean, median and mode if skewed left; mode, median and mean if skewed right. P. 124
Chance	Chance is a possibility of something happening. P. 37
Chance grammar	Chance grammar describes part-whole ratios using the keywords *chance, risk, odds, probability and likelihood*. P. 208
Cherry picking	Selection bias: Selecting just those subjects or data that support your claim.
Clinical trial	Randomized Controlled Trial (RCT) is a controlled experiment (trial) involving random assignment. *Clinical* trial is *the* most common equivalent. P. 73
Close reading	Close reading involves seeing how the presence, choice or absence of a single word or phrase could have a big impact on the statistic or statistical association. Small changes in syntax can create big changes in semantics. P. 85
Coincidence	Coincidence is a noteworthy connection between unlikely events with no obvious connection. P. 37
Columns, rows	Columns run vertically like columns in a building. Rows run horizontally like rows of seats in a theater. P. 165
Common-part comparison	A common-part comparison compares two ratios having a common part of two different wholes. P. 245
Common part	A common-part exists when two part-whole ratios share the same part. P. 245
Comparison bias	Comparison bias occurs when prior differences between the control group and the treatment/exposure group influence the comparison after a treatment/exposure. P. 99
Comparison: mixed-fruit	Mixed fruit comparison: a crude comparison of groups with different mixtures of a related variable. Also known as an 'apples and oranges' comparison. P. 136
Comparison: arithmetic	Arithmetic comparisons compare two values by showing the direction and size of the comparison. P. 62
Comparison: ordered	Ordered comparisons compare two values without mentioning their size or the size of the comparison. P. 60
Comparison: raw	Raw comparisons just present the values to be compared. P. 60
Completion bias	Completion bias: an outcome that is influenced differently by those who do and don't complete. P. 99

Component	Components are cells within a group: a row, a column, or a range. P. 171
Confidence interval	A confidence interval is an interval around the sample statistic (SS) such that 95% of these intervals contain the associated population statistic. P. 97
Confirmation bias	Confirmation bias: selecting just the data that agree with one's thinking, or repeating/confirming an idea so much that it is accepted as true. P. 99
Confounded	Confounded means confused; *confounding* means confusing. P. 27
Confounder	A confounder is a related variable that was not included in generating the association that provides an alternate explanation for an association. Technically a confounder is a third factor that causes the result in an association, and that is related to – but not caused by – the predictor. P. 28
Confusion of the inverse	Confusion of the inverse is a grammatical error where two variables in a ratio are mistakenly exchanged without changing the number. P. 275. The confusion of the inverse exchanges part with whole in a part-whole ratio. P. 170
Context	Context: the relevant circumstances: the reality. P. 11
Control of; Control for	'Control of' is physical; to assign subjects to treatment or control groups, to set the values of relevant factors. P. 82 'Control for' is mental: to take into account or adjust for. P. 82
Control group	The control group is the group not treated or exposed. P. 70
Controlled study	A controlled study is any study that involves at least two groups where one is treated or exposed; the other is not. P. 70
Convenience sample	A convenience sample (a grab sample) is a sample "selected by easily-employed non-random methods." P. 95
Cornfield condition #1	Necessary Condition #1: Simpson's paradox occurs only if the association is bigger for the confounder-outcome than for the predictor-outcome. E.g., the death rate comparison is bigger by patient condition than by hospital. P. 290
Cornfield condition #2	Necessary condition #2: Simpson's Paradox occurs only if the predictor-confounder association is bigger than the original predictor-outcome association. E.g., the predictor- confounder (patients in poor condition) association is stronger than the hospital-death rate association. P. 312
Cross-sectional study	A cross-sectional study is an observational study that involves a single moment in time (unemployment rate) or over a time interval (death rate). P. 72

Crude comparison	Crude comparison: a comparison that conflates (fails to take into account) important related factors. Also known as a mixed-fruit comparison or an apples and oranges comparison. P. 30
Dashed lines	Dashed lines indicate an association. P. 28
Data: count	Count data counts how many things have a discrete quality: *categorical* (male vs. female), *ordinal* (disagree, neutral, agree) or *quantitative* (number of cars).P. 115
Data: measure	Measurement data measures quantities: characteristics that can have any value within some range. P. 115
Deductive reasoning	Deductive reasoning: reasoning where the conclusion must be true if the premises are true and the argument is valid. Often called formal reasoning. E.g., All men are mortal. Aristotle is a man. Therefore, Aristotle is mortal. P. 24
Determiners	Determiners are conditions that determine or delimit the size of the whole or part. P. 167
Diabolical denominator	Diabolical denominator: Changing the denominator can change the direction of an association between two ratios. P. 272
Discriminate	Discriminate (verb) is ambiguous: to discern a difference (good) or to judge with prejudice (bad). P. 21
Discrimination	Discrimination typically means to judge with prejudice. P. 21
Disparate impact	Disparate impact: an unintended disparity between groups resulting from group-neutral treatments. P. 21
Disparity	Disparity**:** a difference (lack of equality or parity) between groups. P. 21
Distinct-part comparison	A distinct-parts comparison compares two ratios involving two different parts of a common whole. P. 245
Distinct parts	Distinct parts exist when two part-whole ratios share the same whole. P. 245
Doing	Doing is when the researcher manipulates or nature intervenes while controlling the subject and the environment. P. 18
Double-blind study	A double-blind study blinds the researcher as well as the subject from knowing which group a subject is in, thereby eliminating bias for both. P. 100
Double-ratio comparisons	Double ratio comparisons are ratio comparisons of ratios. P. 248
Double-who ambiguity	This ambiguity occurs in percentage grammar when two relative pronouns follow *percentage*. P.181

Effect Size	Effect size is the size of a two-group comparison (typically a times ratio) or the size of the slope in covariation. P. 79
Effectiveness	Effectiveness in preventing an outcome is one minus (the rate in the treatment group divided by the rate in the control group). P. 268
Error	Errors are systematic deviations from what is real or true. P. 42
Evidence	Evidence involves less-disputable claims that support the point of the argument. P. 51
Experiment	An experiment is a study involving a doing: subjects are given or assigned a treatment by a researcher or by nature. P. 18
Explanatory power	The more important variable is the variable that has the higher explanatory power: the stronger association with the variable of interest. P. 300
Explanatory power rule	The explanatory power rule: the more important of two binary predictors is typically the one having the greater effect size: the bigger difference, times ratio or percentage difference in the variable of interest. P. 300
Exposure group	The exposure group is the group in an observational study that is exposed. P. 70
Factor	A factor or variable is a property or characteristic of something. P. 16
Family	A family (in housing) is a household whose members are related by blood or law. P. 128
Frequency (rate)	Frequency or velocity (rate): events per unit time (heart rate or speed. P. 199
Frequency distribution	A frequency distribution gives the count of subjects in each category or in a range of values. P. 115
Generalization	Generalization infers a property of a group (population) based on a related property in sample from that group. P. 52
Group in a table	A group is a row, column or table whose subjects make up the subjects in a margin value. P. 171
Half table	A half table is half of a full 100% table with enough information to complete the table. P. 183. A multiple one-way half table consists of a series of one-way half tables placed side-by-side as columns or rows. P. 183
Halo effect	The halo effect is when the researcher's optimism influences the data to support that optimism. P. 99

Hawthorne effect	The Hawthorne effect is a systematic change in response when the subjects know they are the subject of attention. P. 98
Histogram	A histogram is a bar chart where a bar spans an interval, so the bars can touch. P. 116
hypothesis, research	Research hypothesis: a claim involving a difference or change that the researcher hopes will be true in the larger population.. P. 325
Hypothetical thinking (assembly)	Hypothetical thinking (assembly) is thinking about different ways that a statistic could have been created, compared, adjusted or presented. Hypothetical thinking is plausible 'maybe thinking'. P. 85
Hypothetical thinking (confounding)	Hypothetical thinking involves identifying which confounders are plausible and estimating which are the biggest. P. 69
Index values exclusive	Index values can be exclusive (non-overlapping) or non-exclusive. Exclusive index values limit each subject to only one cell. Non-exclusive index values allow overlapping categories. P. 189
Index values exhaustive	Index values can be exhaustive or non-exhaustive. Exhaustive index values cover all relevant values of the index variable. Non-exhaustive index values omit some relevant values. P. 191
Incidence	Incidence **(**rate**):** a relative frequency: events per group size per unit time (2020 birth rate per 1,000 population). P. 199
Indexes	Indexes are the words in a table that indicate the content of the rows or columns.165
Inductive reasoning	Inductive reasoning with statements: reasoning where the conclusion is likely – but not certain – to be true even if all the premises are true. Often called informal reasoning. E.g., All swans I have seen are white. Therefore, all swans are white. P. 24
Inverse ratio	Inverse: a ratio in which the numerator and denominator are switched. In a part-whole ratio, the part and whole are switched. P. 275
Law of averages	The Law of Averages holds that as sample sizes increase, the sample averages will approach the population average. P. 338
Law of very large numbers	Law of Very Large Numbers. Qualitatively**:** The unlikely is almost certain given enough tries. Quantitatively: If an event has one chance in N and there are N tries, then one event is expected: the chance of at least one event is more likely than not. P. 92
Lift ratio	See the Over-involvement ratio.

Line: Dashed	Dashed lines indicate an association. P. 28
Line: Solid	Solid lines with arrows represent causation. P. 28
Longitudinal study	A longitudinal study is an observational study that involves repeated measures: measurement of the outcome at two or more different times on the same or similar subjects. P. 72
Margin cells	Margin cells are cells at the edge of a table (top, bottom, left or right) that include part or all the table. P. 170
Margin values	Margin values are the values at the edge of a table (indicated by "All" or "Total") that include all the subjects in a column or row. P. 170
Margin values	Margin values are either sums or averages. A sum is always bigger than the biggest value it includes, and an average is always smaller. P. 170
Margin-value rule	Margin Value Rule: If a margin value is a sum, then each component of the group is a separate part. If not a sum (if an average), then each component of the group is a separate whole. P. 184
Margin of error	Margin of Error: A range either side of a sample statistic that includes the population statistic 95% of the time. P. 97
Mean	The mean or average is the sum of the values divided by their count. P. 122
Measurement bias	Measurement (researcher) bias is systematic error arising from bad measurements, bad questions or bad judgements. P. 43
Mechanism	A mechanism is the means by which the predictor causes the result. Technically, a mechanism is a third factor that is caused by the predictor and causes the result. P. 55
Median	The median of a distribution is the middle value in a sorted list if odd (the middle of the two center values if even). P. 122
Medical test	Medical tests are tests that involve subjects with one of two conditions, that return one of two outcomes (positive or negative), and that are calibrated by how well the test confirms the known presence and absence of the condition. P. 277
Mix Matching	Mix-matching changes the mix in one group by applying a standard mix and recalculating the weighted average. P. 139
Mixed-fruit comparison	Mixed fruit comparison: a crude comparison of groups with different mixtures of a related variable. Also known as an 'apples and oranges' comparison. P. 136

Mode	The mode is the value or category with the highest frequency. 123 A unimodal distribution has just one peak. A bimodal distribution has two peaks. P. 123
Named Ratio	Named ratios are words that indicate the presence of a ratio: nouns such as rate, percentage or chance, or adverbs such as likely or prevalent in comparisons. P. 162
Necessary condition	A necessary condition is one that must be satisfied before a result can occur. (If the result occurs, the necessary condition must have been true.) P. 153
Non-response bias	Non-response bias: an outcome that is influenced by the mix of subjects that do not participate. P. 99
Nullify	Nullify is where an association vanishes after controlling for a confounder. P. 136
Observational study	An observational study is a study where the investigator observes the result of an exposure: the researcher has no control of anything. P. 71
Outcome	The outcome (result, response or dependent factor) in an association is the factor whose size or existence is being predicted, explained or influenced. P.16
Over-Involvement	Over-involvement ratio (RP) is a ratio of exposure percentages: the percentage of cases that were exposed divided by the percentage of non-cases that were exposed. If RP>1, then RR>1. P. 269
Part	Part designates the group (e.g., men) which if applied to the whole (e.g., soldiers) gives the part within that whole (e.g., male soldiers). P. 166
Part-whole percentage	A part-whole percentage gives the size of the part as a percentage of the whole. P. 166
Percent grammar	Percent grammar describes a part-whole ratio when there is no other named ratio keyword and the % symbol (or 'percent') is followed by 'of' or 'are'. P. 166
Percentage attributable to exposure	The percentage of cases in the exposure group that are attributable to the exposure is the excess between the exposure and control rates as a percentage of the exposure rate. P. 242
Percentage explained by confounder	The percentage difference explained by a confounder is the percent reduction in the original difference after taking into account the influence of the confounder. P. 150
Percentage grammar	Percentage grammar describes part-whole ratios using the keywords *percentage,* fraction *or proportion.* P. 176

Percentage points	Percentage points measure the difference between two percentages. P. 65
Percentile	A percentile is the percentage of subjects who have scores at or below a value. P. 119
Percentile pts	See Percentiles
Percentiles	Percentile points measure the difference between two percentiles. P. 120
Placebo effect	The Placebo Effect: subjects feel or do better after receiving a placebo: an inert (fake) medication or procedure. P. 98
Point	The point is a more disputable claim supported by evidence in an argument. P. 51
Political poll	Political polls forecast the vote in a political event: an election or in passing a proposition). P. 328
Population	A population is any group of interest. E.g., people, plants or stars. P. 94
Prediction vs explanation	Prediction (statistical): The item of interest is the part in a part-whole ratio. Explanation (statistical): The item of interest is a whole in a part-whole ratio. P. 283
Predictor	The predictor (explanatory or independent factor) in an association is the factor that predicts, explains or influences the existence or size of the outcome. P. 16
Prevalence	Prevalence (rate): the ratio of two counts: group count divided by population count at the same time (unemployment rate). P. 199
Prevarication	Prevarication is telling a half-truth by leaving out a most important part. P. 42
Probabilistic causation	Probabilistic causation is causation where ‘Something makes a difference sometimes’. P. 18
Prosecutor's fallacy	The prosecutor's fallacy (the base-rate fallacy) involves treating the confirmation accuracy of a test as though it measured the predictive accuracy thereby ignoring a base rate: the prevalence of the disease in the group. P. 278
Quasi-experiment	A quasi-experiment is an experiment that is not a scientific experiment or a clinical (randomized controlled) trial. Intervention may be done by humans or nature. P. 72
Question bias	Question bias: Wording questions in order to obtain a particular answer. P. 99
Quintiles	Quintiles are fifths of the group; quartiles are fourths and deciles are tenths. P. 121

Random assignment	Random assignment: randomly assigning subjects to the treatment and non-treatment (control) groups – or randomly assigning the treatment and placebo to each subject. P. 73.
Random samples	Random samples are samples in which some element of random selection or assignment was involved. P. 95.
Random sampling: benefit and cost	Random sampling is more likely to yield a representative sample on unknown factors than any other non-random process and it allows one to make statistical inferences, but it requires more time and money. P. 95
Randomized trial	Clinical trials are experiments involving random assignment. P. 73
Randomness	Randomness – pure chance – is the absence of any pattern that will help in predicting the next outcome. P. 37
Rank	Ranks (1st, 2nd, 3rd) measure the order or place of a value in a group of values with 1st being the best. P. 118
Rate	A rate is a ratio that uses *per* to introduce the unit of measure. 199
Rates: Four Kinds	Rates come in four kinds: frequency, prevalence, incidence and growth. P. 199
Rate grammar: clause-based	Clause rate grammar describes a rate using an entire clause: a verb separates the part and whole. P. 202
Rate grammar: phrase-based	Phrase rate grammar describes a rate using just phrases. P. 202
Rel. frequency distribution	A relative frequency distribution shows the percentage in each group by the column height or row length. P. 116
Relative pronouns	Relative pronouns (*who, that* and *which* as well as *what*, *where* or *when*) introduce relative clauses. P. 177
Relative risk	Relative risk (RR): the risk of an outcome in an exposure group (Re) divided by the same risk in the control group (Rc) written as "the relative risk of <outcome> for <exposed> is Re/Rc". P. 268
Replication	Repetition occurs when the experiment is repeated on the same subject in the same condition. P. 18
Representative samples	Representative samples are samples in which the sample matches the population on the relevant factors. P. 95
Representative sampling: benefit	Representative samples take less time and money than random samples, but the sample statistic is not necessarily the best predictor of the population statistic and the margin of error is unknown. P. 95

Researcher bias	Researcher bias is a change in outcome due to a researcher's knowledge of who is in which group. P. 99
Reversal	Reversal is where an association changes direction – a difference changes sign—after controlling for a confounder. P. 136
Safety effect	A Safety Effect is an increase in risky behavior because the subject knows they have safer equipment. P. 98
Sample	A sample is any part of the population. P. 94
Sampling bias	Selection (sampling) bias is systematic error [in the outcome] due to a non-representative selection from a population. P. 43
Sample error	Sample error is the actual difference between a sample statistic and the associated population statistic for a particular sample. P. 94
Sampling error	Sampling error is the *expected* difference between a *randomly-sampled* statistic and the associated population statistic. P. 95
Scientific experiment	A scientific experiment is an experiment that can be repeated. P. 18
Simple test	A simple medical test is one where the accuracy (the error) in confirming is the same for diseased and disease-free.. P. 279
Simpson's Paradox	Simpson's paradox is when an association has one direction at the group level and the opposite direction in each subgroup. P. 137
Single-blind study	A single-blind study uses a placebo to blind the subjects as to whether they are in the treatment or control group and eliminates the placebo effect. P. 100
Skewed distribution	A skewed distribution has one peak with one tail longer than the other. A right-skewed distribution is pulled to the right with a longer right tail. P. 117
Solid lines	Solid lines with arrows represent causation. P. 28
Specification	Specification applies an association in a group to a specific member of that group.52
Spurious association	A spurious association is one that vanishes (no difference, no correlation) after controlling for another factor. P. 135
Standard deviation	Standard deviation, the most common measure of spread, is related to the average variability of the data around the mean ignoring the sign. P. 156
Standardizing	Standardizing involves giving each group the same mixture of a confounder: either the mixture of the entire group or the mixture of one group chosen as the standard. P. 138

Statistical Literacy	Statistical literacy studies how statistics are constructed and manipulated. P. 15 Statistical literacy is the ability to read and interpret statistics in the everyday media. Statistical literacy is critical thinking about statistics as evidence in arguments. P. 2
Statistically significant	Statistically significant describes an outcome that is very unlikely if due just to chance. P. 96
Statistics	*Statistics are numbers in context*. P. 11
Stereotype	A stereotype is a judgment about all those in a group based on a characteristic of some members in that group. P. 52
Studies	Studies are either experiments or observational studies. Experiments involve doing (researchers treat subjects); observational studies involve only seeing (subjects are exposed). P. 71
Subgroup margin of error	The subgroup margin of error is the *maximum* error expected for a particular subgroup. P. 332
Subject bias	Subject (respondent) bias is when people lie or misremember in a systematic way. P. 43
Sufficient condition	A sufficient condition is one such that the result must occur if the sufficient condition is true. P. 153
Survey margin of error	The survey margin of error is the *maximum* error *expected* for statistics involving the entire survey. P. 332
Symmetric distribution	A symmetric distribution has a mirror reflection around its center. P. 117
Tables	Tables are organizations of data into cells that are arranged in rows and columns. P. 165
Take CARE	Take CARE is a good admonition in dealing with statistics. In this course, each letter stands for a kind of influence: C for Confounding, A for Assembly or Assumptions, R for Randomness and E for Error/Bias. P. 14
Take into account	See Control For.
Test and base	In a two-group comparison, the test (T) is the value being compared; the base (B) is the basis of the comparison. P. 62
Test part	A test-part is a test in a comparison and a part in a part-whole ratio. P. 246
Test whole	A test-whole is a test in a comparison and a whole in a part-whole ratio. P. 246

Three-centers rule	Three centers rule: The three measures of center have a natural order in most skewed distributions. It is alphabetic in English: mean, median and mode if skewed left; mode, median and mean if skewed right. P. 124
Times-based ratios	Times-based ratios are comparisons that involve division: times ratio, percent difference and times more. P. 66
Times-less comparison	The new times-less comparison, T is (B/T) times less than B, is unambiguous provided both Test and Base are always positive. P. 66
Treatment group	The treatment group is the group in an experiment that is treated. P. 70
Triangle diagrams	Triangle diagrams show the relationships between three related factors: a predictor, an outcome (result) and a related factor such as a confounder. P. 28
Uncontrolled study	An uncontrolled study involves just a single group. P. 70
Voter expectation	Who do you think will win the upcoming election? P. 329
Voter intention	If the election were tomorrow, who would you vote for? P. 329
Weasel words	Weasel words are words or phrases that suck the meaning out of a claim (just like weasels supposedly suck the yolk out of eggs). P. 42
Weighted average	Weighted average: weights the subgroup averages by their size. Arithmetically it first multiplies the average for each subgroup by the number in the subgroup, sums all these products and then divides the result by the total number in the group. P. 138

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Review of Named Ratios

1. 'Among' and 'per' always introduce a whole.
2. Leading prepositions introduce, determine or delimit a common whole.
3. In statements, a single relative clause after "percentage" always contains a part.
4. Modifiers (leading adjectives or trailing phrases/clauses) typically take on the status of whatever they modify. (Note: one exception in the prior Percentage rule)

"Percent" Grammar (P. 166). Determiners and modifiers can be added.

"% of" present	"Among" absent	#% of <whole> are <part>.
"% of" absent	"Among" present	Among <whole>, #% are <part>.
"% of" present	"Among" present	Among <whole>, #% of <whole> are <part>

E.g., In the U.S., among women, 25% are smokers (or "25% smoke").
The main verb separates part and whole. The whole is on the same side of the main verb as the % symbol; the part is on the opposite side (or is the verb).

"Percentage" Grammar (P. 177). Other modifiers can be added.

"Percentage who*."	The percentage of__	who* are _____	is ___%
Among is absent	{whole}	{part}	. ##
"Percentage who*"	Among _____,	the percentage of ____	is ___ %
is absent	{whole}	{part} .	##
"Percentage who*",	Among ______, the	percentage of __ who* are __	is ___ %
of and among	{whole}	{whole} {part .	##

* Other relative pronouns include *that, which, what, when* and *where*.

Rules for Decoding Tables of Ratios (Percentages or Rates)

Margin values are either sums or averages. A sum is always bigger than the biggest value it includes, and an average is always smaller. P. 170

100% Sum Rule: If a margin value is a 100% sum, then the group is whole and each component is a part. P 171

Margin Value Rule: If a margin value is a sum, then each component of the group is a separate part. If not a sum (if an average), then each component of the group is a separate whole. P. 184

Missing Margin Rule: If margins are missing and the index values are exclusive, they are wholes (unless they add to 100%). P. 188

Questions: Percent versus Percentage Grammar (P. 204).

What percentage of <whole> are <part>?
What is the percentage of <whole> who are <part>?

Comparing two numbers. One is test (T), other is base (B).

1) Difference: # = (T - B): _______ is ______ more/less+ than ______.
{test} # or # percentage pts {base}
2) Times ratio: # = (T/B): ______ is ___ times as much/many as _____
{test} # {base}
3) Percent difference: # = 100(T-B)/B ___ is __ % more / less+ than ___
4) Times difference: # = (T-B)/B ___ is __ times more/less+ than ___
{test} # {base}
+: Difference comparisons allow "er" endings: greater, smaller, etc.
'Often' and 'frequently' can be used with the three ratio comparisons

COMPARING RATIOS: Common Part p. 245. [Distinct part: p. 245]

To delimit a common whole, leading phrases can be added before these templates.
These templates show ratio and percent difference. Use templates above for others

"Percentage" Grammar, Long-Form Compare (P. 253)

The percentage of _________	that are _______	is ___	times as much as	the percentage of _______	that are _______
test whole	common part	##	compare	base whole	common part

Percentage of gals who run is _ times as much as the percentage of guys who run

The percentage of ________	among _______	is ___	% or times more than	the percentage of _______	among _______
common part	test whole	##	compare	common part	base whole

Percentage of runners among gals is ____ % more than that percentage among guys

"Likely" Grammar Rules: Common part p. 257; [Distinct Part p. 260]

1. "among" always indicates a whole
2. "to" indicates a part. (Also, to be, to do, to have, etc.)
3. A part-whole compare must have at least 3 part-whole terms with at least one part and one whole.
4. "as X is" or "than X is" means X is *linked* to the subject. Two linked terms have the same part-whole status.
5. "is likely to" without an object (e.g., *is likely to occur* or *is likely to happen*) indicates the subject is the part.

Common Part Compare: "Likely Among". Part as subject (P. 259)

______ is/are	___	times as likely	among/in _____	as	among/in _____
common part	##	compare	test whole	Indicate	base whole

In 2019, U.S. 12^{th} graders were twice [two times] as likely to smoke as 8^{th} graders.

Common Part Compare: "Likely To". Whole as subject (P. 259)

______ is/are	___	% more/less likely	to _________	than	is/are _______
test whole	##	compare	common part	indicate	base whole

E.g., In 2000, women were 25% more likely to smoke than [were] men