Assessing individual- and community-level proxies of SES to improve racial fairness of pediatric asthma prediction algorithms

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Introduction: Precision medicine algorithms help improve health outcomes by tailoring care to the patient, but concerns about racial equity exist, particularly in the field of pediatric asthma. Studies have investigated the reliable prediction of asthma risk to inform early interventions, but fairness has not often been considered. Previous findings show that two available prediction tools introduce racial bias into early identification of childhood asthma, possibly due to the incorporation of race or other measures as proxies for socioeconomic status (SES). In this study, we evaluated the accuracy and fairness of using individual- and community-level proxies of SES such as insurance status and community deprivation index (CDI).

Methods: Using 2012-2021 vital records obtained from the Ohio Department of Health, we acquired information on child race as reported by their birthing parent, insurance type, and birthing parent education level (BPEL). We also geocoded and matched residential birth addresses to census tracts, using measures from the American Community Survey to obtain an associated CDI. The measures were converted into binary variables: high (12+ years) vs. low (<12 years) BPEL, private vs. non-private (Medicaid or self-pay) insurance, and high (0.43+) vs. low (<0.43) CDI (using a threshold equal to the 75th percentile of 2018 CDIs among children in the U.S.). Race was dichotomized into five categories: Asian, Black, Native American, Pacific Islander/Hawaiian, and white. Using R, we then conducted sensitivity and specificity analyses to determine the degree of accuracy for CDI and insurance status proxies for all, Black, and white children and assess if there were racial differences.

Results: 1,257,391 children (93.8% of all children born in Ohio) were included in this study based on a birthing parent age greater than 18 years, available data for insurance status and BPEL, and an address that could be geocoded to a corresponding CDI value. Considering BPEL as a gold standard, we measured the degree of accuracy for high CDI and/or non-private insurance status proxies. CDI had a low sensitivity (61.2%) and specificity (74.1%), while insurance status had a high sensitivity (91.6%) and low specificity (60.1%). Sensitivity (57.5%) decreased and specificity (82.1%) increased when assessing the proxies in combination compared to either proxy alone. Across all proxies, sensitivities were greater for Black children (CDI: 81.1%>53.7%, insurance status: 94.0%>90.4%, both: 77.0%>50.1%) while specificities were greater for white children (CDI: 81.0%>40.4%, insurance status: 67.0%>27.0%, both: 88.6%>51.0%).

Conclusion: We found that CDI and insurance status, alone or in combination, inaccurately recapitulate SES, as measured by BPEL, and that inconsistencies differ by race. These proxies misclassify Black children from higher SES backgrounds as lower SES, resulting in over-prediction of asthma among Black children by algorithms incorporating SES proxies. Future studies should examine ways to mitigate biases introduced by using SES proxies.

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Assessing individual- and community-level proxies of socioeconomic status to improve racial fairness of pediatric asthma prediction algorithms

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Background

Precision medicine
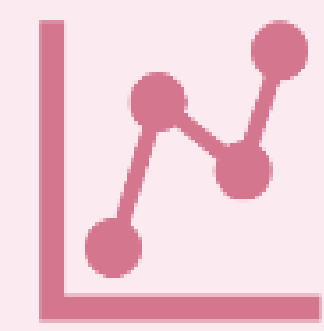
Definition. Integration and analysis of health data sources → individualized care

Potential. Improve health outcomes through enhanced clinical decision making
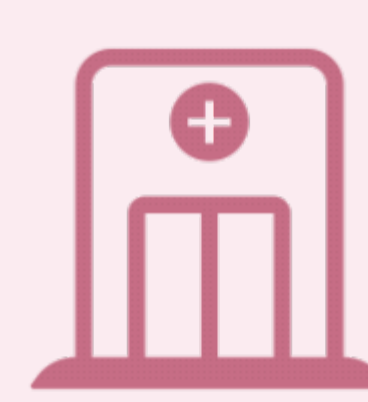
Concern. Encode and exacerbate health disparities through misclassification

Prediction of risk is crucial to informing early interventions, especially in the field of pediatric asthma.

Asthma is the leading cause of pediatric health disparity

Higher prevalence among children from minoritized races

Black children **more likely to visit hospitals** than non-Hispanic white children

Most prediction algorithms incorporate race as a proxy for socioeconomic status (SES), which strongly predicts the development of asthma in children.
- These algorithms introduce disparities in asthma prediction between Black and white children
- Gold standard for estimating SES is birthing parent education level

Objective

We evaluated the accuracy and fairness of using individual- and community-level proxies of SES such as insurance status and community deprivation index.

Methods

Acquired information from the Ohio Department of Health (ODH) 2012-2021 vital records
- Child race
- Insurance type
- Birthing parent education level
- Residential birth address

Geocoded and matched residential birth addresses to census tracts
- Obtained associated community deprivation index based on 6 demographic features

Converted measures into categorical variables
- Race: Asian, Black, Native American, Pacific Islander/Hawaiian, white
- Insurance type: private, non-private (Medicaid or self-pay)
- Education level: high (12+ years), low (<12 years)
- Community deprivation index*: high (0.43+), low (<0.43)

Conducted sensitivity and specificity analyses
- Determined the degree of accuracy for community deprivation index and insurance status proxies for all children
- Assessed if differences in accuracy existed between Black and white children

*threshold equals the 75th percentile of 2018 indices among children in the U.S.

Results

Sample size: 1,257,391 children (93.8% of all children born in Ohio)
- **Inclusion criteria:** birthing parent age >18 years, available data on insurance status and birthing parent education level, address that could be geocoded to a corresponding community deprivation index value
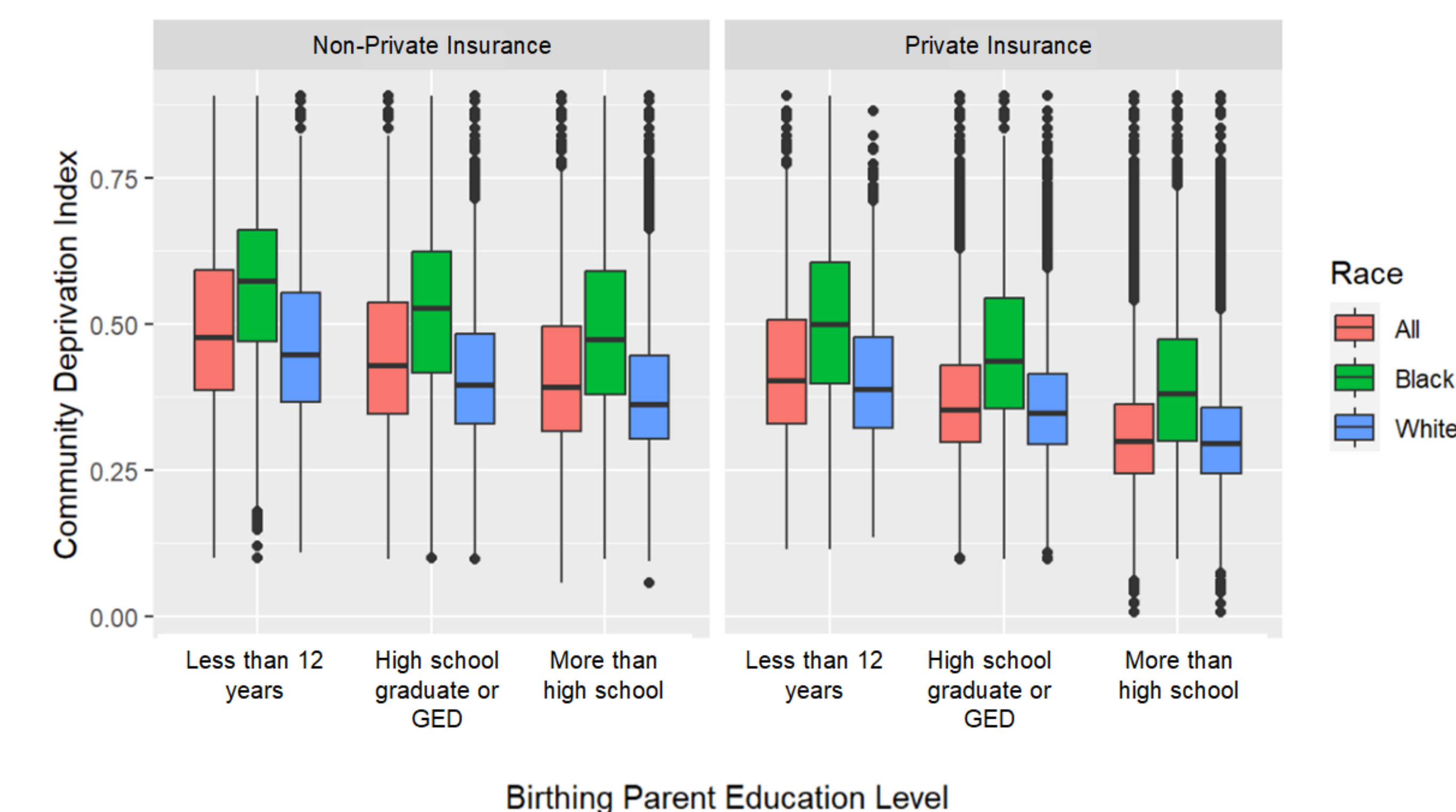
↑ birthing parent education level correlates with ↓ community deprivation index and fraction of children on non-private insurance.

Black children tend to come from families with higher deprivation indices regardless of birthing parent education level or insurance status (Table 1, Figure 1).

Table 1. Comparisons between birthing parent education level, community deprivation index, and insurance status

Birthing parent education level	All Children (n = 1,257,391)		Black Children (n = 216,829)		White Children (n = 963,413)	
	Median (mean) community deprivation index	% with non-private insurance	Median (mean) community deprivation index	% with non-private insurance	Median (mean) community deprivation index	% with non-private insurance
Less than 12 years	0.47 (0.49)	91.6	0.57 (0.56)	94.0	0.44 (0.46)	90.4
High school graduate or GED	0.40 (0.43)	69.7	0.51 (0.52)	86.0	0.38 (0.40)	63.5
More than high school	0.32 (0.34)	27.1	0.44 (0.45)	62.5	0.31 (0.32)	21.5

Figure 1. The relationship between community deprivation index, insurance status, and birthing parent education level differs by race


Sensitivity = how well high deprivation index and/or non-private insurance status represent low birthing parent education level

Specificity = how well low deprivation index or private insurance status represents high birthing parent education level

Sensitivities are greater for Black children while specificities are greater for white children across all proxies (Figure 2).

Figure 2. Sensitivity (A) and specificity (B) analyses of the degree of agreement between SES proxies and birthing parent education level
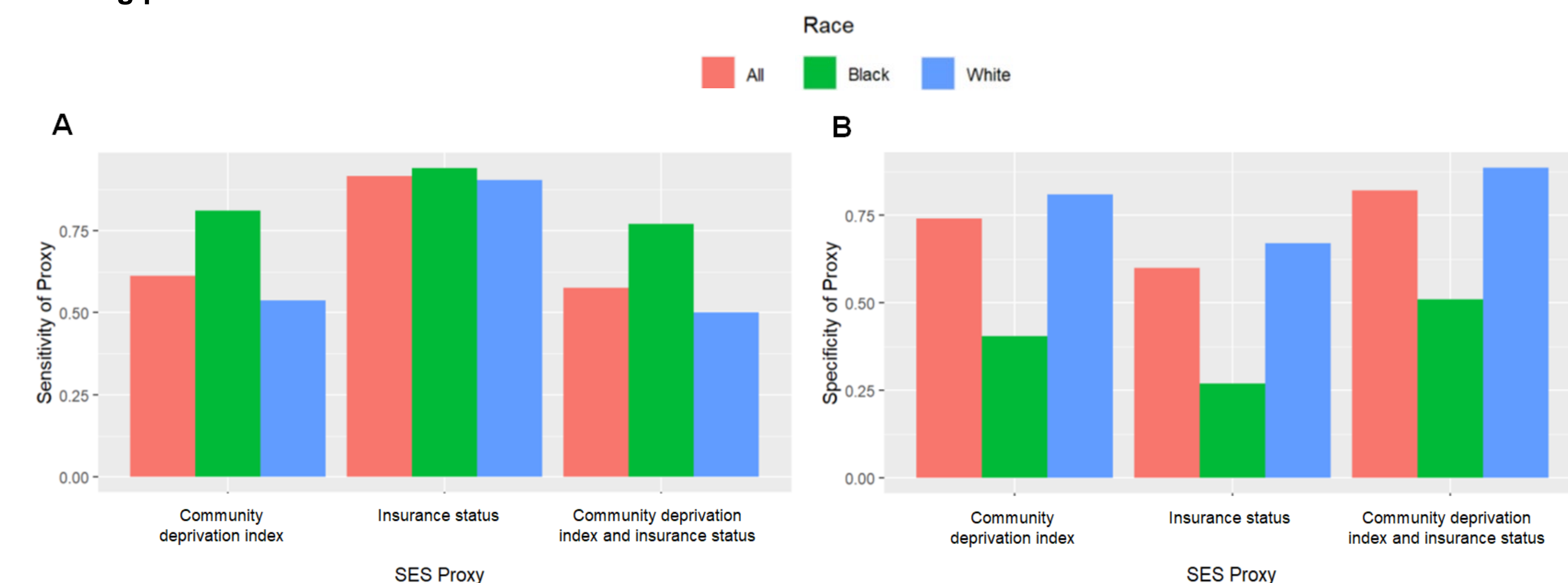
Conclusion

Community deprivation index and insurance status, alone or in combination, inaccurately represent SES, and these inaccuracies differ by race.

Clinical care
- *Overpredict* cases of asthma in Black children

Research
- *Underpredict* cases of asthma in Black children

These proxies misclassify Black children from higher SES backgrounds as lower SES. Therefore, algorithms incorporating SES proxies may overpredict asthma among Black children.

Future Directions

1. Examine how to identify and mitigate bias caused by using SES proxies in epidemiological studies

2. Supplement SES information with additional data for clinical and research use

Acknowledgements

References

The list of references can be viewed by scanning the QR code.