

Assessment of Exposure to High-Performing Schools and Risk of Adolescent Substance Use

A Natural Experiment

Rebecca N. Dudovitz, MD, MS; Paul J. Chung, MD, MS; Sarah Reber, PhD; David Kennedy, PhD; Joan S. Tucker, PhD; Steve Shoptaw, PhD; Kulwant K. Dosanjh, MA; Mitchell D. Wong, MD, PhD

IMPORTANCE Although school environments are thought to influence health behaviors, experimental data assessing causality are lacking, and which aspects of school environments may be most important for adolescent health are unknown.

OBJECTIVE To test whether exposure to high-performing schools is associated with risky adolescent health behaviors.

DESIGN, SETTING, AND PARTICIPANTS This natural experiment used admission lotteries, which mimic random assignment, to estimate the association of school environments and adolescent health. A survey of 1270 students who applied to at least 1 of 5 high-performing public charter schools in low-income minority communities in Los Angeles, California. Schools had an academic performance ranked in the top tertile of Los Angeles County public high schools, applicants outnumbered available seats by at least 50, and an admissions lottery was used. Participants included lottery winners (intervention group [$n = 694$]) and lottery losers (control group [$n = 576$]) from the end of 8th grade and beginning of 9th grade through the end of 11th grade. Intention-to-treat (ITT) and instrumental variable techniques estimated the association of winning the lottery and attending high-performing schools with health behaviors and whether the association varied by sex. Data were collected from March 11, 2013, through February 22, 2017, and analyzed from October 1, 2017, through July 1, 2018.

EXPOSURES Schools were considered high performing if they placed in the top tercile of public high schools in LA County on 2012 state standardized tests. Most students attended that same school for 3 years (9th-11th grades).

MAIN OUTCOMES AND MEASURES Primary self-reported outcomes were 30-day and high-risk self-reported marijuana use. Additional health outcomes included 30-day alcohol use, alcohol misuse, ever being in a fight, ever having sex, and past-year delinquency. Potential intermediate factors (time studying, truancy, school mobility, school culture, school order, teacher support for college, and proportion of substance-using peers in students' social networks) were also examined.

RESULTS Among the 1270 participating students (52.6% female; mean [SD] age at enrollment, 14.3 [0.5] years), ITT analysis showed that the intervention group reported less marijuana misuse than the control group (mean marijuana misuse score, 0.46 vs 0.71), as well as fewer substance-using peers (9.6% vs 12.7%), more time studying (mean, 2.63 vs 2.49 hours), less truancy (84.3% vs 77.3% with no truancy), greater teacher support for college (mean scores, 7.20 vs 7.02), more orderly schools (mean order score, 7.06 vs 6.83), and less school mobility (21.4% vs 28.4%) (all $P < .05$). Stratified analyses suggest that among boys, intervention participants had significantly lower marijuana use (mean misuse score, 0.43 vs 0.88; difference, -0.45 ; 95% CI, -0.78 to -0.13) and alcohol misuse (mean misuse score, 0.52 vs 0.97; difference, -0.44 ; 95% CI, -0.80 to -0.09) scores compared with control participants, whereas no significant health outcomes were noted for girls.

CONCLUSIONS AND RELEVANCE This natural experiment provides evidence that school environments can improve risky behaviors for low-income minority adolescents.

JAMA Pediatr. doi:10.1001/jamapediatrics.2018.3074
Published online October 29, 2018.

- [+ Editorial](#)
- [+ Author Audio Interview](#)
- [+ Supplemental content](#)

Author Affiliations: Author affiliations are listed at the end of this article.

Corresponding Author: Rebecca N. Dudovitz, MD, MS, Department of Pediatrics and Children's Discovery and Innovation Institute, David Geffen School of Medicine at UCLA, 10833 Le Conte Ave, Room 12-358 CHS, Mail Code 175217, Los Angeles, CA 90095 (rdudovitz@mednet.ucla.edu).

Education is a key social determinant of health.¹⁻³ Most studies measure education by academic achievement or attainment.⁴ However, growing recognition that school environments likely influence health through pathways that do not necessarily depend on academic gains is increasing.⁵ In addition to developing students' knowledge and skills, schools function as social institutions, connecting adolescents with peers and adults, transmitting social norms, and encouraging or discouraging specific behaviors. Understanding whether and how the school environment might be intentionally engineered as a platform for health promotion is critical to designing effective health and education policies.⁵

Previous observational studies⁶⁻⁸ have found associations between measures of a supportive school environment and health behaviors such as substance use. A few quasi-experimental studies⁹⁻¹⁴ suggest that exposure to better educational environments improves health behaviors. However, none of these studies examine the transition to high-performing schools or provide detailed data about school environments, social networks, or other factors that might explain how schools affect adolescent health. Hence, whether changes in the high school environment reduce adolescent substance use and, if so, which aspects of the school environment matter most, remains unknown.

To test whether and how school environments influence substance use, we exploit a natural experiment to study whether attending high-performing charter high schools was associated with improved health behaviors for low-income minority adolescents. Although charter and traditional public schools vary in terms of composition and outcomes, charter schools tend to have lower enrollment, serve fewer special education students, and have a higher proportion of low-income and minority students compared with traditional public schools.¹⁵ In the Reducing Inequities Through Social and Educational Change Follow-up (RISE Up) Study, we capitalized on the lottery admission system for several high-performing charter schools in low-income neighborhoods of Los Angeles, California, and prospectively followed up a cohort of adolescents from high school admission through 11th grade. In addition to examining our primary substance use outcomes, we examined other risky health behaviors, such as sexual activity, violence, and delinquency. We also tested several hypothesized pathways linking school environments and health,¹⁶ including school climate measures and peer network characteristics, to understand the mechanism of how better school environments might lead to better health.

Methods

School Recruitment

This longitudinal natural experiment studied the association of high-performing schools with the health of low-income, minority adolescents. The RISE UP Study charter schools were selected based on the following criteria: (1) location in Los Angeles County; (2) most students enrolled are economically disadvantaged (qualify for free or reduced price lunch); (3) aca-

Key Points

Question Is exposure to high-performing school environments associated with a reduction in risky health behaviors for low-income minority high school students?

Findings In this natural experiment of 1270 students who applied via admissions lotteries to high-performing public charter schools in low-income minority communities in Los Angeles, California, lottery winners had lower marijuana misuse scores, fewer marijuana-using peers, less truancy, greater teacher support for college, more orderly school environments, and less school mobility and spent more time studying than lottery losers.

Meaning School environments may influence risky health behaviors and constitute an important prevention tool and target for addressing the social determinants of health.

demic performance in the top tertile of public high schools in Los Angeles County based on 2012 state standardized test scores (Academic Performance Index); (4) oversubscription of applicants (>50 more applicants than seats available); and (5) use of an admissions lottery. We identified 91 public charter high schools in Los Angeles County, of which 32 satisfied the first 3 criteria. All 5 schools that met the remaining 2 criteria agreed to participate in the study. All procedures were reviewed and approved by the institutional review board of the RAND Corporation. Written parental consent and student assent were obtained from all participants.

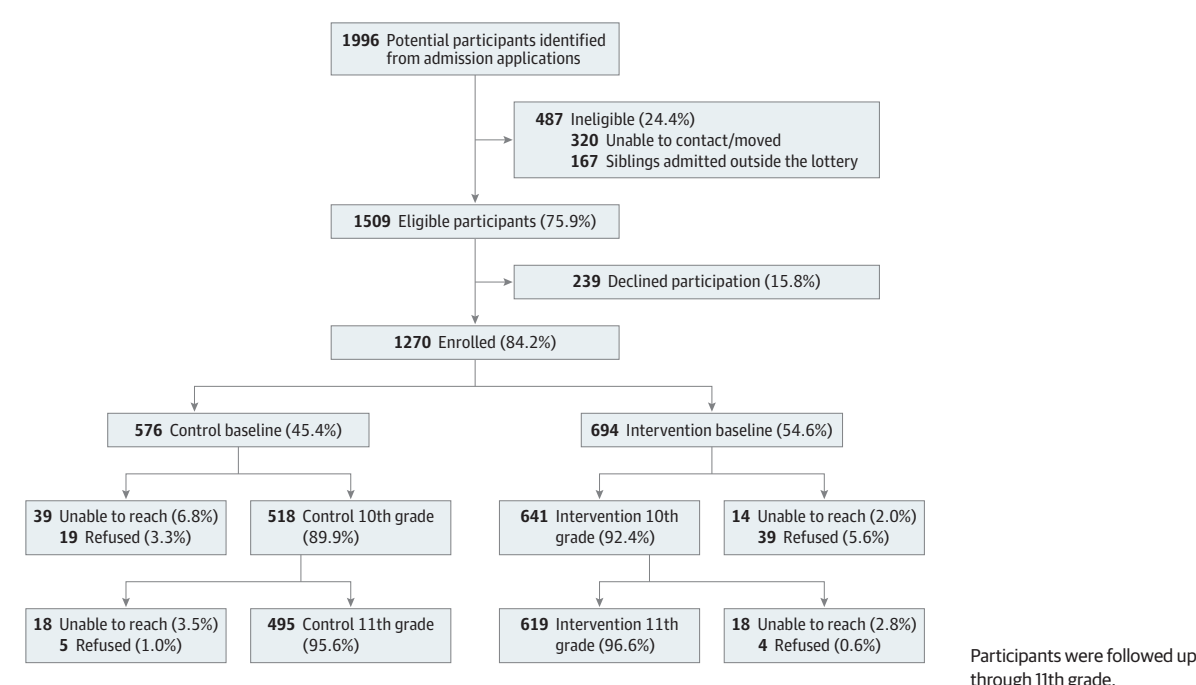
Participant Recruitment

From each school, we randomly sampled, stratified by lottery result, from the list of lottery winners and losers during 2 consecutive years to identify potential study participants. Students were eligible for the study if they applied for 9th grade admission to one of the study schools for the fall of 2013 or 2014, spoke English or Spanish fluently, and resided within Los Angeles County. Siblings of current students were excluded because they were admitted outside the lottery. Of the 1996 potential participants identified (Figure 1), 487 were ineligible, 239 refused participation, and 1270 of 1509 eligible participants consented to participate (participation rate, 84.2%). Of these, 576 were lottery losers (control group) and 694 were lottery winners (intervention group). We did not have control over the random assignment via admissions lottery, but we reviewed each school's lottery procedures to confirm that only basic contact information and no demographic or academic achievement information were contained in the lottery application.

Data Collection

Data were collected from March 11, 2011, through February 22, 2017. Bilingual research assistants completed a face-to-face, baseline computer-assisted survey with students at the end of 8th grade or fall of 9th grade and follow-up interviews during 10th and 11th grades. Interviews were conducted at a location of the participant's choice that afforded sufficient privacy, typically their home or their school. Sections asking about risky health behaviors were collected

Figure 1. Participant Recruitment



using a computer-assisted self-interview to encourage honest responses.¹⁷ No significant difference in survey completion or retention by study arm were noted, and 1114 participants (87.7%) were followed up through 11th grade. Data on participants' schools were collected from the California Department of Education.

Measures

Risky Health Behaviors

Because early marijuana use is associated with more risky substance use and other negative health behaviors over time,¹⁸⁻²⁰ our primary outcomes of interest were 30-day and high-risk marijuana use. At each wave, students self-reported whether they had used marijuana in the previous 30 days and completed a marijuana misuse scale ($\alpha = .85$), an index we adapted from the alcohol misuse scale²¹ of 8 high-risk behaviors that are associated with developing a substance use disorder (eg, getting in trouble because of marijuana use, missing school because of marijuana use, using marijuana at school). The index assessed behaviors in the prior 12 months and ranged from 0 to 8, with higher scores representing more risky substance use.

Additional health outcomes included 30-day alcohol use, the alcohol misuse scale ($\alpha = .88$; range, 0-9, with higher scores indicating more risky alcohol misuse), ever being in a fight, and ever having sex.²² Students also completed a delinquency scale in which they reported the frequency of engaging in 8 delinquent behaviors that have been associated with negative life outcomes in the previous 12 months.²³ The resulting delinquency index ($\alpha = .60$) ranged from 0 to 8, with higher scores representing a greater number of delinquent behaviors.

Secondary Outcomes

We measured factors hypothesized to diminish opportunities and motivate students to engage in risky health behaviors,¹⁶ including social ties to peers with more risky behavior.^{24,25} We used a standard procedure for collecting personal social network data.^{26,27} At each wave, students named 20 people in their social network, identified which of those individuals were peers, and reported whether those peers engaged in alcohol and marijuana use. Based on these responses, we derived separate measures of the proportion of peers in the network using marijuana and alcohol. In addition, increased academic engagement and accountability can reduce unsupervised time outside of school, limiting opportunities for risky behaviors and increasing motivation to engage in prosocial behaviors.^{28,29} Hence, students reported the amount of time per day spent studying and whether they cut school in the last 12 months and completed a 14-item school engagement scale ($\alpha = .80$; range, 1-4, with higher scores indicating greater school engagement).³⁰ To assess school culture, which may influence behavioral norms and social incentives, students completed a 9-item measure of school order ($\alpha = .68$; range, 1-4, with higher scores indicating a more orderly environment) adapted from a measure of home chaos³¹ and a 4-item measure of school safety ($\alpha = .81$; range, 0-3, with higher scores indicating greater perceived school safety)³² and rated the level of teacher support for college attendance (range, 1-4, with higher scores indicating greater perceived teacher support).³³ We also included a measure of school social culture; participants indicated whether 12 traits or behaviors (eg, being a good student, disrupting class, bringing drugs to school) would increase or decrease popularity ($\alpha = .84$;

range, 1-5, with higher scores indicating a more positive school culture) in their school. Finally, participants reported whether they changed schools by the final survey wave. School mobility is thought to increase motivation to engage in risky behaviors as adolescents seek to establish new friends and their place in the social order.³⁴

Covariates

Owing to the lottery design, assignment to the intervention or control group is random. However, students who applied to multiple charter schools had a greater chance of winning at least 1 lottery. We followed the charter lottery literature and controlled for the set of schools to which students and their parents reported applying (the risk set).³⁵ Because students are randomly assigned to the intervention group, we do not need to control for additional covariates to get unbiased estimates; however, including covariates improves power and may reduce bias in small samples that are unbalanced owing to random chance. We therefore control for a number of covariates collected at baseline: sex, race/ethnicity (Latino vs not), native language, being born in the United States, grade point average in 8th grade, parental educational attainment, parental birthplace, parental employment, family structure, and parenting style (as measured by the Index of Parenting Style).³⁶ Because substance use might vary by time of the school year, we also controlled for the month that the survey was conducted.

Statistical Analysis

Data were analyzed from October 1, 2017, through July 1, 2018. We used 2-tailed unpaired *t* tests and χ^2 tests to compare intervention and control participants on baseline covariates as well as parental substance use, with *P* < .05 indicating significance. Using the *xtmixed* command in Stata software (version 14.0; StataCorp), we performed hierarchical longitudinal analyses to estimate the association of winning the lottery with each outcome. We included random effects for student and school to account for multiple observations over time for each individual and nesting of students within schools. We included the covariates described above, fully interacted with grade. We excluded observations from grade 8 because these occurred before the intervention began. We refer to these as the intention-to-treat (ITT) estimates. Some students who won the lottery did not enroll in a top-tertile public school and vice versa. The ITT estimates will therefore underestimate the influence of actually attending a high-performing school. We used instrumental variables analyses to estimate the association of enrolling in a top-tertile public school with 2-stage least squares (2SLS) analysis.^{1,13} Under the assumption that winning the lottery affects outcomes only through enrollment in a high-performing school, the instrumental variable estimate is the local average treatment effect for the students whose decision to enroll in a charter school is determined by the lottery results. Finally, because the factors associated with marijuana use^{37,38} (our primary outcome) and the association between school environments and health likely differ for boys and girls,³⁹ we conducted sex-stratified analyses. Miss-

ing data for all variables (including outcomes) and loss to follow-up or refusal to participate were multiply imputed. Less than 1% of data were missing for each variable, except parental educational level, which had 4.8% missing data. Imputed results were similar to results using unimputed data.

Results

The 1270 study participants (668 [52.6%] girls and 602 [47.4%] boys; mean [SD] age at enrollment, 14.3 [0.5] years) attended 147 different high schools at 9th grade. Of these, 79 (53.7%) were traditional public schools; 41 (27.9%), public charter schools; 17 (11.6%), parochial schools; 4 (2.7%), private schools; and 6 (4.1%), other school types (continuation, alternative, home school, or out of area). Compared with the other 142 schools in the sample, the 5 charter schools that made up the study's sampling frame were smaller (mean enrollment, 463 [interquartile range {IQR}, 471-474] vs 793 [IQR, 345-1517] students), had higher Academic Performance Index scores (mean score, 787 [IQR, 775-809] vs 730 [IQR, 658-807]), and served a higher proportion of minority students (mean Latino enrollment, 90% [IQR, 83%-97%] vs 69% [IQR, 49%-94%]) and those with low parental educational attainment (mean, 44% [IQR, 43%-46%] vs 34% [IQR, 15%-51%]) (all *t* tests, *P* < .001) (eTable 1 in the [Supplement](#)). As expected, the intervention group was much more likely to matriculate into a top-tertile school than the control group (688 [87.9%] vs 144 [29.6%] in 9th grade; *P* < .001), but crossover occurred in both arms, because other schools in the region were also high-performing.

The sample is representative of low-income minority communities in Los Angeles, with 1137 (89.5%) identifying as Latino and only 666 (52.4%) with at least 1 parent who graduated from high school. The characteristics of the intervention and control groups were not significantly different, with the exception of baseline grade point average (**Table 1**), which was controlled for in all analyses. Compared with control students, a greater percentage of intervention students had a baseline grade point average ranging from 3.5 to 4.0 (23.5% vs 20.8%) or had no 8th grade transcripts (21.5% vs 13.4%).

The ITT analyses (**Table 2**) demonstrated that the intervention group had less marijuana misuse than the control group (mean marijuana misuse score, 0.46 vs 0.71), as well as fewer substance-using peers (9.6% vs 12.7%), more time studying (mean, 2.63 vs 2.49 hours), less truancy (84.3% vs 77.3% with no truancy), greater teacher support for college (mean support scores, 7.20 vs 7.02), more orderly schools (mean order score, 7.06 vs 6.83), and less school mobility (21.4% vs 28.4%). Results were similar before and after adjusting for covariates (**Table 2**). The ITT analyses stratified by sex (eTable 2 in the [Supplement](#)) showed that, among boys, intervention participants had significantly lower marijuana use (mean misuse score, 0.43 vs 0.88; difference, -0.45; 95% CI, -0.78 to -0.13) and alcohol misuse (mean misuse score, 0.52 vs 0.97; difference, -0.44; 95% CI, -0.80 to -0.09) scores compared

Table 1. Baseline Characteristics of Intervention and Control Groups

Characteristic	Study Group, No. (%) of Participants ^a		P Value
	Intervention (n = 694)	Control (n = 576)	
Male	325 (46.8)	277 (48.1)	.65
Race/ethnicity			
Latino	636 (91.6)	501 (87.0)	.06
Black	29 (4.2)	38 (6.6)	
White	12 (1.7)	14 (2.4)	
Other	17 (2.4)	23 (4.0)	
US born	608 (87.6)	505 (87.7)	.97
Native English speaker	286 (41.2)	233 (40.5)	.78
Grade point average (8th grade)			
No transcripts	149 (21.5)	77 (13.4)	.001
A (3.5-4.0)	163 (23.5)	120 (20.8)	
B (2.5-3.4)	246 (35.4)	236 (41.0)	
C (1.5-2.4)	114 (16.4)	120 (20.8)	
D or lower (<1.5)	22 (3.2)	23 (4.0)	
Parental			
≥1 Parent born in United States	182 (26.2)	154 (26.7)	.84
≥1 Parent graduated from high school	375 (54.0)	291 (50.5)	.21
≥1 Parent had full-time employment	612 (88.2)	493 (85.6)	.17
Family structure			
2-Parent family	579 (83.4)	457 (79.3)	.14
1-Parent family	100 (14.4)	107 (18.6)	
Nontraditional guardian ^b	15 (2.2)	12 (2.1)	
Parenting style ^c			
Neglectful	231 (33.3)	190 (33.0)	.23
Indulgent	116 (16.7)	120 (20.8)	
Authoritarian	155 (22.3)	126 (21.9)	
Authoritative	192 (27.7)	140 (24.3)	
Student reports seeing parent drunk	185 (26.7)	146 (25.3)	.62
Student reports parent used marijuana	13 (1.9)	17 (3.0)	.20

^a Percentages have been rounded and may not total 100.

^b Includes a relative (eg, grandparent, aunt, uncle, sibling) or foster parent.

^c As measured by the Index of Parenting Style.³⁶

with control participants, whereas no significant health effects were noted for girls.

Instrumental variables (2SLS) analyses (Figure 2, Figure 3, and eTable 3 in the Supplement) estimate the association of attending a high-performing school with our outcomes, separately by grade and sex. The estimates for boys more consistently suggest benefits of attending a high-performing school than they do for girls, although the differences in treatment effects by sex are not statistically significant. Among boys, treatment association with 30-day marijuana use (in 9th grade, $\beta = -8.2$ [95% CI, -15.9 to -0.5]) and misuse of marijuana (in 9th grade, $\beta = -0.6$ [95% CI, -1.1 to -0.1]; in 10th grade, $\beta = -0.2$ [95% CI, -2.0 to -0.6]) and alcohol ($\beta = -1.1$ [95% CI, -2.1 to -0.1] in 10th grade) were negative (indicating improvement) and significant; no significant treatment association with health for girls was noted. For both sexes, attending a high-performing school reduced exposure to marijuana-using peers ($\beta = -10.7$ [95% CI, -17.6 to -3.8] in 10th grade and $\beta = -8.0$ [95% CI, -15.6 to -0.3] in 11th grade for boys; $\beta = -6.2$ [95% CI, -12.1 to -0.3] in 9th grade for girls), increased the percentage with no truancy ($\beta = 15.6$ [95% CI, 4.6-26.5] in 9th grade, $\beta = 12.1$ [95% CI, 0.9-23.3] in 10th grade, and $\beta = 16.2$ [95% CI, 5.8-26.6] in 11th grade for boys; $\beta = 26.8$ [95% CI,

11.8-41.8] in 10th grade for girls), and increased report of teacher support for college ($\beta = 0.4$ [95% CI, 0.2-0.6] in 10th grade and $\beta = 0.5$ [95% CI, 0.2-0.8] in 11th grade for boys; $\beta = 0.5$ [95% CI, 0.2-0.9] in 10th grade and $\beta = 0.4$ [95% CI, 0.002-0.8] in 11th grade for girls) and orderly school environment ($\beta = 0.7$ [95% CI, 0.3-1.0] in 10th grade and $\beta = 0.4$ [95% CI, 0.1-0.7] in 11th grade for boys; $\beta = 0.5$ [95% CI, 0.1-0.8] in 10th grade and $\beta = 0.4$ [95% CI, 0.03-0.7] in 11th grade for girls). A sensitivity analysis examining the proportion of substance-using peers in participants' school-related vs non-school-related social networks revealed similar findings.

Discussion

In this quasi-experimental study, we found that students attending high-performing schools through the charter school admissions lottery had lower rates of risky health behaviors, particularly with respect to substance use. The estimated effects were more consistently beneficial for boys, although not statistically distinguishable from the effects for girls. The fact that these findings are from a natural experiment, rather than observational data, provides compelling evidence that school

Table 2. Intention-to-Treat Analyses Testing the Association of Being Offered Admission to a High-Performing School With Health Behaviors and School-Related Outcomes^a

Outcome	Intervention Group	Control Group	Difference (95% CI) ^b
Health Behaviors			
Marijuana use, %	8.4	10.9	-2.4 (-5.1 to 0.3)
Marijuana misuse score ^c	0.46	0.71	-0.25 (-0.46 to -0.05) ^d
Alcohol use, %	11.8	12.6	-0.8 (-3.8 to 2.1)
Alcohol misuse score ^e	0.72	0.91	-0.19 (-0.44 to 0.06)
Fighting, %	12.9	13.2	-0.3 (-3.4 to 2.8)
Delinquency score ^f	0.54	0.64	-0.10 (-0.26 to 0.06)
Sexually active, %	11.4	12.0	-0.6 (-3.7 to 2.4)
School-Related Outcomes			
Use of marijuana by peers, %	9.6	12.7	-3.2 (-5.0 to -1.3) ^d
Use of alcohol by peers, %	5.9	6.3	-0.4 (-1.8 to 1.0)
Time studying, h	2.63	2.49	0.14 (0.01 to 0.27) ^d
No truancy, %	84.3	77.3	7.0 (3.4 to 10.6) ^d
School engagement score ^g	9.02	9.05	-0.04 (-0.13 to 0.05)
Teacher support for college score ^h	7.20	7.02	0.18 (0.10 to 0.27)
School safety score ⁱ	4.55	4.52	0.03 (-0.06 to 0.12)
School order score ^j	7.06	6.83	0.23 (0.13 to 0.33) ^d
School social culture score ^k	3.97	3.92	0.05 (-0.05 to 0.15)
Changed schools, %	21.4	28.4	-7.0 (-0.1 to -0.02) ^d

^a Reports the estimated outcome in the control and intervention groups at the mean of the controls; the third column in each set reports the coefficient for winning the lottery (intervention) with 95% CIs. Models were estimated using mixed-effects multilevel regression models controlling for the following covariates: number of schools to which students applied, sex, race/ethnicity (Latino vs not), native language, born in the United States, grade point average in 8th grade, parental educational attainment, parental birthplace, parental employment, family structure, parenting style, and interview month.

^b Calculated as intervention group minus control group.

^c Scores range from 0 to 8, with higher scores indicating more risky substance use.

^d Differences were significant at $P < .05$.

^e Scores range from 0 to 9, with higher scores indicating more risky alcohol misuse.

^f Scores range from 0 to 8, with higher scores indicating a greater number of delinquent behaviors.

^g Scores range from 1 to 4, with higher scores indicating greater school engagement.

^h Scores range from 1 to 4, with higher scores indicating greater perceived teacher support.

ⁱ Scores range from 0 to 3, with higher scores indicating greater perceived school safety.

^j Scores range from 1 to 4, with higher scores indicating a more orderly environment.

^k Scores range from 1 to 5, with higher scores indicating a more positive school culture.

environments can influence health for low-income minority students and suggests that investing in healthy schools might yield valuable population health returns.

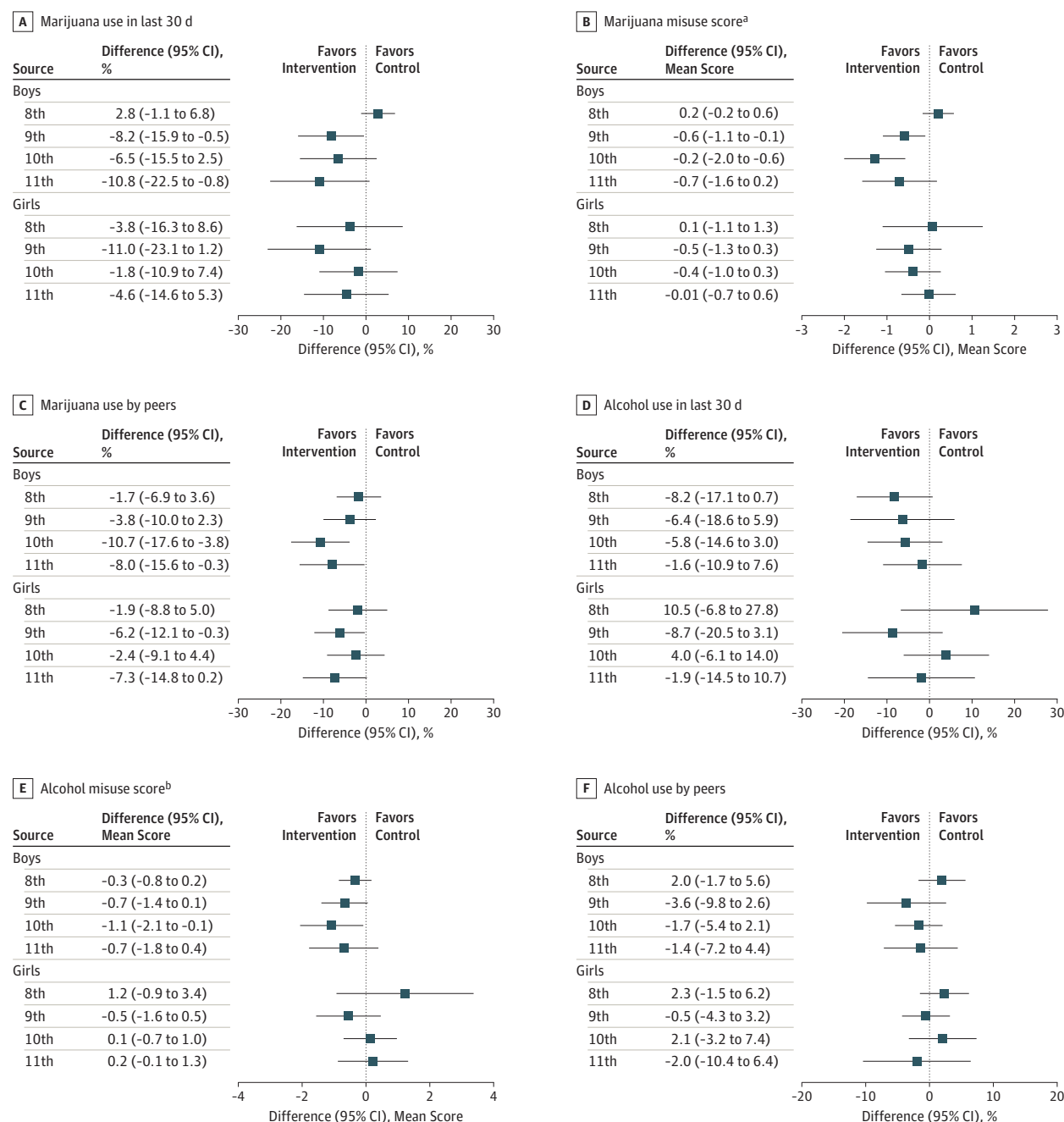
The potential differences in associations for boys vs girls are consistent with studies suggesting sex differences in the factors associated with risky health behaviors and the potential for school environments to intervene on these factors.⁴⁰ For example, prior evidence⁴¹ suggests that boys' social networks are more strongly determined by their school environment. Further, typical school environments may be more negative for boys. This finding is consistent with those from a randomized trial of early high-quality education,⁹ which suggested that low-quality educational environments are more harmful for boys than girls.⁴²

We also noted more consistent effects on marijuana use compared with alcohol use. This finding may be because marijuana use represents a more deviant behavior than alcohol use. For example, in 2015, 55% of Hispanic high school students in Los Angeles reported ever using alcohol, whereas 36% reported marijuana use.²² Whether this pattern changes as marijuana policies change remains to be seen.

Prior research has posited that the link between education and health outcomes might be driven through acquiring greater knowledge, accessing better resources, or improving noncognitive skills.⁴ We found evidence of immediate reductions in risky health behaviors, as early as 9th grade, which is likely inconsistent with mechanisms that depend wholly on improved skills or knowledge. The positive associations noted with intervention students' social networks and school culture provide an alternative and suggestive pathway. These factors are likely to change on entering a new school environment and alter the opportunities and motivations for adolescents to engage in risky behaviors.

If, indeed, the association of school environments with risky health behaviors operates largely through the social interactions that schools facilitate, then greater attention to constructing healthy social environments is warranted. The high-performing schools in this study may have achieved their association with health behaviors purely by isolating students from more deviant peers in other schools. If so, widespread application of this strategy is problematic, to say the least, and would likely magnify health disparities. Alterna-

Figure 2. Association of Attending a High-Performing High School With Substance Use by Grade and Sex



Graphs plot the estimated association of treatment by attending a high-performing high school (95% CI) for boys and girls. We used instrumental variables analyses, and attendance was instrumented with an indicator for winning the charter school lottery. Models control for number of schools to which students applied, sex, race/ethnicity (Latino vs not), native language, born in the United States, grade point average in 8th grade, parental educational attainment, parental birthplace, parental employment, family

structure, parenting style, and interview month.

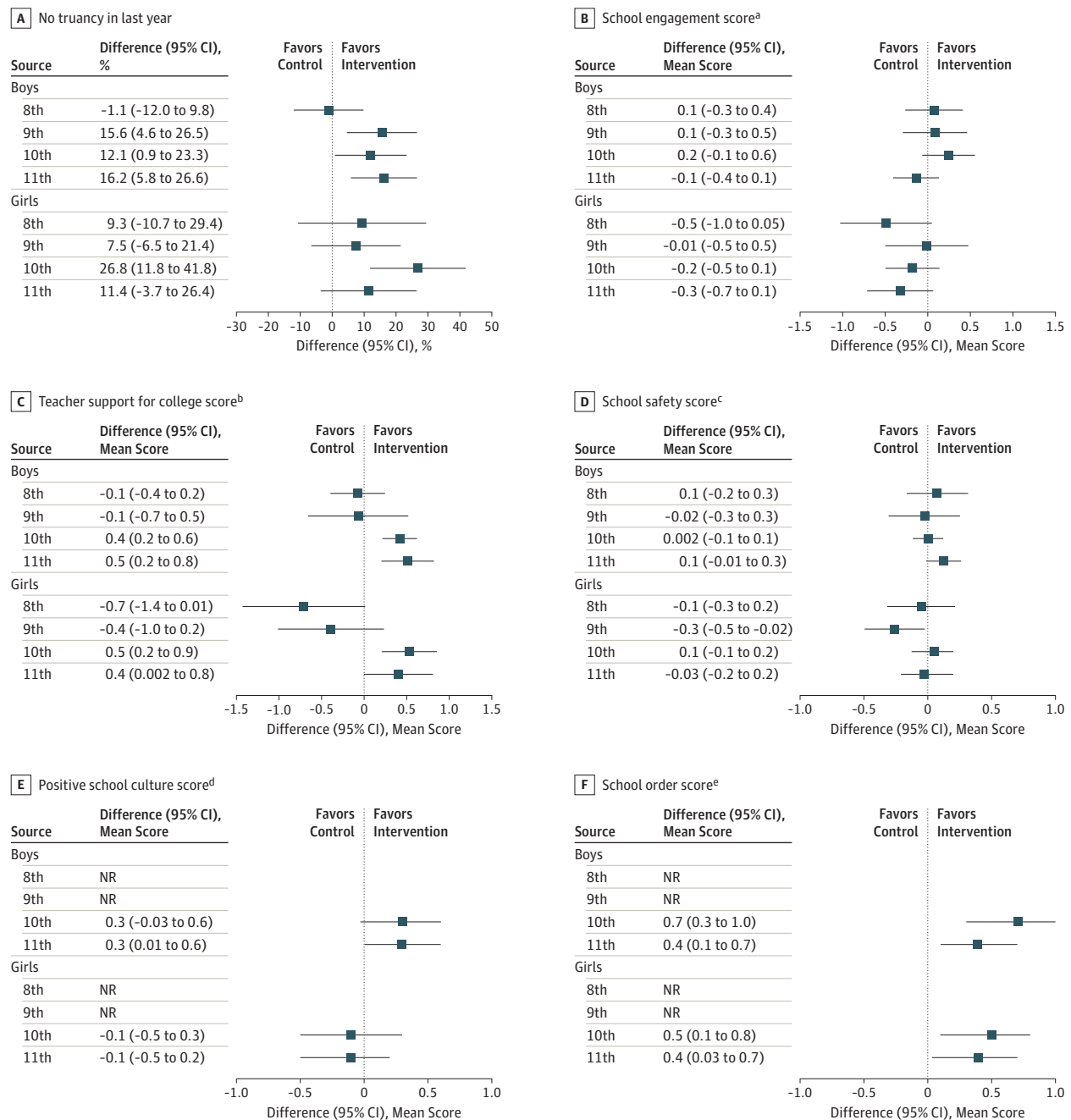
^a Scores range from 0 to 8, with higher scores indicating more risky substance use.

^b Scores range from 0 to 9, with higher scores indicating more risky alcohol misuse.

tively, the associations noted herein may be driven by practices that enhance a positive school culture and supportive adult and student interactions to reinforce those healthy norms. Although the current study cannot distinguish be-

tween these 2 potential pathways, the positive findings associated with increased perceived teacher support for college, school order, and a more prosocial school culture (for boys) suggest important mechanisms for future study.

Figure 3. Association of Attending a High-Performing High School With School Outcomes by Grade and Sex



Graphs plot the estimated association of treatment by attending a high-performing high school (95% CI) for boys and girls. We used instrumental variables analyses, and attendance was instrumented with an indicator for winning the charter school lottery. Models control for number of schools to which students applied, sex, race/ethnicity (Latino vs not), native language, born in the United States, grade point average in 8th grade, parental educational attainment, parental birthplace, parental employment, family structure, parenting style, and interview month. Data were not collected for positive school culture score and school order score in 8th and 9th grades. NR indicates not reported.

^a Scores range from 1 to 4, with higher scores indicating greater school engagement.

^b Scores range from 1 to 4, with higher scores indicating greater perceived teacher support.

^c Scores range from 0 to 3, with higher scores indicating greater perceived school safety.

^d Scores range from 1 to 5, with higher scores indicating more positive school culture.

^e Scores range from 1 to 4, with higher scores indicating a more orderly environment.

Limitations

This study presents a rare opportunity to quantify the association of high-performing schools with health using quasi-experimental data. We observed crossover from both study arms, so the simple intervention-control differences (ITT) will underestimate the influence of school environments on health; the instrumental variables 2SLS analysis estimates adjust for crossovers. The charter schools in this study may not be representative of charter schools as a whole and, although we attempted to characterize how school environments differed for intervention vs control students, additional important differences may not have been measured herein. Also, all data are self-reported, and although participants were assured of the confidentiality of their responses, social desirability might have influenced participants' answers, and this influence might vary by group assignment. Although intervention and control students might have had different exposure to the neighborhood around their schools, which may influence their behaviors, we believe this effect is likely small, because the study charter schools are located in the same general area as most of the comparison schools. The multiple outcomes increase the chances of wrongly rejecting some null hypotheses. However, the outcomes are highly correlated and the consistent pattern in our findings makes this unlikely. Importantly, this sample is predominantly Latino, comes from a single (albeit large) urban area, and is limited to students who applied to an oversubscribed high-performing charter school, so results might not be generalizable to other groups. Also, we present

relatively short-term associations herein, and a longer follow up time might yield different results.

Conclusions

Despite these limitations, this study provides compelling evidence that school environments can influence health and that these influences can be immediate and particularly beneficial to low-income, minority boys. Social experiments such as this are critical for informing effective policies and practices, especially when associations and implications cross multiple sectors. Our findings suggest that investing in high-quality school environments can yield important health returns in addition to academic returns and hence may be of even greater societal value than previously believed. Further, the intermediate outcomes herein suggest specific aspects of a school environment that might be leveraged to support health not just in charter schools. Investing in high-quality public schools may be an important strategy for achieving health equity for all students, and particularly the most disadvantaged. Future studies targeting school-based social networks and school culture, for example, can begin to identify the pathways through which to build healthier schools. Opportunities to rigorously study such interventions and to determine the long-term influences on health and well-being are critically important if we are to move from merely documenting to harnessing the social determinants of health.

ARTICLE INFORMATION

Accepted for Publication: July 6, 2018.

Published Online: October 29, 2018.
doi:10.1001/jamapediatrics.2018.3074

Author Affiliations: Department of Pediatrics and Children's Discovery and Innovation Institute, David Geffen School of Medicine at UCLA (University of California, Los Angeles), Los Angeles (Dudovitz, Chung); General Pediatrics Division, UCLA Mattel Children's Hospital, Los Angeles (Dudovitz); Department of Health Policy and Management, UCLA Fielding School of Public Health, Los Angeles (Chung); RAND Health, RAND Corporation, Santa Monica, California (Chung, Kennedy, Tucker); Department of Public Policy, UCLA Luskin School of Public Affairs, Los Angeles (Reber); National Bureau of Economic Research, Cambridge, Massachusetts (Reber); Department of Family Medicine, David Geffen School of Medicine, UCLA, Los Angeles (Shoptaw); Department of Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine, UCLA, Los Angeles (Shoptaw); Department of Psychiatry, University of Cape Town, Cape Town, South Africa (Shoptaw); General Internal Medicine and Health Services Research, UCLA, Los Angeles (Dosanjh, Wong).

Author Contributions: Dr Dudovitz had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Dudovitz, Chung, Wong.
Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Dudovitz, Shoptaw, Wong.
Critical revision of the manuscript for important intellectual content: Chung, Reber, Kennedy, Tucker, Shoptaw, Dosanjh, Wong.
Statistical analysis: Reber, Wong.
Obtained funding: Chung, Wong.
Administrative, technical, or material support: Dudovitz, Kennedy, Dosanjh, Wong.
Supervision: Wong.

Conflict of Interest Disclosures: None reported.

Funding/Support: This study was supported by grants RO1 DA033362 and 1K23DA040733-01A1 from the National Institute on Drug Abuse, National Institutes of Health (NIH); grant UL1TR001881 from the NIH National Center for Advancing Translational Science, Clinical and Translational Science Institute (CTSI), UCLA; and the Lincy Foundation through the UCLA CTSI Healthy Neighborhood Schools Initiative.

Role of the Funder/Sponsor: The sponsor had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

REFERENCES

- Adler NE, Glymour MM, Fielding J. Addressing social determinants of health and health inequalities. *JAMA*. 2016;316(16):1641-1642. doi:10.1001/jama.2016.14058
- Braveman P, Egerter S, Williams DR. The social determinants of health: coming of age. *Annu Rev*

Public Health. 2011;32:381-398. doi:10.1146/annurev-publhealth-031210-101218

- Viner RM, Ozer EM, Denny S, et al. Adolescence and the social determinants of health. *Lancet*. 2012;379(9826):1641-1652. doi:10.1016/S0140-6736(12)60149-4
- Cutler DM, Lleras-Muney A. Understanding differences in health behaviors by education. *J Health Econ*. 2010;29(1):1-28. doi:10.1016/j.jhealeco.2009.10.003
- Lewallen TC, Hunt H, Potts-Datema W, Zaza S, Giles W. The Whole School, Whole Community, Whole Child model: a new approach for improving educational attainment and healthy development for students. *J Sch Health*. 2015;85(11):729-739. doi:10.1111/josh.12310
- Bonell C, Parry W, Wells H, et al. The effects of the school environment on student health: a systematic review of multi-level studies. *Health Place*. 2013;21:180-191. doi:10.1016/j.healthplace.2012.12.001
- Dudovitz RN, Nelson BB, Coker TR, et al. Long-term health implications of school quality. *Soc Sci Med*. 2016;158:1-7. doi:10.1016/j.socscimed.2016.04.009
- Shackleton N, Jamal F, Viner R, et al. Systematic review of reviews of observational studies of school-level effects on sexual health, violence and substance use. *Health Place*. 2016;39:168-176. doi:10.1016/j.healthplace.2016.04.002
- Campbell F, Conti G, Heckman JJ, et al. Early childhood investments substantially boost adult

- health. *Science*. 2014;343(6178):1478-1485. doi:10.1126/science.1248429
10. Muennig P, Schweinhart L, Montie J, Neidell M. Effects of a prekindergarten educational intervention on adult health: 37-year follow-up results of a randomized controlled trial. *Am J Public Health*. 2009;99(8):1431-1437. doi:10.2105/AJPH.2008.148353
 11. Wong MD, Collier KM, Dudovitz RN, et al. Successful schools and risky behaviors among low-income adolescents. *Pediatrics*. 2014;134(2):e389-e396. doi:10.1542/peds.2013-3573
 12. Fryer RG Jr, Katz LF. Achieving escape velocity: neighborhood and school interventions to reduce persistent inequality. *Am Econ Rev*. 2013;103(3):232-237. doi:10.1257/aer.103.3.232
 13. Dobbie W, Fryer RG Jr. The medium-term impacts of high-achieving charter schools. *J Polit Econ*. 2015;123:985-1037. doi:10.1086/682718
 14. Bond L, Patton G, Glover S, et al. The Gatehouse Project: can a multilevel school intervention affect emotional wellbeing and health risk behaviours? *J Epidemiol Community Health*. 2004;58(12):997-1003. doi:10.1136/jech.2003.009449
 15. Epple D, Romano R, Zimmer R. Charter Schools: A Survey of Research on Their Characteristics and Effectiveness. In: Hanushek EA, Machin S, Woessmann L, eds. *Handbook of the Economics of Education*. Amsterdam, the Netherlands: Elsevier; 2016:139-208. doi:10.1016/B978-0-444-63459-7.00003-8
 16. Bonell C, Fletcher A, Jamal F, Aveyard P, Markham W. Where next with theory and research on how the school environment influences young people's substance use? *Health Place*. 2016;40:91-97. doi:10.1016/j.healthplace.2016.05.006
 17. Booth-Kewley S, Larson GE, Miyoshi DK. Social desirability effects on computerized and paper-and-pencil questionnaires. *Comput Human Behav*. 2007;23(1):463-477. doi:10.1016/j.chb.2004.10.020
 18. Wall M, Cheslack-Postava K, Hu M-C, Feng T, Griesler P, Kandel DB. Nonmedical prescription opioids and pathways of drug involvement in the US: generational differences. *Drug Alcohol Depend*. 2018;182:103-111. doi:10.1016/j.drugalcdep.2017.10.013
 19. Volkow ND, Baler RD, Compton WM, Weiss SRB. Adverse health effects of marijuana use. *N Engl J Med*. 2014;370(23):2219-2227. doi:10.1056/NEJMr1402309
 20. Wagner FA, Anthony JC. Into the world of illegal drug use: exposure opportunity and other mechanisms linking the use of alcohol, tobacco, marijuana, and cocaine. *Am J Epidemiol*. 2002;155(10):918-925. doi:10.1093/aje/155.10.918
 21. Edelen MO, McCaffrey DF, Ellickson PL, Tucker JS, Klein DJ. Creating a developmentally sensitive measure of adolescent alcohol misuse: an application of item response theory. *Subst Use Misuse*. 2009;44(6):835-847. doi:10.1080/10826080802484686
 22. Kann L, McManus T, Harris WA, et al. Youth risk behavior surveillance: United States, 2015. *MMWR Surveill Summ*. 2016;65(6):1-174. doi:10.15585/mmwr.ss6506a1
 23. Murphy DA, Brecht M-L, Huang D, Herbeck DM. Trajectories of delinquency from age 14 to 23 in the National Longitudinal Survey of Youth Sample. *Int J Adolesc Youth*. 2012;17(1):47-62. doi:10.1080/02673843.2011.649401
 24. Tucker JS, de la Haye K, Kennedy DP, Green HD, Pollard MS. Peer influence on marijuana use in different types of friendships. *J Adolesc Health*. 2014;54(1). doi:10.1016/j.jadohealth.2013.07.025
 25. Valente TW, Fujimoto K, Soto D, Ritt-Olson A, Unger JB. A comparison of peer influence measures as predictors of smoking among predominately Hispanic/Latino high school adolescents. *J Adolesc Health*. 2013;52(3):358-364.
 26. McCallister L, Fischer CS. A procedure for surveying personal networks. *Social Methods Res*. 1978;7(2):131-148. doi:10.1177/004912417800700202
 27. McCarty C, Bernard HR, Killworth PD, Shelley GA, Johnsen EC. Eliciting representative samples of personal networks. *Soc Networks*. 1997;19:303-323. doi:10.1016/S0378-8733(96)00302-4
 28. Lee KTH, Vandell DL. Out-of-school time and adolescent substance use. *J Adolesc Health*. 2015;57(5):523-529. doi:10.1016/j.jadohealth.2015.07.003
 29. Li Y, Zhang W, Liu J, et al. The role of school engagement in preventing adolescent delinquency and substance use: a survival analysis. *J Adolesc*. 2011;34(6):1181-1192. doi:10.1016/j.adolescence.2011.07.003
 30. Yazzie-Mintz E. *Voices of Students on Engagement: A Report on the 2006 High School Survey of Student Engagement*. Bloomington: Center for Evaluation and Education Policy, Indiana University; 2007.
 31. Matheny AP Jr, Wachs TD, Ludwig JL, Phillips K. Bringing order out of chaos: psychometric characteristics of the Confusion, Hubbub, and Order Scale. *J Appl Dev Psychol*. 1995;16(3):429-444. doi:10.1016/0193-3973(95)90028-4
 32. Steinberg MP, Allensworth E, Johnson DW. Student and teacher safety in Chicago public schools: the roles of community context and school social organization. https://consortium.uchicago.edu/downloads/8499safety_in_cps.pdf. May 2011. Accessed August 25, 2018.
 33. Luppescu S, Hart H, Rosenkranz T, et al. *CCRS's Survey Reports for Chicago Public Schools*. Chicago, IL: Consortium on Chicago School Research; 2007.
 34. Hagan J, MacMillan R, Wheaton B. New kid in town: social capital and the life course effects of family migration on children. *Am Sociol Rev*. 1996;61(3):368-385. doi:10.2307/2096354
 35. Angrist JD, Pathak PA, Walters CR. Explaining charter school effectiveness. *Am Econ J Appl Econ*. 2013;5(4):1-27.
 36. Steinberg L, Lamborn SD, Darling N, Mounts NS, Dornbusch SM. Over-time changes in adjustment and competence among adolescents from authoritative, authoritarian, indulgent, and neglectful families. *Child Dev*. 1994;65(3):754-770. doi:10.2307/1131416
 37. Chen P, Jacobson KC. Developmental trajectories of substance use from early adolescence to young adulthood: gender and racial/ethnic differences. *J Adolesc Health*. 2012;50(2):154-163. doi:10.1016/j.jadohealth.2011.05.013
 38. Chun H, Mobley M. Gender and grade-level comparisons in the structure of problem behaviors among adolescents. *J Adolesc*. 2010;33(1):197-207. doi:10.1016/j.adolescence.2009.03.010
 39. Galama T, Lleras-Muney A, van Kippersluis H. The effect of education on health and mortality: a review of experimental and quasi-experimental evidence. Oxford Research Encyclopedia of Economics and Finance. <http://economics.oxfordre.com/view/10.1093/acrefore/9780190625979.001.0001/acrefore-9780190625979-e-7>. Accessed August 25, 2018.
 40. Flay BR, Graumlich S, Segawa E, Burns JL, Holliday MY, Aban Aya Investigators. Effects of 2 prevention programs on high-risk behaviors among African American youth: a randomized trial. *Arch Pediatr Adolesc Med*. 2004;158(4):377-384. doi:10.1001/archpedi.158.4.377
 41. Poulin F, Pedersen S. Developmental changes in gender composition of friendship networks in adolescent girls and boys. *Dev Psychol*. 2007;43(6):1484-1496. doi:10.1037/0012-1649.43.6.1484
 42. Brener ND, Eaton DK, Flint KH, et al. *Methodology of the Youth Risk Behavior Surveillance System-2013*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention; 2013.