Statistical Literacy: A New Course

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Abstract: ChatGPT is interviewed on statistical literacy. Chat claims that there are two kinds of statistical inference: population inference and cause-effect inference. Chat identifies confounding as one of the major impediments in inferring causation from correlation. Presents Chat's five reasons for teaching statistical literacy. Examines the use of ordinary English to distinguish association from causation, and to distinguish the mathematical meaning of imply from the everyday meaning. Examines a particular statistical literacy course (Math 1300) taught at the University of New Mexico. Examines how standardization takes into account the influence of a binary confounder using a simple weighted average. Argues that statistical educators should offer statistical literacy for students in non-quantitative majors.

Part 1: Introduction

Statistical Literacy: It's a new field, a big field. Today I want to interview an expert on statistical literacy.

We all know about Artificial Intelligence (AI). You've probably heard of ChatGPT. Today I want to interview Chat on statistical literacy. In particular, I'm asking Chat "Should we offer a separate statistical literacy course?" My questions will be introduced with the word "Chat". Chat's answers will be indented and printed in italics.

Chat, how would you describe yourself?

> *I'm an AI language model created by OpenAI called ChatGPT. My main purpose is to assist users like you by providing information, generating text based on prompts, answering questions, and engaging in conversation on a wide range of topics. I don't possess consciousness, emotions, or personal experiences like a human does.*

Notice that Chat said, "I don't possess consciousness … like a human does." This means that Chat doesn't "think" the way that humans do. This will be important later in this presentation.

Chat, what is the ISLP?

> *The International Statistical Literacy Project (ISLP) is a global initiative aimed at promoting statistical literacy and fostering the use of statistics in everyday life. The project was launched in 1997 in response to the growing importance of statistical literacy in an increasingly data-driven world.*

Notice that Chat says the ISLP was launched in 1997. That's wrong. This year, 2024, is the 30th anniversary of the ISLP. The ISLP was launched in 1994.[1]

Chat, how does the ISLP define statistical literacy?

> *The ISLP defines statistical literacy as the ability to understand, interpret, critically evaluate, and communicate statistical information. Overall, statistical literacy is essential for informed decision-making, evidence-based reasoning, and active participation in society.*

I will focus on the last three abilities in this presentation. Now, let's get specific.

Chat, how does statistical literacy differ from introductory statistics?

> *They … focus on different aspects of … statistical information. Statistical literacy encompasses a broader set of skills related to understanding, interpreting, and communicating statistical*

[1] During the Zoom session, the ISLP secretary, Elisa Falck, wrote, "AI indeed does not get it right every time. The ISLP was founded in 1994, not 1997" ;-)

information… Introductory statistics focuses more specifically on teaching the foundational concepts and techniques of statistical analysis.

I like this distinction. Chat views statistical literacy as a broader set of skills: the ability to understand, interpret, and communicate statistical information. I see 'critically evaluate' as essential to interpretation.

Chat, what does introductory statistics study?

Introductory statistics is a foundational course that introduces students to the basic principles, methods, and applications of statistics. Here are some key topics:

- *Descriptive Statistics, Probability,*
- *Sampling and Sampling Distributions,*
- *Statistical Inference, Regression Analysis,*
- *Experimental Design, Probability Distribution, and Statistical Software.*

This is a standard list. I wanted to focus on statistical inference since it is the most abstract.

Chat, what is statistical inference?

Statistical inference is the process of drawing conclusions or making predictions about a population based on sample data:

Now I asked a slightly different question. And I got a very different answer.

Chat, what kinds of statistical inference are there?

Broadly speaking, there are two main types of statistical inference:

I thought I knew what these two types would be: estimation and decision making (confidence intervals and hypothesis tests). I was wrong. I didn't expect Chat's answer.

Broadly speaking, there are two main types of statistical inference:

- ***Population Inference**: Population inference involves making inferences about a population based on information obtained from a sample of that population.*
- ***Causal Inference**: If there is a cause-and-effect relationship between variables based on observational data or experimental studies.*

I don't recall ever seeing the phrase 'population inference.' But that phrase clearly identifies the type of inference that we mean when we talk about statistical inference as statisticians. As for causal inference, we may talk about that when we introduce random assignment: a type of experiment. But Chat is also talking about cause-and-effect relationships based on observational data.

Chat, which kind of statistical inference is more common in introductory statistics?

In introductory statistics courses, population inference is typically more common and emphasized compared to causal inference. While causal inference is an important topic in statistics and research methodology, it is often introduced later in the curriculum or in more advanced statistics courses...

Chat, which kind of statistical inference is more common in policy debates?

Causal inference tends to be more commonly involved in policy debates for several reasons:

- *Focus on Effectiveness,*
- *Causality and Accountability,*
- *Evidence-Based Policy,*
- *Addressing Complex Problems.*

Here we may see the difference between what we statistical educators want to teach (population inference) and what our students may want to learn (causal inference).

Chat, what are examples of causal claims involving everyday statistics? Note the verbs in the examples.

> *Causal claims involving everyday statistics often arise in various contexts, ranging from health and education to economics and social sciences. Here are some examples:*
>
> - ***Education**: "Increased access to early childhood education programs leads to higher literacy rates in elementary school students."*
> - ***Healthcare**: "Regular exercise decreases the risk of heart disease in middle-aged adults."*
> - ***Economics**: "Raising the minimum wage results in decreased unemployment rates among low-skilled workers."*
> - ***Marketing**: "Launching a new advertising campaign boosts sales for a product by 20% within the first quarter."*
> - ***Technology**: "Introducing a software update improves user satisfaction by reducing app crashes by 30%."*
> - ***Environment**: "Implementation of recycling programs reduces landfill waste by 50% in urban areas."*
> - ***Crime**: "Increased police presence in high-crime neighborhoods leads to a 15% decrease in reported incidents of theft."*
> - ***Nutrition**: "Consuming a diet rich in fruits and vegetables lowers the risk of developing certain types of cancer by 25%."*
> - ***Transportation**: "Expansion of public transportation systems correlates with a decrease in traffic congestion by 20%."*
> - ***Finance**: "Implementing financial literacy programs in schools results in a 15% increase in students' understanding of personal finance concepts."*

Remember that Chat viewed statistical literacy as interpreting and communicating statistical information. I want to shift the focus to communication.

Part 2: Communicating statistical information.

Consider the verbs in the 10 examples Chat gave for causal inference. Here they are: decreases, boosts, improves, reduces, leads to, correlates with and results in.

When statistical educators teach statistics, we typically focus on the difference between association and causation. Figure 1 classifies words and phrases that clearly indicate association (A), that clearly indicate causation (C) and that are in-between (B words). Schield (2023).

A: Association	B: Between	C: Causation
Asserts an association;	Asserts an association	Asserts causation;
Says "what"	but suggest causation	Asserts "how" *
associated/association	increases, raises, ups; cut	cause, create, produce
correlation	"As x ↑, y ↓"; "more x, less y"	effect, result, consequence
Two-group comparisons:	before/after; linked, factor	Sufficient: prevent, stop
"Women live longer than men"	leads to; causal factor	"If X, then Y will happen"
"Men more likely to drink beer"	due to, because of	Contra-factual

Figure 1: A-B-C Classification

Almost all the verbs in the 10 examples weren't Association or Causation words. They were Between words: mainly action verbs. The Between words assert an association, but they suggest (imply) causation. The action verbs (increases, raises, ups, cut) are the most common Between words.

Look at the covariation statement. "As X increases, Y decreases." As statisticians, we know that is just a statement of association. Mathematics doesn't talk about causation. There is no mathematical operator for causation. When we say, "As weight increases, height increases", we don't mean you can expect to get taller if you increase your weight. Nevertheless these in-between words and phrases suggest causation.

Our students need to be informed about these Between words as part of the communication aspect of statistical literacy.

Figure 2 is a list of headlines describing the same statistical result. Focus on just the first two lines.

Study: 45,000 deaths *attributable* to Uninsurance (PNHP 9/17/09)
45,000 American deaths *associated with* lack of insurance (*CNN* 9/18)
No health coverage *tied* to 45,000 deaths a year (*Reuters MSNBC* 9/17)
Lack of insurance *linked* to 45,000 deaths (*White Coat News*, 9/17/09)
Study *links* 45,000 U.S. deaths to lack of insurance (9/17/09)
Study: 45,000 U.S. Deaths *From* Lack of Insurance (MoneyNews 9/17/09)
One American dies every 12 minutes *due to* no health insurance (blog DR)
45,000 Americans die ... *because of* lack of health insurance (blog MyDD)
Study: 45,000 *Uninsured Die* a Year (CBS News, 9/17/09)
Lack of Health Insurance *Kills* 45,000 a Year (Health Insurance com)
Lack of Health Insurance *causes* 44,789 deaths in US every year (blog)
Lack of insurance to *blame* for almost 45,000 deaths: Study (*HealthDay*)

Figure 2: Different Wording for the Same Condition

In the first headline, deaths are attributable to uninsurance", the verb *attributable* has a very specific statistical definition. Statistically, it is a measure of association. The second headline uses the verb *associated with* which clearly indicates an association.

Now look at the connectors in middle lines: *tied to*, *linked to, from, due to, because of, die* and *kills*. The movement from association toward causation is clearly shown in the use of these Between words.

The connectors in the last lines, *causes* and *blame*, assert causation. *Blame* indicates moral causation.

What is the point? It's the words. The words set the context for the numbers. Students need to understand how to use and interpret these words if they are going to understand and interpret statistics in the everyday media.

To see the importance of words, consider this statement that all statisticians are likely to say whenever we teach introductory statistics: "Correlation does not imply causation." Having been trained in mathematics, the word *imply* means *sufficient*. Thus, the phrase *does not imply* means *is not sufficient*.'

Our students are not trained in mathematics. In general usage, *imply* means *supports*. So when statisticians say that *correlation does not imply causation*, the students may think that their teacher is saying that *correlation never supports causation*. If so, they may think that their teacher is not making sense. The students recognize that correlations – associations – are the basis for most of our knowledge of natures and causes.

Again, the importance of words when communicating statistical information. Now turn to another element of statistical literacy according to Chat: Interpreting statistical information.

Part 3: Interpreting statistical information

Chat, why doesn't correlation imply causation? [Chat give a list of reasons. This is just the first one.]

> *Correlation alone does not imply causation. Here's why:*
> - ***Third Variables****: may be causing both observed variables to change. These are often referred to as confounding variables. Confounding variables are extraneous factors that … make it difficult to determine the* ***true causal*** *relationship between them [the independent and dependent variables].*

This is important. Our students should certainly know about confounding. Confounding is what I consider to be not just 'a big idea', but arguably the 'biggest idea' in dealing with statistical information obtained from observational studies.

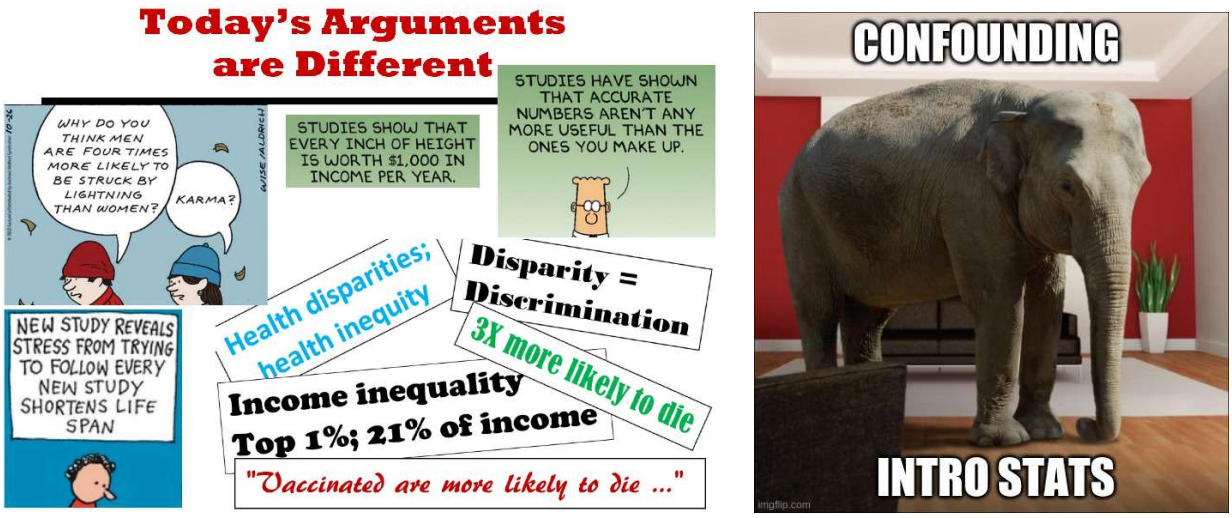


Figure 3: Today's arguments are different; Confounding is the elephant in introductory statistics.

For me, confounding is the 'elephant' in introductory statistics. By 'elephant', I mean something huge, but something we ignore. We know it is there, but we don't want to acknowledge it.

As statisticians we know about confounding. But, it is not featured in our introductory statistics or research methods courses.

I picked 100 introductory statistics textbooks from my shelves. Of these, 80 did not mention confounding or a synonym in the index. Most of the other 20 mentioned confounding briefly in demonstrating that correlation does not imply causation and never mentioned it thereafter. For example, the correlation

between ice-cream sales and burglaries in Canada. Burglars don't commit burglaries in the winter. You could slip, fall and hurt yourself. Burglars commit burglaries in the summer. In the summer, it is hot. That's when people buy ice cream.

Furthermore, there isn't time in teaching the introductory course to free up one or two weeks to teach about confounding. As Allan Rossman (2007) said,

> The GAISE Guidelines present "a great list of goals. These goals are hard to attain – and understand 'why'. You simply can't achieve these goals in one course if you also teach a long list of methods. Most students would be better served by a Stat 100 course than a Stat 101 course."

Finally, teaching confounding complicates things. Confounding is not a simple concept.

Chat, Should statistical educators teach confounding?

> *Yes. Confounding is a fundamental concept in statistics, particularly in the context of research design, data analysis, and inference. Understanding confounding is* essential *for students to conduct valid statistical analyses, interpret research findings accurately, and draw appropriate conclusions from data.*

I was surprised that Chat said "Yes". Normally Chat does not give Yes/No answers. Instead it gives reasons for saying one or the other. Here Chat says Yes because confounding is a fundamental concept.

Chat, what wording indicates that a variable [a confounder] has been 'considered'?

> *Here are some common indicators:*
> - ***Taken into Account**: "We took socioeconomic status into account …."*
> - ***Considered in the Analysis**: "We considered age as a potential confounder…"*
> - ***Accounted for**: "We accounted for seasonality in the time series analysis."*
> - ***Controlled for**: "We controlled for gender differences in analysing educational outcomes."*

Our students need to know about these phrases because they are critically important in reading and evaluating statistics in the everyday media. They need to know how controlling for something can influence an argument when it is present and when it is are absent.

Chat, what techniques control for confounding quantitatively?

> *Several techniques can be used to control for confounding in statistical analyses:*
> - *Stratification:*
> - *Matching:*
> - *Multivariable Regression Analysis:*

Stratification is important. Stratification occurs in a table when the rows breakout different values of a confounder. Comparisons within a row control for that confounder. Does the relationship persist? Does it get bigger, get smaller, disappear (spurious) or reverse? Selection is the simplest way to take into account the influence of a confounder without Algebra or computer software.

Matching is important but usually that is done in selecting the subjects. That usually isn't something that can be done after the data is collected.

Multivariate regression is the 'big gun' for statisticians. But, I can't teach that – as a professional – without teaching the assumptions involved in that model and investigating the diagnostics to see if these assumptions are satisfied. I don't want to teach bad practice to my students.

Later in this presentation, I will demonstrate a situation that allows one to do multivariable regression without using computer software, algebra or diagnostics.

Part 4: Should we offer a separate statistical literacy course?

Chat, should statistical educators offer a separate statistical literacy course?

Offering a separate statistical literacy course can be beneficial for several reasons:

1. ***Focus on Fundamental Concepts****: A statistical literacy course can prioritize teaching fundamental statistical concepts without delving too deeply into mathematical complexities. This allows students to grasp the essence of statistical thinking without being overwhelmed by formulas and calculations.*
2. ***Real-World Applications****: Such a course can emphasize the practical applications of statistics in everyday life, helping students understand how statistics are used in various fields such as politics, healthcare, economics, and more. This approach can enhance students' critical thinking skills and empower them to make informed decisions based on data.*
3. ***Accessible to All****: By offering a separate course focused on statistical literacy, educators can make statistical concepts more accessible to students from diverse academic backgrounds. Not everyone may need or want an in-depth understanding of statistical theory, but everyone can benefit from knowing how to interpret data responsibly.*
4. ***Promote Data Literacy****: In an increasingly data-driven world, promoting data literacy is crucial. A statistical literacy course can teach students how to critically evaluate data sources, recognize common statistical pitfalls and biases, and communicate statistical findings effectively to others.* [When I think of data sources, I think of study design.]
5. ***Complement to Traditional Statistics Courses****: For students who wish to delve deeper into statistical theory or pursue careers in fields that require advanced statistical knowledge, a statistical literacy course can serve as a solid foundation. It can provide the conceptual understanding necessary to excel in more advanced statistics courses.*

Based on Chat's list of benefits, it seems obvious that our students should have the opportunity to study statistical literacy. Here are my ideas for teachers:

We should start with the quantitative needs of today's students.
We should analyze news stories, advertisements and posters.
We should examine the wording used to express statistical ideas.
Statistical literacy should be empirically-based on the everyday statistics students encounter.

If statistical literacy is not empirically based, then we end up teaching our pet ideas. If we like box plots as teachers, we will teach box plots even if students never see these in the everyday media.

Today's arguments are different. Here is what our students are likely to see. This is where statistical literacy needs to be.

Today's student don't know the difference between:

- association and causation
- disparity and discrimination
- hard and soft science,
- a crude and an adjusted comparison

Today's students don't know how to evaluate statistics as evidence. They don't know what 'taking into account' means quantitatively.

These represent a major weakness to today's education.

This is content that we know as statistical educators. We can teach it. Let's see if we should teach it.

Part 5: Investigating a particular Statistical Literacy course.

To better understand a statistical literacy course, we need to examine a specific example. Consider Math 1300 taught by the Math-Stat department at the University of New Mexico. It satisfies a mathematics requirement in the New Mexico General Education curriculum. Statistics majors are required to take this course along with the traditional population-inference course.

Yes, this is my course. It uses my textbook. I'm teaching it. But that's not the point. This is an example.

Someday, hopefully, someone will design a better course and teach it themselves in a different way at another college. Hopefully someone will write a better textbook that is more accessible and valuable to students and is more readily taught by statistical educators.

Focusing on a particular course gives some specific ideas of what could be done.

This course has less than a 30% overlap with a traditional statistics course. The textbook is published by Kendall-Hunt. It is available as a pdf and in hard copy.

This course is in its third year at UNM with over 200 students per year. Figure 4 presents the UNM course description and shows the cover of Schield's Statistical Literacy textbook.

Figure 4: UNM Statistical Literacy Course Description and Schield's Textbook.

How should a confounder-based statistical literacy course relate to a population-inference course? Both are statistics course. Statistics as a discipline studies variation. There are two kinds of variation: random and systematic.

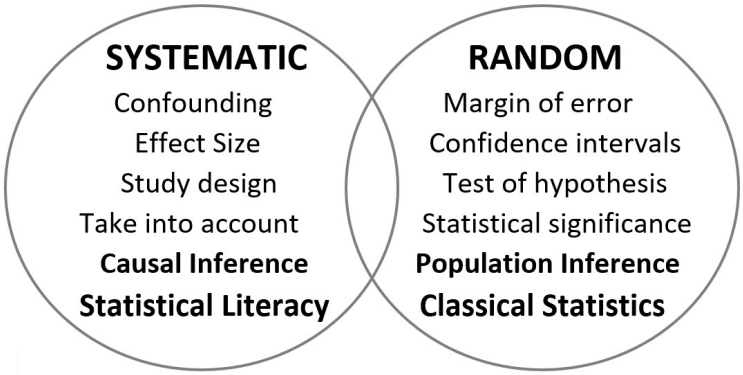


Figure 5: Two-Kinds of Variation

Introductory statistics focuses primarily on random variation and population inference.
Statistical literacy should focus primarily on systematic variation and causal inference.[2]

These two courses have some overlap, but they are fundamentally different.

Here are the two main objectives of the Math 1300 course:

1. Can identify and evaluate known influences (confounding, assembly, randomness and error) on a statistic. Can think hypothetically about influences that are unknown or unmeasured.
2. Can evaluate the strength of evidence provided by statistics in the everyday media, in press releases and in journal articles.

Statistical literacy (Math 1300) is a very different course. Different because it has a different audience.

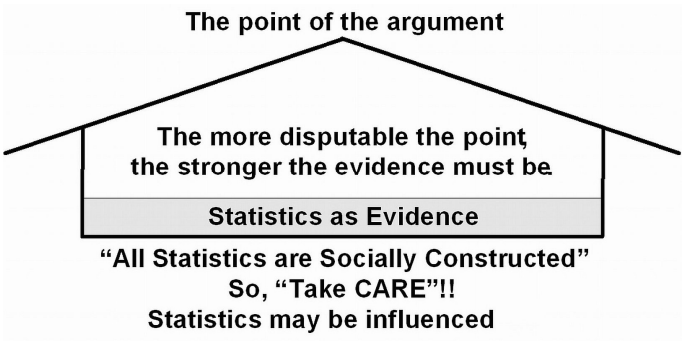
Classical statistics is designed for producers of statistics. Statistical Literacy is designed for consumers of statistics: students in non-quantitative majors such as English, history, music, etc.

Classical statistics focuses primarily on experiments and random surveys. Statistical Literacy focuses primarily on observational studies and confounding.

Classical statistics typically uses computers and algebra. Statistical Literacy doesn't require either.

In Statistical Literacy, context, causation and confounding are central. There is a strong emphasis on the use of ordinary English to describe and compare conditional probabilities. In dealing with quantities, grammatical accuracy is critical. Small changes in syntax can create big changes in semantics.

Statistical Literacy can be a stand-alone survey course or serve as a bridging course to classical statistics (Stat 101) for those students with weak quantitative skills.



SCIENCE SAYS	
Hard Science	**Soft Science**
Experiments	**Observational studies**
Ideal experments	Longitudinal studies
Randomized trials	Cross-sectional studies
Quasi-experiments	Anecdotal reports

Figure 6: Argument as a House. Two Types of "Science says"

The left side of Figure 6 shows the role of statistics in an argument. One way to visualize an argument is to view it as a house where the basement supports the walls, the walls support the roof. The point of an argument is like the point of a roof. Typically, the statistics are in the basement. Statistics typically function as evidence in an argument.

The right side of Figure 6 shows how the phrase 'science says' (or 'studies say') can involve either hard science (experiments) or soft science (observational studies). In dealing with Covid, the studies testing the drugs effectiveness involved hard science (randomized trials). Whereas the studies testing the

[2] Systematic is something that repeats predictably. Systemic refers to a system as in systemic racism.

effectiveness of masks in protecting one from Covid was largely soft science (based on observational studies).

To see why statistics based on experiments provide stronger evidence than those based on observational studies, consider the nature of statistics.

Figure 7 illustrates important characteristics of all everyday statistics.

Statistics: Four Important Things	
1	Statistics are numbers in context
2	Statistics can be influenced
3	Statistics are socially constructed
4	"Take Care" with statistics

Figure 7: Four Important Things to Know about a Statistic

Since all everyday statistics can be influenced, and since there are an incredibly large number of potential influences, it is necessary to classify these influences. One way is to classify them into four categories.

C = **Confounding**: Statistics are influenced by related factors.
A = **Assembly**/Assumptions: Statistics are influenced by other choices.
R = **Randomness**: Statistics are randomly influenced by chance.
E = **Error**: Statistics are systematically influenced by mistakes or bias.

Figure 8: Four Kinds of Influence on a Statistic

Randomness and error (bias) are covered in the traditional classic population inference course. Confounding and Assembly (assumptions) are essential and unique in this statistical literacy course.

Notice that the first letter of each of the four categories forms the word CARE which ties out with the admonition to "Take CARE" when dealing with statistics. Students have found this structure very helpful in organizing their thinking about the strength of a particular statistic. In fact, they found it to be the most helpful idea in the entire course.

Now consider two important topics in this course: the diabolical denominator and standardization.

The diabolical denominator highlight the fact that the choice of a denominator can change the size of a ratio, the size of a comparison of ratios and the direction of that comparison.

The left side of Figure 9 shows the COVID death rates for Michigan (left) and Rhode Island (right). Per capita (per million population), Rhode Island has the higher Covid death rate. But per test and per case, Rhode Island has the lower COVID death rate. The choice of the denominator changes the direction.

Mich.	Total Covid Deaths	R.I.
20,098	per million CASES	18,022
???	per million INFECTIONS	???
1,399	per million T E S T S	665
1,662	per Million P O P U L A T I O N	2,521

www.worldometers.info/coronavirus/country/us/ as of 5/1/2021
Total tests given exceeded the population for both states

Male%	Compare Rates between Levels	Black%
93%	PRISON	38%
73%	ARRESTS	26%
75%	C R I M E S Committed	25%
49%	P O P U L A T I O N	13%

2019: https://bjs.ojp.gov/library/publications/list?series_filter=Criminal%20Victimization
ucr.fbi.gov/crime-in-the-u.s/2019/crime-in-the-u.s.-2019/topic-pages/tables/table-42

Figure 9: Covid Death Rates by State (left); Prevalence of Men and Blacks in Prison (right)

The right side of Figure 9 shows the composition of those in prison. Men are 93% of those in prison, but only 49% of the population. This is a big disparity. Could it be sexual discrimination? Yes. I've never heard anyone argue that before. If so, should we be putting more women in prison – or fewer men?

How does the government know the statistics for crimes committed since about half of all crimes are not reported? The US Government does a survey asking if the respondent has been the victim of a crime. If so, then that data is used to create the data per crime committed.

The far right side of Figure 9 shows the prevalence of Blacks: 38% of those in prison versus 13% of those in the population. Another big disparity. But look at Blacks as a percentage of those arrested (26%) and of those committing crimes (25%). The disparity is smaller. The choice of the denominator changes the size of the disparity. Could this gap be due to racism? Yes. Could it be due to related factors? Yes. Hypothetical thinking is required to think of alternative explanations for these remaining disparities. Maybe the reason that men commit more of the crimes than women is that men are bigger. They are more accustomed to using their size. Maybe the reason the percentage in prison is even larger is that men are more likely to commit more violent crimes (severity) than women.

What about the racial disparities. Why the higher prevalence of Blacks among those in prison than among those arrested? One reason might be recidivism. 74% for Blacks, 70% for Whites and 67% for Hispanics[3]. Another might be the severity of the crime. Again, hypothetical thinking is the doorway to searching for data to test the hypothesis.

Just because a part of a disparity is explained or eliminated by taking into account a particular factor does not mean that racism has been eliminated. It may be that the factor in question is itself due to racism.

Standardization:

So how can students take into account the influence of a related factor quantitatively without computer software and without algebra or calculus? Simple. Use standardization.

Standardization is an old technique used before computers. Standardization converts a mixed fruit comparison (an apples and oranges comparison) into a same fruit comparison (an apples and apples comparison).

Figure 10 shows the mean income for working men and women. Before standardization, working women ern 73 cents for every dollar a man earns.

Mean Income by Gender and Work Status					Pctg who are	Worker Income	
2020	Workers	Col %	FT/Perm	Other	FT/Perm	Adjusted	Col %
Male	$64,200	100%	$79,800	30,900	**68%**	$64,200	100%
Female	46,600	*73%*	73,200	10,100	58%	**53,100**	*83%*
Difference	17,600	27%	6,600	20,800		11,100	17%

Apply male percentage (68%) to females. $**53,100** =**.68***73,200+**(1-.68)***10,100

Assume mean incomes are 1.3 times medians. Controlling for work eliminates 37% of gap

Table A7: www.census.gov/library/publications/2021/demo/p60-273.html

Figure 10: Mean Income by Gender: Before (left) and After (right) Standardization

But that comparison is a crude comparison – a mixed fruit comparison. It's not fake news, but it doesn't tell the story behind the statistics. Notice the difference in work status shown in the center section where 68% of men work full-time permanent but only 58% of women do so. Standardizing means giving both group the same mixture of the confounder.

[3] https://usafacts.org/articles/how-common-is-it-for-released-prisoners-to-re-offend/

On the right side, women's income is adjusted by giving them the same work status mixture (68%) as the men. The weighted average calculation is shown just below the table on the right.

Using the adjusted income (after taking into account work status), women earn 83 cents for every dollar a man makes. Controlling for work status eliminates or explains 37% of the original gap.

OTHER DIFFERENCES

This statistical literacy course is different. Here are some differences:

- The Law of Very Large Numbers. Qualitatively, the unlikely is almost certain given enough tries. Quantitatively, if a rare event has one chance in N and there are N tries, then one event is expected (on average) and the chance of at least one event is more likely than not.
- In most skewed (lognormal) distributions, the mean, median and mode line up in alphabetic order.
- Cornfield condition: the necessary condition for a confounder to nullify or reverse an association.
- Confusion of the inverse in ordinary English. The "percentage of men who run" vs. "the percentage of men among runners."
- Percentage tables are presented as 100% row tables, 100% column tables, 100% total tables, half tables, two-way half tables and tables without margins.
- If two 95% confidence intervals do not overlap, then the difference in sample means is statistically significant.
- Statistical significance can be influenced in an observational study or survey.
- A statistically significant result means there is a 95% chance (Bayesian) the research hypothesis is true provided the research hypothesis was more likely than not to be true prior to the test.

Student evaluations and comments

1st year	4th year	Category
95%	87%	Valuable in helping you read the news
65%	79%	Helpful in developing critical thinking
32%	61%	Should be required for graduation

Source 1st year students: Schield (2022). Source 4th year students: Schield (2016).

Student comments:

- "*the first time I feel like I'd actually use a math class outside of the classroom regularly*"
- "*I enjoyed critical thinking and the news stories*."

This level of positive feedback is important. I don't get this kind of feedback when I am teaching classical statistics (population inference) to students in non-quantitative majors.

Part 6: We should offer a Statistical Literacy course.

Teaching statistical literacy is imperative. Many if not most of today's political and social arguments involve everyday statistics: statistics based on observational studies where confounding is a big issue. Today's students need to learn about confounding.

In my opinion, statistical educators have:

- Have no expertise on whether an association is due to causation (a disparity is due to discrimination).
- Lots of expertise on confounding and how an association can be influenced by confounders.

Here is my big assertion. Statistical Literacy is the future. As AI improves and big data gets bigger, human intelligence (HI) will become even more important. Human intelligence (HI) involves hypothetical thinking about statistics: thinking about what *could* have influenced an association, and what *should* have been taken into account.

Here are my recommendations:

1. Read Joel Best's *Lies, Damned Lies and Statistics*. University of California Press.
2. Investigate this course. Research some of the papers. Buy the textbook. Teach part of it.
3. Support offering the course as an option for all your students. Convert a section of Stat 101 to Stat 100: statistical literacy
4. Teach a statistical literacy course. Teaching is the best way to learn a subject. Statistical Literacy is very different.

Best wishes.

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Portals to Schield's publications:
Schield, M. Most of Schield's publications by topic and date. www.StatLit.org/Schield.htm
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