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Racial/ethnic disparities in childhood obesity: The role of school segregation

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Abstract

Objective: Recent studies have observed that racial or ethnic adult health disparities revealed in national data dissipate in racially integrated communities, supporting the theory that "place, not race" shapes the nature and magnitude of racial/ethnic health disparities. This study tested this theory among children.

Methods: In 2020, the racial/ethnic childhood obesity disparities within integrated schools and between segregated schools were estimated using statewide cross-sectional data collected in 2019 on fifth, seventh, and ninth grade students from California public schools.

Results: School segregation accounted for a large part of the obesity disparities between White children and children of color (Latino, Black, and Filipino children). In racially integrated schools, obesity disparities were much smaller than those in statewide data, whereas racial or ethnic childhood obesity disparities were larger when comparing children in majority-White schools with those attending schools with a majority enrollment of children of color, except for Asian children, who generally had lower obesity rates than their White peers.

Conclusions: School-level racial segregation is a salient contributor to racial/ethnic childhood obesity disparities. Reducing obesity disparities may be particularly effective if place-level interventions target socioeconomically disadvantaged integrated schools and segregated schools attended primarily by children of color.

INTRODUCTION

Obesity rates among youth aged 2 to 19 years in the United States have remained stable in the past several years for some, but not all, population subgroups (1,2). Black and Latino youth, relative to White peers, as well as socioeconomically disadvantaged youth compared with affluent youth, have not experienced the same leveling off in obesity rates (3). For example, between 2000 and 2016, youth obesity prevalence among White female individuals increased from 12% to 13.6% but increased from 21.5% to 25.1% among African American female individuals and from 15.4% to 23.5% among Hispanic female individuals. Among male youth, during the same period, obesity increased from 11.0% to 14.7% among White individuals, from 16.5% to 19.3% among African American individuals, and from 22.9% to 28% among Hispanic individuals (3). Because children with obesity are more likely to have obesity as adults, racial/ethnic obesity disparities during childhood may be a mechanism that gives rise to adult disparities in chronic disease and other outcomes associated with obesity (4,5). Given the US demographic trends, it is imperative that we identify salient factors associated with childhood obesity disparities to create effective solutions to achieve health equity (6,7).

Studies among adults have shifted the focus from quantifying racial/ethnic disparities nationally to examining disparities within racially integrated neighborhoods, thereby testing the theory of "place, not race" (8-12). Building on prior work that has named racial residential segregation as a fundamental cause of health disparities (13), this theory, which posits that the characteristics of places where

people live, not individual-level characteristics, are the primary drivers of health disparities, highlights the need for analytical strategies that can overcome confounding of individual-level race and racial segregation (10). Analyses that fail to accurately account for racial/ethnic residential segregation may incorrectly attribute racial/ethnic disparities to person-level characteristics/behaviors instead of community-level factors and their upstream determinants, including structural racism (14,15).

To estimate racial disparities while tightly controlling for racial residential segregation, authors of these studies (8-12) concentrated their data collection on an integrated Baltimore, Maryland, neighborhood, i.e., adjustment through stratification that focused on one strata of the integrated/segregated spectrum. In this neighborhood, where neither African American individuals nor White individuals have a clear majority, residents' health behaviors are similarly constrained/supported by the characteristics of the neighborhood. Importantly, by calculating disparities between African American and White residents within the same neighborhood, the authors held all characteristics of place constant by design, regardless of whether neighborhood characteristics were measured or not. They showed that their theory held because racial/ethnic disparities in a range of outcomes were consistently smaller in the racially integrated neighborhood compared with national-level disparities that used individual-level race/ethnicity as a variable but did not consider residential segregation (8-12).

It is less clear whether health disparities among child populations are smaller within racially integrated places in comparison to state- or national-level disparities. Intrinsically linked with residential segregation (16,17), school segregation/integration may play an important role in childhood obesity disparities because children spend a large proportion of their time in or around schools. Emerging literature has shown that racial/ethnic disparities in childhood obesity are attenuated after adjustment for school-neighborhood factors (16-20), and that school factors can explain a large fraction of observed racial/ethnic disparities for many health outcomes, highlighting schools' unique effect on children's health disparities (21). School racial/ethnic segregation can shape obesity disparities through multiple interrelated mechanisms. Direct mechanisms include resources, constraints, and opportunities to consume a healthy diet and engage in physical activity, given that segregated schools attended primarily by children of color tend to have higher exposures to obesogenic factors such as greater availability of unhealthy foods inside and near schools and fewer resources for physical activity (19,22-27) in comparison with schools attended primarily by White children. In addition, minority-segregated schools also may have higher levels of exposure to violence and social stressors inside and near schools that can influence physical activity, mental health, and other biological factors that are directly or indirectly linked to higher obesity risk (28-31).

This study investigates whether school segregation is a driver of childhood obesity disparities. Although the effects of residential and school segregation are difficult, if not impossible, to disentangle, this study uses a statewide surveillance data set from children attending California public schools to examine racial/ethnic obesity disparities in relation to school integration/segregation. First, as predicted by the "place, not race" theory, our central hypothesis is that racial/ethnic disparities within integrated schools are smaller compared with statewide disparities that do not account for racial/ethnic school segregation/integration. As in the integrated Baltimore neighborhood study (8-12), this disparity measure is intrinsically adjusted for all observed and unobserved school-level factors among children attending integrated schools. Second, we also estimate disparities comparing obesity rates among children of color who attend minority-segregated schools with obesity rates among White children who attend White-segregated schools. We hypothesize that disparities calculated between segregated schools will be larger than state-level disparities, given the differences in obesogenic features of the environments inside/near minority- versus White-segregated schools. Together, the disparities within integrated and between segregated schools shed light on the effect of school segregation.

Study Importance

What is already known?

- Racial/ethnic obesity disparities among adults are smaller in integrated residential areas and larger between segregated areas.

What does this study add?

- The theory of "place, not race" is supported by data on childhood obesity.
- School segregation is a contributor to racial/ethnic childhood obesity disparities.

How might these results change the direction of research or the focus of clinical practice?

- Findings imply that school segregation matters more than individual-level race.
- Interventions must prioritize non-White-segregated schools and disadvantaged schools.

METHODS

Study design, population, and outcome

This cross-sectional study evaluates disparities in childhood obesity using overweight/obesity rates obtained from the California Department of Education (CDE) for students enrolled in fifth, seventh, and ninth grade and attending California public schools in the 2018 to 2019 school year who participated in the California FitnessGram test. The FitnessGram is a physical fitness test required

for all children in the aforementioned grades that is administered in the spring of the academic year. Deidentified FitnessGram data sets are publicly available. The study was exempt by the author's universities' institutional review boards given that we used publicly available data.

The main outcome of interest was the body composition assessment of FitnessGram (32). For this assessment, objectively measured height and weight are used to obtain children's BMI. Then BMI is compared with the Centers for Disease Control and Prevention (CDC)'s age- and sex- specific BMI reference distributions to categorize children into three groups: healthy fitness zone (HFZ), needs improvement (NI), and high risk (HR), which correspond to the BMI categories of "normal weight," "overweight," and "obesity," respectively, based on the CDC reference distribution (32). We use the term "overweight/obesity" to refer to the combined category of NI and HR.

Students missing body composition data were excluded. Missing data were primarily due to data masking implemented by the CDE to protect children's confidentiality. Specifically, the CDE purposefully marks data as "missing" when there are <10 children within each subgroup defined by grade and race/ethnicity at a given school. The sample size threshold of 10 was selected by the CDE; sample sizes fewer than this were deemed to increase the risk of identifying individual children and their weight status (33).

School segregation/integration measure

In order to compare overweight/obesity rates for each group of children of color (Asian, Black, Filipino, and Latino children) with those of White children, independently of the presence of other children in the schools, we did the following: 1) developed a straightforward definition of segregated and relatively more integrated schools that maximized the use of unmasked (i.e., available) FitnessGram data; and 2) conducted sensitivity analyses using more restrictive definitions described later in this paper. We used the CDE sample size threshold of 10 to classify schools into one of the following four categories for each group of children of color: (1) The label of "integrated schools" was used for schools that had unmasked data for >10 children of color and >10 White children. Schools in this category are relatively more integrated in the sense that they have enough White children and enough children of color such that children in neither group have a high risk of being personally identified. Although the level of integration may vary within these schools, this definition can be considered as a minimum level of integration. With this definition, schools with very large percentages of minority children could be considered integrated if the number of White children was sufficiently large such that they were not personally identifiable and vice versa. (2) Schools segregated toward children of color were those that had data available for >10 children of color but ≤10 White children. In these schools, obesity rates for White children were masked because the low number of White children posed a risk to confidentiality. This label was applied to each school for each racial/ethnic group; we use labels such as "Black-segregated schools" and similar labels for other groups. (3) "White-segregated" schools (i.e., the reverse of category 2) were those that had data available for ≤10 children of color but >10 White children. (4) For a given racial/ethnic versus White comparison, "excluded schools" were those that had data available for ≤10 children of color and ≤10 White children. These schools were excluded because outcome data were masked for children of both groups. These categories maximize the use of available data and they are correlated with the percentage of White children in the school (see sensitivity analyses described later in this paper). These categories were also created for each grade level to conduct grade-specific analyses.

Other variables

For descriptive purposes, data from the 2015 American Community Survey were used to determine socioeconomic characteristics of the schools' neighborhoods, including census tract-level median annual household income and percentage of adults aged ≥25 years in the census tract with ≥16 years of education (34). The percentage of children who qualified for free or reduced-price meals and student enrollment by race/ethnicity within each school were obtained from the CDE (35).

Statistical analyses

Descriptive statistics were calculated for all schools combined and by school segregation category. ANOVA was used to determine whether school characteristics differed significantly across school segregation categories. For each racial/ethnic group, two disparity measures were calculated. First, within each integrated school, we compared overweight/obesity prevalence among each racial/ethnic subgroup with the overweight/obesity prevalence among White children. We then calculated the average disparity across all integrated schools. This analysis, which we call "disparity within integrated schools," automatically adjusts for observed and unobserved school-level and school-neighborhood-level factors.

A second disparity measure compared each group of children of color attending their respective Asian-, Black-, Filipino-, or Latino-segregated schools with White children attending White-segregated schools. Therefore, comparisons between racially segregated schools reflect the average difference in overweight/obesity prevalence between White children in White-segregated schools and children of color in minority-segregated schools. This comparison is called the "disparity between segregated schools." Regression adjustment for school-level factors of this disparity measure was not conducted, as it would result in biased inferences about child-level disparities because not all other variables can be "held constant," including school-level segregation. Moreover, because segregation gives rise to differences in other neighborhood-level factors that are consistently related to weight status (e.g., obesogenic environments),

as well as to individual-level socioeconomic disadvantage for individuals living in segregated areas (e.g., limited access to employment opportunities) (15), adjustment for these factors would be consistent with a mediation analysis, which is not of primary interest in this study.

The online Supporting Information gives the formulas for the calculation of the disparities and their standard errors. Standard errors were used to calculate 95% confidence intervals for the disparities.

Sensitivity analyses

We used two alternative definitions of school segregation/integration based on the school-wide enrollment for each racial/ethnic group. As in prior studies about "place, not race" (8), the first alternative definition of integrated schools required that neither of the racial/ethnic groups being compared had a majority (>50%) of the school's enrolled student population. The alternative definition of schools segregated toward children of color required enrollment of children of color to be a majority (>50%) of the school's student body and analogously for White-segregated schools. The second definition of segregation/integration was based on the index of concentration at the extremes (36), computed separately for each group of children of color. The index ranges from −1 to 1, in which −1 reflects that no White children are enrolled in the school, and 1 is interpreted as only White children are enrolled. The continuous index of concentration at the extremes was then categorized into tertiles. Schools in the lower tertile were labeled as segregated toward children of color, those in the middle tertile were labeled as integrated, and those in the upper tertile were categorized as White-segregated. Furthermore, because the masking of data is more likely among schools with lower enrollment, we also conducted sensitivity analysis among schools with enrollment above the first quartile of enrollment across all schools.

Analyses were conducted using SAS version 9.4 (SAS Institute Inc.).

RESULTS

The body composition assessment of the FitnessGram test was applied to 1,363,961 children during the 2018-2019 school year, of whom 54% were Latino, 23% were White, 9.5% were Asian, 5.4% were Black, and 2.4% were Filipino. Other races/ethnicities were excluded from the analyses because the small sample sizes within schools led to masking of most of their data. Data for the five major racial/ethnic groups included in the analysis (n = 1,271,980) were collected within 8,933 schools.

Among all groups of children of color, Asian students were the most likely to attend integrated schools (Table 1). A total of 72% of Asian students attended Asian-White integrated schools, whereas 50% of Black students attended Black-White integrated schools, and 50% and 56% of Filipino and Latino children attended Filipino-White and Latino-White integrated schools, respectively. Latino children were the most likely to attend schools with few to zero White peers: 43% of Latino children attended Latino-segregated schools, whereas 15%, 24%, and 9% of Asian, Black, and Filipino children had few to zero White schoolmates.

Given segregation, it is unsurprising that segregated and integrated schools were situated in neighborhoods with significantly different socioeconomic profiles (Table 1). Asian-White and Filipino-White integrated schools were in more-affluent neighborhoods (e.g., median household income = $92,000 and $83,000, respectively) compared with their comparison White-segregated schools ($69,000 and $76,000), which were, in turn, more affluent than Asian- ($68,000) and Filipino- ($69,000) segregated schools. In contrast, Black-White- ($72,000) and Latino-White- ($73,000) integrated schools were more socioeconomically disadvantaged than their comparison White-segregated schools ($79,000 and $87,000, respectively) but were much more affluent than Black- ($49,000) and Latino- ($52,000) segregated schools. Supporting Information Table S1 shows confidence intervals for all disparity estimates discussed later in this paper.

Statewide disparities

Across fifth, seventh, and ninth grades combined, White children had an overall 28% overweight/obesity prevalence statewide, whereas the prevalence was significantly higher among Latino (48%), Black (42%), and Filipino (31%) populations (Figure 1, top). Asian children had a slight but significantly lower (24%) overweight/obesity prevalence than White children (28%), thereby demonstrating a "reverse" disparity. When analyzed separately by grade, these statewide patterns generally held across each grade, although the disparities were smaller in higher grades (data not shown).

Among Latino and Black youth, the disparities are concentrated in the obesity (vs. overweight) classification (Figure 1, bottom). For example, of the 19% absolute Latino/White difference in overweight/obesity prevalence, about three fourths of it (14%) is due to obesity.

Disparities within integrated schools

The overweight/obesity gaps between Latino, Black, and Filipino students compared with White students were smaller within integrated schools relative to the statewide average disparities (Figure 2). In general, White students in both integrated and segregated schools had a similar prevalence of overweight/obesity as reported for White children in statewide data. The state-level difference in overweight/obesity between Latino and White children was 19%, but this disparity narrowed to 11% when comparing rates between White and Latino children in integrated schools. The difference in overweight/obesity prevalence between Black and White children also narrowed from 13% statewide to 6% within integrated

TABLE 1 Number of students in fifth, seventh, and ninth grade participating in the 2018-2019 California FitnessGram and characteristics of schools[a] that students attended

	Integrated[a,b] schools	Minority-segregated schools[a,b]	White-segregated schools[a,b]	Excluded schools[a,b]
Asian-White comparison				
Asian students, *n* (%)	93,232 (72%)	19,584 (15%)	10,112 (8%)[d]	5,727 (4%)[d]
White students, *n* (%)	161,927 (53%)	2,399 (1%)[d]	127,729 (42%)	13,258 (4%)[d]
Schools, *n* (%)	1,720 (21%)	509 (6%)	2,756 (34%)	3,184 (39%)
School enrollment (*n*)	1,166	656	643	521
% of Enrolled students who are White	31%	5%	40%	10%
% of Enrolled students who are Asian	20%	33%	3%	3%
% of Students in FRPM	37%	64%	53%	80%
Median household income ($)[c]	91,544	67,749	68,556	51,395
% with ≥16 years of education[c]	43	29	30	18
Black-White comparison				
Black students, *n* (%)	36,351 (50%)	17,819 (24%)	10,882 (15%)[d]	7,642 (10%)[d]
White students, *n* (%)	102,808 (34%)	2,628 (1%)[d]	186,848 (61%)	13,029 (4%)[d]
Schools, *n* (%)	1,116 (13%)	680 (8%)	3,360 (40%)	3,210 (38%)
School enrollment	1,347	654	678	515
% of Enrolled students who are White	24%	4%	41%	10%
% of Enrolled students who are Black	9%	23%	2%	4%
% of Students in FRPM	57%	84%	43%	77%
Median household income ($)[c]	71,913	48,653	79,292	54,483
% with ≥16 years of education[c]	31	18	36	20
Filipino-White comparison				
Filipino students, *n* (%)	16,497 (50%)	3,132 (9%)	9,227 (28%)[d]	4,190 (13%)[d]
White students, *n* (%)	70,282 (23%)	722 (0.2%)[d]	219,374 (72%)	14,935 (5%)[d]
Schools, *n* (%)	610 (8%)	142 (2%)	3,866 (48%)	3,434 (43%)
School enrollment	1590	825	727	528
% of Enrolled students who are White	23%	4%	38%	9%
% of Enrolled students who are Filipino	7%	15%	2%	1%
% of Students in FRPM	44%	64%	47%	78%
Median household income ($)[c]	83,323	69,124	76,513	52,912
% with ≥16 years of education	36	25	35	19
Latino-White comparison				
Latino students, *n* (%)	407,134 (56%)	312,777 (43%)	4,401 (1%)[d]	3,997 (1%)[d]
White students, *n* (%)	253,362 (83%)	12,303 (4%)[d]	36,294 (12%)	3,354 (1%)[d]
Schools, *n* (%)	3,808 (43%)	3,475 (39%)	668 (8%)	955 (11%)
School enrollment	912	567	460	353
% of Enrolled students who are White	33%	6%	55%	31%
% of Enrolled students who are Latino	44%	76%	19%	35%
% of Students in FRPM	49%	81%	33%	55%
Median household income ($)[c]	72,760	51,553	87,203	66,439
% with ≥16 years of education[c]	33	18	43	30

Abbreviation: FRPM, Free or Reduced-Price Meals.

[a]Integrated schools were defined as those attended by >10 White children and >10 children of the specific race/ethnicity subgroup; minority-segregated schools had >10 children of the specific race/ethnicity subgroup and <10 White children (vice versa for White-segregated schools); excluded schools had <10 White children and <10 children of the specific race/ethnic subgroup.

[b]ANOVA *p* values comparing school characteristics across the level of integration/segregation in the schools (all $p < 0.001$).

[c]Characteristics of census tract where the school is located.

[d]Children with missing data due to masking of data for confidentiality purposes.

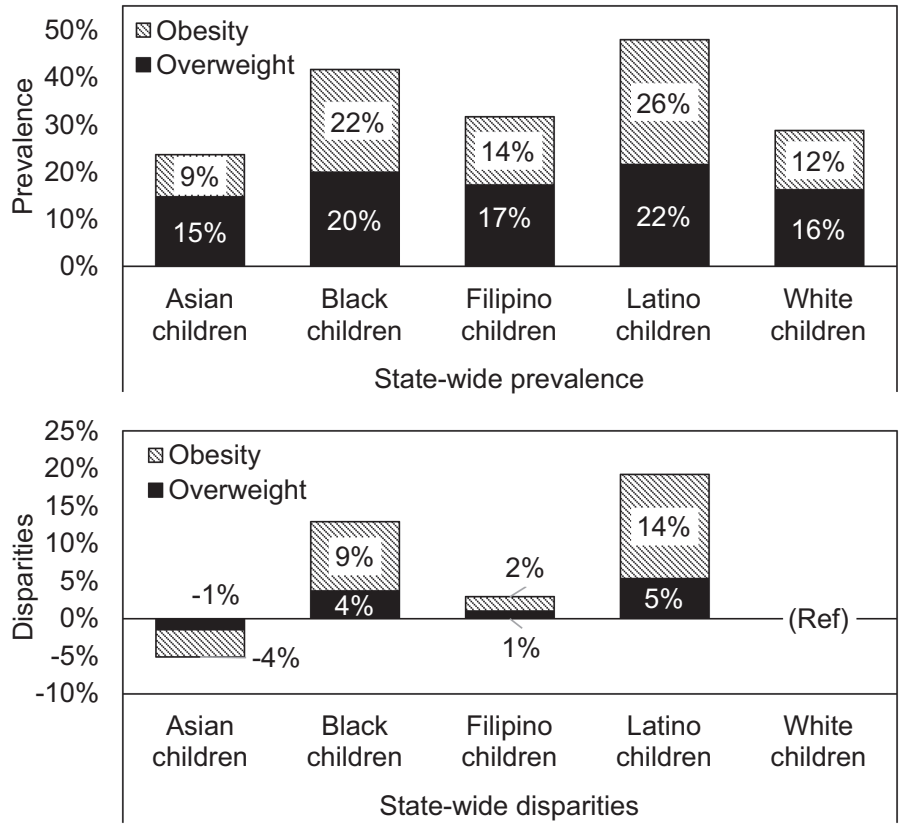

FIGURE 1 (Top) Statewide prevalence of overweight and obesity; (bottom) disparities among children attending California public schools by race/ethnicity (fifth, seventh, and ninth grades combined). FitnessGram data for the 2018-2019 school year, California

schools. Furthermore, for Filipino children, relative to White children, the statewide overweight/obesity disparity was 3% but reversed to −1% within integrated schools. In contrast, the magnitude of the difference between Asian children and White children attending integrated schools (4%) was similar to the statewide difference (5%). The disparities within integrated schools differ only slightly by grade, with slightly more notable grade-related differences among Black and Filipino children (data not shown).

Disparities between segregated schools

By contrast, the overweight/obesity gap between Latino, Black, and Filipino children compared with White children was larger between segregated schools, relative to statewide disparities (Figure 3). Whereas the disparity in overweight/obesity between Latino and White children was 19% at the state level, it was 22% when comparing Latino children in Latino-segregated schools with White children in White-segregated schools. The statewide disparity in overweight/obesity prevalence between Black and White children was 13% but rose to 18% between segregated schools, as did the disparity between Filipino and White children (statewide = 3%; between segregated schools = 8%). Overweight/obesity differences between Asian and White children were similar statewide and between segregated schools. The disparities between segregated schools were larger than the disparities within integrated schools for all groups except Asian children (Supporting Information Table S1).

Sensitivity analyses

As shown in Supporting Information Figure S1, the analysis using alternate definitions of integrated/segregated schools and those focused on schools with larger enrollments did not give meaningfully different results.

DISCUSSION

Consistent with our a priori hypothesis, compared with state-level estimates, racial/ethnic obesity disparities were smaller or nonexistent in integrated schools. Furthermore, relative to state-level racial/ethnic disparities, differences in obesity rates were larger between Latino, Black, and Filipino children in segregated schools compared with White children in White-segregated schools. We also found that Asian children as a whole tended to have a lower overweight/obesity prevalence than White children.

To our knowledge, this is the first investigation examining childhood obesity disparities specifically within integrated schools to begin to elucidate the role of school segregation in the racial/ethnic

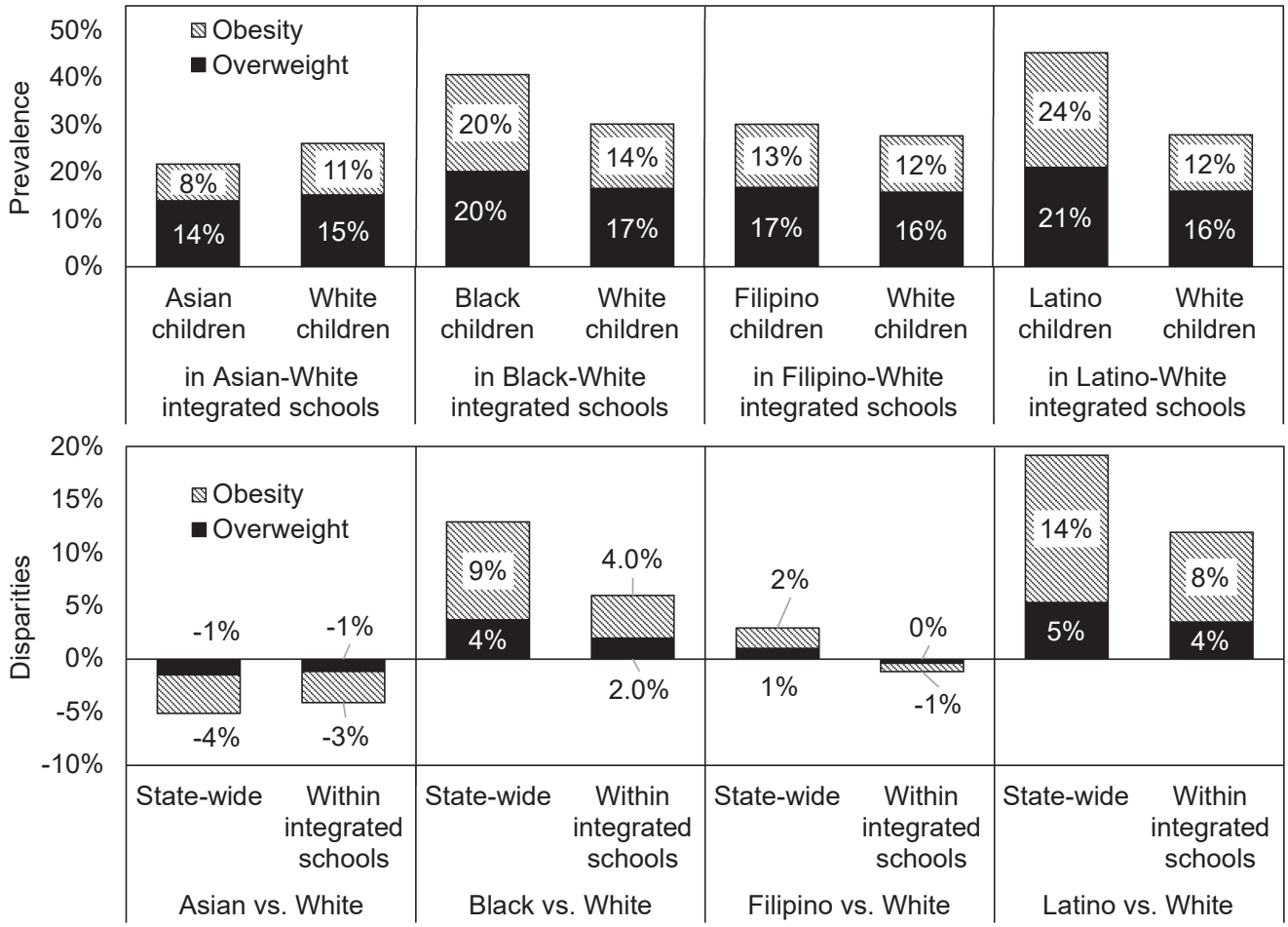

FIGURE 2 (Top) Overweight and obesity prevalence in integrated schools by child race/ethnicity; (bottom) statewide disparities and disparities within integrated public schools in California. FitnessGram data for the 2018-2019 school year, California. Integrated schools are those with data available for >10 White children and >10 children of the specific race/ethnicity subgroup

patterning of obesity among youth. This study contributes to emerging literature that has separated the potential effects of individual-level race/ethnicity from the influences of segregation. The finding that disparities were smaller in integrated schools than at the state level further supports the theory of "place, not race" (9). LaVeist et al. (9) examined several adult health outcomes and found that disparities were smaller in a racially integrated low-income neighborhood in Baltimore compared with those estimated from national data. Consistent with those findings, the present study suggests that place-level factors that are often consequences of segregation have more influence on health disparities than individuals' race itself (13,15).

Other studies among children have examined the association between residential and/or school segregation and childhood obesity or how their adjustment attenuates disparities (18-27) but have not estimated disparities within integrated areas. This study's analytical approach, which stratified schools according to whether or not they are integrated, served a dual purpose. First, the within-school differencing approach calculated person-level disparities within integrated schools while tightly controlling for characteristics of the places where integrated schools are situated. This allowed us to compare obesity between children of color and White children who share the same school environment. By design, the approach equalizes observed and unobserved school- and school-neighborhood-level factors linked to segregation, such as area-level income. Further adjustments for child-level socioeconomic differences would be expected to yield even smaller disparity estimates within integrated schools. Second, our analytic approach also makes explicit that the difference in overweight/obesity rates between children of color in segregated schools and White children in White-segregated schools is a comparison of populations that attend schools in vastly different places. Although adjusted estimates can be useful for certain purposes, e.g., monitoring population-level disparities, the difference in place characteristics for Latino- and Black-segregated compared with White-segregated schools is so vast that attempting to adjust for covariates, either at the school or individual level, would yield an invalid estimate of individual-level disparities due to regression extrapolation (11,29).

Multiple interrelated mechanisms operating at multiple levels play a role in racial/ethnic obesity disparities. At the macro level, structural racism and related institutional policies and practices result in racial segregation and systemic economic disinvestment in

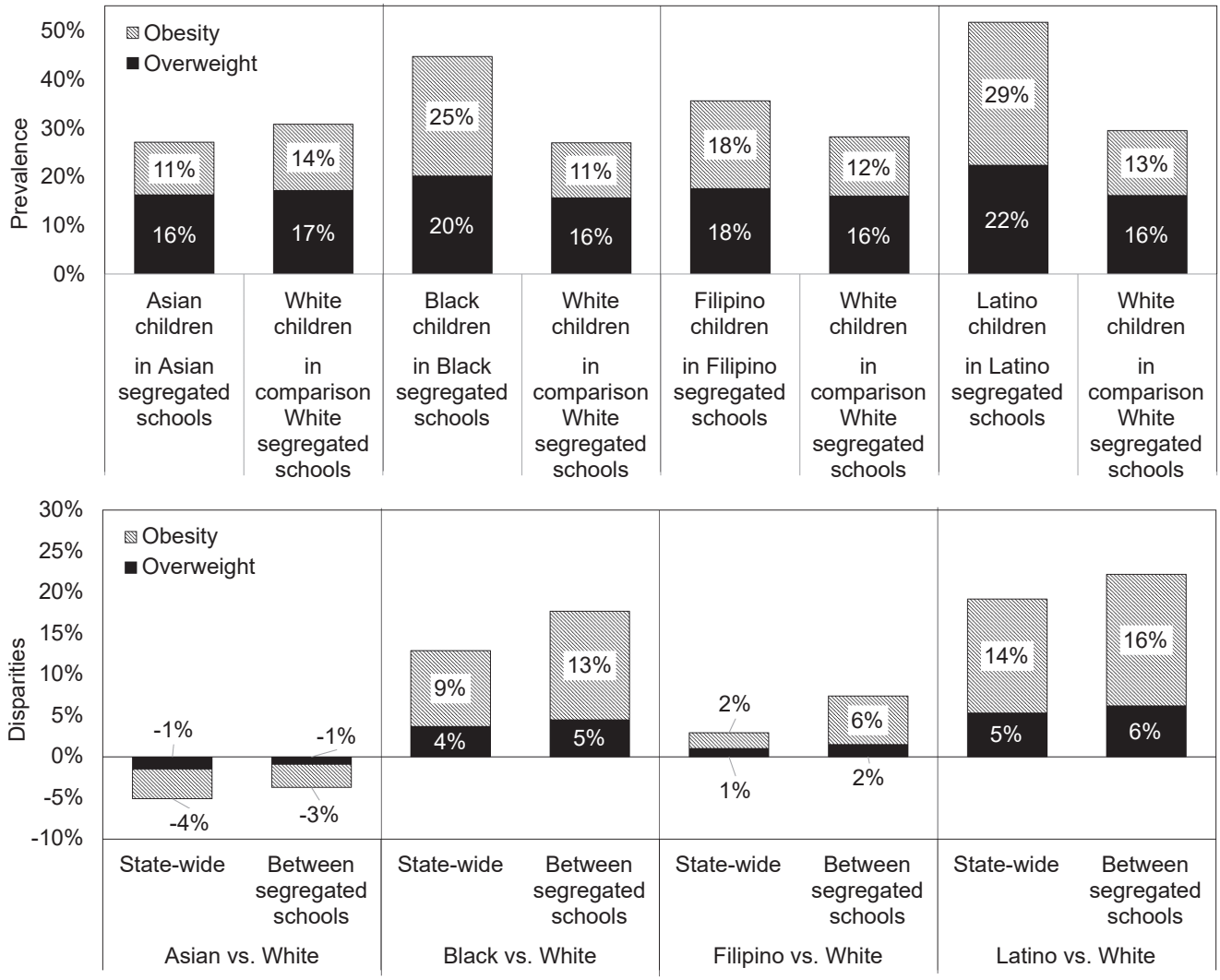

FIGURE 3 (Top) Overweight and obesity prevalence among children in segregated schools; (bottom) statewide disparities and disparities between segregated public schools in California. FitnessGram data for the 2018-2019 school year, California. Segregated schools are those attended by >10 children of one group and 10 or fewer children of the corresponding comparison group

neighborhoods (13-15). In this study, minority-segregated schools were in far less affluent places compared with integrated schools. Less-affluent places are more likely to have obesogenic features, and this likely explains the higher rates of obesity among Latino, Black, and Filipino children in minority-segregated schools compared with their co-ethnic peers in integrated schools. Regarding racially integrated schools, those attended by a mix of Latino-White and Black-White students were situated in places with fewer socioeconomic resources than White-segregated schools. Therefore, in integrated schools, White children were exposed to the same area-level disadvantage as their non-White counterparts and had slightly higher overweight/obesity rates compared with White children in White-segregated schools. Similarly, White adults in an integrated Baltimore neighborhood had worse health than estimated in national data (9). Although the socioeconomic circumstances of individual children and their families likely vary across integrated and segregated schools, those circumstances are likely driven by larger economic and social processes that shape racial segregation (13-15).

Racial residential segregation is associated with reduced availability of healthy food outlets, less space, and fewer resources and opportunities for physical activity but a greater availability of unhealthy food outlets at the neighborhood level. These neighborhood attributes influence health behaviors and related outcomes, including diet, physical activity, and health outcomes such as body weight (37). In particular, differential food enviornment exposure is one of the most direct and well-documented mechanisms for obesity disparities among schoolchildren. Schools attended primarily by children of color tend to have lower-quality food enviornments both inside schools and in the school neighborhoods (24,25); junk-food availablitly and advertisements are associated with the purchasing and consumption of unhealthy foods and poorer-quality diets and obesity (38-41). Differential availability of material and social resources that support physical activity across varying levels of school integration/segregation is another possible mechansim (27,42). A nationally representative study documented that disparities in physical activity levels among Hispanic and Black adolescents compared with White

adolescents were greatly diminished or reversed when accounting for the characteristics of the schools they attended, including racial composition and economic resources (23). These mechanisms are part of a broader constellation of differences in material and social characteristics across levels of school segregation (16,19,22,26-28,30,42,43), including exposure to violence, a barrier to physical activity (29). Identifying place-based mechanisms linking school racial/ethnic segregation to child obesity disparities is critical for the design of interventions to advance health equity beginning in childhood (18).

Future research should examine the joint role of individual-level economic factors and racial/ethnic segregation to shed additional light on disparities and ways to reduce them (43). We examined racial/ethnic segregation specifically, but we were unable to conduct analyses that jointly examine economic and racial/ethnic disparities because the publicly available data from the CDE does not allow cross-classification of these factors within schools. Additionally, future research should employ analytical approaches to disentangle the confounding effects of segregation and race/ethnicity and produce valid estimates of individual-level disparities attributable to person-level factors, and, thus, amenable to individual-level interventions, versus disparities driven by segregation and concomitant place-based or structural interventions. Given findings from this study and previous studies, estimating disparities within more granular levels of geography is critical to more accurately account for environmental factors. As shown here, disparities estimated at large levels of aggregation are confounded by place characteristics, and, thus, underestimate or overestimate disparities at more granular geographical levels where interventions typically are implemented.

This study has several limitations. The findings may not be generalizable beyond California, although given that this state is one of the most diverse in the country, results are likely generalizable to similarly diverse metropolitan areas. This study was based only on children attending public schools because private schools were not required to report FitnessGram data. However, because only 7.6% of all children in California attended private schools in the 2018-2019 school year, and such students likely have a higher socioeconomic advantage and lower prevalence of overweight/obesity, this population is unlikely to have a significant effect on disparity estimates reported here. Additionally, the study had a smaller number of Filipino children, potentially making estimates less robust for this subgroup. Our primary definition of integration/segregation relied on the number of children with reported body composition data and maximized the number of children included in the analysis. However, the results could have been influenced by the definition. Additionally, multiple sensitivity analyses showed that the results are robust to the definition of integration/segregation.

CONCLUSION

This study found that racial/ethnic overweight/obesity disparities were larger between racially segregated schools and smaller or nonexistent within integrated schools, a critical distinction that is likely driven by differences in social- and built-environment factors associated with segregation. Research and interventions must carefully consider segregation to understand, address, and monitor progress in health equity. Place-level interventions that target integrated schools in socioeconomically disadvantaged neighborhoods and segregated schools attended primarily by children of color may be more fruitful than individual-level behavioral interventions in improving health equity.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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