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RESEARCH ARTICLE

School-based racial segregation, social support, and late-life cognitive function in the Study of Healthy Aging in African Americans (STAR)

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Abstract

INTRODUCTION: School-based social support for Black students may mediate or modify the association between school segregation and late-life cognition.

METHODS: Study of Healthy Aging in African Americans participants ($n = 574$) reported segregated school attendance and school-based social support. Associations of segregated schooling with domain-specific cognitive outcomes and effect modification or mediation by school-based social support were evaluated with linear mixed models.

RESULTS: Segregated school attendance was associated with increased likelihood of school-based social support. Segregated (vs. desegregated in 6th grade) school attendance was associated with lower executive function ($\beta = -0.18 [-0.34, -0.02]$) and semantic memory z-scores ($\beta = -0.31 [-0.48, -0.13]$). Social support did not mediate these associations. Estimates for segregated school attendance were attenuated among those who felt supported, although there was limited evidence of statistically significant effect modification.

DISCUSSION: Early-childhood school segregation was associated with poorer cognitive function. Sources of resilience within racialized educational experiences should be further evaluated to bridge inequities.

KEYWORDS

Black, cognition, cognitive decline, epidemiology, executive function, school segregation, semantic memory, social support

Highlights

- School segregation is a form of structural racism that affected the educational experiences of Black youth with potentially lasting consequences for healthy brain aging.

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- Black students who attended a segregated school experienced greater school-based social support, which may highlight a potential source of resilience and resistance against the effects of racism-related stressors on cognitive function.
- The estimated adverse association between attending a segregated school on cognition was larger for students without an adult at school who cared about them versus those with an adult at school who cared about them, but estimates were imprecise.

1 | BACKGROUND

Although education is a well-established factor of cognitive performance in later life,¹⁻⁶ less research has addressed how racialized school experiences in the United States (US), especially during or around the time of legally segregated schools, may be a driver of the disproportionate burden of poor cognitive aging experienced by older Black adults.⁷⁻¹⁰ In the early 20th century, schools legally designated for Black students received fewer resources and had larger classroom sizes and shorter school terms than schools designated for White students.¹¹⁻¹⁴ Such restrictions hinder lower student-teacher ratios, which may facilitate more intensive student-teacher interactions and more cognitively stimulating environments for the development of neural circuitry,^{15,16} which in turn may enhance cognitive reserve early in life. Though Black students may have experienced greater access to material resources after the US Supreme Court declared segregated schools unconstitutional in 1954,^{17,18} records indicate that Black students faced school-based discrimination, coercion, and other social inequalities in legally desegregated schools across the US.¹⁹ Outside of the South, *de facto* school segregation was present via economic policies (e.g., school funding mechanisms) and racial residential segregation, which perpetuated a cumulative disadvantage of opportunities and resources for marginalized minoritized populations.^{20,21} The hostile school environments and increased experiences of interpersonal racism that Black students faced in desegregated schools may partially offset the possible benefits of increased educational resources and funding^{14,19} on cognitive development.²² However, likely due to data constraints, research⁷⁻¹⁰ has generally focused on availability of resources without consideration of school social environments.

Supportive or discriminatory experiences in schools affect educational outcomes and health risks later in life. Racism-related stressors are associated with poorer mental health, neurodegeneration, and cardiovascular disease in later life,²³⁻²⁵ all risk factors for cognitive impairment. Furthermore, schooling experiences and chronic stress during early childhood may have more salient effects on cognitive aging²⁶ due to the heightened neuroplasticity during this period.^{27,28} On the other hand, greater school-based social support has been associated with greater well-being in adolescence and higher educational attainment.²⁹⁻³¹ School-based social support (e.g., emotional, instructional) confers health and academic benefits by increasing resiliency,^{32,33} which enables individuals to better cope with stressors in and outside of school. Greater student-teacher racial concordance and staff diversity have also been associated with indicators of school-based social support such as higher teacher expectations, culturally

relevant instruction, and positive role modeling.³⁴⁻³⁶ It is unclear whether the impact of school-based social support varies by grade level. Some studies suggest that teacher support is more impactful during elementary education, as students usually have one teacher who can provide personalized attention.^{37,38} As students encounter multiple teachers for different subjects in later grades, it can become more challenging both for teachers to provide individualized support and for students to seek it out effectively. Conversely, during adolescence, relationships with non-parental adults become increasingly significant as adolescents seek support from adults beyond their immediate family.^{39,40} This is noteworthy, especially considering that Black students in racially segregated schools may have found sources of resilience and resistance through nurturing social relationships with adults in those school settings.^{41,42} Black teachers in segregated schools were often highly regarded by their communities and students yet were fired once these schools desegregated or closed, potentially removing sources of social support to Black students who then attended desegregated schools.^{43,44} However, to our knowledge, no studies have specifically evaluated whether attending historically segregated schools is associated with greater school-based social support. To understand the overall impact of school segregation on cognitive aging, it is important to consider both its potential benefits and harms driven by differential sociopolitical and schooling environments and the inequitable distribution of resources in schools.^{7-10,14,17-19}

This study extends prior research by examining the association between attending segregated schools in the mid-20th century and late-life cognitive function and decline, as well as whether school-based social support mediates or moderates these associations. We hypothesize that attending a segregated school will be strongly associated with cognitive performance for 1st and 6th grades and moderately for 9th and 12th grades. Students attending racially segregated schools will be more likely to experience school-based social support, which will partially mediate the effects of attending segregated schools. We further hypothesize that the harmful effect of segregated school attendance on cognition was more pronounced for students without school-based social support than among those with such support.

2 | METHODS

2.1 | Participants

Data came from the first three waves of the Study of Healthy Aging in African Americans (STAR), a cohort of Black Kaiser Permanente

Northern California (KPNC) members. The first wave was initiated in 2017, followed by the second wave in 2019, and the third wave in 2021. The average interval between administration across these waves was 1.14 years. KPNC is an integrated healthcare delivery system that provides care to more than 4.6 million individuals.⁴⁵ KPNC members have comparable distributions of race and ethnicity, educational attainment, and health indicators to all insured adults 26 to 84 years of age in Northern California; however, the KPNC membership underrepresents people from lower socioeconomic strata than the geographic region.⁴⁶ To be eligible for STAR, KPNC members had to have participated in at least one voluntary checkup between 1964 and 1985 (called the Multiphasic Health Checkup), self-identified as Black or African American, and be aged 50 years or older on January 1, 2018. The purpose of STAR is to examine the effects of psychosocial and health factors across the life course on cognitive aging among Black older adults. There are currently three waves of data from STAR participants. Exclusion criteria included electronic medical record diagnosis of dementia or other neurodegenerative diseases (frontotemporal dementia, Lewy body disease, Pick's disease, Parkinson's disease with dementia, Huntington's disease) and presence of health conditions that would impede participation in study interviews (defined as hospice activity in the past 12 months, history of severe chronic obstructive pulmonary disease in the past 6 months, congestive heart failure hospitalizations in the past 6 months, and history of end-stage renal disease or dialysis in the past 12 months). The study was approved by the KPNC and University of California Davis Institutional Review Boards and all enrolled participants provided written informed consent.

From the 764 participants who completed a baseline survey, these analyses excluded those without baseline cognitive assessment scores as well as anyone missing covariate information (Figure S1). We conducted grade-specific analyses of school exposures, excluding individuals without information on school segregation status or school-based social support for those specific grades. The majority of the missing data was due to attrition prior to the collection of school-based social support measures during Wave 2 of STAR. We did not exclude individuals missing relevant information at other grade levels to maintain analytical power, and the possibility of inducing selection bias since the educational context (e.g., school segregation status and social support) may be associated with attending 12th grade. A total of 494 participants for 1st grade, 566 for 6th grade, 574 for 9th grade, and 556 for 12th grade contributed to the grade-specific analytical models. To assess potential differences, we compared the sociodemographic characteristics of participants who did and did not participate in Wave 2, when the school-based social support question was asked (Table S1).

2.2 | Study measures

2.2.1 | Cognitive performance

Domain-specific cognitive function was assessed on three occasions with the Spanish and English Neuropsychological Assessment Scales (SENAS). SENAS is a battery of cognitive tests that has under-

RESEARCH IN CONTEXT

- 1. Systematic review:** The literature was reviewed using traditional sources (e.g., PubMed, ERIC). The few studies that examined associations between school segregation and cognition in Black adults informed the hypotheses, are discussed, and are cited. Most health research about school-based social support has focused on adolescent mental health, but none has evaluated its role in the association between school segregation and cognition.
- 2. Interpretation:** Black adults who had attended segregated instead of desegregated schools were more likely to report having experienced school-based social support. Early-life segregated schooling may be deleterious for cognition in middle- to older-aged Black adults, particularly for students without school-based social support.
- 3. Future directions:** This research emphasizes the schooling environment's role in early life and underscores a gap in our current theories on how education influences brain aging. Further studies identifying and examining sources of resilience among Black students in schools are warranted to better understand how to eliminate racial disparities in brain health.

gone extensive development using item response theory methodology for valid comparisons of cognition and cognitive change across racial/ethnic and linguistically diverse groups. The SENAS measures utilized in this study offer a comprehensive assessment of multiple cognitive domains and demonstrate sensitivity across the entire spectrum of cognitive function, without notable floor or ceiling effects.^{47,48} Domains of executive function and verbal episodic memory were assessed on three occasions; conversely, semantic memory was only assessed on two occasions. The executive function composite is constructed from component tasks of category fluency, phonemic (letter) fluency, and working memory (digit-span backward, list sorting). The verbal episodic memory score is derived from multitrial word-list-learning tests, as well as a delayed recall component. The semantic memory composite is constructed through verbal (object naming) and non-verbal (picture association) tasks. Cognitive assessment shifted from in-person to phone due to the COVID-19 pandemic at the end of Wave 2 and throughout Wave 3. We were unable to assess semantic memory by phone due to the visual prompts used in these tests, so subsequent analyses only assessed associations at baseline for semantic memory. While these three domains of cognition have been associated with education in earlier life, semantic memory exhibits greater stability throughout the lifespan than executive function or episodic memory.^{49,50} As such, examining domain-specific cognition would better capture the hypothesized sensitive period effect of attending a segregated school on cognition. Additionally, prior research demonstrated domain-specific effects of school segregation and school

characteristics,^{7-10,15} so domain-specific measures were assessed in this study. We standardized the domain-specific scores at each wave to the baseline sample.

2.2.2 | School segregation

During Wave 1 interviews, participants were asked if they attended school at grades 1, 6, 9, and 12. For each grade, individuals who reported attending that specific grade were then asked the following question: "Was this a segregated school?" with response options of "yes," "no," or "don't know." We created four grade-specific binary variables indicating whether participants self-reported if they attended a segregated school (1 = yes, segregated; 0 = no, desegregated). Participants who did not attend a specific school grade were set to missing for that grade and that grade's school segregation status.

2.2.3 | School-based social support

School-based social support (potential effect measure modifier and/or mediator) was retrospectively assessed for each grade (1st, 6th, 9th, and 12th) at Wave 2 with the following item: "Do you feel that there was a teacher or another adult at this school who really cared about you as a person?" We created separate dichotomized (1 = yes; 0 = no) school-based social support variables for each grade.

2.2.4 | Covariates

We considered confounders that were determined temporally prior to experiences of school segregation. Potential confounders included baseline age (continuous), sex/gender (male/female), birth in the Southern US, and parental education. Parental education was defined as the highest level of education achieved by either the participant's mother figure or father figure, whichever was higher or non-missing. We established a binary variable to indicate parental education of less than high school versus high school completion or more. We included a missing indicator for those without information on parental education as this could be indicative of socioeconomic disadvantage. Participants reported their state of birth, which was then coded as "Southern" versus "other" based on the US Census Bureau's regional designations.⁵¹ For longitudinal models we controlled for years since baseline interview and accounted for the shift in interview mode due to the COVID-19 pandemic by creating a binary indicator of whether the interview at each wave was conducted in person or over the phone.

In a subsequent model, we also accounted for participants' educational attainment, which could plausibly mediate the association between school segregation and cognitive performance. One mechanism by which school segregation may influence cognitive performance is through decreased educational attainment.¹⁷ Therefore, models that include educational attainment may underestimate the total effect of attending a segregated school at a specific grade. Educational

attainment was reported as the last grade or highest level in school participants completed and received credit for and operationalized as a continuous variable of the estimated years of completed education (i.e., bachelor's degree = 16). Nevertheless, by incorporating educational attainment in supplemental models, we may potentially isolate the influence stemming from components related to school quality and environment.

2.3 | Statistical analyses

We examined the distribution of demographics and school-based social support for each grade-specific analytic sample. We compared characteristics of participants by whether they attended a segregated school at that grade.

We then estimated the associations between grade-specific school segregation and domain-specific cognitive function and decline using linear mixed-effects models with random effects for intercept and slope. Models included a time term, reflecting the number of years since study baseline, as well as a multiplicative term for the interaction between grade-specific school segregation and time to capture rate of change in cognitive z-scores over time. Since there was no evidence of an association with the rate of decline (Table S2), we removed the interaction term and proceeded to estimate the association of grade-specific school segregation and domain-specific cognitive level using all available follow-up waves to increase our sample size and power. We estimated the associations between grade-specific school segregation and average cognitive level using covariate-adjusted linear mixed-effects models allowing for random intercepts and slopes. Across our models, we first adjusted for baseline age, years since baseline interview, gender, Southern birth state, parental education, and interview mode; we then additionally adjusted for educational attainment. We did not adjust for potential practice effects because prior work done in STAR suggests that the magnitude of the practice effects is minimal in this cohort.⁵²

To better understand the interrelationships in our data and to evaluate the role of school-based social support, we first estimated the grade-specific associations between school segregation and school-based social support using log-binomial regression adjusting for age and gender. Next, we estimated the association between grade-specific school-based social support and cognitive function using a series of linear regressions adjusting for age and gender. To evaluate potential mediation, we then re-estimated the association between school-based segregation and cognitive outcomes controlling for school-based social support and compared the magnitude of the coefficients corresponding to school-based segregation in linear mixed models with versus without this control. The plausible confounders included in these models are the same as those reported above when assessing the association between grade-specific school segregation and average cognitive level.

To separately evaluate potential effect measure modification, we estimated associations between grade-specific school segregation and cognitive outcomes in models that were stratified by school-based

TABLE 1 Cohort characteristics of the Study of Healthy Aging in African Americans (STAR) ($n = 764$).

	Mean (SD) or %
Age (years; mean)	68.7 (8.8)
Education (years; mean)	14.4 (2.5)
Female	68.3%
Birth in Southern USA	36.5%
≥HS parental education	65.3%
Grade 1	
Attended school	99.6%
Attended a segregated school	33.3%
Experienced school-based social support	52.1%
Grade 6	
Attended school	99.5%
Attended a segregated school	28.0%
Experienced school-based social support	59.6%
Grade 9	
Attended school	98.7%
Attended a segregated school	24.0%
Experienced school-based social support	55.5%
Grade 12	
Attended school	94.9%
Attended a segregated school	17.9%
Experienced school-based social support	58.5%

Note: Up to 29.8% of participants were missing school-based social support measures for a given grade.

social as well as via multiplicative interaction terms (i.e., between school segregation and school-based social support).

Finally, in sensitivity analyses, we used multiple imputation ($n = 30$ imputed datasets) with chained equations to address missingness on covariate or school-based support measures. Estimates were averaged across the multiply imputed datasets, and standard errors were calculated using Rubin's combining rules.⁵³ Analyses were performed using Stata 17.0 (StataCorp, College Station, TX, USA).

3 | RESULTS

3.1 | Descriptive findings

Cohort participants averaged 68.7 ($8.8 \pm$ SD) years of age at their first interview, and 68% were women (Table 1). Over a third were born in a Southern state. Participants averaged 14.4 ($2.5 \pm$ SD) years of schooling, and over half had at least one parent who had completed high school. These sociodemographic characteristics followed similar patterns for participants who provided information regarding school segregation status for each grade level (Table S3). The percentage of individuals attending a segregated school decreased with increasing

TABLE 2 Prevalence and grade-specific point estimates for association of school segregation on school-based social support in Study of Healthy Aging in African Americans (STAR).

	Percentage (%)	RR	95% CI
Model 1 ($n = 494$)			
Attended segregated school in 1st grade	80.5	1.15	1.04, 1.28
Model 2 ($n = 566$)			
Attended segregated school in 6th grade	84.3	1.17	1.07, 1.28
Model 3 ($n = 574$)			
Attended segregated school in 9th grade	80.5	1.17	1.05, 1.29
Model 4 ($n = 556$)			
Attended segregated school in 12th grade	87.5	1.18	1.08, 1.29

Note: Models are adjusted for age and sex. Among those who attended a desegregated school, the prevalence of reporting school-based social support was 71.1% for 1st grade, 72.6% for 6th grade, 68.0% for 9th grade, and 73.5% for 12th grade.

Abbreviations: CI, confidence interval; RR, risk ratio.

grade level: 34% of participants attended a segregated school in 1st grade, 27% attended a segregated school in 6th grade, 23% attended a segregated school in 9th grade, and 17% attended a segregated school in 12th grade.

Participants who reported attending a segregated school were more likely to report experiencing school-based social support (81% vs. 71% for 1st, 84% vs. 73% for 6th, 81% vs. 68% for 9th, and 88% vs. 74% for 12th grade), compared to those who attended a desegregated school (Table 2).

3.2 | Cognitive outcomes

3.2.1 | Grade-specific school segregation status and domain-specific cognitive function

Although we found some evidence that segregated schooling in 1st and 6th grade was associated with lower domain-specific cognitive function (i.e., executive function and semantic memory), the following results provide suggestive, but not compelling, evidence of an early-life-sensitive period since the confidence intervals (CIs) overlap across all grades. However, we saw no evidence of an effect on domain-specific cognitive function for 9th and 12th grade.

Average baseline executive function z-scores were similar for participants who attended a segregated school versus a desegregated school in grades 1, 9, or 12 ($\beta = -0.01$; 95% CI: $-0.19, 0.17$ for 1st; $\beta = -0.10$; 95% CI: $-0.27, 0.06$ for 9th; and $\beta = -0.08$; 95% CI: $-0.26, 0.10$ for 12th grade). Attending a segregated (vs. desegregated) school in 6th grade was associated with lower executive function ($\beta = -0.18$; 95% CI: $-0.34, -0.02$) (Model A, Table 3).

TABLE 3 Grade-specific estimated mean differences in cognitive function z-scores for participants attending segregated versus desegregated schools.

	n	Model A			Model B Adjusted for Model A covariates and grade-specific school-based social support		
		β	95% CI		β	95% CI	
Executive function							
Grade 1: segregated versus desegregated school	494	-0.01	-0.19	0.17	-0.01	-0.20	0.17
Grade 6: segregated versus desegregated school	566	-0.18	-0.34	-0.02	-0.19	-0.36	-0.03
Grade 9: segregated versus desegregated school	574	-0.10	-0.27	0.06	-0.11	-0.27	0.06
Grade 12: segregated versus desegregated school	556	-0.08	-0.26	0.10	-0.09	-0.27	0.09
Semantic memory							
Grade 1: segregated versus desegregated school	494	-0.21	-0.40	-0.01	-0.20	-0.40	-0.01
Grade 6: segregated versus desegregated school	566	-0.31	-0.48	-0.13	-0.31	-0.49	-0.13
Grade 9: segregated versus desegregated school	574	-0.15	-0.33	0.03	-0.15	-0.33	0.03
Grade 12: segregated versus desegregated school	556	-0.11	-0.31	0.08	-0.11	-0.31	0.08
Verbal episodic memory							
Grade 1: segregated versus desegregated school	494	0.02	-0.15	0.20	0.02	-0.16	0.19
Grade 6: segregated versus desegregated school	566	0.02	-0.14	0.18	0.02	-0.14	0.18
Grade 9: segregated versus desegregated school	574	0.02	-0.14	0.18	0.01	-0.15	0.17
Grade 12: segregated versus desegregated school	556	0.03	-0.14	0.21	0.02	-0.16	0.20

Note: Model A adjusted for baseline age, time since baseline, gender, Southern birth, parental education, and interview mode. Model B adjusted for Model A plus grade-specific school-based social support.

Average semantic memory z-scores were lower for participants who attended a segregated school versus a desegregated school ($\beta = -0.21$; 95% CI: $-0.40, -0.01$ for 1st grade; $\beta = -0.31$; 95% CI: $-0.48, -0.13$ for 6th grade; $\beta = -0.15$; 95% CI: $-0.33, 0.03$ for 9th grade; $\beta = -0.11$; 95% CI: $-0.31, 0.08$ for 12th grade), although estimates were imprecise for 9th and 12th grade.

There was no evidence of an association between attending a segregated school at any grade and verbal episodic memory scores ($\beta = 0.02$; 95% CI: $-0.15, 0.20$ for 1st; $\beta = 0.02$; 95% CI: $-0.14, 0.18$ for 6th; $\beta = 0.02$; 95% CI: $-0.14, 0.18$ for 9th; and $\beta = 0.03$; 95% CI: $-0.14, 0.21$ for 12th grade). Associations between school segregation and cognitive function were similar following additional adjustment for the participants' educational attainment (Table S4) and when using the pooled imputed datasets (Table S5).

3.2.2 | Grade-specific school segregation status and school-based social support

In each grade-specific model, those who attended a segregated school were 1.15 to 1.18 times as likely to report having experienced school-based social support (risk ratio [RR] for 1st grade = 1.15; 95% CI: 1.04, 1.28; RR for 6th grade = 1.17; 95% CI: 1.07, 1.28; RR for 9th grade = 1.17; 95% CI: 1.05, 1.29; and RR for 12th grade = 1.18; 95% CI: 1.08, 1.29) compared to those who attended a desegregated

school (Table 2). This supports our hypothesis that Black students who attended segregated schools would be more likely to receive school-based social support.

3.2.3 | School-based social support to domain-specific cognitive function

School-based support (vs. no support) at any grade was not associated with baseline executive function, semantic memory, or verbal episodic memory z-scores. Estimates were imprecise, with point estimates close to the null (Table S6).

3.2.4 | Grade-specific school segregation status and domain-specific cognitive function when accounting for grade-specific social support

Across cognitive domains and grade levels, the estimated associations between grade-specific school segregation status and domain-specific cognitive function were nearly identical after further adjustment for grade-specific school-based social support (Model B, Table 3). Contrary to our hypothesis, school-based social support is not a mediator of the association between segregated school attendance and domain-specific cognitive function.

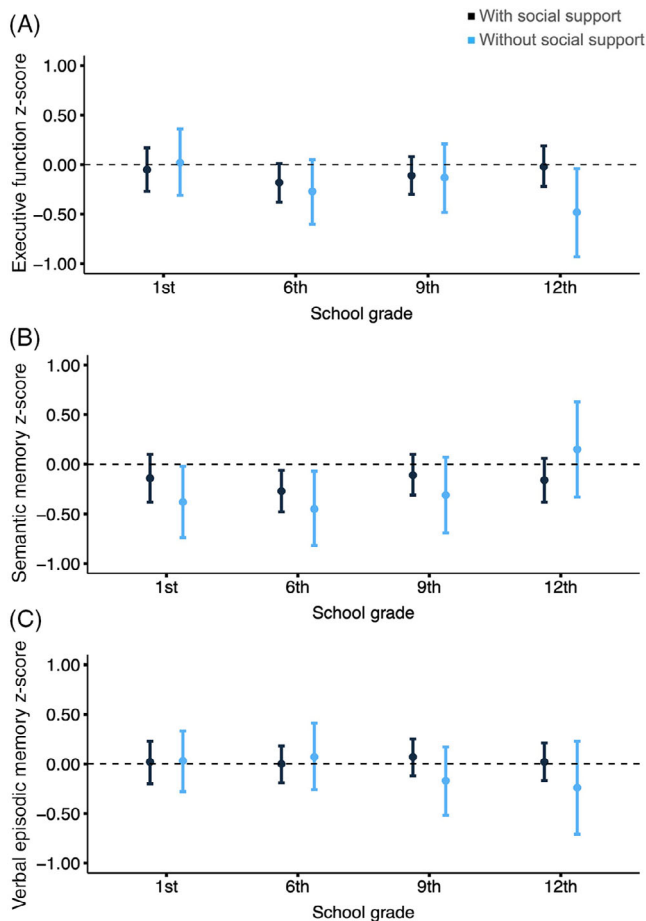


FIGURE 1 Grade-specific mean differences in cognitive function z-scores for participants attending segregated versus desegregated schools (referent) by grade-specific school-based social support.

3.2.5 | Possible effect measure modification of grade-specific school segregation status by grade-specific social support on domain-specific cognitive function

As hypothesized, school-based social support is a weak moderator of the association between attending a segregated school and domain-specific cognitive function. Results described in what follows suggest that the estimated negative impact of attending a segregated school was more pronounced for students without school-based social support compared to their peers who did report receiving social support.

The association between grade-specific school segregation status and executive function was similar for those who did and did not report school-based social support in grades 1, 6, and 9 (Figure 1; interaction term p values $> .10$ Table S7). However, in grade 12, attending a segregated school was associated with lower executive function z-scores among those *without* school-based social support ($n = 134$, $\beta = -0.48$; 95% CI: $-0.93, -0.04$), but not among those *with* school-based social support ($n = 422$, $\beta = -0.02$; 95% CI: $-0.22, 0.19$ Table S8; interaction term $\beta = 0.47$; 95% CI: $-0.02, 0.95$ interaction term p value = $.06$).

Similarly, attending a segregated (vs. desegregated) school in 1st grade was associated with lower baseline semantic memory z-scores ($n = 127$, $\beta = -0.38$; 95% CI: $-0.74, -0.02$) among participants *without* school-based social support, but not among those *with* school-based social support ($n = 367$, $\beta = -0.14$; 95% CI: $-0.38, 0.10$). However, the interaction coefficient was imprecise ($\beta = 0.15$; 95% CI: $-0.22, 0.53$; Table S7). There were otherwise similar associations between grade-specific school segregation status and semantic memory for those who did and did not report school-based social support for grades 6, 9, and 12 (Table S8).

Across all models, we observed no evidence of statistically significant associations between school segregation and verbal memory z-scores, regardless of the presence of school-based social support (Table S8).

Finally, estimates from multiple imputation resulted in attenuated conclusions that were, however, similar to those found in our primary analyses (Tables S9 and S10).

4 | DISCUSSION

In a cohort of Black Americans aged 50 years or older residing in Northern California, over a third had attended a racially segregated school in 1st grade, which, due to structural racism, received fewer resources than schools designated for White students.^{11–14} School segregation was less common at successively higher grade levels – likely due to the rapid desegregation of schools during the 1950s to 1980s and migration away from segregated Southern states – yet 17% of respondents attended a racially segregated school in 12th grade. Attending a segregated school in 6th grade was associated with lower baseline executive function scores, and attending a segregated school in 1st or 6th grade was associated with lower semantic memory scores compared to those who attended a desegregated school. Other associations were inconsistent, with wide confidence intervals that could not rule out harm or benefit. Participants who attended a segregated school at a given grade level were *more* likely to report school-based social support at that grade level than those who attended desegregated schools. We found no evidence that school-based social support mediated the associations between school segregation and cognitive function. On the other hand, we found that the harmful effect estimates associated with attending a segregated school were modestly attenuated among those who felt supported compared to their counterparts who did not feel supported, although interaction terms were imprecisely estimated.

Our findings add to the nascent body of research examining the role of racialized school experiences in shaping late-life cognitive outcomes among Black adults. Prior literature on the effects of school segregation has been mixed.^{7–10} Similar to our findings, studies have found that ever (vs. never) attending a segregated school was associated with poorer performance in measures of spatial ability, language, perceptual speed,⁷ and other fluid and crystallized cognitive abilities.¹⁰ Prior findings from this cohort evaluating the timing of desegregation⁹ found that those who transitioned to a desegregated school between 1st and 6th grade had better executive function and semantic memory scores

than those who only attended segregated schools. This is aligned with the vast literature on the importance of early childhood education on cognitive development^{28,54–56} and is consistent with our finding that attending a segregated school in early life (1st, 6th grade) but not in later grades. Our findings suggest that attending primary schools that systematically received fewer resources can have lasting impacts on cognitive aging for Black students and underscore the need to distinguish across the timing of attending a segregated school, as well as various cognitive domains, to understand the school segregation–cognition relationship better. Additional research in larger cohorts is needed to test multiple lifecourse frameworks formally, including grade-specific information, and to identify potential mechanisms to inform education reforms and broader policies.

Conversely, findings from the Minority Aging Research Study (MARS) documented an inverse association between attending a legally desegregated school and the level of cognitive function among Black adults in the US South.⁸ Authors hypothesized that students in recently desegregated schools experienced higher levels of interpersonal discrimination. Birth cohort and migration differences between STAR participants (California) and MARS (Chicago) may partially explain differences in the results. MARS participants were, on average, born in earlier birth cohorts than STAR participants. Therefore, their experiences of desegregation were more likely to be in the years immediately following the Supreme Court ruling. Additionally, there may be differences in the schooling environment and community between Chicago and California.

Prior studies evaluating school segregation and cognitive decline found no significant differences in the rate of cognitive decline by school type,^{7,8} suggesting that differences in schooling environments, particularly in early life, may only affect cognitive function levels, but not necessarily rates of decline.⁷ This is consistent with our null findings on cognitive decline; however, our results should be interpreted cautiously due to the sample size and relatively short follow-up period.

Our study further examined whether school-based social support played a role in explaining and/or mitigating the effects of school segregation. There is less literature on the health benefits of school-based social support during the Jim Crow era outside of historical accounts of the personal experiences of students, with mixed findings related to the immediate psychological consequences of integration.^{57–59} Recent studies suggest that social support from teachers has been associated with higher educational attainment, improved well-being, and lower depressive symptoms among adolescents.^{29–31} Although we found no evidence that school-based social support mediated the association of school segregation on cognitive function, our findings suggest that school-based social support may help buffer some of the effects of attending a segregated school. This would be consistent with studies that reported that increased social support and group identity found in minoritized communities may ameliorate some of the effects of discrimination experienced in later life.^{60–62}

Lastly, the lack of attenuation in estimates from models that additionally adjusted for years of schooling suggests that the association between school segregation and domain-specific cognition is not

entirely mediated by educational attainment. This may reflect the broader structural inequities in access to quality education, encompassing both *de jure* and *de facto* segregated school experiences in this cohort of older Black Americans, as well as other underlying differences in the schooling environment (i.e., discrimination).⁶³ These findings are consistent with prior research suggesting that administrative measures of school quality reflecting the availability of resources¹⁵ and literacy⁶⁴ are major contributors to cognitive disparities across racial and ethnic groups, independent of educational attainment. The diminished resources and academic opportunities in predominantly Black schools may contribute to decreased socioeconomic opportunities in midlife, thereby reinforcing racially segregated residential and economic environments,⁶⁵ access to healthcare-related resources, and exacerbating racial health inequities.⁶³ In addition, systemic barriers and discriminatory policies create significant hurdles for Black adults in securing employment, advancing in their careers, and achieving economic mobility.⁶⁶ Future research should explore the cumulative disadvantage that may be experienced by individuals who attended segregated schools and the extent to which systematically reduced access to resources for these schools mediates the association with late-life cognition. The persistence of *de facto* school segregation highlights the continued impact of institutional racism on school experiences and socioeconomic opportunities, with lasting implications for cognitive aging across generations.

Our analysis has several limitations. While we adjusted for birth in Southern states as a proxy for early-life and educational experiences particular to that geographic region, residual and unmeasured confounding likely persists. Second, the self-reported school segregation and school-based social support measures may be subject to recall bias. Participants' current perceptions and experiences may influence their recollection of past social support received at school, and there may be discrepancies between actual experiences and retrospective reporting. However, the intensity of national controversy and interpersonal discriminatory experiences related to school integration may have improved recall. Though we were interested in the influence of *de jure* or *de facto* school segregation, the non-specific interview question may have resulted in underreporting of attending a segregated school, which would underestimate the potentially harmful effects of segregation on cognition if there is a negative association. Although STAR participants were born throughout the US (e.g., 37% in the South) or abroad, they all lived in Northern California by 1985. Additionally, STAR participants were more likely to have attended 12th grade and reported better health than Black adults aged 50+ in the US (95% vs. 87% attended 12th grade⁶⁷; 73% vs. 69% "excellent/very good/good"⁶⁸) (estimates calculated by authors). Differences between STAR participants and the broader US population may limit the generalizability of our findings. Lastly, the imprecision of our estimates was likely driven by the small sample sizes partly due to the attrition in the sample before Wave 2 when school-based social support was assessed. Individuals who did not participate in Wave 2 were more likely to have been born in the South and have attended segregated schools (Table S1). Depending on the true underlying relationship between segregated school attendance and cognition,

our analyses may have under- or overestimated this association. Additional research in larger samples with various educational trajectories and experiences specific to attending segregated schools is needed.

Our study has several strengths. First, we focused on experiences relevant to older cohorts of Black Americans that are most likely to have contributed to racial disparities in cognitive aging. Our study is the first to evaluate the role of school-based social support in the association between attending a segregated school and cognitive outcomes among Black older adults and underscores the importance of exploring and identifying sources of Black resilience to cognitive aging. Moreover, our study includes long-term KPNC members, making it unlikely that differential access to healthcare services drove the findings presented. Finally, the assessment of cognitive function using the SENAS has been validated across racially and educationally diverse groups and is sensitive to detect early cognitive changes.

Education is viewed as a mechanism for social mobility with many downstream health benefits, including improved late-life cognitive function.^{22,69} However, the desegregation process after *Brown v. Board of Education* should not be conflated with educational equity. Our findings suggest that attending a segregated school in early childhood is associated with poorer executive function and semantic memory in later life, independent of educational attainment and school-based social support, likely due to the systematic under-resourcing of schools designated for Black students. Findings of the associations between school segregation and late-life cognitive function inform early-life school-based interventions (e.g., redistricting, equitable school resource allocation) to promote healthy cognitive aging and equity. Unfortunately, *de facto* racial segregation remains relevant for younger birth cohorts,⁷⁰ as reflected in the fact that over a third of K-12 public school students (about 18.5 million students) attend predominantly same-race/ethnicity schools,⁷¹ which are more likely to receive fewer resources.⁷² Future work should explore how other characteristics of the educational experience, and their timing, including school quality indicators and additional dimensions of segregation (e.g., residential) during childhood, affect cognition to further understand how structural racism may affect domain-specific late-life cognitive outcomes and may contribute to the higher dementia burden among older Black adults in the US.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest. Author disclosures are available in the [supporting information](#).

CONSENT STATEMENT

This study was approved by the KPNC and University of California Davis Institutional Review Boards, and all enrolled participants provided written informed consent.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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