ASSOCIATION VS. CAUSATION; DISPARITY VS. DISCRIMINATION

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Association is not causation. This fact is central to the teaching of statistics. This paper identifies six problems in the standard presentation. Solutions are presented. One problem involves connecting these abstract ideas with their expression in ordinary English: an important part of statistical literacy. These expressions are grouped into an A-B-C classification: A indicates association, C indicates causation and B indicates in-between. This classification is extended to handle disparity and discrimination. Disparity is linked to association (descriptive); discrimination is linked to causation (inferred). Statistical educators have no expertise in deciding whether an association is causation or whether a disparity is discrimination. But they have expertise in analyzing the effects of context on a statistical association or disparity.

ASSOCIATION VERSUS CAUSATION

Almost all introductory statistics courses start by noting that "correlation is not causation." Examples are given such as the gender discrimination at UC Berkeley, the correlation between ice cream sales and burglaries, etc. This standard introduction is unhelpful – if not wrong – in six ways:

1. Correlation measures the co-variation between two factors: a common relationship in science. Correlation excludes two-group comparisons: a more common relationship in everyday life. Correlation involves a complex quantitative relationship – far from anything students encounter.
2. Students do not have a clear separation between association and causation. For them, association is the doorway – the sign – of causation. Causal connections always have an observed association.
3. Students do not know how to interpret "not" in saying "Association is not causation." Does 'not' mean 'never'. If 'not' does not mean 'never', what does it mean? Saying "Association does not imply causation" is almost always misunderstood. For mathematicians, 'does not imply' means 'is not sufficient'. For most students and citizens, 'does not imply' means 'does not support'.
4. The examples involved usually involve confounding. But most students have never heard that word and are not familiar with how a confounder can influence an association.
5. Even if students understand confounding, these confounder-based examples are not helpful. The typical introductory statistics course involves randomness. Using confounder-based examples to introduce randomness is 'bait and switch'.
6. Students have difficulty distinguishing association from causation when using ordinary English which means they have trouble distinguishing disparity from discrimination.

Here are six solutions that match the six problems listed above:

1. Ignore correlation (the measure of covariation) and focus on association instead. Describe association using 'two-group comparisons' and 'two-factor covariation'. Provide examples using ordinary English for qualitative (ordered) and quantitative (arithmetic) cases. See Figure 1.

Figure 1: Association: Two-Group Comparison and Two-Factor Covariation

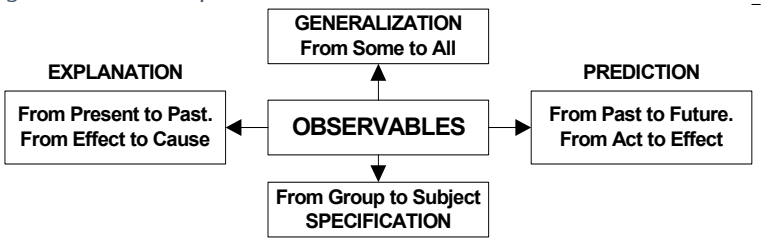
ASSOCIATION (statistical)

Comparison (Two-groups)	Type	Co-Variation (Two factors)
Women live longer than men	Ordered	As height increases, weight increases
US women live five years (6.6%) longer than men.	Arithmetic	For each additional inch in height, weight increases by five pounds

2. Students may think of internal causation (I hit the ball) or external causation that is generally sufficient (lightning causes thunder). Talk about social causation. What causes wealth or poverty? Introduce inference: inferring something less well known from something more well-known.

Inference is the doorway – the starting point – in showing the benefit of an association. Figure 2 shows how observable associations (center) are the basis for four different kinds of inference.

Figure 2: Inferring Unobservables from Observable Associations



3. To help students understand the 'not' in association is not causation, say, "Association is not always – not necessarily – causation". Instead of saying "Association does not imply causation", say "Association is not sufficient for – does not prove – causation."
4. To help students see confounding can influence an association, use simpler examples. (1) People who shave their faces are typically taller than those who shave their legs. So, if you want to grow taller, shave your face. Obviously, this conclusion is false. The inference is confused: confounded by gender. Men are more likely to shave their face; men are more likely to be taller. (2) Readers of home and fashion magazines are more likely to get pregnant than readers of car and sport magazines. So, if you want to get pregnant, read home and fashion magazines. This is generally false. The magazine has nothing to do with pregnancy (although it may provide tips on finding a romantic partner). Having a uterus (typically female) is a necessary condition. So, if women are more likely to read home and fashion magazines than to read car and sport magazines, the confusing association may be untangled with gender as the confounder.
5. To better prepare students for a randomness-based course, use randomness in extremes to distinguish association from causation. (1) In a face-to-face class, have students flip coins and record the outcomes. Identify the student with the longest consecutive run of heads or tails. Could this indicate that this student has special powers – that they are luckier than other students? Maybe… What is another explanation? Coincidence. How can we tell whether the result is skill or luck? Repeat the study. In this way, students get the two big ideas of introductory statistics: An association can be due to randomness. If an outcome is due to randomness, then it is not expected to repeat. (2) Introduce the *Sports Illustrated* Jinx. Athletes highlighted on the cover of *Sports Illustrated* magazine seldom do as well the next year. Yes, there may be causal reasons. Athlete slacks off, etc. But the extremes in runs and in being on the cover of *Sports Illustrated* could both be just coincidence. Coincidence in extremes seldom repeats.
6. Introduce students to the wording used in everyday English to describe association and causation.

Association versus Causation in the Everyday Media

Some 2,000 news stories were analyzed in their usage of the keywords indicating association and causation. (Schield and Raymond, 2009). The results were summarized into a three-group A-B-C classification. 'A' words signify pure association; 'C' words signify pure causation; 'B; words signify 'Between' association and causation. 'Between' words have a causal connotation, but in fact only assert an association. 'Between' words are much more common in the everyday media than words indicating pure association or pure causation. See Figure 3. Students don't really understand the association-causation distinction until they can connect it with what they read in the everyday media.

In these 2,000 news stories, 74% included words involving association, causation or both. Of those stories involving association or causation, 21% involved Association keywords (static two-group comparisons), 66% involved Between words such as action verbs (cuts, ups, increases, etc.), changeable two-group comparisons and covariation (As X increases, Y increases), and 15% involved Causation keywords such as sufficient, temporal and quasi-casual keywords. Static two-group comparisons are those involving two groups with static characteristics: women live longer than men on average. Changeable two-group comparisons (Between) are those involving changeable characteristics: women who eat nuts have a fewer health problems [than women who do not eat nuts].

Figure 3: A-B-C Classification in the Natural World

Semantics: Association is not [necessarily] Causation

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

Based on common usage by many today, but not "etched in stone" for all. * Other words OK in context. Schield V0K

Benefits of an Association

While all of the foregoing are important, a full presentation requires that students recognize the benefits of identifying an association? See Figure 2. Association is the doorway to knowledge, to science and to improved decision-making. Associations can be extremely valuable. Claiming causation requires an argument. Citing an association is not sufficient.

- Associations support generalizations. Suppose that eating lemons cured scurvy in a few sailors. Perhaps eating lemons would cure scurvy for most –perhaps even all – sailors: a generalization.
- Associations support predictions, even if we don't know their causes. The ancients used associations to predict tides, seasons and eclipses long before they understood the solar system.
- Associations support specification. Suppose there is an association between some symptoms and a cure. If your symptoms are similar to those having a certain condition (scurvy), then perhaps your condition may be improved by using the same cure (lemons).
- Statistical associations may support causal connections. For 17th century German monks, colic (abdominal blockage) was more prevalent among wine drinkers than non-drinkers. In 17th century England, colic was more prevalent among cider drinkers than non-drinkers. In both cases, it wasn't the wine or cider. It was something connected to both. Both wine and cider were sweetened with lead acetate. Colic was a result of lead poisoning.

DISPARITY VERSUS DISCRIMINATION

Discrimination is of two kinds: direct and indirect. (Brown, 2021) Direct discrimination is explicit. E.g., a sign saying "Asians, Jews or females need not apply." Indirect (systemic) discrimination is subtle – implicit. E.g., a sign saying "Those under 6' in height need not apply". Indirect (systemic) discrimination requires a disparity as evidence.

Association and disparity both describe a more factual -- more readily observable – connection or difference. Causation and systemic discrimination both describe something less factual: more unobservable. So disparity is to discrimination as association is to causation. Just as association and causation keywords can be classified into three groups, so can the words related to disparity and discrimination.

As shown in Figure 4, the 'Between' group is the most widely used. These 'Between' words seem to have a moral connotation. They seemingly imply something that is unfair. But, by themselves, they are purely descriptive. Only when they are used in the context of an ethical premise (often hidden or assumed), do they take on an ethical element.

For some, finding a disparate impact on a protected class is obviously and necessarily discrimination with prejudice. But for the US legal system, this disparate impact is just the first step. A common second step is whether the difference in rates exceeds some minimum amount. The 80-20 rule requires that the pass rate for a protected minority be at least 20% less than that for the reference class before the burden of proof shifts from those arguing discrimination to those accessed of discriminating. (Wikipedia) Satisfying the four-fifths rule is just the first step in the US legal system.

Equating disparity with bias and discrimination may seem plausible. It may still be unjustified for three reasons. (1) Discrimination and bias are equivocal. (2) Disparities can be influenced by confounders. (3) Not all race-gender disparities are treated as discrimination.

Figure 4: A-B-C Classification of Human (Conceptual) Causation

Differences or Disparities are not [necessarily] Discrimination

A: Association	B: Between	C: Causation (moral)
Math Differences:	Descriptive Differences	Immoral Differences:
Count/Rate/Amount	with a Moral Connotation	Evaluative or Judgemental
different, unequal	unequal/inequality	inequity/inequitable/injustice
Rank: first, second, last	disproportional	unfair/unjust/undeserved
Superlatives: highest/lowest	discriminate: discern difference	discriminate: with prejudice
Comparatives: more, higher,	disparity / disparate impact	discrimination*
times as much, percent more	bias (tendency: non racist/sexist)	biased, racist, sexist

* Discrimination: direct/intended (racist/sexist) vs indirect/unintended; individual vs social (systemic or structural)
Based on common usage by many today, but not "etched in stone". V0P

1: Discrimination and Bias are Equivocal

Discrimination is equivocal. Discrimination can be descriptive: discriminating shoppers get good value for their money. Discrimination can be evaluative: a discriminatory law required Jews to wear a six-pointed star. This descriptive-evaluative nature of discrimination can be seen in definitions. Some place the descriptive definition first; others place it second. (Schield, 2020).

Bias is equivocal. Bias can be descriptive: she had a bias (tendency) toward action. Bias can be evaluative: many East Europeans are biased against gypsies. Dictionary definitions may be descriptive followed by an evaluative usage involving 'usually' or 'especially'. (Schield, 2022).

- A test or process may be descriptively biased when it produces different outcomes for different groups but group membership can be related to the outcome of interest. For example, a test for proficiency in long distance running may select more east-African Blacks since they tend to have less leg mass and more red blood cells. A test for longevity may select more women than men if women have more estrogen and estrogen combats cholesterol and heart attacks. Saying these tests are biased is to use 'bias' descriptively.
- A test or process may seem unfairly biased when it produces different outcomes for different groups and group membership is not obviously related to the outcome of interest. Why are men more prevalent among those receiving Nobel Prizes or being grand life-masters in duplicate bridge? Why are men more prevalent among those who have Down syndrome, are autistic, mentally ill or homeless? What seems like gender bias may be explained if the standard deviation in IQ is greater for men (14.9) than for women (14.1) even though the two groups have equal IQ on average. (Dreary, 2004).

2: Disparities can be Influenced by Confounders:

The Black-White income gap is often mentioned as a sign of racial discrimination. Statistical educators have no expertise in deciding whether an association is causation or whether an observed disparity is discrimination. But they have expertise in analyzing the effects of context on a statistical association or disparity. As shown on the left in Table 1, White families earned about $118,000; Black families earned about $82,000. White families earned 45% ($37,000) more than Black families. (Census Bureau, 2020) This disparity could be due to discrimination.

In the center of Table 1, families are separated by family structure: by whether the family is headed by a married couple or not. Notice that the Black-White income disparities are much smaller for each kind of family structure: $18,700 for families headed by a married couple; $14,200 for families headed by an unmarried individual. Some may wonder how these gaps of less than $19,000 for each kind of family structure can yield a gap of more than 36,000 when combined.

Table 1: US 2020 Mean Incomes for Black and White Families

Mean Income: 2020		---------- Family Structure ---------			----- Standardized ------	
Families	All	Married	Unmarried	%Married	% Married	All
White	$118,388	$133,585	$66,800	77.2%	73.1%	$115,628
Black	$81,537	$114,860	$52,564	46.5%	73.1%	$98,110
Gap	$36,851	$18,725	$14,236		Combined	$17,518

https://www.census.gov/data/tables/time-series/demo/income-poverty/cps-finc/finc-01.html

The big difference is in the mixture: the mix! Married couples head 77% of White families (47% of Black families). This is a big difference. This Black-White disparity is a crude association: a mixed-fruit comparison or an apples and oranges comparison. To create an apples and apples (same-fruit) comparison, we need to standardize.

Standardization is shown on the right side of Table 1. When combined, 73% of these families are headed by a married couple. Using that percentage generates a mean income of $116,000 for White families ($98,000 for Black families). After taking into account family structure, the Black White income gap drops from $37,000 to $18,000: a decrease of more than 50%.

Does this prove that much – if not most – of the original Black White income gap is not due to discrimination? No! First, statisticians have no expertise in saying whether a disparity is caused by discrimination. Second, statisticians recognize that discrimination in some other area could create the observed disparity in family structure. Suppose that the criminal justice system discriminates against Blacks. Those in prison are less likely to get married or to stay married.

Consumers of social statistics should always think hypothetically about what else could have been taken into account (controlled for) in creating an observed disparity. Teaching confounding and standardizing requires different techniques. (Schield, 2021).

3: Not All Race-Gender Disparities Are Treated as Discrimination

Is it possible that some race-gender disparities are not racist or sexist? Consider this data:

- 99:1 is the ratio of opposite-sex to same-sex households headed by a married-couple. (Census Bureau, 2021). Same-sex marriage has been legal in all US states since 2015. If marriage were random, one might expect half of all marriages to involve same-sex partners. Is this sexist? If not discrimination, what might explain this extreme disparity? Psychology, culture or lifestyle?
- 93:7 is the male-female ratio of US [state and federal] prison inmates as of 2018. (Department of Justice, 2020). If half the population is male, then we might expect that half the prison population would be male. Men are 14 times (93.3/6.7) as prevalent in prison as they are in the population. Is this gender discrimination? Should we seek reparations for incarcerated men? Should we find ways to incarcerate more women? We don't seem to do either of these. What is an alternate explanation for this extreme disparity? Perhaps men commit more crimes than women. In 2019, the male-female ratio on reported offenses was 2.6 to 1: 4.33 million to 1.67 million. (FBI, 2020). However not all arrests are equally likely to result in prison sentences. According to the same data, the male-female ratio on violent crime was 3.8 to 1: 233 thousand to 62 thousand. The male-female ratio on murder or non-negligent manslaughter is 7.1 to 1: 5,461 to 771. These different comparisons do not fully explain the 14 times as prevalent in prison, but they do show that the choice of the basis for comparison is critical.
- 75:25 is the male-female ratio of US arrests. (FBI, 2020). Is this disparity due to sexual discrimination? Are the police biased in arresting men disproportionately? One explanation is that men commit more crimes than women. Unfortunately, not all crimes are reported. In the US victimization survey, crime victims noted that 75% of their victimizers were men (US Department of Justice Statistics, 2019) If 75% of victimizers are men, it is hard to argue that a 75:25 gender arrest disparity is biased.
- 26:13 is this. Blacks are twice as likely among those arrested (26%) as among the population (13%). Could this disparity be due to racial discrimination? Absolutely. What is an alternate explanation? Perhaps Blacks commit more crimes per capita. Is there data on this? Yes. In the

US victimization survey, victims report that 25% of their victimizers were Black. (US Department of Justice Statistics, 2019). Does this prove that Blacks are not discriminated against in arrests? Absolutely not. Perhaps the victims are racially biased in their self-reporting.

CONCLUSION

The phrase "association is not [sufficient for] causation" is central to the teaching of statistics. But it takes practice to enable students to understand the full meaning and to recognize it when it presents in the everyday media. "Disparity is not [sufficient for] discrimination" is a logical application of "association is not causation". Statistical educators are the appropriate faculty to note the similarity and to help students distinguish two things that are all-too-often treated as synonymous.

By noting that (1) discrimination and bias are equivocal, that (2) race-gender disparities can be influenced (confounded), and that (3) not all disparities are grounds for discrimination, students may realize why one must give reasons for why a disparity is strong evidence for causation or discrimination. Given this exposure, students may recognize a wider range of possible explanations and develop a more nuanced understanding of what should be done – if anything – to reduce an undesirable disparity. Hopefully, this exposure will raise the level of social discourse and facilitate a more productive exchange of views.

To repeat, statisticians have no expertise in whether an association is causation or whether a disparity is discrimination. But they do have expertise in evaluating the quality of the data involved.

None of this is designed to show that discrimination – specifically systemic discrimination – does not exist. Statisticians are not the judges in such matters. The statistician's role is to question and evaluate the statistics involved in such arguments.

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