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Testing mediating pathways between school segregation and health: Evidence on peer prejudice and health behaviors

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Abstract

School racial segregation is increasingly recognized as a threat to US public health: rising segregation in recent decades has been linked to a range of poor health outcomes for Black Americans. Key theorized mediators of these harms remain underexamined, including experiences of interpersonal and institutional racism driving increased stress, and peers' health behaviors influencing students' own. Using cross-sectional survey data on a national sample of adolescents, we investigated associations between school segregation and these two potential mediating pathways, operationalized as adolescents' perceptions of prejudice from fellow students and the health behaviors of their peers (drinking and smoking). We further investigated whether associations were modified by individual race/ethnicity and school racial composition.

Pooling across all schools and students, higher levels of school segregation were associated with decreased perceptions of peer prejudice (OR 0.54, 95% CI=0.34–0.86), but not with peers' health behaviors. However, this masked important differences by respondents' race/ethnicity and school racial/ethnic composition. In predominantly White schools, school segregation was not associated with Black students' perceptions of peers' prejudice, but higher levels of segregation were associated with increased rates of peers' drinking and smoking. In predominantly non-White schools, in contrast—where most Black students are educated—higher levels of school segregation were not associated with perceived peer prejudice nor unhealthier peer behaviors for Black students (in fact, peers' health behaviors *improved*). And across both school types, higher levels of district segregation were associated with *lower* odds of reporting peer prejudice among non-Black students of color.

Our findings suggest that the paths between school segregation and poor health depend on the type of school children attend in segregated districts. In schools predominantly serving students of color, structural factors upheld by school segregation—i.e., material, educational, disciplinary, or economic disadvantage—likely dominate over peer behaviors as the primary drivers of segregation's health harms.

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Keywords

segregation; schools; racism; race/ethnicity; health behaviors; discrimination; peer effects; United States

INTRODUCTION

School racial segregation is increasingly recognized as a threat to public health in the US;¹⁻⁶ it has also been subject to dramatic swings in policy intervention. Nearly 70 years ago, the US Supreme Court found school racial segregation unconstitutional, initiating a series of lawsuits ordering the integration of Black and White students.^{7,8} Integration improved Black students' educational attainment, increased their long-term earnings, and improved their self-rated health.⁹⁻¹⁴ Beginning in the 1990s, however, the Supreme Court reversed course, allowing school districts to be released from their integration orders with nominal effort.⁸ Hundreds of the roughly 1,000 school districts under an integration order have since been released from legal oversight,¹⁵ yielding a US school system that—despite weak trends towards the *integration* of residential neighborhoods—is growing ever more racially segregated.^{7,8,10}

Recent research using releases from court desegregation orders as a natural experiment finds this rising school segregation may drive behavioral problems and alcohol consumption among Black students² and poorer self-rated health and higher rates of binge drinking when they reach adulthood.¹ Other epidemiologic work using similar quasi-experimental methods suggests school segregation increases rates of teenage pregnancy among Black adolescents^{4,5} and, in recent decades, has increased rates of preterm birth among Black women,⁶ with health consequences of its own.¹⁶⁻²⁰

Past conceptual frameworks suggest three pathways linking school segregation and health: (1) underinvestment in predominantly Black segregated schools, leading to lower educational attainment and subsequent poverty; (2) experiences of interpersonal and institutional racism driving increased stress; and (3) risky peer health behaviors influencing students' own behavioral health.^{1,2} While the first pathway is well-established—racial integration increases social and economic resources for Black people, while racial segregation impoverishes⁹⁻¹³—remarkably little quantitative work has examined whether school segregation is associated with interpersonal discrimination in schools, nor with peers' health behaviors. This is a critical omission: stress caused by peer discrimination is argued to be an important driver of poor health and the adoption of unhealthy coping behaviors,²¹⁻²⁵ and peers' health behaviors can powerfully shape one's own,²⁶⁻²⁹ making both leading hypotheses for how school segregation gets under the skin to cause disease.

These questions remain underexplored; even the direction of the relationship between school segregation and these potential mediators is unclear. Higher segregation, for example, could either increase or decrease students' perceived experiences of racial discrimination. Higher segregation could *decrease* peer discrimination by reducing the number of interactions between students of color and White students (at least on average). Conversely, higher segregation could *increase* students' perceptions of peer discrimination: segregation-induced

disinvestment from schools of color could mean students feel increasingly discriminated against as a racial/ethnic class, and thus be more attuned to, and impacted by, the racial prejudice they experience from their White peers.^{30–33} Because experiences of discrimination at school can drive increased stress and the adoption of unhealthy coping behaviors,^{34–36} the direction of the relationship between segregation and students' perceptions of prejudice matters.

The direction of the association between segregation and peers' health behaviors is similarly unclear, and is complicated by school racial composition. White students tend to initiate cigarette smoking and alcohol consumption at higher rates and at younger ages than Black students,^{37,38} suggesting that increasing segregation might *worsen* the health behaviors of peer networks in predominantly White schools while *improving* peers' health behaviors in predominantly non-White schools. Conversely, if increasingly segregated schools with fewer and fewer White students are increasingly targeted for underinvestment, more severe school discipline, and concentrated disadvantage due to the economic marginalization of communities of color,^{39–43} the stress of this structural violence could drive unhealthy coping behaviors such as smoking or drinking across peer networks (suggesting segregation would *worsen* peers' health behaviors in predominantly *non-White* schools, not the other way around).^{44–48}

In this paper, we thus test empirically whether school district racial segregation is associated with experiences of interpersonal racism, proxied by students' perceptions of peer prejudice, as well as peer health behaviors. We use data from a nationally representative, school-based cohort of adolescents,⁴⁹ with which we merge school segregation data.^{15,50} To provide a full picture of students' experiences, we estimate associations overall as well as by students' race/ethnicity—i.e., separately for non-Hispanic Black students, non-Hispanic White students, and non-Black students of color—as well as by school racial composition. By allowing for differences in school segregation's effects by school racial composition, we contribute to an in-depth understanding about both how district-level school segregation impacts health behaviors and *for whom, in which kinds of schools*. Quality evidence on these questions matters especially for short-term interventions, given that combating more upstream factors (e.g., school segregation itself) will require longer-term political and legal transformations. If peer effects are minor contributors to segregation's impacts, for example, targeting them now will not yield the improvements in health Black students deserve.

METHODS

Sample & Data

We linked health outcome data from the National Longitudinal Study of Adolescent to Adult Health (Add Health)⁴⁹ with administrative data on school district characteristics.^{15,50,51} Add Health is a longitudinal study of a school-based, nationally representative cohort of US adolescents who were in grades 7 through 12 during the 1994–95 school year. Initially, 90,118 children in 145 schools were administered an in-school questionnaire; a smaller sample of approximately 20,000 were administered in-home interviews in subsequent waves. Our main study involves data from the larger in-school sample (initial n=90,118). We also

conducted sensitivity analyses (described below) using Wave 1 of the longitudinal in-home survey (initial n=20,745).

We merged these Add Health data with school district data compiled from various sources. This included district-level school racial segregation experienced by Add Health respondents during the 1994–1995 school year, as well as related school district characteristics, derived from the Stanford Education Data Archive (SEDA).^{15,51} Add Health provided the Census block number of respondents' schools (for the in-school sample) or of respondents' home addresses (for sensitivity analyses using students in Wave 1 of the in-home survey). To complete the linkage, we created a crosswalk mapping Census blocks onto school districts using the geospatial analysis software ArcGIS.

We further restricted our samples to respondents who (1) attended public schools in districts with segregation data (n=74,281), (2) reported at least one outcome of interest (n=68,947), and (3) were not missing the study covariates. Our main, final sample included 53,275 respondents in the in-school sample (in 114 schools from 72 school districts), and 12,793 in the Wave 1 in-home sample for sensitivity analyses. A sample selection flow chart can be found in eAppendix I (Figure e1).

Exposure

Our exposure was district-level, between-school racial segregation, measured at the beginning of the 1994–1995 school year. School racial segregation was operationalized using the Black-White dissimilarity index, a commonly used metric to quantify within-district distributional disparities in school racial composition.^{4,14,52–54} Specifically, the Black-White dissimilarity index represents the proportion of Black or White students who would need to change schools to achieve a uniform distribution of Black and White students across a district. The index ranges from 0 to 1, with higher values representing higher segregation. For example, a value of 0.35 would mean that 35% of Black or White students would have to change schools to eliminate within-district, between-school segregation. A dissimilarity index value of more than 0.6 is considered highly segregated.^{52,53}

Outcomes

Interpersonal discrimination: perceived peer prejudice—Add Health's in-school sample was asked to rate how strongly they agreed with the statement, "*the students at [my] school are prejudiced,*" using a 5-point Likert scale. We dichotomized this into a binary variable measuring whether students agreed or strongly agreed (vs. neither agreed nor disagreed, disagreed, or strongly disagreed) that their peers were prejudiced. We dichotomized perceptions of prejudice because, from a theoretical perspective, we only expect prejudice to matter negatively for health if students agree or strongly agree that fellow students are prejudiced (i.e., the difference between "neutral" [3] and "agree" [4] is expected to be quite different in terms of its health consequences than the difference between "strongly disagree" [1] and "disagree" [2]).

Peer network health behaviors—As part of their in-school survey study, Add Health created a social network matrix linking each respondent to the responses of everyone in their

school, including who each respondent nominated as their friends. While the matrix itself is not available to researchers, Add Health provides outcome variables representing mean values among each respondent's nominated friends.

We focus on the following network health behavior outcomes for each respondent: (1) proportion of peers who ever drank alcohol, (2) how often peers smoked cigarettes in the last 12 months, (3) how often peers drank alcohol in the last 12 months, and (4) how often peers "got drunk" in last 12 months. For the last 3 outcome variables, Add Health reported the mean value that a respondents' peers had done a behavior in the last 12 months on a 7-point Likert scale (never, once or twice, once a month or less, 2–3 days a month, 1–2 days a week, 3–5 days a week, every day or almost every day). Higher values indicated *unhealthier* behaviors among a respondent's friends.

Covariates

Association modifiers: School racial composition—For school racial composition, we calculated whether schools were above the median value for the proportion of their students who were non-Hispanic White, calculated across Add Health sample schools. After considering several categorizations summarizing schools' racial compositions, this measure did the best job separating schools into those that primarily served non-Hispanic White students (hereafter referred to 'predominantly White schools') from those that served either a more racial/ethnically diverse or majority-racial-minority student body while also preserving statistical power (hereafter referred to as 'predominantly non-White schools,' for brevity; see eAppendix II).

Association modifiers: Race/ethnicity—Add Health asked respondents two main race/ethnicity questions: their race (White, Black or African American, Asian or Pacific Islander, American Indian or Alaska Native, or other) and their ethnicity (whether respondents were Hispanic/Latino). We classified students as either non-Hispanic Black, non-Hispanic White, or as non-Black students of color. These three racial/ethnic groups represent students who were the primary targets of anti-Black school segregation in the US (Black and White students, respectively), contrasting each of their experiences with those of non-Black students of color whose segregation histories are more varied and complex (both as larger groups—e.g., shifting laws around Asian Americans' ability to attend racially integrated schools over time—and within those groups—e.g., Vietnamese Americans and Chinese Americans, who have different immigration and economic histories and thus have been targeted for structural exclusion through distinct paths).^{55–58} Associations among this latter group represent "spillover" effects of Black-White school segregation (our exposure); while the proportion of public school students this group represents has grown,⁵⁹ their experiences with respect to school segregation remained understudied in the context of school desegregation policy efforts.

Potential confounders—We controlled for individual-level demographics, school racial composition, and district-level variables that may have confounded the relationship between school segregation and our outcomes. Individual-level covariates included a respondent's grade, age, binary sex, and highest parental education level (less than high school, high

school or GED, some college, or college graduate or more). In regressions with the full sample (i.e., not stratified by race/ethnicity), respondent's race/ethnicity was also included as a covariate. In the Wave 1 sample, we were also able to control for parental age, race/ethnicity, household income, and parental marital status (single, married, or separate/widowed/divorced). We also adjusted in our Wave 1 models for residential Census tract poverty rate (which we could not do in the larger, in-school surveys, as the in-school survey did not collect residential address data).

At the school district level, we controlled for district urbanicity (urban vs. rural), geographic region (Northeast, South, Midwest, West), total enrollment, and district residential segregation. The latter was measured as the Black-White dissimilarity index, calculated across Census tracts within a district.

Statistical analysis

Add Health's data is hierarchical, with individual respondents nested within schools nested within districts. We thus fit three-level multilevel random intercept models, which accounted for the non-independence of respondents within the same schools and districts. These models estimated the cross-sectional association between district-level segregation and our outcomes, conditional on the covariates listed above, using multilevel logistic regression for our binary outcomes (odds ratios) and multilevel linear models for our continuous outcomes. We fit these models overall and stratified by race/ethnicity and school racial composition.

Sensitivity analyses

We also conducted sensitivity analyses using alternative measures of interpersonal discrimination and peers' health behaviors, as well as assessing whether data missing-ness may have affected our results. Sensitivity analyses are detailed in eAppendix IV.

Briefly, for alternative measures of interpersonal discrimination, Add Health's in-school questionnaire also included five other questions measuring students' experiences of exclusion and belonging at school, potentially providing an opportunity to measure discrimination and social exclusion more holistically. As a sensitivity analysis, we performed reliability checks and a factor analysis to assess whether these items could be added together into a single scale (see eAppendix III) and performed related outcome regressions.

For alternative measures of peers' health behaviors, sensitivity analyses assessed relationships between school segregation and the health behaviors of students' closest friends (eAppendix IV). This was measured only among students in the smaller, Wave 1 in-home sample, who were asked how many of their 3 closest friends drank or smoked.

Finally, we performed sensitivity analyses on missing-ness by performing multiple imputation and re-running our models, as detailed in the sensitivity analysis section of our Results, below.

RESULTS

Sample characteristics

Sample characteristics for the in-school sample are reported in Table 1. Overall, 40% of the sample agreed or strongly agreed that other students at their school were prejudiced. Roughly 60% of students' peer networks had ever had alcohol. Because we only have mean values of peer networks' responses to questions about frequency of smoking, drinking, and getting drunk on a Likert scale, the means of these variables are not directly interpretable. But each behavior was more frequent in predominantly White than predominantly non-White schools.

On average, students were roughly 15 years old, with ~25% in middle school (grades 7–8, plus a handful in 6th), another 40% in early high school (grades 9–10), and roughly a third in later high school (grades 11 and 12). Overall, the in-school sample was 58% non-Hispanic White, 15% non-Hispanic Black, and 28% non-Black students of color. This distribution varied by school racial composition, with non-Hispanic White students representing 36% of students in predominantly non-White schools (followed by non-Hispanic Black students, at 26% of this subsample, and other racial/ethnic students, at 37%) vs. 81% of the students in predominantly White schools.

Interpersonal discrimination: Perceived peer prejudice

Overall, higher levels of school segregation were associated with *lower* odds of students reporting peer prejudice (Figure 1). A 1-unit increase in the dissimilarity index (from a completely integrated district to a completely segregated district) corresponded to 0.56 times the odds of reporting fellow students to be prejudiced (CI=0.35, 0.89; $p=0.014$). Stratifying by race/ethnicity, this was especially the case for students who were non-Hispanic White or of other, non-Black racial/ethnic groups; point estimates for Black students were in the same direction, but were attenuated, with confidence intervals that crossed the null.

Models stratified by school racial composition showed varied associations between school segregation and the outcome depending on school type (Figure 1). As in models that pooled all schools together, in predominantly non-White schools, higher school segregation was associated with lower odds of students reporting peer prejudice (again, particularly among White students and non-Black students of color). In contrast, among students attending predominantly White schools, living in a more segregated district had no relationship with perceived prejudice, with estimates near 0. Non-Black students of color were the exception, perceiving less prejudice from other students in more segregated districts regardless of school racial composition.

Peer network health behavior outcomes

Overall, we did not find statistically significant associations between segregation and peers' health behaviors across all schools (Figure 2). However, significant associations emerged when results were stratified by school racial composition and race/ethnicity.

For Black students attending predominantly White schools, a 1-unit increase in school segregation was associated with a higher frequency of peer smoking, a higher probability of peers having ever drunk alcohol, and a higher frequency of peer drinking (Figure 2). Non-Black students of color in Whiter schools similarly saw a higher frequency of peer smoking associated with higher district segregation.

Conversely, non-Black students of color attending predominantly non-White schools experienced the opposite trend: higher segregation was associated with *less* frequent peer smoking and *less* frequent drinking to the point of drunkenness.

Sensitivity Analyses

In sensitivity analyses, we investigated alternate outcome measures. We first assessed whether students' perceptions of peers' prejudice would be better assessed as part of a scale constructed from related questions about students' experiences of exclusion and belonging (eAppendix IV). Reliability metrics and factor analyses demonstrated that Add Health's question soliciting perceptions of peer prejudice measured a distinct construct from other exclusion and belonging questions (such as "I feel like I am part of the school" or "I feel socially accepted at this school"). Regression models predicting scale values constructed from the five other exclusion and belonging questions were largely null, returning statistically non-significant estimates close to 0 for nearly all racial groups and school types (eAppendix IV, Figure e5). The exception was non-Black students of color in predominantly non-White schools, among whom higher levels of segregation were associated with fewer feelings of social exclusion.

We next assessed whether relationships between school segregation and peers' health behaviors differed if we analyzed the health behaviors of students' closest friends, rather than of their broad social networks (eAppendix IV, Figure e6). Here, students in our smaller, Wave 1 in-home sample were asked how many of their 3 closest friends drank or smoked. We fit logistic regressions predicting whether at least one of their 3 closest friends smoked. Results were generally consistent with our main findings, but with one qualitative distinction: estimated coefficients for predominantly White schools were much less precise, due to a smaller sample size. However, among Black students in predominantly non-White schools, higher levels of segregation were associated with lower odds of having a close friend who smoked (OR=0.4, CI=0.19–0.83, $p=0.014$), or drank (OR=0.28, CI=0.14–0.57, $p<0.001$); that is, the more segregated a district was, the lower the chance that Black students had close friends who exhibited poorer health behaviors.

Finally, we assessed whether data missingness influenced our results. We first performed multiple imputation in our main in-school data, including dummy variables for schools and districts to account for the multilevel nature of the data; individuals lacking school segregation data because their residential location did not match our school district cross-walk were excluded (see Figure e1). Because the combination of multi-level models, multiple imputation, and a relatively low number of districts often made convergence across every imputation impossible for many race-school composition-outcome combinations, we had to be creative when assessing the impact of data missingness. In particular, in lieu of running multilevel models on our imputed data (due to convergence problems), we re-fit our

models while simply using cluster-robust sandwich estimator standard errors that accounted for district-level clustering, first on our complete case data and then again on our imputed data. While standard errors when the number of clusters is relatively low can be biased, comparing estimates from analyses run on complete cases vs. imputed data can help us assess how big of an impact data missing-ness had.

First, we compared peer health behavior results from complete case models to those run on our imputed data (Appendix Table e6). Models failed to converge for White students attending predominantly non-White schools, but in all other cases we could make a direct comparison. Point estimates and inferences were quite similar when imputed data vs. complete cases were analyzed. However, estimates for peer smoking among non-Black students of color attending predominantly White schools—indicating that higher segregation was associated with more peer smoking in this population—were attenuated in our imputed data, and no longer achieved statistical significance.

Second, we examined results for peer prejudice (Appendix Table e7). Estimates were functionally identical between models run on complete cases vs. on imputed data, though in some cases convergence issues precluded us from comparing estimates. (Models using clustered standard errors for Black students in general and for White students in predominantly non-White schools failed in our imputed data; some dummy variables were dropped in several imputations but not in others, making combining estimates via Rubin's rules impossible.)

DISCUSSION

Recent epidemiologic evidence indicates that rising school segregation in the last three decades has harmed Black Americans' health. This includes more childhood behavioral difficulties, more alcohol consumption in childhood and adulthood, and poorer adult self-rated health.^{1,2} What mediates these relationships, however, is an open question. Prior research has demonstrated that school segregation lowers educational attainment and long-term incomes for Black students in the US; constrained educational and economic opportunities are thus leading candidates for mediators of segregation's health effects.^{9–14} In this paper, we examined two other proposed mediators: interpersonal discrimination (proxied by perceived prejudice from other students) and peers' health behaviors.

We found limited evidence for peer health behaviors as a mediator. If peer health behaviors mediated segregation's health harms, we would expect higher segregation to be associated with unhealthier peer smoking and drinking. We found this for only one group: students of color attending predominantly White schools (particularly, Black students), a finding which appeared fragile to accounting for data missing-ness. While these results are important, they apply to a relatively small minority: most Black students, for example, are educated in schools with less than 25% White enrollments (even lower than most schools in our "predominantly non-White" category).⁵⁹ Our results show that in these more diverse schools, higher segregation was either not associated with peer health behaviors or was associated with *healthier* peer smoking and drinking.

Similarly, if perceived prejudice from other students mediated segregation's health harms, we would expect higher segregation to be associated with a greater probability of students agreeing that their peers at school are prejudiced. Instead, we find the opposite: more school segregation was associated with a *lower* probability of peer prejudice, particularly in schools predominantly serving students of color.

Our findings on perceptions of lower peer prejudice in more diverse schools are in line with past research on school racial composition and peer-to-peer discrimination, describing the ways racial composition affects within-school perceptions of social power.³³ More segregation may mean a smaller, less socially dominant White student population in schools with large enrollments of students of color. In turn, research suggests this may mean less interracial animus: schools with more even distributions of students from different racial/ethnic groups have been shown to experience more balanced social power across race, reducing experiences of racial discrimination.³³

However, it is also possible that our findings are driven by other phenomena. The White students attending predominantly White vs. predominantly non-White public schools may simply systematically differ. For example, the type of non-Hispanic White students attending less-White schools in segregated districts may have parents who are happy to comply with neighborhood public school assignment in predominantly of-color neighborhoods; these families may be less likely to hold racist sentiments, on average. In contrast, White students whose parents proactively choose to live in an area where the schools serve mostly White families, or who would rather send their children to private school than see them educated alongside students of color, may, bluntly, hold more racist views (again, on average); higher segregation may select their children out of schools predominantly serving students of color.

Implications for Policy & Research

Our study has three broad policy implications. First, in schools with fewer White students, higher school segregation may not generate poor health via worsening peer health behaviors or an increasing feeling of prejudice from other students. Other mediating paths are more likely to dominate in mediating segregation's negative health impacts: fewer educational opportunities, more severe school discipline, a slipperier school-to-prison pipeline, or other material manifestations of structural stigma and of structural racism.^{60–66} Black students' perceptions that they are being discriminated against due to an unfair distribution of resources—e.g., that their schools are targeted for underfunding because they mostly serve Black youth—may also be important for health.³⁰ In any event, effective interventions appear more likely to be *structural* than interpersonal, involving the redistribution of funding and opportunity or the replacement of punitive discipline with schooling that supports, heals, and empowers.^{58,67}

That being said, second, the effects of school segregation may depend on school racial composition; interventions should be designed accordingly. In particular, the *mediators* of segregation's health effects may change depending on school composition: effects via a lack of educational opportunities in schools predominantly serving students of color, for example, vs. effects via poorer peer health behaviors in predominantly White schools. Specifically, our study showed students of color attending predominantly White schools report peer

networks that (on average) smoke and drink more frequently than their peers in less segregated districts. Thus, as peers' health behaviors can powerfully influence one's own, interventions that reduce smoking and drinking in predominantly White, segregated schools are warranted, and may disproportionately benefit the health of students of color who are educated there. Further, parents and administrators running programs that bring students of color into White, segregated schools (but which are not large enough to meaningfully reduce district-wide segregation – i.e., are not intended to integrate those schools to any meaningful extent) should be conscious that while this may provide their transfer students with greater educational opportunities, the substance use of their peers may in fact *worsen*. Indeed, years later, students of color who attended predominantly White schools in Add Health reported they were in worse average health than students who attended predominantly non-White schools, even controlling for family socioeconomic status.⁶⁸ Students of color in these programs may thus require interventions to prevent alcohol and smoking uptake.

Relatedly, third, the association between Black-White segregation and the social determinants of health does not appear limited to Black or White students. Anti-Black segregation affects entire school systems' social ecology, including non-Black students of color: it shapes the health behaviors of their peers, their experiences of interpersonal discrimination, and the resources available to them at their schools. This makes anti-Black school segregation a *collective* public health problem, reaching across racial/ethnic group membership. The reverse may also be true: the segregation of Asian, indigenous, or Hispanic students may matter not only for their health but for the health of student of other races or ethnicities, though this has been markedly less well-studied in quantitative epidemiology.

For research, epidemiologists should be conscious that models estimating the *overall* effects of segregation on health are in fact *averaging* effects across White schools and schools predominantly serving students of color; effects in these two contexts may further be mediated via distinct paths. This creates a problem for comparing estimates across studies: the effects of school racial segregation in a given study will depend on the distribution of schools in their sample (with respect to schools' racial compositions). That is, even if the effects of segregation are identical in Sample A and Sample B *conditional on school racial composition*, the effects of segregation *unconditional* on school racial composition will likely differ. Those collecting data for epidemiologic studies of school segregation should be mindful that administrative data on *schools* may be as important as data on district-wide school segregation itself.

Limitations & Strengths

This study has important limitations. First, we used data primarily from the Add Health in-school sample, only allowing a cross-sectional analysis. Although reverse causation is unlikely—student perceptions of peer prejudice and peers' health behaviors are unlikely to cause school segregation, as opposed to the other way around—longitudinal analyses showing that changes in school segregation co-occur with changes in our outcomes would offer a more compelling causal argument. Second, our study may suffer from unmeasured confounding, such as from parental beliefs about racial discrimination influencing both

where parents choose to send their children to school as well as students' interactions with their peers. As another example, the in-school survey data we analyze lacked family income data, forcing us to rely on parental education as an indicator of family SES (though our sensitivity analyses using Add Health's smaller, longitudinal sample data from in-home interviews included parental income and residential Census tract poverty and came to similar conclusions; see Appendix IV, Figure e6.). Third, we lack information on discrimination by teachers or by others outside of school who may treat students differently after learning they attend a segregated school predominantly serving one racial group or another; it may be that there are important interpersonal discrimination pathways we simply did not measure. Fourth, Add Health included a limited number of Black and non-Black racial/ethnic minority students within school types (e.g., in above vs. below median % White schools) and included students from a limited number of districts, impacting statistical power and external generalizability. Fifth, our study is restricted to the 1994–1995 school year and focuses only on adolescents; the association between school segregation at the district level and peers' prejudice or health behaviors may have changed over time or may be different for younger children. Sixth, outcomes and covariates were self-reported, and may therefore be subject to reporting biases. Finally, we measure only segregation within districts, across schools; segregation between districts, or across educational tracks within schools,^{69–72} may be equally important.

This study also benefits from several strengths. We provide among the first evidence on several hypothesized mediators linking school segregation and health: perceived peer prejudice, (a proxy for interpersonal discrimination) and peers' health behaviors. Our multi-level data allowed us to consider the potential impact of school segregation by race/ethnicity and by school racial composition, allowing us to contribute to existing research on the contextual factors (i.e., school segregation, school racial composition) that matter for racial discrimination and overall health among racial minorities.^{30,73,74} Add Health's network data provided a rich picture of children's social worlds, worlds with potentially important implications for their well-being. Further, this network data, as well as data on segregation, were measured empirically (i.e., were not based on a focal child's personal assessment of their school or network), preventing recall bias and measurement error. Findings were also broadly consistent when applying methods to account for missing data.

More generally, our study underscores that critical gaps remain in our understanding of the long-run health impacts of school segregation, including its potential mediators and the policies that should be implemented to ensure fairer and more healthful environments for racial minority students. Findings provide fruitful ground for research and for policymakers and school administrators to better support the health of US youth and combat the health harms of structural racism.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

DECLARATIONS & ETHICAL APPROVAL

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Highlights

- School segregation has been linked to poorer health for Black US Americans
- Key hypothesized mediators of this relationship remain un-tested
- We estimate links between segregation, peer prejudice, & peer health behaviors
- We find limited evidence that these factors mediate segregation's health harms
- Poorer educational resources due to segregation are the likely dominant mediators

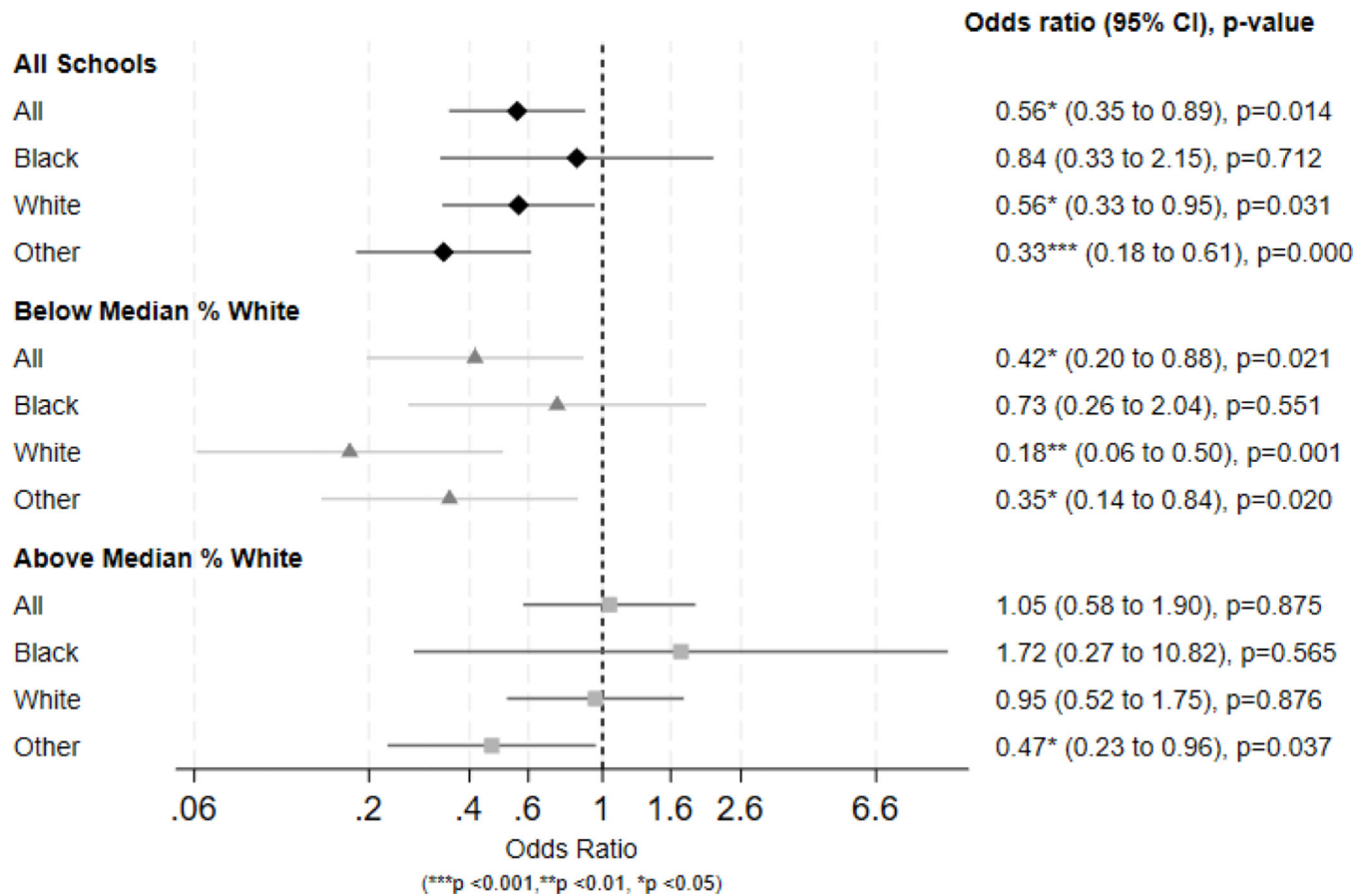
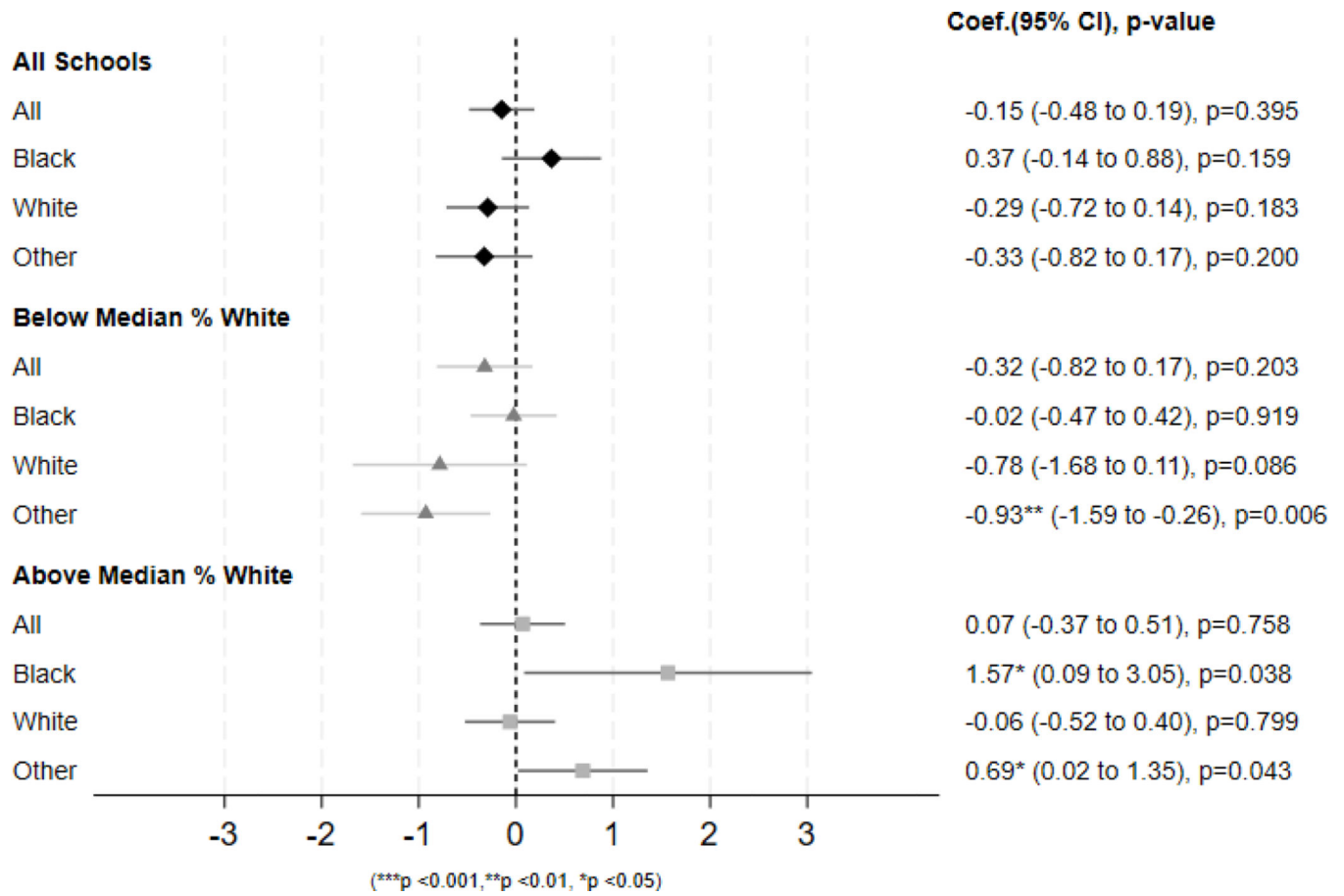
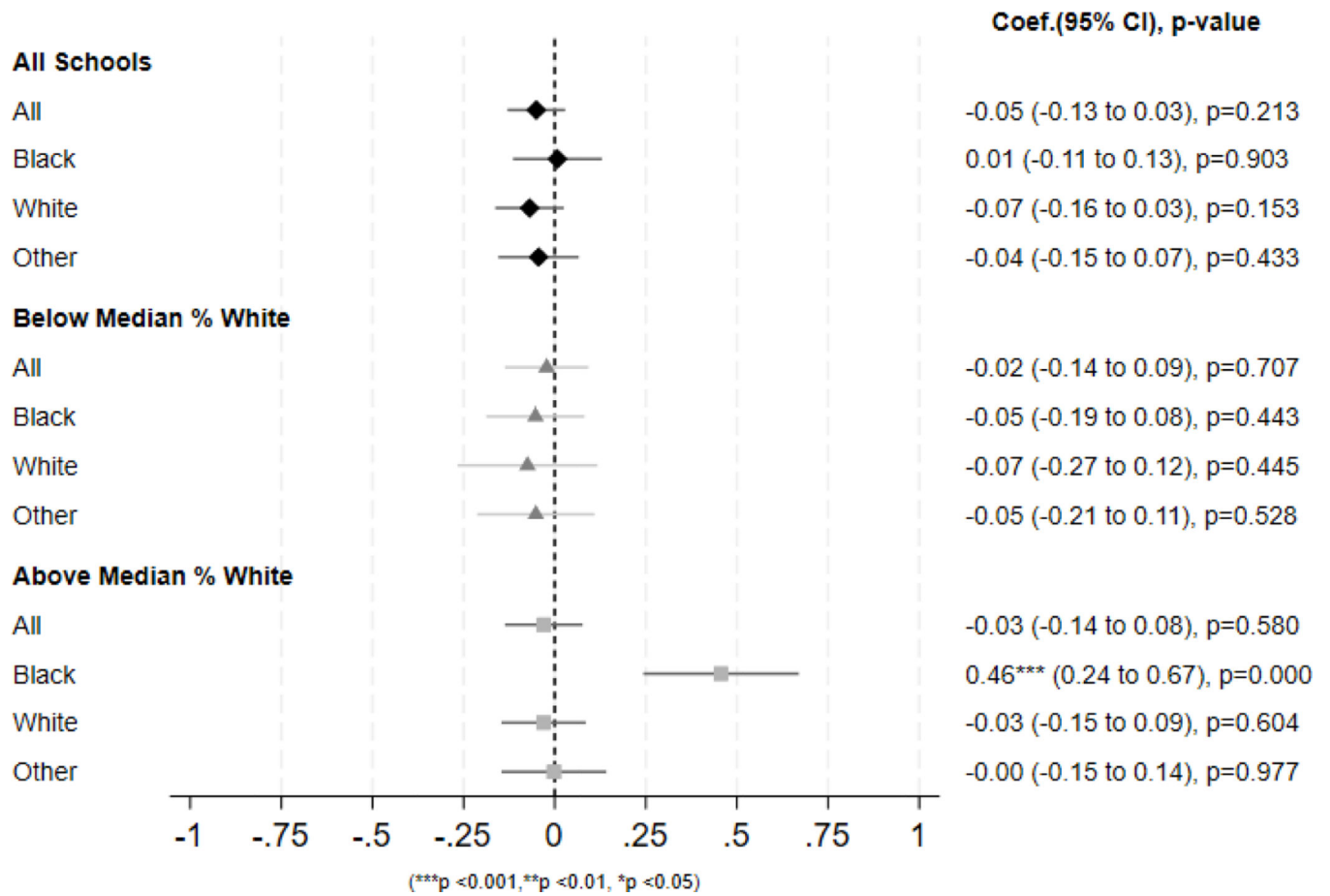
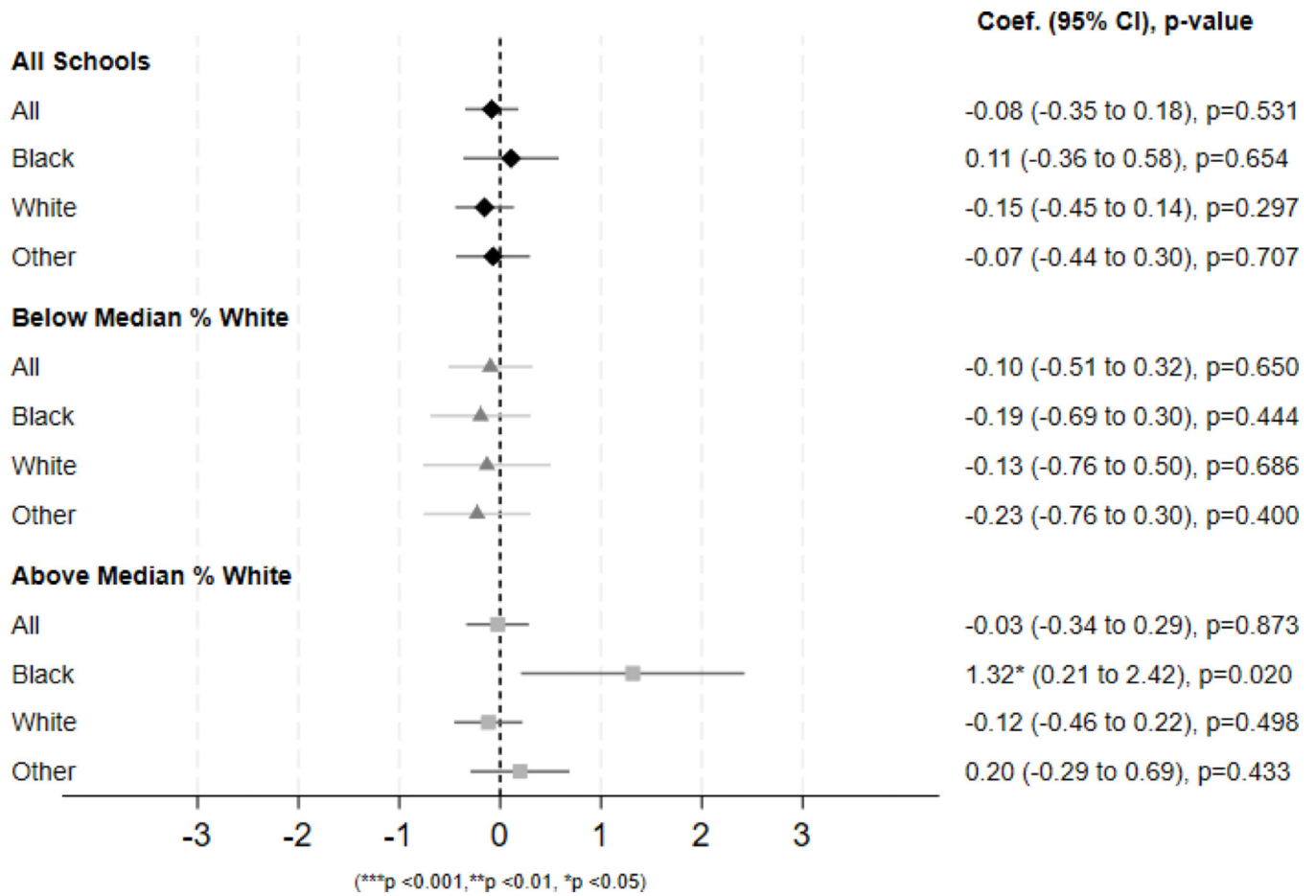


Figure 1. Associations between school segregation and perceptions of peer prejudice, by race and school racial composition

Note: Estimates were calculated using fully adjusted multilevel models (students nested within schools nested within districts) analyzing data from Add Health's in-school sample (n=53,275); they represent odds ratios associated with a 1-unit change in the dissimilarity index. "Other" represents non-Black students of color. *** represents $p < 0.001$, ** $p < 0.01$, and * $p < 0.05$.







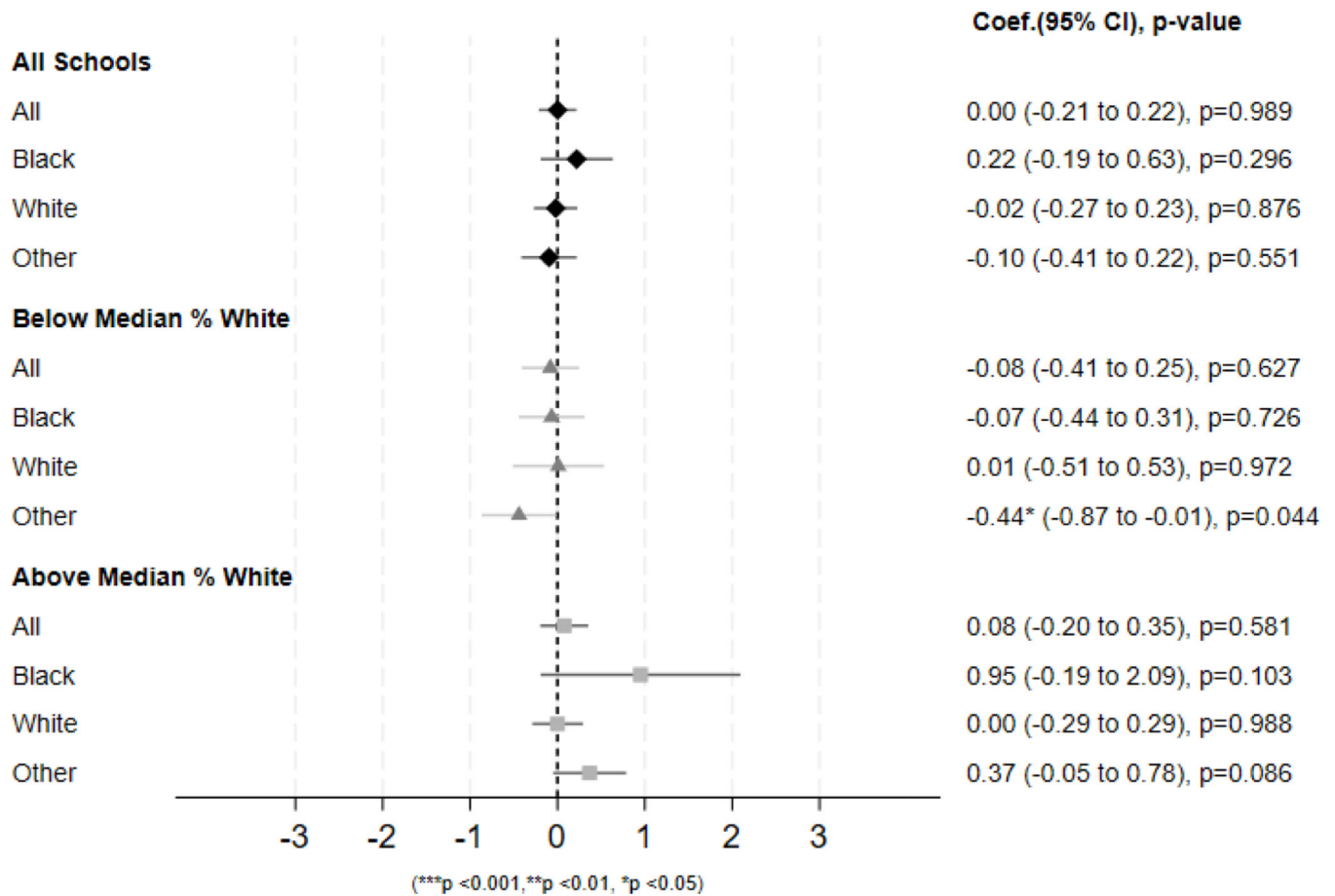


Figure 2. Associations between school segregation and students' broader social networks' health behaviors, by race and school racial composition

I. Smoking frequency*

II. Ever drank alcohol

III. Drinking frequency*

IV. Frequency of drinking until drunk*

Note: Estimates were calculated using fully adjusted multilevel models (students nested within schools nested within districts), analyzing data from Add Health's in-school sample (n=3,275). All estimates represent the change associated with a 1-unit change in the dissimilarity index. "Other" represents non-Black students of color.

* Outcome values represent the means of variables asking students about their health behaviors, averaged across all Add Health participants a given student identified as friends. In particular, frequency variables represent the mean of a 7-point, ordered, categorical Likert scale representing the frequency of a health behavior in the past 12 months. Estimates for "ever drank alcohol" represent percentage point changes in the proportion of respondent's friends who had ever drank alcohol.

Table 1.

In-school sample characteristics: prevalences and means (SD)

Variable	School Type		
	All	Predominantly non-White (below median % White)	Predominantly White (above median % White)
Exposure			
School segregation (B-W Dissimilarity index)	0.37 (0.19)	0.42 (0.22)	0.32 (0.15)
Outcomes			
Perceived peers to be prejudiced	39.80%	35.90%	43.90%
Peer health behaviors			
Ever drank alcohol	0.60 (0.31)	0.59 (0.32)	0.60 (0.31)
Smoking (freq.)	1.20 (1.40)	1.04 (1.30)	1.35 (1.46)
Drinking (freq.)	1.23 (1.00)	1.19 (1.00)	1.27 (1.00)
Getting drunk (freq.)	0.70 (0.86)	0.64 (0.84)	0.76 (0.87)
Covariates			
Grade, %			
6	0.05%	0.04%	0.05%
7	12.04%	11.76%	12.35%
8	12.72%	12.81%	12.62%
9	20.46%	19.61%	21.38%
10	20.41%	20.75%	20.04%
11	18.11%	18.50%	17.69%
12	16.21%	16.54%	15.86%
Race/ethnicity, %			
Non-Hispanic Black	15.46%	26.50%	3.55%
Non-Hispanic White	58.14%	36.58%	81.40%
Non-Black students of color	26.41%	36.92%	15.07%
Age	15.03 (1.67)	15.07 (1.68)	14.99 (1.67)
Sex - Female	52.57%	53.20%	51.88%
Parental education			
< High school	9.33%	12.07%	6.37%
High school graduate or ged	32.14%	31..3%	33.04%
Some college	18.86%	18.67%	19.07%
College graduate or more	39.68%	37.97%	41.52%
Geographic region			
Northeast	18.94%	25.82%	11.52%
South	22.61%	14.84%	30.99%
Midwest	47.30%	53.08%	41.06%
West	11.16%	6.26%	16.43%
School location			

Variable	School Type		
	All	Predominantly non-White (below median % White)	Predominantly White (above median % White)
Urban	29.72%	46.93%	11.15%
Suburban	57.76%	46.48%	69.90%
Rural	12.52%	6.60%	18.90%
District residential segregation (B-W Dissimilarity index)	0.41 (0.22)	0.51 (0.22)	0.31 (0.17)
District enrollment size	72877.32 (1.5e+05)	1.3e+05 (1.9e+05)	10113.12 (9600.69)
Number of districts	72	36	36
Number of schools	114	60	54
Number of students	53,275	29,236	24039

Note: Data was drawn from Add Health's in-school sample.

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