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**Association of attending a high-performing high school with substance use disorder and health outcomes in young adults**

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**KEY POINTS**

**Question:** Is attendance at a high-performing public school associated with improved health behaviors and health in young adulthood?

**Findings:** In this natural experimental cohort study of 1270 low-income adolescents, those attending high-performing schools reported substantially lower rates of risky substance use and delinquent behaviors through age 21. Attending high-performing schools was linked to substantially better physical health and lower obesity rates among males but substantially worse outcomes among females. These results were not explained by improvements in educational outcomes.

**Meanings:** Which high school you attend may affect your future risk of substance use, poor physical health and obesity.

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**ABSTRACT**

**Importance.** Interventions directly targeting social factors, such as education, may have the potential to greatly improve health.

**Objective.** To determine the association of attending a high-performing public high school with substance use, physical health, and mental health.

**Design.** We conducted a natural experimental cohort study using the random admissions lottery of high-performing public high schools.

**Setting.** We selected subjects who applied to at least one of five high-performing public charter high schools in low-income neighborhoods of Los Angeles. Subjects attended 147 different high schools.

**Participants**. We randomly selected admission lottery winners and wait-listed applicants and surveyed them from transition into 9$^{th}$ grade through 3 years after high school completion, starting in March 2013 through June 2021.

**Intervention**. Attendance at a high-performing high school.

**Main outcomes and Measures.** Self-reported alcohol and cannabis misuse, delinquent behaviors, physical and mental health, and body mass index.

**Results.** The study sample included 1270 primarily Latinx and African American adolescents. The 694 lottery winners (Intervention) and 576 waitlist (Control) were similar in almost all characteristics at baseline. Median follow up was 6.4 years. Those attending a high-performing school had a 53% lower rate of hazardous or dependent alcohol use (5.4% Intervention and 11.6% in the Control, difference= -6.2, 95%CI,-11.9 to -0.55) among men and women; 42% lower rate of self-reported fair or poor physical health (23.0% vs. 13.3%, difference=-9.7, 95%CI, -18.3 to -1.0) among men; and 33% lower rate of being obese or overweight (43.7% vs. 29.3%, difference=-14.4, 95%CI, -25.7 to -3.0) among men. Among women, high-performing schools was linked to equally large differences in physical health and obesity, but in the opposite direction. Few differences



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in mental health outcomes were observed. Adjusting for education outcomes did not significantly change these findings.

**Conclusions and Relevance.** Those attending a high-performing high school had lower rates of problematic substance use through young adulthood independent of academic achievement. Physical health and obesity outcomes were also better, but only for men; the intervention group had worse physical health outcomes among women for unclear reasons. Schools are a potent social determinant of health and an important target for future health interventions.

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## INTRODUCTION

Michael Marmot once said, “Every minister is a health minister, and every sector is a health sector. If we put fairness at the heart of all policies, health would improve.”[1] Numerous observational studies suggest poverty and related social determinants profoundly shape health and well-being from conception to death.[2] Yet, effective health interventions targeting social factors remain elusive and understudied.

Some small studies show early childhood education substantially improves a range of health outcomes.[3–6] The Moving To Opportunities (MTO) Study found moving to more affluent neighborhoods improved education and income outcomes for younger children[7] and had some benefits on girl’s behavioral health.[8] However, moving led to worse economic outcomes for older children, more anxiety and substance use among boys, and few differences in physical health for either boys or girls.[7–11]

Although intervening on social determinants of health presents substantial challenges, society already invests heavily in education. Public education has also markedly changed during the last two decades partly due to policies including the No Child Left Behind and Every Student Succeeds Acts. Yet, we have not rigorously examined whether improvements in secondary education can improve health.

We conducted the Reducing Inequities Through Social and Educational Change Follow-up (RISE-Up) Study, a natural experiment using admissions lotteries of public charter high schools to identify comparable groups of adolescents randomized into high- and lower-performing schools. We previously reported outcomes through 11$^{th}$ grade and found attending a high-performing school led to small but significant reductions in cannabis and alcohol misuse and lower risk of having substance using friends.[12] In the present study, we examined longer-term results through age 21. We hypothesized exposure to high-performing high schools would be associated with lower risky cannabis

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and alcohol use (primary hypothesis), lower rates of other delinquent behaviors, and improved mental and physical health.

## METHODS

### Study Design and Population

We conducted a natural experimental, prospective, cohort study of adolescents who applied to one or more high-performing charter schools in low-income communities of Los Angeles in the spring of 2013 or 2014.

### School and Participant Recruitment

In fall 2012, from 522 public high schools in Los Angeles, we identified all public charter high schools serving low-income communities (n=91) performing in the top tercile of public schools (n=30) based on the Academic Performance Index (estimated from standardized test scores and rates of attendance and graduation).[13] Of these 30 schools, we recruited all 5 with more than 50 applicants than available seats. Applications were open to all and only required contact information. We observed the random lottery of all 5 schools (spring 2013) and selected subjects from the top (winners) and bottom (waiting list) of the lottery. Unable to recruit enough subjects in 2013, we repeated recruitment in 2014 using the same procedures. Subjects admitted outside the lottery due to sibling preference and those who move from the area were excluded from the study.

### Data collection

After obtaining parental and student consent, we surveyed adolescents at the end of 8$^{th}$ grade through the beginning of 9$^{th}$ grade (baseline), and then annually from 10$^{th}$ grade through approximately age 21. The fourth follow up survey (December 2018-April 2020), and the fifth follow up survey (February 2020-June 2021) were conducted by telephone or in person. We collected school transcripts, standardized test data from the

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California Department of Education, and college matriculation data form the National Student Clearinghouse.[14]

**Measures**

We used the Alcohol Use Disorders Identification Test (AUDIT) to identify less risky (score<8) versus hazardous/dependent alcohol use (score≥8).[15] Cannabis misuse was assessed using an 8-item measure adapted from the alcohol misuse scale.[16] We assessed prior year engagement in nine delinquent behaviors (none vs. any): graffiti, damaging property, shoplifting/stealing, driving a car without the owner's permission, burglary, armed robbery, selling illicit drugs, gang participation, and participation in a gang fight.[17] Self-reported height and weight was used to calculate body mass index (BMI) and BMI percentile.[18,19] Subjects reported general physical and mental health (fair/poor vs. good/very good/excellent), depression (Center of Epidemiological Studies-Depression (CES-D) 10 scale ≥10 vs. lower),[20,21] hopelessness,[22] self-efficacy,[23] and moderate/severe generalized anxiety using the GAD-7 scale (score≥10).[24]

**Covariates**

Students reported baseline demographics (sex, ethnicity, language, birthplace), parental employment and birthplace, parenting style,[25] and family structure (1-parent, 2-parent, or other). Because applying to more schools would improve the chances of admission, we adjusted for the combination of charter schools to which the student applied ("risk set").[26,27]

**Statistical analysis**

We conducted intent-to-treat (ITT) analyses using mixed effects models to estimate the association of winning the admissions lottery with adolescent outcomes. To adjust for the hierarchical data structure of students nested within schools, school was included as a random effect. Previous charter school lottery studies estimated the causal effect of attending a high-performing school, referred to as the treatment on the treated (TOT),

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using 2-stage least squares analysis.[27–29] Using similar methods, admission lottery assignment served as an instrumental variable since it is random, conditional on the risk set, and thus exogenous of the outcomes. Finally, we conducted longitudinal instrumental variables analyses examining repeated outcomes measures at all 5 follow-up surveys, adjusting for clustering of multiple observations per student.

All models controlled for student demographics, 8th grade GPA, risk set, and parental and family characteristics. We conducted additional analyses adjusting for high school GPA, high school completion, 11th grade standardized tests scores, and 4-year college matriculation. We tested for an interaction effect between exposure to a high-performing school and sex using bootstrapping to estimate 95% confidence intervals. We imputed missing data using multiple imputation with chained equations. Stata 17.0 was used for all analyses. The institutional review board at UCLA approved this study.

**RESULTS**

At baseline, we recruited 1270 students, of whom 576 (45%) were wait-listed (Control) and 694 (55%) were lottery winners (Intervention). As reported previously,[12] the Control and Intervention were similar in ethnicity, sex, U.S. birthplace, native English language, parenting style, and family structure. Among the Intervention and Control, respectively, 88% and 92% were Latinx, 7% and 4% where non-Latinx black, and 6.4% and 4.1% were non-Latinx white or other. Among both groups, about half were males, 88% were born in the U.S., and 41% were native English speakers. Subjects were followed for a median of 6.4 years. By follow-up survey 5 (age 21), 420 (72.9%) and 541 (78.0%) of the Control and Intervention, respectively, remained in the study (p=0.04). (**Figure 1**)

Among the Control and Intervention, those lost to follow-up were more likely have characteristics indicative of higher risk, e.g. 1-parent families, lower 8th grade GPA, and worse test scores.(**Table 1**) However, of the retained sample through the age 21 follow-

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up survey, the two study arms had similar baseline characteristics with one exception--the Intervention was slightly more likely to be Latinx (92.1% vs. 88.3%, p=0.05).

To estimate the outcomes of attending a high-performing high school, we used three analytic methods. First, intent-to-treat (ITT) compared lottery winners to lottery wait-listers. Second, instrumental variables analysis estimated the "treatment on the treated" (TOT) effect of attending a high-performing school, accounting for cross-over between the Control and Intervention. Of the 694 lottery winners, 613 (88%) attended a high-performing school (top tercile on the Academic Performance Index), and 81 (11%) attended a lower-performing school. Of the 576 lottery losers, 357 (62%) attended a lower-performing school and 219 (38%) attended a high-performing school (p<0.001). Third, we conducted longitudinal TOT analyses using instrumental variables that included repeated outcome measures from all 5 follow-up waves.

Overall, rates of risky behaviors were lower in the Intervention than the Control group (**Table 2**). Specifically, 5.1%, and 11.4% respectively, reported hazardous or dependent alcohol use at age 20 (TOT model difference was -6.3% p=0.03). As expected, this difference was smaller in the ITT model (-3.3%, p=0.07). Examining both age 20 and 21 surveys together when the AUDIT questionnaire was asked, attending a high-performing school was associated with lower rates of hazardous/dependent alcohol use (5.4% vs11.6%; difference= -6.2%; 95% CI -11.9 to -0.55) and a relative risk reduction of 53%. Cannabis misuse scores were also lower (better) among the Intervention at age 20 (ITT difference -3.3, p=0.008; TOT difference -6.4 p=0.008). Differences in cannabis misuse were not statistically significant at age 21; however, across repeated measures from 10$^{th}$ grade through age 21, cannabis misuse scores were significantly lower in those attending a high-performing school (TOT longitudinal differences -3.5, p=0.02). The proportion engaged in one or more delinquent behaviors was also lower in the Intervention group at age 20 (ITT difference -5.4%, p=0.02; TOT difference -11.5%,

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p=0.01) and at age 21 (ITT difference -3.2%, p=0.09; TOT difference -6.0%, p=0.054). Despite this, the proportion engaging in delinquent behaviors was similar between the groups across all follow-up waves. The estimated treatment effect on these behavioral outcomes was similar for males and females, and formal tests for an interaction effect (**right column, Table 2**) were not statistically significant.

Those who attended a high-performing high school reported better physical health and BMI outcomes, but only among men. (**Table 3**) Women who attended high performing schools had worse physical health outcomes than those who attended lower-performing schools. Among men at age 20, for example, the proportion who reported being in fair or poor health (compared to good, very good, or excellent health) was 16.2% in the Intervention group vs 24.5% in the Control group (ITT difference -8.3%, p=0.04). This difference was -14.5% in the TOT model (p=0.07) equal to a 49% risk reduction of being in fair/poor health. Among women, however, Intervention had higher rates of fair/poor health (25.4% vs. 15.5% at age 20, p=0.10; 30.3% vs. 13.5% at age 21, p=0.05). Intervention males were less likely to be obese or overweight (TOT difference -21.6%, p=0.004 at age 20 and -12.3%, p=0.14 at age 21; longitudinal TOT difference -14.4%, p=0.013). In contrast, Intervention women had higher rates of being overweight or obese (difference 13.9% at age 20, p=0.10 and 19.3%at age 21, p=0.02), with a relative increased risk of 43% and 59% at age 20 and 21, respectively. An interaction term between the intervention and sex was statistically significant ($p<0.05$) for almost all physical health and BMI outcomes and across all statistical models.

Among men and women, the proportion reporting fair or poor mental health was higher in the Intervention group (TOT longitudinal model: 20.0% in the Intervention vs. 11.4% in the Control, p=0.04) (**Table 4**). These differences appear greater among women compared men, but an interaction was not statistically significant. Few differences were observed for other mental health outcomes except for anxiety among young adult

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men. Intervention males reported lower rates of moderate to severe anxiety compared to Control males at age 20 (ITT difference -11.2%, p=0.002; TOT difference -13.5%, p=0.04).

We hypothesized high school education outcomes might mediate the relationship between attending a high-performing school and outcomes in early adulthood. However, additional analyses controlling for high school completion, 11$^{th}$ grade standardized test scores, high school GPA, and matriculation to a 4-year college did not significantly change the results (**eTables 1-3**).

**DISCUSSION**

To date, few interventions targeting the social determinants of health have been tested. In the present study, we used the random admissions lotteries of several high performing public schools to conduct a natural experiment, examining the health outcomes of two comparable cohorts of students exposed to different academic environments. We found attending a high-performing high school was associated with substantial benefits across several health and behavioral outcomes. Specifically, we observed lower rates of hazardous and dependent alcohol use, cannabis misuse and delinquency. We also observed better self-reported physical health and lower BMI among young adult males who attended high performing schools. These findings are important given the magnitude of the differences observed. For example, we estimate that among males, the Intervention group had 50% lower rates of risky alcohol use and delinquent behaviors and 42% lower rate of reporting fair or poor physical health compared to Controls. Even a conservative estimate from the ITT analysis indicates a 30% reduction in fair or poor physical health by young adulthood. We estimate attending a high-performing school reduced rates of being obese or overweight by 33% over the course of the study follow-up (43.7% vs 29.3%), findings largely driven by the male subsample. Furthermore, these outcome measures, including problem drinking, self-reported health, and obesity are important and widely used predictors of all-cause mortality.[30–33]

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Despite improvement in physical health and obesity among young adult males, rates of obesity and fair/poor physical health was worse among Intervention females compared to Control females. The differential effect of education interventions on health favoring boys has been observed in the Perry Preschool and other education studies, [5,34,35] but reasons for this are unclear. One explanation is that higher-performing schools raise expectations for success, potentially creating greater tension around decisions about education, career, and family. These expectations may differ for women and men in our study. Women and men may also cope differently with these expectations, possibly leading women to experience more stress and worse physical health.

The precise mechanisms of how schools in our study influenced health is unknown, but the five high-performing study schools shared several characteristics. All were relatively small with fewer than 150 students per grade. They had similar structure based on minimizing total student load (TSL), defined as the total number of students a particular teacher is responsible for in any single semester.[36] Thus, a teacher in these charter schools with 5 periods with 30 students each has a TSL equal to 150 compared to teachers in some traditional public schools who have a much higher TSL. Lower TSL may help teachers monitor and support their students, which is linked to better academic and behavioral outcomes.[37–39] The study schools were public charter schools with more local autonomy over staffing and curriculum, and none had special health promotion programs. While some may argue charter schools attract more engaged, higher performing students, existing evidence suggests otherwise.[40]

To better understand how high-performing schools influence substance use and health outcomes, we conducted analyses controlling for intermediate educational outcomes. However, these analyses indicate the study findings were not mediated by better academic achievement. Other possible mechanisms may include greater support from teachers and other adults, more structured school environments, higher academic



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expectations and long-term goal setting, and less exposure to peers who engage in risky behaviors.

Strengths of our study include the examination of five different high-performing charter schools in Los Angeles serving a wide geographic area of low-income neighborhoods. Students in our study attended 147 different high schools, representing a variety of school environments. While not a true randomized trial, our study's natural experimental design avoids selection bias inherent in observational studies. The ITT and TOT models also produced qualitatively similar results. The ITT estimates are more conservative and may underestimate the true effect due to cross-over between the study arms. In contrast to an "as-treated" analysis, which would ignore the random lottery assignment and be subject to selection bias, the TOT model uses instrumental variables to account for both the random lottery and adjust for crossovers to better approximate a treatment effect unbiased by cross-over or selection.[27–29] Some previous natural experimental studies of charter schools have examined the impact on health but were limited to studying just one charter school.[29,41] They also used a cross-sectional design, sampling students several years after high school graduation, which may have increased recruitment bias. In contrast, we prospectively sampled students at the time of the lottery and followed the cohort over several years.

**Limitations**

Our study limitations include reliance on self-report. Furthermore, subjects were not blinded to the study intervention, thus social desirability bias may have occurred. However, evidence of systematically different responses by study arm or sex was not apparent, and self-reported height and weight in this age group has been found to be accurate in other studies.[42,43] Despite very strong yearly retention rates (>95%), Control subjects were slightly less likely to be retained. Those lost to attrition were more likely to be male and had worse baseline academic performance, indicating higher risk. If so,



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retention bias would likely lead to underestimated rates of poor health or health behaviors in the sample overall and bias estimates toward the null for analyses in which the Intervention appeared to do better than the Control. While the random lottery assignment likely reduces the potential for bias in the study arms, unobserved socioeconomic and other factors could have confounded the results through differential attrition. We studied charter public schools because admissions lotteries are required. However, many other types of successful school models exist, and not all charter schools perform better than traditional public schools. Thus, our results may not generalize to other school models nor suggest that all charter schools have the same health impact. Our findings may not generalize to adolescents from higher-income families. We identified high-performing schools using a composite measure of test scores and attendance and graduation rates, but better school performance metrics likely exist.

**Conclusion**

Finding effective, affordable, and scalable solutions to combating poverty and its negative effects on health is enormously challenging. Schools, however, are a well-established social institution, broadly accepted as a fundamental right for all children. While views may differ about education funding and best practices, schools are an everyday part of almost every child's life, fortuitously at an early life stage when long-term health trajectories can be shaped. The present results suggest high-performing public schools may have an impact on a range of behaviors and health outcomes with a large effect, which is particularly impressive given the marginal cost of the "intervention" is zero. Thus, while improving schools is complicated, as a health intervention, costs are not necessarily a barrier. Furthermore, high-performing schools may have a large impact substance use and obesity--two significant and intransigent public health problems. The worse physical health outcomes observed among young adult women in high-performing



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schools is concerning, and further inquiry is imperative. Ultimately, improving schools has great potential as an effective and scalable strategy to improve health.

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**Figure 1. Participant Recruitment and Retention**

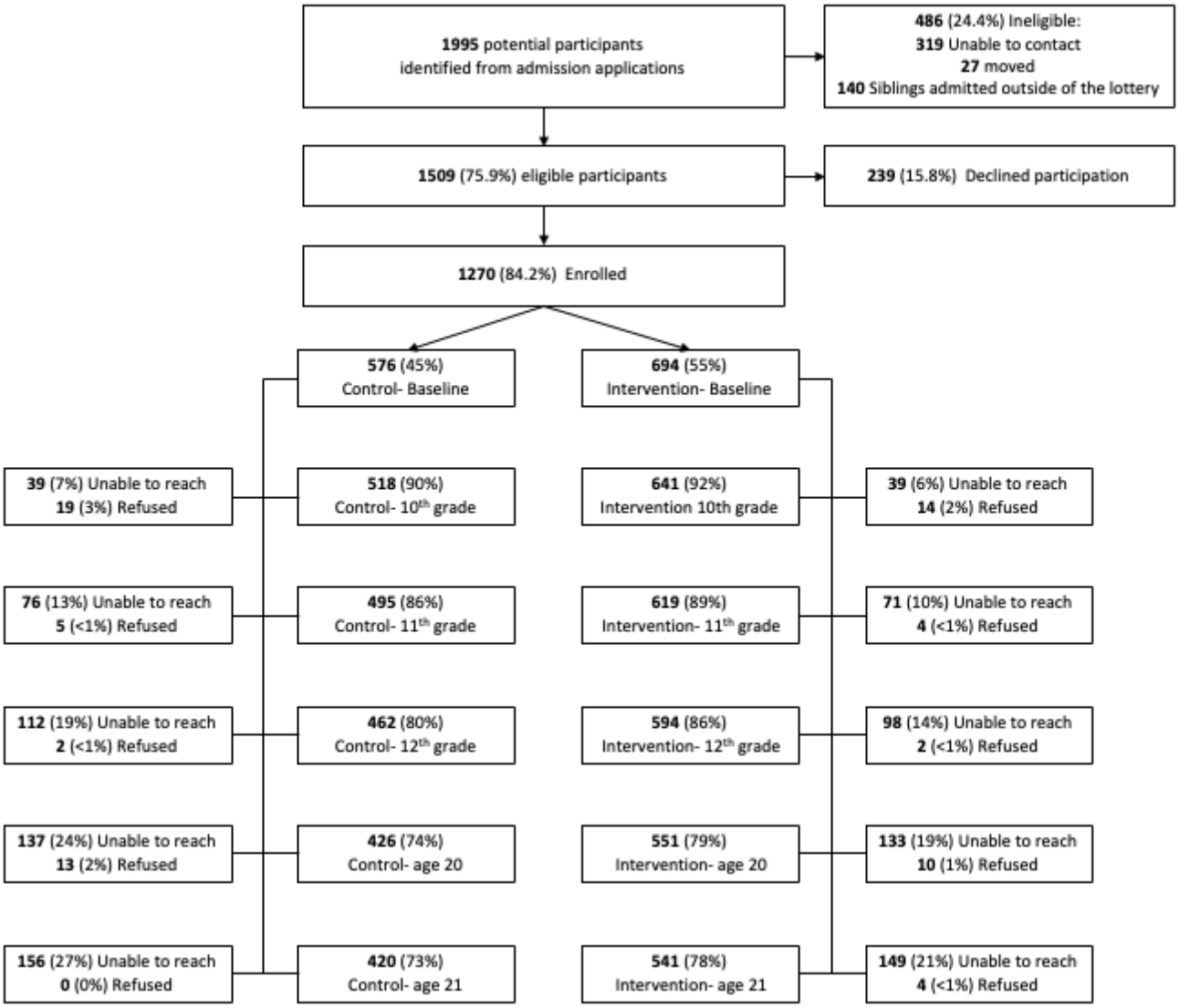


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**Table 1. Baseline demographics of the Intervention and Control group stratified on whether the sample was retained through the age 21 survey or lost to follow up.**

| | Control | | | Intervention | | | |
|---|---|---|---|---|---|---|---|
| | **Retained through age 21 survey** | **Lost to follow up** | **P value** (retained vs. lost to follow-up) | **Retained through age 21 survey** | **Lost to follow up** | **P value** (retained vs. lost to follow-up) | **P value comparing retained Intervention vs Control** |
| **N (%)** | 420 (72.9%) | 156 (27.1%) | | 541 (78.0%) | 153 (22.0%) | | |
| **Sex** | | | | | | | |
| Female | 232 (55.2%) | 67 (42.9%) | 0.009 | 296 (54.7%) | 73 (47.7%) | 0.13 | 0.87 |
| Male | 188 (44.8%) | 89 (57.1%) | | 245 (45.3%) | 80 (52.3%) | | |
| **Race** | | | 0.06 | | | 0.003 | 0.25 |
| Asian | 5 (1.2%) | 2 (1.3%) | | 13 (2.4%) | 2 (1.3%) | | |
| Black | 22 (5.2%) | 17 (10.9%) | | 24 (4.4%) | 18 (11.8%) | | |
| Native American | 3 (0.7%) | 3 (1.9%) | | 4 (0.7%) | 4 (2.6%) | | |
| White | 380 (90.5%) | 133 (85.3%) | | 495 (91.5%) | 128 (83.7%) | | |
| Other/Mixed | 10 (2.4%) | 1 (0.6%) | | 5 (0.9%) | 1 (0.7%) | | |
| **Ethnicity** | | | 0.08 | | | 0.22 | 0.05 |
| Latinx | 371 (88.3%) | 129 (82.7%) | | 498 (92.1%) | 136 (88.9%) | | |
| Non-Latinx | 49 (11.7%) | 27 (17.3%) | | 43 (7.9%) | 17 (11.1%) | | |
| **US Born** | 370 (88.1%) | 135 (86.5%) | 0.61 | 468 (86.5%) | 140 (91.5%) | 0.10 | 0.46 |
| **Native English speaker** | 161 (38.3%) | 72 (46.2%) | 0.09 | 218 (40.3%) | 68 (44.4%) | 0.36 | 0.54 |
| **Parent US born** | | | 0.35 | | | 0.004 | 0.51 |
| No | 313 (74.5%) | 108 (69.2%) | | 408 (75.4%) | 102 (66.7%) | | |
| Yes | 106 (25.2%) | 48 (30.8%) | | 133 (24.6%) | 49 (32%) | | |
| Don't know | 1 (0.2%) | 0 (0%) | | 0 (0%) | 2 (1.3%) | | |
| **Parent full-time employed** | | | 0.63 | | | 0.50 | 0.50 |
| No | 57 (13.6%) | 25 (16%) | | 60 (11.1%) | 20 (13.1%) | | |
| Yes | 362 (86.2%) | 131 (84%) | | 480 (88.7%) | 132 (86.3%) | | |
| Don't know | 1 (0.2%) | 0 (0%) | | 1 (0.2%) | 1 (0.7%) | | |
| **Parenting Style** | | | 0.87 | | | 0.06 | 0.73 |
| Average | 207 (49.3%) | 73 (46.8%) | | 284 (52.5%) | 70 (45.8%) | | |
| Neglectful | 86 (20.5%) | 35 (22.4%) | | 99 (18.3%) | 44 (28.8%) | | |
| Indulgent | 41 (9.8%) | 19 (12.2%) | | 43 (7.9%) | 14 (9.2%) | | |
| Authoritarian | 38 (9%) | 12 (7.7%) | | 51 (9.4%) | 12 (7.8%) | | |
| Authoritative | 48 (11.4%) | 17 (10.9%) | | 64 (11.8%) | 13 (8.5%) | | |
| **Family Structure** | | | <0.001 | | | 0.43 | 0.48 |
| Other | 6 (1.4%) | 6 (3.8%) | | 12 (2.2%) | 3 (2%) | | |
| 1-parent | 65 (15.5%) | 42 (26.9%) | | 73 (13.5%) | 27 (17.6%) | | |
| 2-parent | 349 | 108 | | 456 (84.3%) | 123 (80.4%) | | |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (83.1%) | (69.2%) | | | | | |
| **8th grade grade point average** | | | <0.001 | | | <0.001 | 0.51 |
| <2.0 | 41 (9.8%) | 37 (23.7%) | | 51 (9.4%) | 24 (15.7%) | | |
| 2.0-2.5 | 80 (19%) | 39 (25%) | | 86 (15.9%) | 42 (27.5%) | | |
| 2.6-3.0 | 103 (24.5%) | 38 (24.4%) | | 119 (22%) | 41 (26.8%) | | |
| 3.1-3.5 | 91 (21.7%) | 30 (19.2%) | | 141 (26.1%) | 27 (17.6%) | | |
| 3.6-4.0 | 95 (22.6%) | 7 (4.5%) | | 132 (24.4%) | 18 (11.8%) | | |
| Unknown/missing | 10 (2.4%) | 5 (3.2%) | | 12 (2.2%) | 1 (0.7%) | | |
| **Standardized Test Scores** | | | | | | | |
| **8th grade Math (%)** | | | 0.0005 | | | 0.004 | 0.99 |
| Below basic | 86 (21.8%) | 50 (34%) | | 115 (22.2%) | 48 (33.3%) | | |
| Basic | 97 (24.6%) | 45 (30.6%) | | 126 (24.3%) | 40 (27.8%) | | |
| Proficient or above | 212 (53.7%) | 52 (35.4%) | | 277 (53.5%) | 56 (38.9%) | | |
| **8th grade English (%)** | | | <0.001 | | | 0.013 | 0.18 |
| Below basic | 58 (14.7%) | 39 (26.5%) | | 72 (13.9%) | 26 (18.1%) | | |
| Basic | 122 (30.9%) | 59 (40.1%) | | 134 (25.9%) | 51 (35.4%) | | |
| Proficient or above | 215 (54.4%) | 49 (33.3%) | | 312 (60.2%) | 67 (46.5%) | | |

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**Table 2. Comparison of Control and Intervention groups in alcohol and cannabis use and delinquent behaviors at age 20 and 21.**

| | All | | | Females | | | Males | | | Sex interaction |
|---|---|---|---|---|---|---|---|---|---|---|
| **Outcome/ Model** | **Control** | **Intervention** | **Difference (95%CI)** | **Control** | **Intervention** | **Difference (95%CI)** | **Control** | **Intervention** | **Difference (95%CI)** | **P value** |
| **Alcohol use-Hazardous/Dependent (%)** | | | | | | | | | | |
| ITT age 20 | 8.91 | 5.64 | -3.27 (-6.78, 0.24)* | 9.01 | 6.00 | -3.01 (-7.84, 1.81) | 8.89 | 5.11 | -3.78 (-8.90, 1.34) | 0.55 |
| TOT age 20 | **11.38** | **5.06** | **-6.33 (-12.02, -0.63)**** | 11.72 | 5.43 | -6.29 (-15.73, 3.16) | 11.16 | 4.50 | -6.65 (-15.36, 2.05) | 0.97 |
| ITT age 21 | 8.86 | 6.01 | -2.85 (-6.80, 1.09) | 8.95 | 7.38 | -1.56 (-7.14, 4.01) | 9.14 | 6.86 | -2.28 (-7.81, 3.25) | 0.40 |
| TOT age 21 | 11.56 | 5.46 | -6.11 (-12.97, 0.76)* | 12.20 | 4.75 | -7.46 (-16.01, 1.10)* | 10.53 | 6.52 | -4.02 (-13.97, 5.94) | 0.68 |
| TOT longitudinal | **11.64** | **5.43** | **-6.21 (-11.87, -0.55)**** | 11.85 | 5.12 | -6.73 (-14.62, 1.17)* | 11.42 | 5.89 | -5.53 (-13.39, 2.33) | 0.85 |
| **Cannabis misuse score** | | | | | | | | | | |
| ITT age 20 | **13.43** | **10.12** | **-3.31 (-5.76, -0.85)***** | 11.35 | 9.77 | -1.59 (-4.85, 1.67) | **15.60** | **11.17** | **-4.43 (-8.22, -0.65)**** | 0.49 |
| TOT age 20 | **15.93** | **9.53** | **-6.40 (-11.16, -1.63)***** | 13.28 | 9.00 | -4.28 (-11.15, 2.58) | **18.27** | **10.46** | **-7.81 (-13.09, -2.53)***** | 0.56 |
| ITT age 21 | 11.14 | 10.58 | -0.55 (-3.08, 1.97) | 10.00 | 9.77 | -0.23 (-3.33, 2.86) | 12.19 | 11.14 | -1.05 (-5.12, 3.02) | 0.50 |
| TOT age 21 | 11.69 | 10.38 | -1.30 (-4.82, 2.22) | 10.20 | 9.73 | -0.47 (-5.76, 4.83) | 13.18 | 11.29 | -1.89 (-6.30, 2.52) | 0.75 |
| TOT longitudinal | **9.18** | **5.68** | **-3.51 (-6.52, -0.49)**** | 7.96 | 5.50 | -2.46 (-6.52, 1.60) | 10.19 | 6.06 | -4.13 (-8.39, 0.14)* | 0.74 |
| **Delinquent behaviors (%)** | | | | | | | | | | |
| ITT age 20 | **13.62** | **8.18** | **-5.44 (-9.94, -0.95)**** | **12.44** | **7.02** | **-5.42 (-10.85, 0.00)**** | 13.51 | 9.93 | -3.58 (-10.35, 3.19) | 0.41 |
| TOT age 20 | **18.29** | **6.82** | **-11.47 (-20.25, -2.68)**** | **17.30** | **6.00** | **-11.30 (-21.95, -0.66)**** | 18.21 | 8.46 | -9.76 (-21.55, 2.04) | 0.88 |
| ITT age 21 | 8.79 | 5.60 | -3.19 (-6.87, 0.48)* | 7.16 | 4.86 | -2.31 (-6.72, 2.11) | 10.58 | 7.39 | -3.18 (-8.93, 2.57) | 0.88 |
| TOT age 21 | 11.29 | 5.28 | -6.01 (-12.14, 0.11)* | 9.12 | 4.46 | -4.67 (-13.51, 4.17) | 12.52 | 6.91 | -5.62 (-14.88, 3.65) | 0.91 |
| TOT longitudinal | 11.33 | 10.74 | -0.59 (-5.37, 4.19) | 10.33 | 9.26 | -1.07 (-7.45, 5.30) | 12.06 | 12.77 | 0.71 (-6.19, 7.61) | 0.98 |

**Table 2 Legend.**
Results in bold indicate p≤0.05.
*p<0.10
** p≤0.05
** p≤0.001
Intent-to-treat (ITT) analyses are based on mixed effects models with intervention and control group assignment based on the admissions lottery. Treatment on the Treated (TOT) models employ instrumental variables analysis using the admissions lottery assignment as the instrument and attendance in a high-performing school (defined as school-level test scores in the top tertile of public high schools in Los Angeles County) as the exposure. Longitudinal models use all outcomes measures across up to 5 waves of follow-up surveys, adjusted for clustering at the subject level. All models adjust for sex, Latino ethnicity, U.S. birth, native English language, 8th

grade grade point average, risk set based on which high schools the student applied to, parental birthplace, 1 or more parent working full time, parenting style at home, family structure.

**Table 3. Comparison of Control and Intervention groups in global physical health, body mass index and obesity at age 20 and 21.**

| | All | | | Females | | | Males | | | Sex interaction |
|---|---|---|---|---|---|---|---|---|---|---|
| **Model/ Outcome** | **Control** | **Intervention** | **Difference (95%CI)** | **Control** | **Intervention** | **Difference (95%CI)** | **Control** | **Intervention** | **Difference (95%CI)** | **P value** |
| **Physical health-fair/poor (%)** | | | | | | | | | | |
| ITT age 20 | 21.50 | 21.13 | -0.37 (-5.96, 5.22) | 19.77 | 24.53 | 4.76 (-2.99, 12.51) | **24.50** | **16.24** | **-8.26 (-16.17, -0.34)**** | **0.01** |
| TOT age 20 | 21.78 | 21.07 | -0.72 (-10.70, 9.27) | 15.51 | 25.43 | 9.92 (-1.96, 21.80) | 29.46 | 14.92 | -14.54 (-30.05, 0.97)* | 0.07 |
| ITT age 21 | 23.19 | 25.99 | 2.80 (-3.18, 8.78) | **20.53** | **28.84** | **8.31 (0.11, 16.51)**** | 27.05 | 22.10 | -4.94 (-13.54, 3.65) | **0.01** |
| TOT age 21 | 21.08 | 26.47 | 5.39 (-9.03, 19.81) | **13.47** | **30.29** | **16.82 (0.36, 33.28)**** | 30.08 | 21.35 | -8.73 (-24.43, 6.97) | **0.05** |
| TOT longitudinal | 17.38 | 18.01 | 0.64 (-5.96, 7.23) | 12.83 | 21.29 | 8.46 (-1.49, 18.40)* | **23.01** | **13.33** | **-9.67 (-18.30, -1.05)**** | **0.005** |
| **Body mass index percentile (%)** | | | | | | | | | | |
| ITT age 20 | 64.95 | 62.74 | -2.21 (-6.36, 1.94) | 64.88 | 67.20 | 2.32 (-2.78, 7.41) | **65.54** | **56.88** | **-8.66 (-15.37, -1.95)**** | **0.03** |
| TOT age 20 | 66.66 | 62.31 | -4.35 (-11.82, 3.12) | 62.76 | 67.63 | 4.87 (-4.32, 14.06) | **70.74** | **55.49** | **-15.25 (-25.16, -5.34)***** | **0.02** |
| ITT age 21 | 66.80 | 65.43 | -1.37 (-5.43, 2.69) | 66.61 | 68.76 | 2.15 (-3.00, 7.31) | **67.75** | **60.92** | **-6.84 (-13.35, -0.32)**** | **0.04** |
| TOT age 21 | 67.83 | 65.19 | -2.64 (-10.01, 4.73) | 64.80 | 69.08 | 4.28 (-5.79, 14.36) | **71.94** | **59.87** | **-12.07 (-21.36, -2.78)**** | 0.08 |
| TOT longitudinal | 66.68 | 63.12 | -3.56 (-10.38, 3.26) | 63.01 | 67.52 | 4.52 (-4.81, 13.84) | **70.57** | **57.47** | **-13.10 (-22.94, -3.26)***** | **0.02** |
| **Overweight/obese (%)** | | | | | | | | | | |
| ITT age 20 | 43.21 | 42.44 | -0.78 (-7.85, 6.29) | 38.49 | 45.16 | 6.67 (-2.58, 15.92) | **50.44** | **38.18** | **-12.26 (-22.28, -2.24)**** | **0.01** |
| TOT age 20 | 44.40 | 42.15 | -2.25 (-14.24, 9.75) | 32.51 | 46.42 | 13.91 (-2.66, 30.47)* | **57.81** | **36.22** | **-21.59 (-36.10, -7.07)***** | **0.01** |
| ITT age 21 | 44.43 | 47.11 | 2.68 (-4.21, 9.58) | **41.01** | **50.54** | **9.53 (0.29, 18.77)**** | 49.37 | 42.42 | -6.94 (-17.14, 3.26) | **0.03** |
| TOT age 21 | 42.43 | 47.56 | 5.13 (-7.78, 18.04) | **32.91** | **52.20** | **19.30 (3.37, 35.22)**** | 53.62 | 41.36 | -12.26 (-28.67, 4.15) | **0.03** |
| TOT longitudinal | 35.57 | 33.71 | -1.86 (-10.34, 6.63) | 28.17 | 36.97 | 8.80 (-3.80, 21.39) | **43.67** | **29.28** | **-14.38 (-25.74, -3.02)**** | **0.009** |

**Table 3 Legend**

Results in bold indicate p≤0.05.

*p<0.10

** p≤0.05

** p≤0.001

Intent-to-treat (ITT) analyses are based on mixed effects models with intervention and control group assignment based on the admissions lottery. Treatment on the Treated (TOT) models employ instrumental variables analysis using the admissions lottery assignment as the instrument and attendance in a high-performing school (defined as school-level test scores in the top tertile of public high schools in Los Angeles County) as the exposure. Longitudinal models use all outcomes measures across up to 5 waves of follow-up

surveys, adjusted for clustering at the subject level. All models adjust for sex, Latino ethnicity, U.S. birth, native English language, 8th grade grade point average, risk set based on which high schools the student applied to, parental birthplace, 1 or more parent working full time, parenting style at home, family structure.

**Table 4. Comparison of Control and Intervention groups in mental health outcomes at age 20 and 21.**

| | All | | | Females | | | Males | | | Sex interaction |
|---|---|---|---|---|---|---|---|---|---|---|
| **Outcome/Model** | **Control** | **Intervention** | **Difference (95%CI)** | **Control** | **Intervention** | **Difference (95%CI)** | **Control** | **Intervention** | **Difference (95%CI)** | **P value** |
| **Mental health-fair/poor (%)** | | | | | | | | | | |
| ITT age 20 | **12.11** | **17.65** | **5.55 (0.08, 11.01)**** | 15.05 | 20.20 | 5.15 (-2.59, 12.89) | 9.51 | 13.45 | 3.93 (-2.51, 10.37) | 0.60 |
| TOT age 20 | **8.21** | **17.73** | **9.52 (0.29, 18.75)**** | 11.08 | 19.78 | 8.70 (-6.84, 24.24) | 7.15 | 14.08 | 6.92 (-4.38, 18.22) | 0.89 |
| ITT age 21 | 15.66 | 19.82 | 4.16 (-1.13, 9.45) | **16.22** | **23.77** | **7.55 (0.05, 15.06)**** | 15.41 | 14.71 | -0.70 (-8.06, 6.66) | 0.20 |
| TOT age 21 | 12.52 | 20.54 | 8.01 (-0.25, 16.28)* | **9.80** | **25.09** | **15.29 (0.86, 29.72)**** | 15.84 | 14.60 | -1.24 (-12.51, 10.03) | 0.23 |
| TOT longitudinal | **11.36** | **20.03** | **8.67 (0.47, 16.88)**** | 11.40 | 23.28 | 11.89 (-1.02, 24.80)* | 12.43 | 15.36 | 2.94 (-6.73, 12.60) | 0.29 |
| **Depression (%)** | | | | | | | | | | |
| ITT age 20 | 23.61 | 20.77 | -2.84 (-8.47, 2.79) | 25.23 | 24.69 | -0.54 (-8.55, 7.46) | 22.45 | 15.37 | -7.09 (-14.91, 0.74)* | 0.62 |
| TOT age 20 | 25.76 | 20.26 | -5.49 (-17.44, 6.46) | 25.72 | 24.59 | -1.14 (-18.81, 16.54) | 26.71 | 14.24 | -12.48 (-28.45, 3.50) | 0.46 |
| ITT age 21 | 24.41 | 25.97 | 1.56 (-4.36, 7.49) | 27.49 | 31.83 | 4.34 (-4.11, 12.80) | 18.60 | 17.72 | -0.89 (-9.88, 8.10) | 0.34 |
| TOT age 21 | 23.22 | 26.24 | 3.02 (-6.72, 12.75) | 23.80 | 32.59 | 8.79 (-3.22, 20.80) | 23.41 | 17.75 | -5.66 (-15.42, 4.11) | 0.13 |
| TOT longitudinal | 21.74 | 20.87 | -0.87 (-7.31, 5.58) | 25.51 | 25.28 | -0.24 (-10.72, 10.25) | 17.69 | 15.42 | -2.28 (-9.54, 4.99) | 0.79 |
| **Anxiety- moderate to severe (%)** | | | | | | | | | | |
| ITT age 20 | 12.48 | 9.98 | -2.50 (-6.82, 1.81) | 11.31 | 12.88 | 1.57 (-4.61, 7.74) | **17.21** | **5.98** | **-11.23 (-18.31, -4.15)***** | 0.20 |
| TOT age 20 | 14.37 | 9.53 | -4.84 (-12.35, 2.67) | 9.91 | 13.17 | 3.27 (-5.97, 12.50) | **18.60** | **5.11** | **-13.49 (-26.45, -0.54)**** | 0.20 |
| ITT age 21 | 13.24 | 15.97 | 2.72 (-2.17, 7.61) | 14.53 | 17.32 | 2.79 (-4.03, 9.61) | 12.42 | 13.19 | 0.76 (-6.82, 8.34) | 0.67 |
| TOT age 21 | 11.19 | 16.44 | 5.25 (-3.27, 13.76) | 12.16 | 17.81 | 5.64 (-4.15, 15.44) | 12.25 | 13.62 | 1.37 (-10.96, 13.70) | 0.67 |
| TOT longitudinal | 14.02 | 14.05 | 0.02 (-7.12, 7.17) | 12.34 | 16.60 | 4.27 (-6.11, 14.65) | 16.45 | 10.41 | -6.04 (-16.01, 3.93) | 0.20 |
| **Self-efficacy score** | | | | | | | | | | |
| ITT age 20 | 33.29 | 33.36 | 0.07 (-0.52, 0.66) | 33.36 | 32.97 | -0.39 (-1.16, 0.38) | 33.23 | 33.83 | 0.61 (-0.31, 1.52) | 0.10 |
| TOT age 20 | 33.24 | 33.38 | 0.14 (-1.01, 1.29) | 33.71 | 32.89 | -0.82 (-2.42, 0.79) | 32.86 | 33.93 | 1.07 (-0.31, 2.44) | 0.22 |
| ITT age 21 | 33.75 | 33.58 | -0.18 (-0.74, 0.39) | 33.79 | 33.20 | -0.59 (-1.33, 0.14) | 33.68 | 34.05 | 0.37 (-0.50, 1.24) | 0.10 |
| TOT age 21 | 33.89 | 33.55 | -0.34 (-1.37, 0.68) | 34.30 | 33.10 | -1.20 (-2.41, 0.01)* | 33.45 | 34.11 | 0.65 (-0.81, 2.12) | 0.15 |
| TOT longitudinal | 33.30 | 32.98 | -0.32 (-1.06, 0.41) | 33.66 | 32.74 | -0.92 (-1.97, 0.13)* | 33.04 | 33.22 | 0.18 (-0.82, 1.18) | 0.14 |
| **Hopelessness score** | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ITT age 20 | 10.22 | 10.42 | 0.20 (-0.32, 0.71) | 10.30 | 10.74 | 0.44 (-0.25, 1.13) | 10.21 | 10.14 | -0.06 (-0.80, 0.67) | 0.39 |
| TOT age 20 | 10.14 | 10.48 | 0.33 (-0.77, 1.44) | 9.96 | 10.79 | 0.83 (-0.89, 2.56) | 10.24 | 10.13 | -0.11 (-1.26, 1.03) | 0.52 |
| ITT age 21 | **10.27** | **10.78** | **0.51 (0.00, 1.02)**** | 10.38 | 10.99 | 0.61 (-0.06, 1.29)* | 10.13 | 10.53 | 0.39 (-0.38, 1.17) | 0.45 |
| TOT age 21 | 9.88 | 10.87 | 0.99 (-0.13, 2.11)* | **9.86** | **11.10** | **1.24 (0.06, 2.43)**** | 9.89 | 10.59 | 0.69 (-0.82, 2.21) | 0.65 |
| TOT longitudinal | 8.14 | 8.52 | 0.38 (-0.16, 0.92) | 8.09 | 8.52 | 0.43 (-0.39, 1.24) | 8.23 | 8.50 | 0.27 (-0.44, 0.98) | 0.42 |

**Table 4 legend**
Results in bold indicate p≤0.05.
*p<0.10
** p≤0.05
** p≤0.001
Intent-to-treat (ITT) analyses are based on mixed effects models with intervention and control group assignment based on the admissions lottery. Treatment on the Treated (TOT) models employ instrumental variables analysis using the admissions lottery assignment as the instrument and attendance in a high-performing school (defined as school-level test scores in the top tertile of public high schools in Los Angeles County) as the exposure. Longitudinal models use all outcomes measures across up to 5 waves of follow-up surveys, adjusted for clustering at the subject level. All models adjust for sex, Latino ethnicity, U.S. birth, native English language, 8$^{th}$ grade grade point average, risk set based on which high schools the student applied to, parental birthplace, 1 or more parent working full time, parenting style at home, family structure.

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