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Scale matters: Patterns of inequity in measures of structural racism can reverse direction when using the relative vs. the absolute scale

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A B S T R A C T

Quantifying the effect of structural racism on health is a subject of sustained interest. To measure structural racism, analysts often calculate contrasts between marginalized and privileged groups on measures of social determinants in health. These contrasts are predominantly calculated on the relative scale, rather than the absolute scale. In this paper, we investigated the rank ordering of 38 US states in terms of the relative and absolute difference in education and incarceration between Black and White individuals using 2015–2019 data from the American Community Survey and the National Prisoner Statistics. The state-level Black/White ratios and Black-White differences in education were highly correlated (Spearman's rank coefficient = 0.99) and resulted in few rank changes. Conversely, ratios and differences in incarceration were only modestly correlated (Spearman's rank coefficient = 0.43), and resulted in thirteen rank changes of ten or more positions. For incarceration, broad trends in state ordering reverse when considering differences rather than ratios. We contend that for incarceration, the absolute difference is the more meaningful contrast, as it counts the number of additional Black individuals incarcerated. For education, the decision between the relative and absolute scale matters less since the differences and ratios are so highly aligned that states generally fare the same regardless of the measure chosen. Before linking measures of structural racism to health outcomes, researchers are advised to decide the scale for each measure based on conceptual theory and an explicit value judgement.

1. Introduction

One of the core principles of quantitative social science is the use of contrasts to enable comparison. Contrasts quantify how much worse or better off one group is than another across some measure of interest. The two most common ways to form these contrasts are using division to calculate the relative difference (or ratio) between the measures from each group or subtraction to calculate the absolute difference between the measures from each group.

Social scientists are well-versed in the reasons why this choice of relative or absolute contrast matters. When a reference group's measure is small, even a small departure in the comparison group's measure can result in a large ratio. For example, if the reference group's value is 0.01 and the comparison group's value is 0.02, the ratio is 2. The same ratio occurs when the reference group's value and the comparison group's value are much larger, for example, when the reference group's value is 0.3 and the comparison group's value is 0.6. Thus, ratios can conflate very small and very large absolute differences in a measure.

The decision to focus on the relative or the absolute difference can result in drastically different interpretations of the same data. For example, Kaufman described the findings from a 2010 study, where the authors used ratios contrasting tuberculosis incidence rates between Black and White Americans to illustrate that the Black/White ratio increased from 6.9 in 1990 to 7.9 in 2005 (Kaufman, 2025; Orsi et al., 2010). Had the authors instead focused on absolute differences, they would have found that the number of additional cases of tuberculosis among Black Americans compared to White Americans decreased from 28.8 to 10.3 per 100,000 persons per year. The change in the ratio frames the results as worsening inequity, while the change in the absolute difference frames the results as improving inequity. This example exemplifies that the relative and absolute contrasts emphasize different aspects of inequality; the ratio quantifies the excess risk in relative terms, while the absolute difference quantifies the magnitude of excess in terms of the number of additional individuals affected in the comparison group in relation to the reference group (Kaufman, 2025).

Contrast measures are used by social scientists to enable measurement of structural racism, and to study the linkage between structural racism and health outcomes. Contrasts link the conceptualization of structural racism, described by Brown and colleagues as “a distributional system that divvies out (or withholds) resources and risks according to assumed category membership” (Brown et al., 2025), to the measurement of structural racism, where the disproportional

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distribution of resources and risks are contrasted. A 2012 structured review of health inequalities research included 344 peer-reviewed articles and found that 75% of the articles reported only relative measures, 18% reported only absolute measures, and 7% reported both relative and absolute measures (King et al., 2012). A more recent 2024 scoping review by Hing et al. identified sixty-three papers operationalizing various measures of structural racism. Of 63 papers they reviewed, 20 used ratios to directly measure the exposure of interest (e.g., the Black/White ratio in incarceration), or used Black/White ratios as inputs into a summary score or as inputs to an unsupervised model of the structural racism construct (Hing et al., 2024). This proclivity towards ratios was highlighted again in 2025 by Brown et al.: "One of the most common approaches to measuring structural racism involves using ratio measures of Black-White inequality across a range of institutions, such as poverty, unemployment, homeownership, college graduation, and incarceration rates" (Brown et al., 2025).

Because the relative and absolute scales quantify different aspects of inequity and can frame the same data in opposing directions, our objective in this study was to investigate how patterns in measures of social and economic inequity are affected by the use of relative (Black/White ratios) or absolute (Black-White differences) contrasts. We considered two commonly used measures of racial inequity in education and incarceration, and examined these measures in the United States at the state-level, as the relatively small number of states allows for a clear illustration of the results. Conceptually, the state unit captures the historical and contemporary state-level policies that affect conditions of daily living (Hardeman et al., 2022). The policy landscape is composed of hundreds of laws linked to structural racism, with some policies exacerbating racial inequities in health, and other laws mitigating inequities (Agénor et al., 2021; Degli Esposti et al., 2020; Rosenquist et al., 2020). Policies have been described as "the causes of the causes of the causes", where the policies cause inequities in social determinants, economic resources, and proximity to power, and these inequities cause racial disparities in health outcomes (Bambra, 2016). Our objective in this paper was to focus exclusively on the first causal linkage in that chain – on the measurement of state-level inequities in social determinants, and to investigate the role of the scale of measurement on state rank. While linking to health outcomes is the natural next step in this analysis, we do not study that latter linkage in this paper, in order to concentrate carefully on the first step. In particular, our objective was to determine how much the rank ordering of Black-White inequity in education and incarceration across states changed when based on the relative vs. absolute difference in each measure.

2. Methods

We excluded twelve states containing less than 50,000 Black individuals in 2020 from the analysis (i.e., Alaska, Hawaii, Idaho, Maine, Montana, New Hampshire, New Mexico, North Dakota, South Dakota, Utah, Vermont, Wyoming). These states were comprised of 0.74% of the total US Black population and were excluded because we were concerned that the small populations of Black individuals partially reflected strong selection of Black individuals with high socio-economic position into these states. For example, previous work by Veazie et al. found that Hawaii, Montana, Idaho, New Hampshire, and Maine had the Black-White ratios in median income closest to 1 (Veazie et al., 2025). Thus, our concern was that measures of structural racism including the difference and ratio measure do not accurately capture the construct well in states with small and highly selected Black populations. We focused the analysis on the remaining 38 states.

We used the 2015–2019 5-year American Community Survey to measure inequities in education between Black and White individuals (United States Census Bureau, 2024). We extracted the total number of Black (any ethnicity) and non-Hispanic White individuals 25 years and older, and the number who did not have a Bachelor's degree or higher, and used this information to calculate the proportion of individuals 25 years or older in each state who do not have a Bachelor's degree or higher, separately for Black and White adults.

We used data from the Bureau of Justice Statistics' National Prisoner Statistics to estimate the number of incarcerated non-Hispanic Black and non-Hispanic White individuals within each state and year who were serving year-long sentences or longer (United States Bureau of Justice Statistics, 2024). For incarceration, we linked the extracted numerators to the corresponding state-year-race specific population denominator (aged 15–64 years old) abstracted from the Surveillance, Epidemiology, and End Results Program (National Cancer Institute, 2024). We then calculated the incarceration proportion for each state-race-year combination, and took the average across years to yield the average incarceration proportion for each combination of state and race.

We then calculated the Black/White ratio and Black-White differences in these proportions, separately for the education and incarceration measures. For example, in Alabama among Black individuals aged 15–64 years, 17.00 individuals per 1000 were incarcerated, compared to 6.11 individuals per 1000 among White individuals. Thus, the Black/White incarceration ratio is equal to $17.00/6.11 = 2.78$, and the Black-White incarceration difference is equal to $17.00–6.11 = 10.89$ per 1000 individuals. For each measure, we summarized the association between the two measures using the Spearman's rank correlation coefficient. States were then ranked from highest to lowest on the ratio scale, and ranked again on the difference scale. The number of positions each state moved in the ranking was recorded.

As a sensitivity analysis, we reran the analysis using county-level rather than state-level data to assess how sensitive the results were to the geographic unit of analysis and the dataset used. For education, we continued to use the 5-year American Community Survey to extract county-level estimates, such that the sensitivity analysis for the education variable only investigated how varying the spatial unit affected the findings. For incarceration, the county-level analysis used data from the Vera Institute for Justice, which compiled data at the county level (Hinds et al., 2020). In 2019, Vera collected quarterly data from state corrections sources and the National Corrections Reporting Program on race-specific jail and prison population counts, and divided these counts by the 15–64-year-old population to derive proportions. For this analysis, we used the race-specific proportions of Black and White individuals in jail to investigate how sensitive the results were to a change in spatial unit and a change in dataset. In both analyses we restricted to counties with less than 100 individuals in either the Black or White population denominator.

3. Results

Education. Fig. 1 shows a scatter plot comparing each US states' Black/White ratio in the proportion of individuals with less than a college education vs. the Black-White difference in that measure. The correlation between the ratio and difference is 0.99, showing that a state with a higher ratio almost certainly has a higher difference than a state with a lower ratio. The range between the 10th and 90th percentiles for the ratios is from 1.12 to 1.34, demonstrating that the ratio varies narrowly across states. At the extremes, West Virginia had the smallest Black/White ratio (1.06) and Black-White difference (5.19 per 100 individuals), while Connecticut had the largest ratio (1.41) and difference (22.73 per 100 individuals). This means that in West Virginia, for every 100 White adults and Black adults, there were approximately five more Black adults without a college education than White adults. In Connecticut, there were approximately 23 additional Black adults without a college education compared to White adults for every 100 individuals of each race. Thus, the Black-White difference in education varies widely, despite the narrow range of the Black/White ratios.

Fig. 2 presents the states, ordered in the panel on the left from smallest to largest ratio (panel A), and ordered in the panel on the right from smallest to largest difference. Of the 38 states, 12 do not change

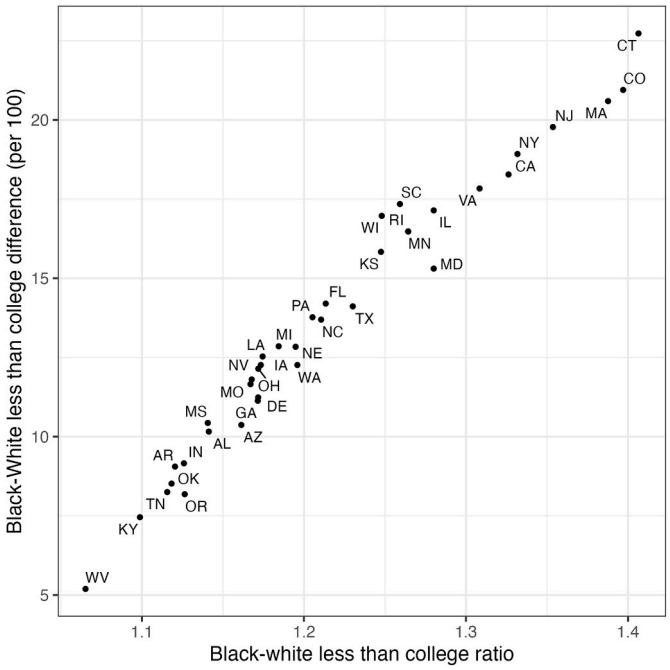

Fig. 1. Black/White less than college risk ratio vs. Black-White risk difference (per 100), 2019

their rank, and the maximum absolute change in rank is five positions. Overall, the ranking of US states by the Black/White ratio in education is similar to the ranking of US states by the Black-White difference in education.

The sensitivity analysis included 2241 counties, as 979 counties were removed due to small population sizes. Similar to the state-level analysis, the correlation coefficient was 0.99 between the ratio and difference measures. Comparing county rankings, 59% of the counties moved 50 positions or fewer (out of a possible 2126 positions), and 79% moved 100 positions or fewer, demonstrating that the rankings based on the relative and absolute measures were also relatively consistent at the county level.

Incarceration. Fig. 3 shows the scatter plot for incarceration, with a correlation of 0.43, demonstrating a much weaker relationship between the ratio and difference scales for this measure. Running a vertical line across the plot, one can find states with a near identical ratio (e.g., Massachusetts's ratio = 5.9 and Michigan's ratio = 6.2) whose difference measures are wide apart (Massachusetts's difference is 5.7 per 1000 population, and Michigan's difference is 18.4 per 1000 population). In Mississippi, the state with the lowest ratio, a Black adult is approximately 2.5 times as likely as a White adult to be serving a prison sentence of one-year or longer, while in New Jersey, the state with the highest ratio, a Black adult is 11 times as likely than a White adult to be serving this same prison sentence. Thus, the relative inequity is much higher for incarceration than for education, and the range across states is much wider. The range in the risk difference is also wide; For every 1000 adults in Massachusetts, there are approximately 6 additional Black adults serving prison sentences of one-year or longer compared to White adults, while in Wisconsin, there were approximately 34 additional Black adults serving year-long prison sentences compared to White adults for every 1000 individuals. Panel A of Fig. 4 illustrates that the states with the smallest ratios also have the highest incarceration

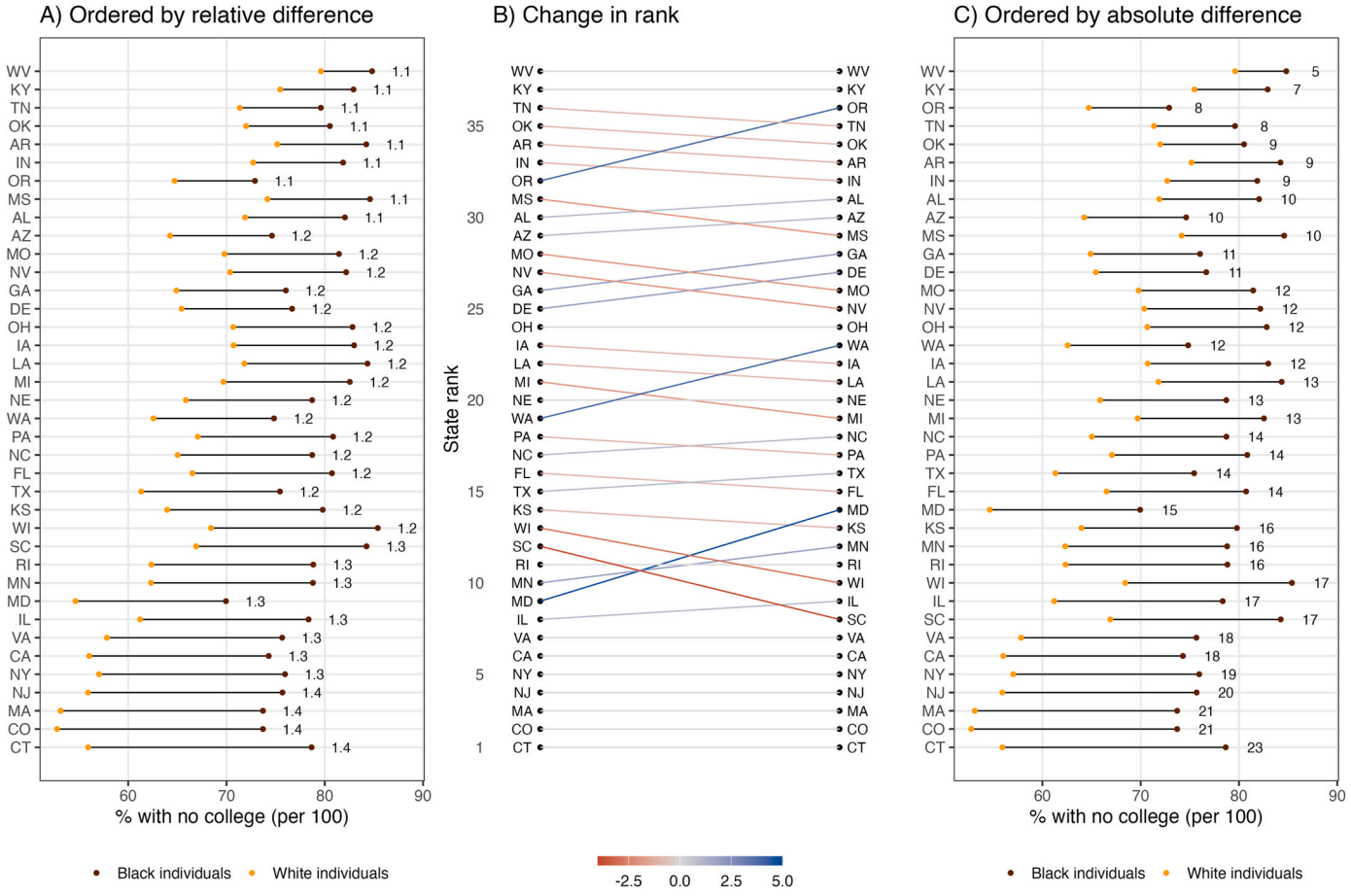

Fig. 2. A) Black/White less than college risk ratio, C) Black-White risk difference (per 100), and B) change in state position when ranked by A vs C.

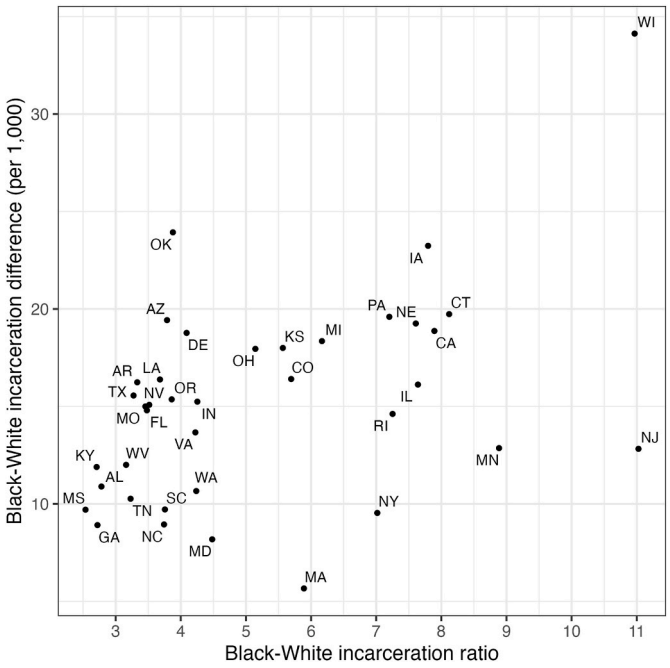

Fig. 3. Black/White incarceration risk ratio vs. Black-White risk difference (per 1000), 2019

prevalences for White individuals (orange dots further to the right for states near the top of the plot vs. states near the bottom of the plot).

Panel B of Fig. 4 shows that many states underwent substantial shifts in rank, with states changing a maximum of 25 positions. Thirteen states moved up or down by ten positions or more, demonstrating that broad trends in state ordering reverse when considering differences rather than ratios.

The sensitivity analysis included 2013 counties, as 1129 counties were excluded due to small population sizes or missing jail statistics in the dataset. The correlation between the ratio and difference measures was 0.74, much higher than for the state level analysis. Comparing county rankings, 21% moved 50 positions or fewer (out of a possible 2012 positions), and 32% moved 100 positions or fewer. Twenty-three percent of counties moved 500 positions or more, which corresponds to a relative change of 24.9% (500/2012) of the total number of positions or more. Overall, a meaningful number of counties moved a substantial number of positions in rankings between the ratio and difference scales, despite the moderately high correlation coefficient. A supplementary analysis that further restricted to counties with population denominators of 1000 or larger for each racial group had very similar findings, with the exception of a larger percentage of counties changing positions by more than one-quarter of the total number of positions available (Supplementary Appendix 1).

4. Discussion

Researchers commonly use racial inequities in social determinants as independent variables in studies examining the relationship between inequity in social determinants and health. More recently, researchers have attempted to quantify the measure of structural racism through the creation of summary scores, and latent or clustering models that use racial inequities in social determinants as inputs. Here, we illustrated

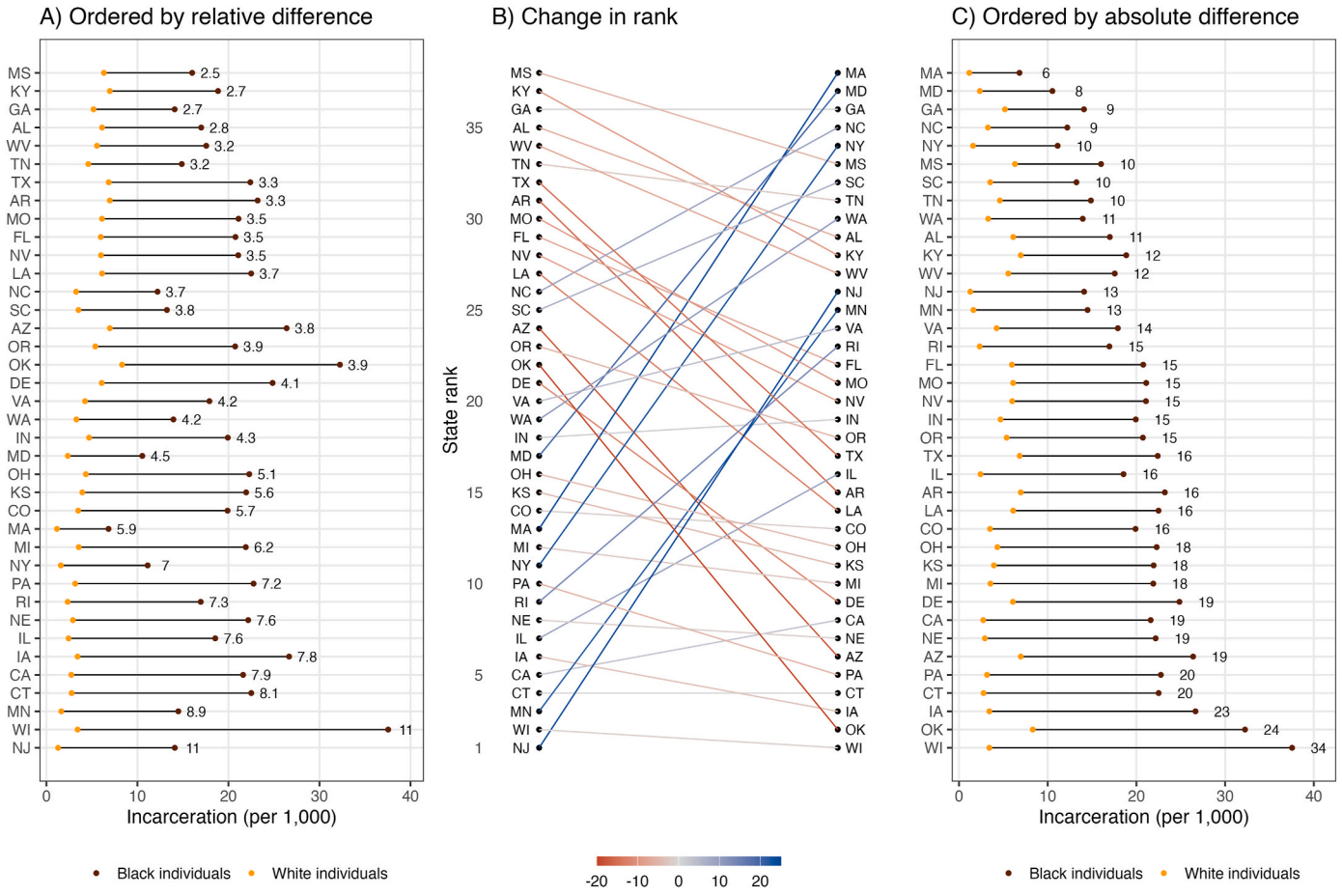

Fig. 4. A) Black/White incarceration risk ratio, C) Black-White incarceration risk difference (per 1000), and B) change in state position when ranked by A vs C.

that the choice between relative and absolute differences of these measures can have a large effect on how states are classified, such as for the Black/White inequity in state-level incarceration. In scenarios like this, if the relationship between a racial inequity in a social determinant and a health outcome were studied, the pattern of the association would be in the opposite direction depending on whether the relative or absolute scale was used to quantify the inequity. For example, suppose that a research team chose to study the relationship between the Black/White relative inequity in incarceration and some health outcome at the state-level and found that larger relative inequity is associated with more favorable health outcomes. If they instead chose to examine the Black-White absolute difference, they would have arrived at a seemingly contrary conclusion: that the absolute difference is associated with less favorable health outcomes. This difference in the findings is driven by the aspect of inequality that the relative and absolute measures capture.

It is important that researchers intentionally choose between the relative and absolute contrasts based on the aspect of inequality that they value (Asada, 2007; Harper et al., 2010; Kaufman, 2025). For incarceration, we contend that the absolute difference is the more meaningful contrast than the ratio, as it counts the number of additional Black individuals incarcerated in Michigan vs. in Massachusetts compared to White individuals for a given population size. Our rationale is that the absolute difference emphasizes the aspect of inequality that matters for incarceration: because Black individuals are incarcerated more frequently and sentenced for longer durations than White individuals (United States Sentencing Commission, 2023), there are 12.7 more Black people than White people per 1000 incarcerated in Michigan than in Massachusetts (e.g., $PD_{MI} - PD_{MA} = [18.4–5.7]$ per 1000).

For education, a researcher could employ a similar argument for preferring the absolute difference: that the number of additional adults with higher education is the meaningful measure, as these individuals have more access to jobs with higher incomes, and better ability to accumulate wealth through investments. On the other hand, a researcher may focus on how education affects an individual's ability to compete in the labor market. If structural racism and personal discrimination did not exist, then an individual's education relative to other job applicants ought to be a driving force in their ability to gain employment in the sector they are trained in. The decision between the relative vs. absolute scale matters less for education, as the differences and ratios are so highly aligned to the point that the general picture about how states fare in terms of education inequity is the same regardless of which measure is used. In either case, a different group of researchers may arrive at different conclusions than we have about whether to choose the relative or absolute measure for representing inequities in incarceration and education. The key point is that researchers need to deliberately decide between the contrast scales, and provide justification for their choice. In some cases, like for incarceration, this decision can have significant implications including reversing the patterns in the data, and could plausibly lead to large differences in how units are classified and the direction of the relationship between the racial inequity in the social determinant and health.

One important question is why the relative and absolute contrasts result in similar state rankings for education but not for incarceration. The primary difference is the magnitude of the base rates. For education, the minimum measure in the referent group was 53% of White individuals with no college in Colorado. Contrast this with incarceration, where the minimum measure in the referent group was 0.12% of White individuals incarcerated in Massachusetts. The other key difference is that for education, the Black/White ratio is between 1.1 and 1.4 for all states. Under this setting (referent group proportion near 50%, Black/White ratio ranging from 1.1 to 1.4), the correlation between the absolute and relative measures will be high (Supplementary Appendix 2: Fig. S1). However, once we combine a rare measure in the referent group with a relatively higher measure in the comparison group (as in the case of incarceration), we yield a setting where the absolute and relative measures may be less strongly correlated (Supplementary Appendix 2: Fig. S4). While the correlation is higher after conditioning on referent measures that are within a narrow range (Supplementary Appendix 2: Fig. S6), it becomes weaker when evaluated for the group overall.

Based on this analysis, we propose a framework for researchers who are studying the relationship between structural racism and a health outcome of interest. Our framework includes four steps:

1) **Decide the scale for each measure of structural racism:** *A priori* the researchers should decide based on conceptual theory and an explicit value judgement whether the absolute or relative scale encapsulates the aspect of the disparity that they deem most relevant for each measure of racial inequity (Asada, 2007; Harper et al., 2010).
2) **Create a composite structural racism measure:** The primary analysis should then use the chosen measurements (e.g., the Black-White absolute risk difference in incarceration, and the Black/White relative difference in education, alongside other inequities in such as housing, employment, and income) as inputs into a latent model (or another model that combines information across measures) in order to derive one singular measure of structural racism in each spatial unit of analysis.
3) **Conduct the primary analysis:** Analyze the relationship between the health outcome of interest and the composite measure of structural racism, using regression models for example.
4) **Conduct sensitivity analyses:** The researchers could calculate alternative contrast measures, create scatter plots comparing the relative vs. absolute contrast measure for each input variable, and calculate how much the rank ordering of spatial units is affected by a change in scale. If changing the scale of measurement has a meaningful impact on the rank order, then the researchers may wish to conduct a sensitivity analysis where an alternative measurement scheme is used and see how this affects the grouping of spatial units in Step 2, and the relationship with the health outcome in Step 3. Note that a moderately high correlation between the two measures does not necessarily imply that there will not be substantial shifts in rank for some units.

Two limitations are important to consider. First, on both the relative and absolute difference scale the exact rank of any state is measured with a degree of uncertainty, which we did not show (Andersson et al., 1998). The ordering should be viewed with this uncertainty in mind, and readers are cautioned against over-interpreting the ranking of states, especially in the case of education where the ranges of state-level ratios and differences were small, implying that minor changes in each state's measure could result in a relatively large change in rank. This limitation is a large issue for spatial units that have small population sizes for either the reference and/or the comparison group, which is an important concern for analyses done on smaller geographic units, such as counties or census tracts. Small population sizes result in increased variability in the estimates and the width of their confidence intervals, such that the most extreme measures are likely estimated among units with the smallest population sizes and may be due to chance alone rather than a truly extreme level of inequity in the smaller unit. When small population size is a concern, researchers should consider approaches that account for varying imprecision across units. One approach is to use shrinkage methods to stabilize the contrast measures (Greenland, 2000). Shrinkage methods consider the underlying sample sizes that inform the measurement and pull extreme measures towards the ensemble mean, creating stabilized measures. These stabilized measurements should be used instead of crude measures in Step 3 of the proposed framework. Another approach is to incorporate weights in Step 3 of the analysis, such as the sum of the reference group and comparison group's population sizes.

A second limitation is in the ability of the relative and absolute differences to capture structural racism under a conceptual model where structural racism causes universal harm in the social determinant. For

example, the states with the smallest absolute and relative measures for education generally have higher proportions of White individuals without a college degree (e.g., West Virginia, Kentucky) compared to the states with larger absolute and relative measures (e.g., New York and California). If structural racism operates to reduce education for everyone, then West Virginia, Kentucky and other similar states (i.e., states with high proportions of less educated White individuals coupled with relatively low absolute and relative differences) actually have more structural racism, not less (McGhee, 2021). We did not tackle these difficulties with interpretation, but they highlight that both the difference and ratio mask the baseline risk, which may serve as another important proxy for structural racism, especially under a conceptual model like universal harm where structural racism hurts everyone (Brown and Homan, 2024). Thus, models of structural racism that use racial inequities of inputs may also wish to include the baseline measure among the reference group (Stovitz and Shrier, 2013).

The decision of whether to use relative or absolute measures of inequities as a proxy for structural racism is an important one. Because states can have the same relative difference but dissimilar absolute differences, or vice versa, deciding which measure to use can lead to differences in how spatial units are classified. This choice is not just a technical or mathematical decision, it is also an ethical one as it involves deciding which aspect of inequality is most relevant for each measure (Harper et al., 2010).

Ethical statement

This study is not considered human subjects research and no ethics approval was required.

CRediT authorship contribution statement

Corinne A. Riddell: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft. **Mathew V. Kiang:** Methodology, Writing – review & editing. **Jay S. Kaufman:** Methodology, Writing – review & editing.

Declaration of competing interest

The authors have nothing to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2026.119598.

Data availability

Data will be made available on request.

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