



Original Research

Unveiling disparities: examining differential item functioning's impact on racial health equity among white and black populations



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ABSTRACT

Objectives: This paper aims to examine the psychometric properties of social capital indicators, comparing Black and White respondents to identify the extent of measurement invariance in social capital by race.

Study design: We used data from the longitudinal study Midlife in the United States (MIDUS), waves 1 through 3 (1995–2016).

Methods: Data were from 6513 respondents (5604 White and 909 Black respondents). Social capital indicators were social cohesion, contributions to community, and community involvement. We used Structural Equation Modeling and Item Response Theory methods to test for measurement invariance in social capital by race.

Results: We observed violations of longitudinal and multi-group measurement invariance (MI) at configural and metric levels on two scales. Factor structures and indicator loadings were inconsistent over time. In IRT analysis, 'Many people come for advice' exhibited Differential Item Functioning (DIF), indicating a consistent advantage for White respondents on the contributions to community scale. Despite similar social capital levels ($P(\chi^2, 2) = 0.00$), DIF was found in all contributions to community items and some community involvement items when examining race and education interaction.

Conclusions: Invariance issues in social capital items suggest potential biases in comparing Black and White respondents. Recognizing these biases is essential. Future social capital research should assess existing data assumptions and involve stakeholders from diverse communities in creating new items.

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Introduction

Definition of social capital in public health research

In public health, social capital can be summarized as features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation that people can then draw upon for their own good or for the mutual benefit of the collective.^{1–3} Social capital can exist at multiple levels but is most often conceptualized at the individual and group levels.³ The basis of social capital is not only individual actors and their relationships but also the social structures within which they are embedded. For

example, an informal social group or a neighborhood. Many aspects of social capital relate to shared values, social support, trust, attitudes, and norms that exist within social groups.⁴ In public health, some examples of its measurement at the individual level are indicators of trust in others in a neighborhood, belonging to a community, and community involvement.⁵

Structural racism and the impact on the social capital

Structural racism creates inequalities by shaping the distribution of opportunities and resources, extending beyond individual behaviors.^{6–8} This pervasive issue is deeply ingrained in historical, societal, institutional, organizational, and governmental structures through formal and informal processes, limiting opportunities and resources for certain segments of the population. Supported by existing power structures, structural racism influences health outcomes. Structural racism has determined the level, quality, and

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access of individual and community-level access to social capital⁹ through racist policies such as redlining, racial residential segregation, exclusionary zoning, suburbanization, gentrification, subprime lending, foreclosures, and evictions, as well as other practices such as tearing apart Black communities with highways.¹⁰

Structural racism has also influenced how we conceptualize and measure social capital by giving priority to the experiences and lens of White people, who are the majority in the United States. Inequality in access to social capital has also been documented for racial and ethnic minorities.¹¹ A deficit of social capital in Black communities can be viewed as the result of racial capitalism in the United States.

Studies assessing race differences in the association between social capital and health

Current social capital theories often overlook power dynamics and the influence of race.^{12,13} This oversight can lead to biased assessments of how social capital operates, especially when using measures such as voting to capture social capital.¹⁴ The preponderance of social capital studies is rooted in a White, mainstream United States perspective, which makes cross-group comparisons problematic.^{2,15} Consequently, there have been few social capital studies among Black American respondents and limited measures that reflect the Black experience in the United States.¹⁶ Understanding how social capital impacts the health of Black individuals compared to other racial groups is crucial, given historical anti-Black oppression.^{17–19} Examining how social capital functions (at least through psychometric analysis) for Black individuals, in contrast to White populations, can aid in addressing racial health disparities.

The need for psychometric research to assess race differences in social capital indicators

While there are several studies that evaluated whether the associations between social capital and health outcomes vary by race,^{20–23} there are methodological problems that limit the inference of racial differences (if any are found) or the usefulness of the results for designing culturally sensitive interventions. The primary methodological limitations are that the social capital questions themselves may be biased because these questions were often developed with limited inclusion of different racial groups, specifically Black people in America. In U.S. studies, many social capital items used in public health and criminology research were developed by White male scholars like Robert Putnam, James Coleman, and Robert Sampson. While not inherently limiting, intersectionality research underscores the significance of diverse scholarly contributions, particularly from Black scholars, to avoid perpetuating privilege and power imbalances.^{14,24} There is potential divergence in how race influences social capital measurement; for example, Robert Putnam's measures (e.g. presence of bowling alleys in a neighborhood or number of volunteer associations in a neighborhood for people to participate)²⁵ may resonate more with White America, while work by Black scholar dean and colleagues in Philadelphia highlights unique indicators like neighborhood block parties. Recognizing the impact of race and socioeconomic position on measurement validity, it's crucial in health disparities research to scrutinize assumed salience for the entire nation.

Prior studies that assess race differences in social capital items

Psychometric studies that compare the item validity and reliability of social capital items by race/ethnicity, or socioeconomic status are relevant to assessing potential racial bias in the items. In

our previous work using population-based data among adults in Philadelphia, PA, we evaluated the psychometric properties of social capital indicators used in the public health field, such as “people in my neighborhood are willing to help their neighbors”, “belonging to my neighborhood”, and “people in the neighborhood can be trusted”, comparing Black and White respondents to identify whether there was lack of measurement invariance in racial groups. We found a lack of measurement invariance across racial groups on several social capital items. Measurement invariance refers to any scenario where the probability of endorsing a particular social capital question differs for individuals who have the same underlying level of social capital but belong to different racial groups.²⁶ Lack of measurement invariance at the item level is also called differential item functioning (DIF) in the psychometric literature. One example of an item lacking measurement invariance is when Black and White respondents rate their trust in neighbors differently. Lack of trust might be due to differential social and cultural backgrounds and is not an attribute of trust in the community. We suggested that our findings could be related to the way these items were developed without considering different group characteristics and that some items may not be appropriate for Black compared to White respondents. The problem is that once a lack of measurement invariance is identified, it is difficult to revise and prevent if data has been collected. This failure involves a lack of validity for between-group comparisons as their scores indicate attributes other than the one the measure is intended to measure.²⁷ This is elusive because Black and White respondents may differ in the prevalence of a particular variable, rendering invalid the comparisons of item parameters that do not take into account differences in the distribution of the latent construct.²⁸

The present study

While one previous study²⁶ was conducted in one American Northeastern city with a diverse racial population, those findings may not reflect patterns across the wider United States, where racial composition is more variable, and may not reflect differences over time. We therefore replicated the analyses of that previous study by investigating the differential item functioning of social capital indicators. However, in this present study, there are two additional strengths. First, this study compared race amongst a more geographically diverse national sample with an older age distribution using several social capital scales with a variety of items that are frequently used in social capital research. Second, we tested for longitudinal measurement invariance using data collected at three different time points spanning almost three decades. Similar to the previous study, we additionally examined measurement invariance by race and socioeconomic status based on the intersectionality framework and prior historical work showing that both race and class matter in health disparities.^{29,30}

Methods

In the following sections, we present details about the data and study sample and the statistical analyses we performed to achieve our study goal. A confirmatory factor analysis (CFA) was performed to establish that the indicators function as a scale measuring an underlying construct (social capital). Structural equation modeling (SEM) was conducted to investigate if the results of the CFA analysis sustain over time. A multigroup CFA was conducted to investigate if the results from CFA sustained across groups. Item response theory (IRT) DIF was performed to investigate if individual indicators sustain their psychometric properties across groups.

Data and sample

In the present study, we used the publicly available longitudinal data from the Midlife in the United States (MIDUS) study.³¹ MIDUS is an ongoing national longitudinal study led by the University of Wisconsin-Madison and currently funded by the Institute on Aging. The MIDUS study investigates the role of behavioral, psychological, and social factors on age-related variations in health and well-being of adults aged 25 to 74 in the United States. The MIDUS study's mission is to study health in the United States adult population as an integrated biopsychosocial process that unfolds across decades of adult life.³² In the present study, we used data from the three main waves of the MIDUS study and included the Milwaukee surveys to increase the representation of minority groups (1995–2016). We analyzed data from 5604 White and 909 Black respondents.

Measures

Our measurement invariance study focuses on three social capital indices assessed in the MIDUS: social cohesion, contributions to community, and community involvement.³¹

Social cohesion

The social cohesion scale assesses respondents' perceptions of reliance on and trust in their community, incorporating seven indicators such as belonging, closeness to others, comfort from the community, reliance on neighbors in distress, trust in neighbors, and feeling safe during the day and night. Responses range from “a lot” (1) to “not at all” (4). We reverse coded this scale, with higher scores indicating higher social cohesion.

Contributions to community

The contributions to community scale gauges the extent of the respondent's contributions to their community across six indicators, including unique contributions, transferable skills, being sought for advice, feeling needed, positive influence on others, and a willingness to teach to others. Response options range from “A lot” (1) to “Not at all” (4). We reverse coded this scale, with higher scores indicating higher community contributions.

Community involvement

Community involvement assesses the participant's engagement in their community through five indicators, including current, past, and future contributions to others' welfare, perceived control over these contributions, and the thought or effort invested. Responses range from 0 to 10, with 0 indicating the worst possible contribution and 10 the best. Higher scores signify higher levels of community involvement.

Sociodemographic characteristics

For our study on social capital indicators' measurement invariance, we focused on two sociodemographic characteristics: race (White and Black samples from MIDUS data) and education attainment (four levels: less than high school, GED or HS-Graduate, some college, college graduate or higher). In analyses, education levels were grouped into low (less than high school and GED or high school graduate) and high (some college and college graduate and higher). Sociodemographic data were sourced from the initial MIDUS data collection wave.

Statistical analysis

We created an a priori hypothesis to minimize the false detection of the lack of measurement invariance.³³ We hypothesized observing a lack of measurement invariance in all items with

scores for White respondents showing constantly higher social capital levels compared to Black respondents. A set of statistical analyses was conducted to investigate measurement invariance in the scales. In the subsections of this section, we explain the CFA first, followed by the longitudinal measurement invariance analysis, multiple-group CFA, and IRT measurement invariance analysis.³⁴

Confirmatory factor analysis

We performed several CFA modeling to verify that the measures in the study (social cohesion, contributions to community, and community involvement) had construct validity.

Longitudinal measurement invariance

An investigation of the measurement invariance of the scales was performed both at the construct level and at the item level. At the construct level, measurement invariance was evaluated over time (three waves of the MIDUS study) using a longitudinal SEM approach. In longitudinal SEM, a response is modeled as follows:

$$X_{ijt} = \tau_{jt} + \lambda_{jt}\xi_{it} + u_{ijt}$$

where X_{ijt} are responses at time t to item j by person i , τ_{jt} are the intercepts, λ_{jt} are factor loadings at time t for item j , ξ_{it} are the common factor score at time t for person i , and u_{ijt} are the unique factor scores at time t on item j for person i .

We used Cheung and Rensvold's (2002) criteria of a change (Δ) of 0.01 in Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) values as indications of the violation of measurement invariance.³⁵ A $\Delta\text{CFI}/\text{TLI} > 0.01$ shows a nontrivial violation of measurement invariance. The longitudinal measurement invariance evaluation was performed using R with the *lavaan* package version 06–16.³⁶

Multiple-group measurement invariance

In addition to conducting measurement invariance analysis over time, we performed measurement invariance studies across the race and education groups using multiple-group confirmatory factor analysis (MG-CFA). The demographic variable race included the White and Black samples, and the education variable included low and high education levels. In MG-CFA (a modeling approach within the SEM framework), sequential equality constraints (on the factorial structure, factor loadings, and threshold parameters) are imposed on the model parameters across different groups (e.g. White and Black respondents, low or high education), and the CFA models are fit to the data. To quantify invariance, we used changes in the CFI, TLI, and RMSEA fit indices and followed Cheung and Rensvold's (2002) recommendation to flag violations of parameter invariance across groups. Multiple group measurement invariance evaluation was performed using R with the *lavaan* package version 06–16.³⁶

Item response theory

We used the IRT framework to conduct measurement invariance analysis at the item level. Because the responses in the measures were ordered categorical, we used the graded response model (GRM) to fit the data.³⁷ In GRM, a response to an item i is split into m_i -ordered categories where for each category the probability of a response is calculated as follows:

$$P_1(\theta) \equiv P(u_i \geq 1 | \theta) = \{1 + \exp[-a_i(\theta - b_{i_1})]\}^{-1}$$

$$P_2(\theta) \equiv P(u_i \geq 2 | \theta) = \{1 + \exp[-a_i(\theta - b_{i_2})]\}^{-1}$$

$$P_{(m_i-1)}(\theta) \equiv P(u_i \geq m_i-1|\theta) = \left\{ 1 + \exp \left[-a_i \left(\theta - b_{i(m_i-1)} \right) \right] \right\}^{-1}$$

where a_i are the discrimination parameters and $b_{i(m_i-1)}$ are the ordered location parameters.

We reserve the term DIF to describe item-level measurement analysis in the IRT framework in this manuscript. Our primary interest in using IRT methods was to investigate uniform and non-uniform DIF across races (White and Black respondents) and educational attainment (low and high education). A more detailed description of the CFA and imputation methods used in this manuscript is available in [supplementary files](#).

Results

We present the results of the quantitative analyses in the following order. First, we present the descriptive statistics for the contributions to community and community involvement scales stratified by race (White and Black respondents) and data collection time points (waves 1–3). Next, results are presented from the CFA modeling. Finally, measurement invariance results (longitudinal, multiple-group, and IRT DIF analyses) are presented.

Descriptive statistics

Table 1 shows the mean and standard deviation (SD) values for the scale scores on waves 1–3 for White and Black participants who responded to the contributions to community (on a 1–4 scale) and community involvement (on 0–10 scale) items in the MIDUS survey. We did not include descriptive statistics of the social cohesion scale because it did not fit the CFA as explained below in the next section, and we excluded the scale from the analysis.

Confirmatory factor analysis to test for construct validity

First, we verified a unidimensional construct for the contributions to community scale with fit indices CFI = 0.98, TLI = 0.98, and RMSEA = 0.03. As for the community involvement scale, the fit indices obtained included CFI = 0.91, TLI = 0.90, and RMSEA = 0.05, showing a good fit for a one-factor model. As mentioned earlier, the CFA results for the social cohesion scale showed poor model fit indices with CFI = 0.76, TLI = 0.75, and an RMSEA = 0.06; therefore, we excluded the social cohesion scale from further statistical analyses of measurement invariance.

The results of the longitudinal and multi-group measurement invariance are reported in [supplementary files](#). Briefly, we found that in the contributions to community scale, measurement invariance at the metric level is violated in Black groups, while in the community involvement measure, measurement invariance is violated at the configural and metric levels in all groups.

Table 1
Descriptive statistics of contributions to community and community involvement stratified by race (White and Black respondents), using the Midlife in the US dataset.

	White respondents (n = 5604)						Black respondents (n = 929)					
	Wave 1		Wave 2		Wave 3		Wave 1		Wave 2		Wave 3	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Contributions to community	2.82	0.63	2.82	0.64	2.80	0.65	2.98	0.63	2.08	0.78	2.11	0.77
Community involvement	6.70	1.84	6.70	1.84	6.58	1.88	7.14	2.05	7.52	1.85	7.39	1.71

Item response theory measurement invariance

Contributions to community

The results of the IRT-based measurement invariance across races and education attainment levels are included in Table 2. In addition, Fig. 1 shows item true score plots for a selection of items flagged as DIF. Black and White participants would respond differently to items such as “making unique contributions to society,” “people coming for advice,” and “feeling other people need you.” Overall, the item ‘many people come to you for advice’ showed uniform DIF in the middle of the scale continuum, where White participants are more likely to select higher response categories. The item ‘feel other people need you’ showed uniform DIF almost across the entire scale continuum. When adjusted for education, participants with low and high education attainment respond differently to items such as “important skills to pass along to others,” “many people come to you for advice” and “good influence on others’ lives” and “like to teach things to people.” When groups are formed by the interaction of race and education, all items in the contributions to community measure show DIF.

Community involvement

Table 3 shows that several items function differently if the respondents are from a different racial or educational group. Black and White participants respond differently to the item “contributions to others welfare 10 years ago.” In the lower-than-mean tail of the construct, White people had higher probability to endorse higher categories. Whereas in the upper-mid tail, Black participants had a higher probability of endorsing higher categories of the item. When adjusted for education, participants with low and high education attainment respond differently to all the items. When groups are formed by the interaction of race and education, no DIF results are obtained due to small cell sizes.

Discussion

In this study, we examined the psychometric properties of social capital indicators to identify whether the questions function differently by race (i.e. between Black and White people) in a geographically diverse sample of Americans at midlife. We tested whether there is a longitudinal violation of measurement invariance in social capital indicators and scales stratified by race and educational attainment. Also, we wanted to observe if there was uniform and non-uniform DIF in the studied items. We found a longitudinal violation of measurement invariance and significant DIF at the item level, indicating there is systematic measurement error. Our findings may signal the need to inspect social capital items that were developed and tested among samples predominantly from mainstream White Americans.

The longitudinal violation of measurement invariance has several implications. Measurement invariance arises from the interaction of item and group properties. In longitudinal studies, the researcher is interested in knowing if there is a change in measurements of a particular construct (e.g. social capital) over a

Table 2
DIF results for items in the contributions to community scale on race and education.

Item	Type of DIF	Group favored
DIF Type and Group Membership Advantage in Contributions to Community Measure by Race		
Made unique contributions to society	Uniform	White respondents
Important skills to pass along to others	Non-DIF	Neutral
Many people come to you for advice	Uniform	White respondents
Feel other people need you	Uniform	Black respondents
Good influence on others' lives	Non-DIF	Neutral
Like to teach things to people	Non-DIF	Neutral
DIF Type and Group Membership Advantage in Contributions to Community Measure by Education		
Made unique contributions to society	Non-DIF	Neutral
Important skills to pass along to others	Uniform	High education
Many people come to you for advice	Uniform	High education
Feel other people need you	Non-DIF	Neutral
Good influence on others' lives	Uniform	High education
Like to teach things to people	Uniform	High education
DIF Type and Group Membership Advantage in Contributions to Community Measure by Race*Education		
Made unique contributions to society	Uniform	White respondents – Low education
Important skills to pass along to others	Non-uniform	White respondents – Low education
Many people come to you for advice	Uniform	White respondents – Low education
Feel other people need you	Uniform	Black respondents – Low education
Good influence on others' lives	Uniform	White respondents – Low education
Like to teach things to people	Uniform	White respondents – Low education

DIF, differential item functioning.

Group Advantage implies that conditioned on trait score, the designated group has higher likelihood of endorsing higher categories of an item than the other groups.

period of time measured on multiple occasions. A potential problem in longitudinal studies is that the participants may change their perception of the construct, and therefore, the measurements obtained may no longer represent true changes in the construct but changes in the perception of the construct. This has implications for within-group comparison, where individuals are measured on two or more occasions and the change is the outcome of interest. In such designs, an index that is not invariant over time will produce unreliable results about the true change over time.

Therefore, in longitudinal studies in behavioral sciences, the researcher should ensure that the construct and its structure (e.g. factor loadings and correlations) remain invariant across time points. Our results suggest that context has been ignored in the creation or understanding of social capital.^{9,38–40} The confirmation of uniform and non-uniform DIF suggests that some items may not be meaningful for one of the groups or that some key concepts of the item are understood differently by both groups. This has important implications. When comparisons are made between two groups on the results of the same scale, it is essential that the scale does not produce biased results in favor of either group, making the comparison invalid. Multiple-group measurement invariance analysis ensures that a measure is a reliable instrument to compare two groups. Additionally, the lack of a good fit for the social cohesion scale impeded its use for further analysis.

The findings suggest that we need to involve several racial groups in scale development, cognitive interviews, and expert review. We need to find out from each racial group what about social capital is meaningful to ensure content validity and develop measurement-invariant scales, which can be accomplished through qualitative studies. Prevention efforts must start at the item content development stage with input from stakeholders with expertise and experience in racial and cultural studies. Secondly, we showed that measures and/or their indicators may change their perceived meaning over time. Measurement variance (change) over time implies that we should also be assessing the conditions through which social capital has changed over time

and not assume that it is static. The cornerstone of our approach lies in employing scales that are valid, reliable, and free of DIF. It is only through the effective utilization of these scales that we can ensure the acquisition of top-tier data, thereby establishing a solid foundation for informed interventions. As we gain precise and reliable insights, we equip ourselves to evaluate the distinctive influence of social capital and how it affects health-related outcomes within every community.

Our findings should be considered in the context of some limitations. First, educational attainment is most often the way that education is operationalized in health surveys. However, there are limits with using educational attainment because years of education are not independent of social context, which may influence social capital formation as well as health outcomes.⁴¹ Therefore, other measures of socioeconomic status should be evaluated in future research and may possibly illuminate some of the unexpected findings. Second, we studied item-level measurement invariance (DIF), not scale-level. However, item-level analyses are crucial if items are meant to be used individually or if single items are considered to be used in computer adaptive testing (CAT).

Despite these limitations, our study had significant strengths that made important contributions to the literature on the topic. First, we validated the presence of DIF by race with two other measures of social capital (contributions to community and community involvement) beyond what was evaluated in previous research. This confirms that DIF may indeed be a problem for many social capital measures. Next, we went beyond cross-sectional analyses²⁶ and utilized longitudinal data because we know that social capital may change over time and racial DIF could be confounded by temporal societal external trends (e.g. the election of a Black president, changing economic climate). Another strength of our study was to combine scale level measurement invariance with item-level DIF using IRT. This is methodologically sound because if measurement invariance is violated at any level of the scale (configural, metric, or scalar), one can look at the item and category level DIF statistics for a deeper analysis of the issue.

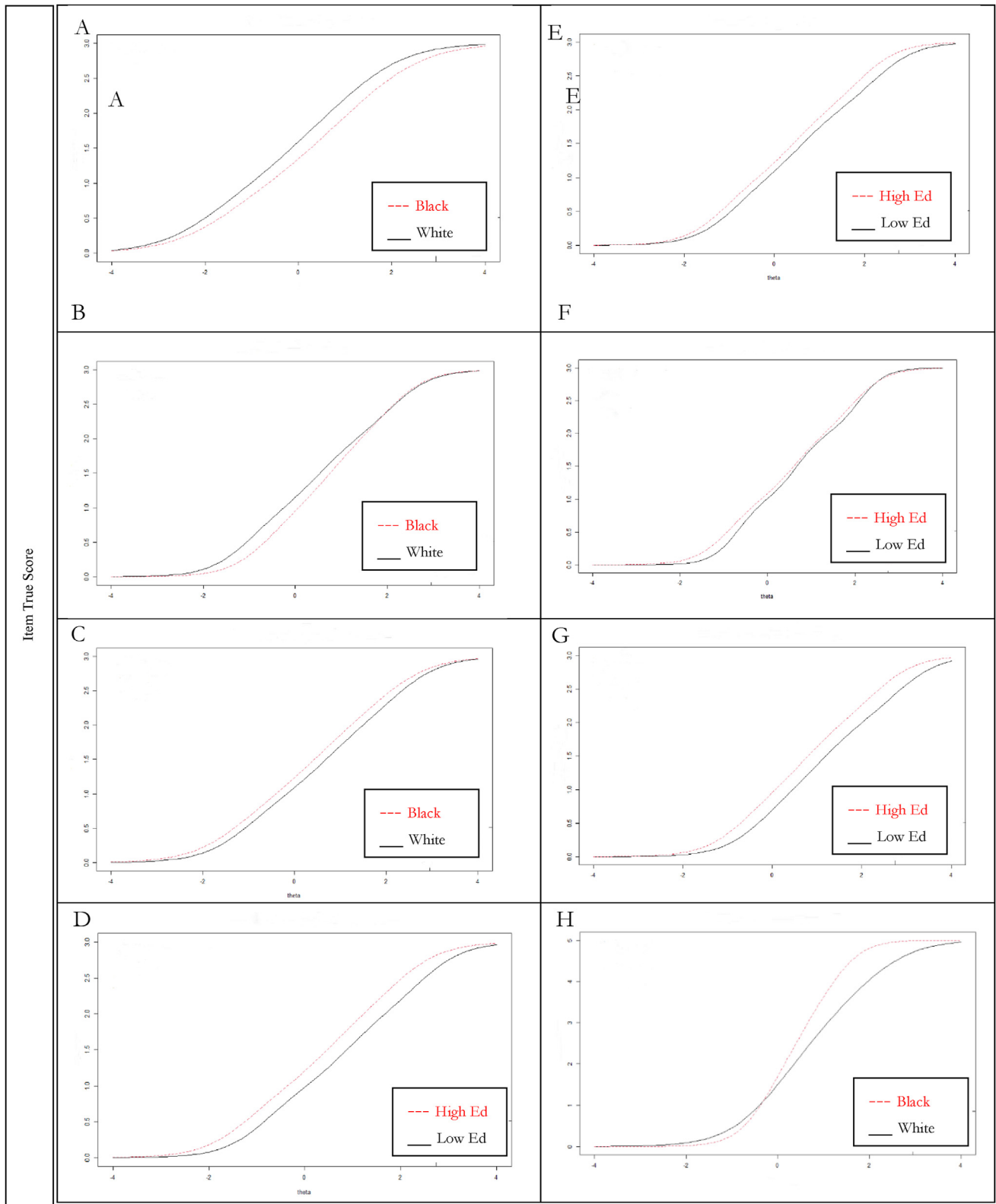


Fig. 1. Item true scores plots for items flagged as DIF (Differential Item Functioning). A: “Made unique contributions to society”; B: “Many people come to you for advice”; C: “Feel other people need you”; D: “Important skills to pass along others”; E: “Many people come to you for advice”; F: “Good influence on others’ lives”; G: “Like to teach things to people”; H: “Contributions to others welfare 10 years ago. Please note that other items that were flagged as DIF are not shown in Fig. 1.

Table 3
DIF results for items in the community involvement scale on race and education.

Item	Type of DIF	Group favored
DIF Type and Group Membership Advantage in Community Involvement Measure by Race		
Current contribution to others welfare	Non-DIF	Neutral
Contribution to others welfare 10 years ago	Non-uniform	White respondents have a below mean trait score, and black respondents have above-mean trait score (on average, leaning toward Black people)
Contribution to others welfare 10 years future	Non-DIF	Neutral
Amount control contribution to others welfare	Non-DIF	Neutral
Thought or effort into contribution to others welfare	Non-DIF	Neutral
DIF Type and Group Membership Advantage in Community Involvement Measure by Education		
Current contribution to others welfare	Uniform	Low education
Contribution to others welfare 10 years ago	Nonuniform	Low education is below the mean trait score; high education is above the mean trait score
Contribution to others welfare in the 10 years future	Uniform	Low education
Amount control contribution to others welfare	Uniform	Low education
Thought or effort into contribution to others welfare	Uniform	Low education

DIF, differential item functioning.

No results of DIF Type and Group Membership Advantage in Community Involvement Measure by Race*Education are displayed due to low cell size. Group Advantage implies that conditioned on trait score, the designated group has higher likelihood of endorsing higher categories of an item than the other groups.

Conclusion

Our study revealed psychometric differences in three social capital items between Black and White individuals, indicating potential biases in commonly used health disparities research measures. Caution is necessary in interpreting results, as variations in social capital-health associations may stem from capturing diverse experiences beyond individual control. To address this, we recommend psychometric analyses of existing measures, careful selection of social capital scales for original data collection, and consultation with racial minority participants. Incorporating qualitative methods like interviews or focus groups is advised for deeper insights. An inclusive approach is crucial for developing new scales and involving diverse groups in discussions to enhance relevance. Additionally, future steps involve exploring race differences at the aggregate level, using area-based proxies like census tracts and considering the impact of aggregate environmental features, such as racial residential segregation, on social capital.

Author statements

Ethical approval

We received IRB approval from University of Maryland Baltimore. The protocol was considered exempt of human subjects research since we used a secondary data source.

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Competing interests

The authors declare to not have any conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2024.03.006>.

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