

School Poverty, Institutional Resources, and Academic Achievement: A Mediation Analysis of U.S. High Schools

Abstract

In this study, we examine whether differential access to advanced academic opportunities mediates the relationship between school-level poverty concentration to how students score in ACT on average. By using data from 7,227 U.S. high schools, we integrated socioeconomic indicators with institutional resource measures from the Civil Rights Data Collection. With schools serving higher concentrations of economically disadvantaged, we found that students were offered significantly fewer AP courses, reduced calculus access, higher suspension rates, and elevated chronic absenteeism. We further leveraged multiple linear regression analysis to show that these institutional differences account for approximately 12% of the poverty-achievement relationship, with 88% remaining unexplained. These findings show that improving school resources is an important step, but addressing larger socioeconomic challenges is still crucial to closing achievement gaps.

Introduction

We all come to know that standardized test scores serve as critical gatekeepers for college admission, yet substantial disparities persist across schools serving different socioeconomic populations. We initially discovered that our analysis of socioeconomic predictors identified that the percentage of students eligible for free or reduced-price lunch (a school-level poverty measure) explained the largest portion of variance in ACT performance, surpassing community college education rates, median income, and unemployment combined.

This finding raised a critical question that we further asked: Do achievement gaps reflect primarily student demographics, or do they stem from systematic inequalities in institutional resource allocation? We hypothesize that if high-poverty schools systematically offer fewer college-preparatory opportunities, students would face structural barriers to developing advanced skills regardless of individual capabilities.

To answer this, we integrated three datasets: EdGap.org provided school-level ACT scores and socioeconomic indicators for 7,986 schools; the Common Core of Data supplied school characteristics; and the Civil Rights Data Collection contributed institutional measures including AP/IB programs, advanced mathematics offerings, teacher qualifications, counselor availability, disciplinary rates, and chronic absenteeism.

Our research examines whether schools serving higher percentages of economically disadvantaged students offer fewer advanced academic opportunities, and whether differential access to college-preparatory coursework helps explain the poverty-ACT relationship.

Theoretical Background

School-level poverty concentration creates institutional effects beyond individual student circumstances. When schools serve predominantly low-income populations, they experience compounding constraints such as difficulty recruiting teachers, limited funding for advanced courses, reduced parent volunteer capacity, and weakened political influence. These constraints may manifest in reduced access to college-preparatory coursework that prepares students for standardized tests. Following this logic, we further deduced to the fact that school climate factors also differ systematically. For instance, high-poverty schools more frequently employ punitive discipline including suspensions, disrupting learning time. Additionally, chronic absenteeism correlates strongly with poverty and predicts lower achievement. By understanding whether these institutional patterns mediate the poverty-achievement relationship provides insight into modifiable factors schools can address.

Methodology

Data Preparation: We filtered to traditional high schools with complete ACT data, resulting in 7,227 schools across 20 states. We corrected impossible values (negative ACT scores, negative percentages) and used iterative imputation for missing socioeconomic predictors. We merged three datasets using standardized 12-digit school identification codes across the EdGap data (containing ACT scores and community socioeconomic indicators), the Common Core of Data (containing school characteristics like location and type), and the Civil Rights Data Collection (containing institutional resources like AP courses and disciplinary data). This three-way merge achieved a 96% match rate, meaning we successfully linked institutional resource data to 6,921 of our 7,227 schools.

Measuring Resources: We found out that the raw counts of resources such as teachers, AP courses, enrollments conflates access with school size. For example, a school with 2,000 students and 40 AP courses appears to offer "more" than a school with 200 students and 5 AP courses, even though the smaller school provides greater per-student opportunity (1 course per 40 students versus 1 per 50). To isolate actual resource access from size effects, we converted all counts to rates per 100 students such that it would provide standardized measures comparable across school sizes. We validated this approach by confirming rate variables showed minimal correlation with total enrollment, demonstrating we successfully mitigated confounding by school size by leveraging total enrollment variable. We also discovered our imputation model predicted values exceeding logical bounds that we took immediate action to capped at 100%.

Analysis Strategy: We first used Analysis of Variance (ANOVA), a statistical test that determines whether average resource levels differ significantly across groups. For this to work, we divided schools into tertiles: low, medium, and high poverty such that it based on the percentage of students eligible for free or reduced-price lunch. This approach leverages the natural data distribution for balanced comparisons, ensuring measurable differences across poverty levels. Figure 1 validates this method by clearly showing how average ACT scores vary across these groups.

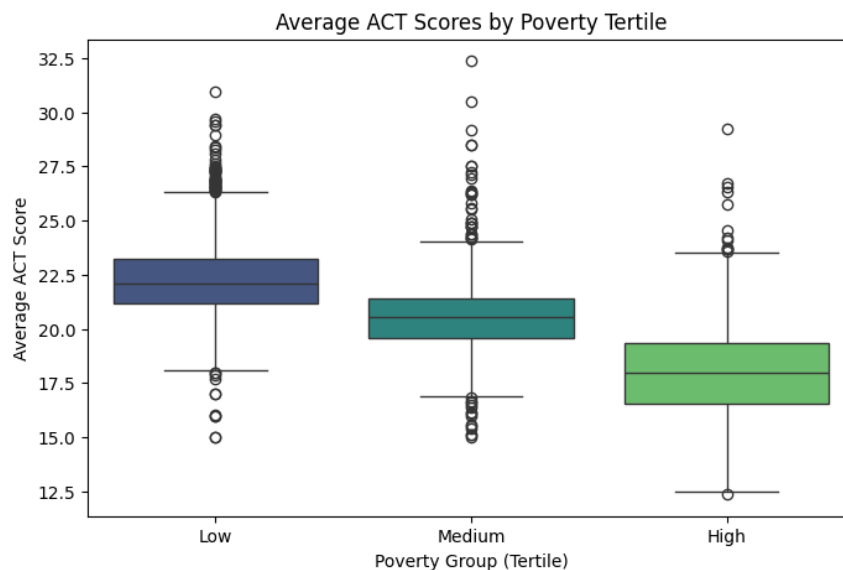


Figure 1. Boxplot of average ACT scores by poverty tertiles (low, medium, high), based on the percentage of students eligible for free or reduced-price lunch. Higher poverty levels are associated with lower ACT scores, emphasizing the impact of socioeconomic disadvantage and lack of institutional resources on academic outcomes.

We then used multiple regression analysis, a technique that quantifies how multiple factors simultaneously predict an outcome while controlling for each other. We standardized all predictors (mean=0, SD=1) allowing direct effect size comparison. We fit three models: (1) baseline with socioeconomic predictors only, (2) full model adding institutional resources and school size controls, (3) reduced model removing non-significant predictors.

Computational Results

Descriptive Patterns

Our merged dataset contained 34 variables covering socioeconomic context, school characteristics, and institutional resources. Initial correlation analysis (Figure 2) revealed free lunch percentage showed the strongest negative correlation with ACT scores ($r = -0.78$). Among institutional variables, calculus enrollment and AP enrollment showed moderate positive correlations with ACT (0.30-0.34), while suspension rates showed strong negative correlation (-0.35).

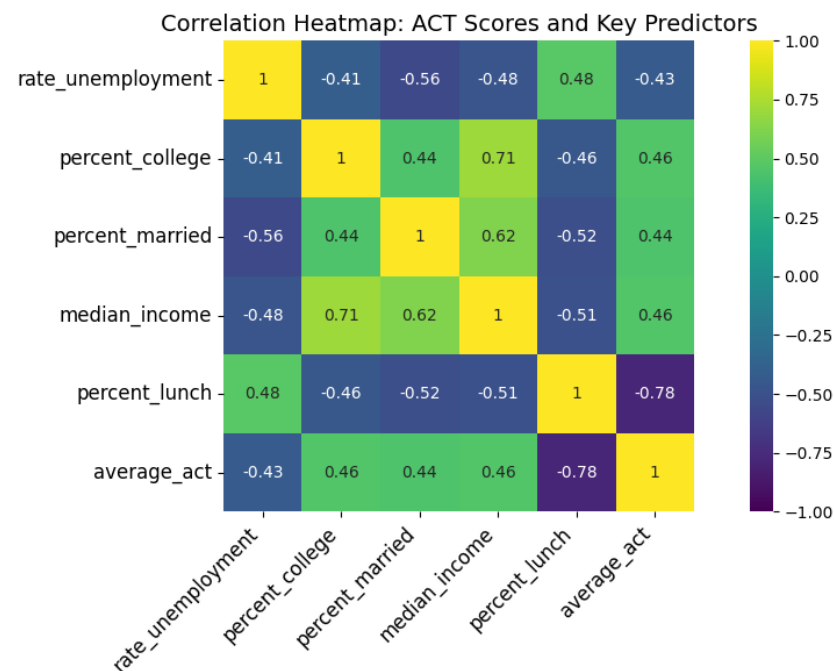


Figure 2. Correlation matrix showing relationships between school poverty concentration (percent_lunch), ACT scores, and institutional resource measures. Darker colors indicate stronger correlations.

Resource Disparities Across Poverty Levels

Analysis of variance demonstrated all six institutional measures differed significantly across poverty groups (all $F > 67$, all $p < 0.001$). The F-statistic tests whether differences between groups are larger than expected by random chance, in which the values above 67 indicate the resource gaps we observed are extremely unlikely to occur if poverty level didn't truly affect resources. Figure 3 displays mean resource levels by poverty group, revealing consistent gradients where medium-poverty schools fall between extremes.

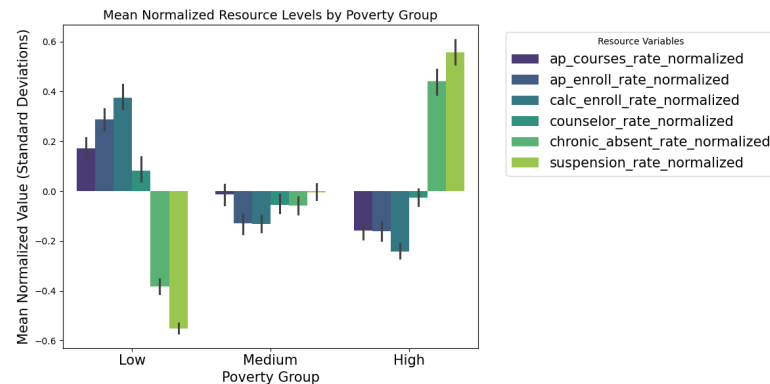


Figure 3. Mean institutional resource levels by school poverty concentration group. Positive values indicate above-average resources; negative values indicate below-average. Error bars represent 95% confidence intervals.

Low-poverty schools averaged +0.17 SD for AP courses and +0.38 SD for calculus enrollment; high-poverty schools averaged -0.16 SD and -0.24 SD respectively. High-poverty schools showed chronic absenteeism +0.44 SD above mean and suspensions +0.56 SD above mean, compared to -0.38 SD and -0.55 SD for low-poverty schools.

Mediation Through Regression

Table 1 presents three regression models testing how poverty affects ACT scores. In the baseline model, poverty's effect was -1.78 points; when we added institutional resources (AP courses, calculus, discipline, attendance), poverty's direct effect dropped to -1.57 points. This 12% reduction indicates partial mediation, meaning some of poverty's impact on test scores works through these institutional factors, though most (88%) operates through other unmeasured pathways.

But why "mediation"? The institutional resources sit "in between" poverty and achievement—high poverty leads to fewer resources, which then leads to lower scores. We're measuring the indirect pathway.

Predictor	Predictor	Full Model	Reduced Model
Intercept	20.30***	20.30***	20.30***
Unemployment Rate	-0.12***	-0.13***	-0.13***
College Education %	0.28***	0.17***	0.16***
Free Lunch % (Poverty)	-1.78*	-1.57*	-1.57*
AP Calculus Rate	—	0.10***	0.10***
Calculus Enrollment Rate	—	0.24***	0.24***
Counselor Rate	—	-0.01	—
Chronic Absenteeism Rate	—	-0.13***	-0.14***
Suspension Rate	—	-0.25***	-0.25***
Total Enrollment	—	0.21***	0.21***
R²	0.628	0.657	0.657
MAE	1.15	1.11	1.11
RMSE	1.53	1.47	1.47

*Table 1: Predictors standardized (mean=0, SD=1). * $p < 0.05$, ** $p < 0.001$. Coefficients represent change in ACT score per one standard deviation increase in predictor.

Four institutional factors emerged as significant: calculus enrollment (+0.24), AP courses (+0.10), suspension rate (-0.25), and chronic absenteeism (-0.14). School size showed positive effect (+0.21), and controlling for it revealed AP courses' true contribution. These values show the direction and strength of each factor's impact such that its positive numbers help ACT scores while negative numbers hurt them. We further investigated and found out an anomalous such that larger schools offer fewer AP courses per capita while achieving higher scores through other advantages, indicating confounding factors that regression had limited explanations.

Discussion

Our findings provide clear answers while revealing important nuances. Schools serving higher poverty concentrations unambiguously offer fewer advanced opportunities, in which the consistency across multiple measures demonstrates systematic institutional inequalities rather than isolated gaps. For example, if one school lacks advanced courses due to unique circumstances (e.g., staffing shortages or budget cuts), that would be an isolated gap. However, that wasn't the implication we got from this analysis such that the disparities in advanced opportunities (like fewer AP courses or calculus classes) are consistent across many schools serving high-poverty populations.

However, these disparities partially explain the poverty-achievement relationship. The 12% mediation effect confirms that advanced coursework access, disciplinary climate, and engagement patterns meaningfully affect outcomes independent of poverty. This 12% represents the portion of poverty's effect that operates through institutional resources: the poverty coefficient decreased from -1.78 in the baseline model to -1.57 when adding resource variables, with a reduction of 0.21 points, or 12% of the original effect ($0.21/1.78 = 0.12$). This means that roughly one-eighth of why high-poverty schools have lower ACT scores can be attributed to their having fewer AP courses, less calculus access, more suspensions, and along with higher absenteeism. The remaining 88% operates through unmeasured mechanisms like instructional quality differences, peer academic norms, family learning supports, summer learning patterns, and developmental impacts of economic stress. One methodological insight proved important: initially, AP course availability seemed unrelated to ACT scores. This surprised us until we discovered that larger schools offer fewer AP courses per student yet score higher for other reasons (specialized teachers, broader resources). Controlling for school size revealed AP courses' true positive effect. Without this control, we would have incorrectly concluded AP programs don't matter.

Policy Implications: Resource allocation matters as schools can expand advanced courses, reform discipline, and improve attendance. However, the modest 12% mediation cautions against expecting resource equalization alone to eliminate gaps, ensuring that all schools, regardless of poverty levels, have access to the same quality and quantity of resources, such as advanced courses, experienced teachers, and support services. Even perfect institutional equity would leave most disparity intact. From our analysis we would recommend implementation such that comprehensive approaches must simultaneously address institutional resources and broader developmental supports including healthcare, housing stability, early childhood programs, and summer learning.

Conclusions

Achievement gaps reflect both institutional inequalities and broader socioeconomic factors. Schools serving concentrated poverty face systematic disadvantages such as reduced advanced coursework, elevated punitive discipline, and higher disengagement. Statistical mediation reveals approximately 12% of the poverty vs. achievement relationship operates through these institutional factors, with calculus access, AP availability, suspension rates, and absenteeism as significant mediators. The persistence of 88% unexplained effect underscores that poverty operates primarily through mechanisms beyond course offerings as this would likely include instructional quality, peer norms, family supports, and cumulative developmental impacts. Meaningful progress toward equity requires coordinated efforts across multiple systems, extending beyond school boundaries. For practice, schools should prioritize expanding advanced coursework and reforming discipline while maintaining realistic expectations about achievable improvements through institutional reforms alone.

References

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