eAppendix for: Mediation of neighborhood effects on adolescent substance use by the school and peer environments in a large-scale housing voucher experiment

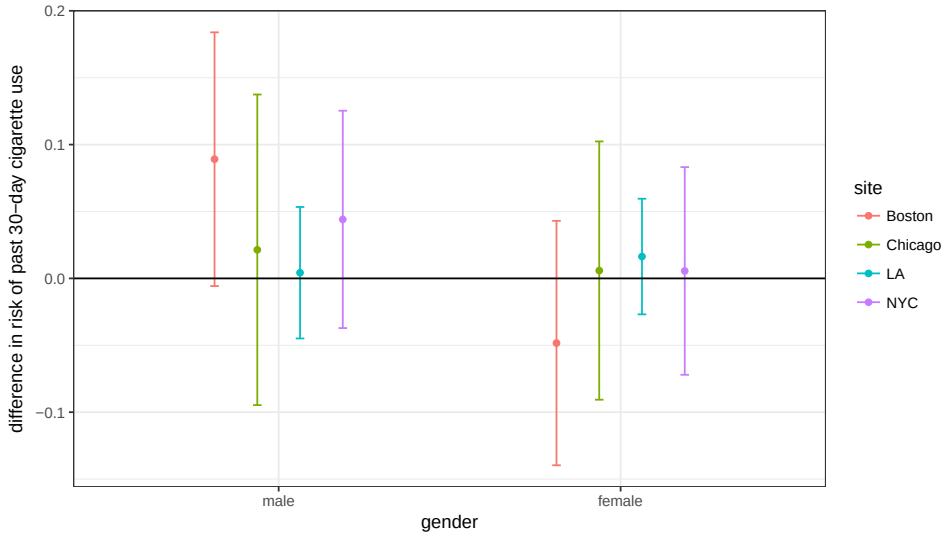
Kara E. Rudolph, Oleg Sofrygin, Nicole M. Schmidt, Rebecca Crowder, M. Maria Glymour, Jennifer Ahern, Theresa L. Osypuk

Baseline covariates

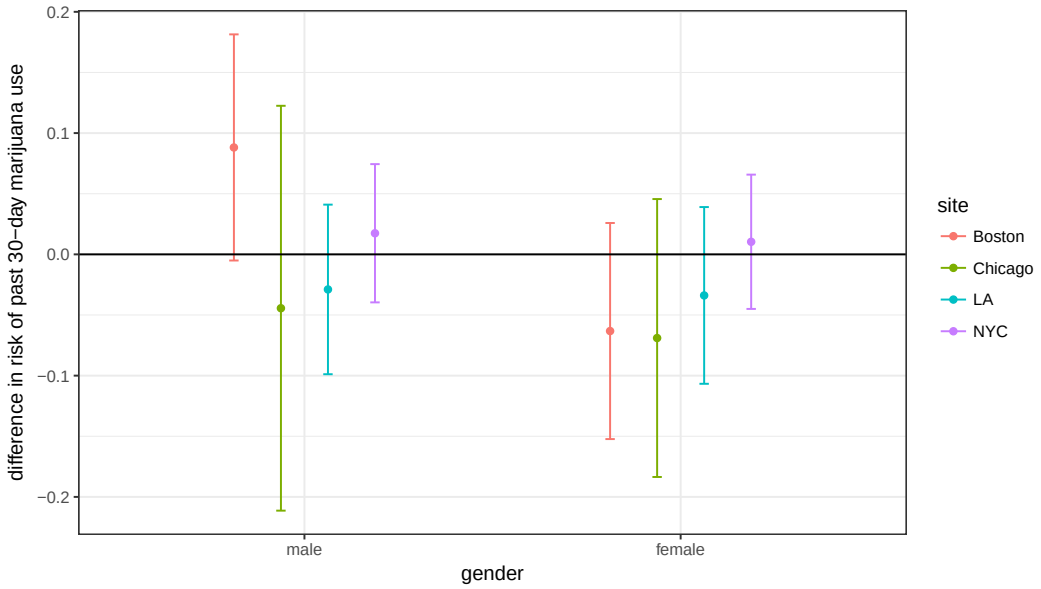
- Adolescent demographic characteristics: gender (male/female) (for the drug use analytic sample; only boys were included in the cigarette use analytic sample), age, race/ethnicity (categorized as black, latino/Hispanic, white, other), number of family members (categorized as 2, 3, or 4+), MTO city (for the cigarette use analytic sample; only the Boston site was included for the drug use analytic sample).
- Characteristics related to the child's behavior and learning: child was suspended or expelled from school during 2 years prior to baseline, child had gone to a special class or school or had gotten special help in school for a learning problem during 2 years prior to baseline, someone from school asked to discuss problems the child had with schoolwork or behavior during the 2 years prior to baseline, child enrolled in special class for gifted and talented students, child had problems that made it difficult to get to school or play active games/sports, child required special medication or equipment, child ever repeated a grade.
- Adult household head characteristics included: level of education (graduated high school vs not), marital status (never vs ever married), whether had been a teen parent, work status, receipt of AFDC/TANF, car ownership, disability status.
- Neighborhood characteristics: family lived in neighborhood for at least 5 years; felt neighborhood streets were unsafe at night; household member had been assaulted, threatened with a knife or gun, or robbed during the 6 months prior to baseline; chat with a neighbor at least once per week; would likely tell neighbor if neighbor's child was getting into trouble; family living in neighborhood; friends in neighborhood; very dissatisfied with neighborhood; poverty level of neighborhood.
- Reported reasons for participating in MTO: to get away from drugs or gangs, to have access to better schools.

- Moving-related characteristics: confidence about finding an apartment in a different part of the city, moved more then 3 times during the 5 years prior to baseline, and previous application for Section 8 voucher.

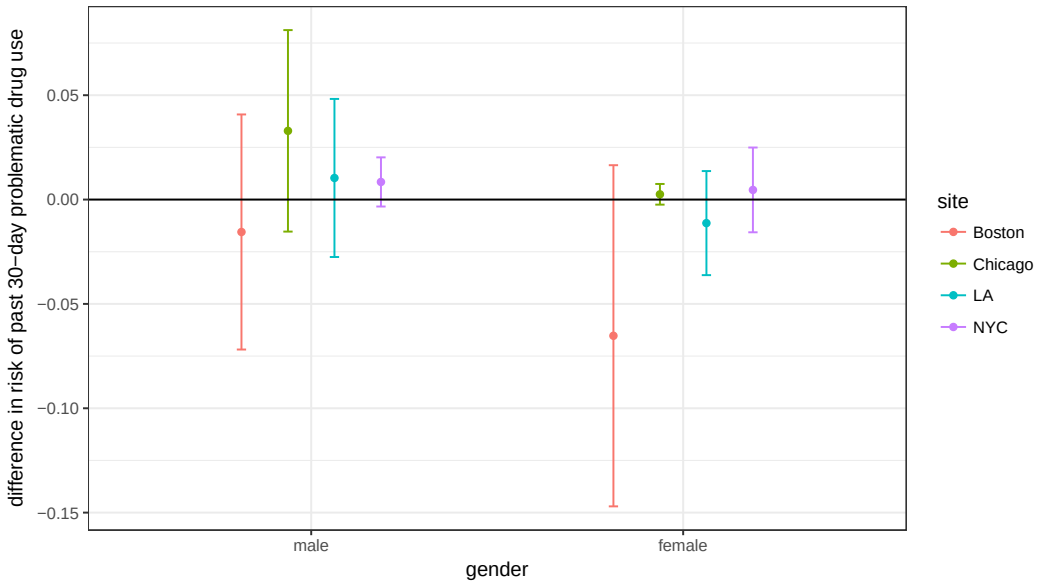
Total effect estimates by gender and site



eFigure 1: Estimates and 95% confidence intervals for the total effect of voucher randomization on past 30-day cigarette use by gender and site. Data from the Moving to Opportunity experiment, interim follow up.



eFigure 2: Estimates and 95% confidence intervals for the total effect of voucher randomization on past 30-day marijuana use by gender and site. Data from the Moving to Opportunity experiment, interim follow up.



eFigure 3: Estimates and 95% confidence intervals for the total effect of voucher randomization on past 30-day problematic drug use by gender and site. Data from the Moving to Opportunity experiment, interim follow up.

Baseline and follow-up characteristics by randomization status for each analytic sample

eTable 1: Characteristics by randomization status for the cigarette use sample, survey weighted and combined across 30 imputed datasets. Percentages unless otherwise specified.

	Boys, N=664		Girls, N=997	
	Control	Voucher	Control	Voucher
Parent baseline characteristics				
Boston	28.19	24.65	25.31	24.29
Chicago	36.99	37.48	23.94	24.99
LA	0	0	22.71	19.21
NYC	34.82	37.87	28.04	31.51
High school graduate or GED	40.40	39.87	35.17	35.89
Never married	57.06	57.85	55.87	52.57
Teen at birth of first child	21.98	22.84	20.80	24.88
Working	27.60	26.41	23.35	27.38
Welfare receipt	80.05	75.55	75.74	72.36
Car	15.66	13.60	21.04	21.70
Household member with disability	19.86	20.11	17.53	19.68
2 household members	7.37	6.09	7.14	8.21
3 household members	25.58	23.46	20.92	21.75
4 household members	20.43	22.85	23.57	28.16
Household member victim of a crime	38.61	43.19	44.25	41.56
Lived in neighborhood for 5 years	63.86	66.55	69.18	69.70
Chat with neighbors	57.05	51.63	50.70	45.23
Would tell family if neighbor's kid was in trouble	60.53	56.52	50.59	54.08
No family in neighborhood	60.65	62.93	68.49	63.76
No friends in neighborhood	39.85	38.92	38.61	39.10
Feel safe at night in neighborhood	44.24	44.60	47.93	45.40
Very dissatisfied with neighborhood	45.86	48.12	43.45	42.36
Adolescent baseline characteristics				
Age, years	9.08	9.30	9.36	9.24
Black	64.13	66.40	54.86	54.21
Hispanic	35.22	33.13	27.88	31.96
White/Other	0.65	0.47	17.25	13.82
Behavioral problems	9.35	12.28	2.09	5.68
Ever been expelled	6.84	13.25	3.26	5.13
Enrolled in gifted programs	19.96	17.73	12.59	14.06
Learning problems	23.31	23.69	12.63	11.94
School has called about problems	38.80	36.46	14.66	16.39
Conditions that prevent school attendance or play	5.60	8.85	4.81	6.10
Special medicine	10.85	13.91	5.34	7.46
Ever repeated a grade	33.32	34.06	25.31	23.99
Adolescent follow-up characteristics				
Moved with the voucher	0.00	41.67	0.00	51.76
Positive school climate	77.34	73.00	73.67	69.25
Feels safe at school	76.15	75.40	78.04	77.83
Has friends who use drugs	26.09	27.73	19.70	26.46
Participates in after-school sport or club	16.97	15.21	4.12	8.34
Cigarette use	6.74	11.78	7.61	7.37

eTable 2: Characteristics by randomization status for the marijuana use sample, survey weighted and combined across 30 imputed datasets. Percentages unless otherwise specified.

	Boys, N=640		Girls, N=507	
	Control	Voucher	Control	Voucher
Parent baseline characteristics				
Boston	27.94	27.29	50.82	49.65
Chicago	0	0	49.18	50.35
LA	37.55	30.07	0	0
NYC	34.51	42.64	0	0
High school graduate or GED	36.95	36.90	38.87	41.69
Never married	50.61	49.79	63.12	58.61
Teen at birth of first child	19.23	18.83	17.34	27.79
Working	24.93	25.39	28.29	32.77
Welfare receipt	77.55	72.66	71.57	68.44
Car	23.86	24.27	18.99	21.84
Household member with disability	20.04	20.03	14.78	19.58
2 household members	5.69	5.42	7.81	9.38
3 household members	23.03	26.27	22.46	24.04
4 household members	19.11	26.12	24.96	26.18
Household member victim of a crime	38.57	46.42	30.69	33.83
Lived in neighborhood for 5 years	65.66	65.44	64.39	64.86
Chat with neighbors	54.82	52.55	53.70	46.97
Would tell family if neighbor's kid was in trouble	61.08	58.40	52.33	57.04
No family in neighborhood	68.94	66.15	67.10	55.11
No friends in neighborhood	37.50	35.62	40.75	33.69
Feel safe at night in neighborhood	49.95	49.11	39.73	35.82
Very dissatisfied with neighborhood	36.92	45.06	41.15	35.68
Adolescent baseline characteristics				
Age, years	9.29	9.35	9.09	9.03
Black	43.56	46.87	62.81	65.31
Hispanic	55.80	53.13	11.84	18.11
White/Other	0.64	0	25.34	16.58
Behavioral problems	9.41	12.10	2.12	5.24
Ever been expelled	7.20	12.58	2.64	6.89
Enrolled in gifted programs	20.66	16.91	9.41	11.00
Learning problems	24.36	23.57	15.79	10.57
School has called about problems	38.65	34.47	10.51	16.52
Conditions that prevent school attendance or play	4.72	9.78	4.81	4.93
Special medicine	10.93	16.37	5.36	9.82
Ever repeated a grade	28.04	31.15	29.94	25.29
Adolescent follow-up characteristics				
Moved with the voucher	0.00	48.94	0.00	48.58
Positive school climate	70.33	69.64	77.83	69.32
Feels safe at school	68.78	72.55	77.53	80.35
Has friends who use drugs	26.22	30.09	18.63	31.88
Participates in after-school sport or club	19.25	15.82	3.81	8.84
Marijuana use	5.36	7.80	12.08	5.15

eTable 3: Characteristics by randomization status for the problematic drug use sample, survey weighted and combined across 30 imputed datasets. Percentages unless otherwise specified.

	Boys, N=861		Girls, N=731	
	Control	Voucher	Control	Voucher
Parent baseline characteristics				
Boston	20.49	19.25	0	0
Chicago	26.89	29.63	32.16	32.81
LA	27.54	21.11	30.72	25.41
NYC	25.08	30.00	37.12	41.79
High school graduate or GED	38.50	38.08	33.73	34.14
Never married	57.34	55.91	57.78	53.07
Teen at birth of first child	25.37	22.90	22.91	27.99
Working	25.53	25.99	19.09	25.11
Welfare receipt	79.67	75.22	82.57	76.76
Car	21.87	21.34	21.86	19.79
Household member with disability	17.80	17.75	17.80	19.00
2 household members	7.00	5.07	7.59	7.07
3 household members	21.45	23.13	19.19	19.93
4 household members	18.84	23.14	23.34	28.36
Household member victim of a crime	39.27	45.95	50.95	45.55
Lived in neighborhood for 5 years	65.16	68.17	70.77	75.06
Chat with neighbors	55.86	52.09	49.18	45.64
Would tell family if neighbor's kid was in trouble	59.60	55.90	47.78	56.38
No family in neighborhood	60.99	61.81	65.41	62.60
No friends in neighborhood	36.73	34.58	35.45	40.64
Feel safe at night in neighborhood	48.46	47.35	50.51	50.01
Very dissatisfied with neighborhood	41.24	46.87	44.07	45.07
Adolescent baseline characteristics				
Age, years	9.19	9.28	9.53	9.32
Black	58.46	61.85	63.29	60.90
Hispanic	41.07	37.91	28.94	31.17
White/Other	0.47	0.24	7.77	7.93
Behavioral problems	8.37	11.65	2.57	6.13
Ever been expelled	9.23	13.45	3.91	4.92
Enrolled in gifted programs	20.33	16.54	11.90	14.96
Learning problems	23.70	22.55	9.42	11.78
School has called about problems	37.67	34.25	17.42	16.06
Conditions that prevent school attendance or play	4.88	8.73	4.13	5.64
Special medicine	9.12	12.94	5.26	5.82
Ever repeated a grade	27.95	30.01	24.46	23.70
Adolescent follow-up characteristics				
Moved with the voucher	0.00	48.94	0.00	48.58
Positive school climate	72.41	72.50	72.37	71.20
Feels safe at school	71.39	74.87	78.30	76.26
Has friends who use drugs	24.83	27.73	19.24	21.80
Participates in after-school sport or club	16.80	15.04	2.98	7.23
Problematic drug use	1.97	2.99	0.80	0.74

Sensitivity analyses subgroups

eTable 4: Site subgroups for each sensitivity analysis.

Sample	Sensitivity Analysis 1		Sensitivity Analysis 2		Sensitivity Analysis 3	
	Boys	Girls	Boys	Girls	Boys	Girls
Cigarette Use	Boston, Chicago	All	All	All	All	All
Marijuana Use	Boston, Chicago	All	Chicago, LA	All	All	All
Problematic Drug Use	Boston, Chicago, LA	Chicago, LA, NYC	All	Chicago, LA, NYC	All	All

First-stage effects for sensitivity analyses

eTable 5: Risk differences of the effect of voucher receipt on the mediator by outcome sample for Sensitivity Analysis 1 that compares the restricted voucher group to the control group. Marginal effects, adjusting for baseline covariates and adherence, Z.

Mediator	Boys RD (95% CI)	Girls RD (95% CI)
Cigarette Use Sample		
Feels safe at school	0.060 (0.039, 0.081)	0.001 (-0.002, 0.005)
Positive school climate	0.037 (0.013, 0.061)	-0.008 (-0.012, -0.005)
Participates in after-school sport or club	0.008 (-0.002, 0.017)	0.006 (0.005, 0.008)
Has friends who use drugs	-0.011 (-0.039, 0.016)	0.032 (0.019, 0.044)
Marijuana Use Sample		
Feels safe at school	0.058 (0.041, 0.074)	0.000 (-0.003, 0.004)
Positive school climate	0.037 (0.016, 0.058)	-0.007 (-0.010, -0.004)
Participates in after-school sport or club	0.009 (-0.001, 0.018)	0.006 (0.005, 0.007)
Has friends who use drugs	-0.011 (-0.038, 0.017)	0.034 (0.021, 0.047)
Problematic Drug Use Sample		
Feels safe at school	0.051 (0.041, 0.062)	-0.028 (-0.032, -0.025)
Positive school climate	0.036 (0.026, 0.046)	-0.008 (-0.011, -0.004)
Participates in after-school sport or club	0.008 (0.003, 0.012)	0.003 (0.002, 0.004)
Has friends who use drugs	0.018 (0.001, 0.034)	0.032 (0.019, 0.044)

eTable 6: Risk differences of the effect of voucher receipt on the mediator by outcome sample for Sensitivity Analysis 2 that uses lifetime outcomes. Marginal effects, adjusting for baseline covariates and adherence, Z.

Mediator	Boys RD (95% CI)	Girls RD (95% CI)
Cigarette Use Sample		
Feels safe at school	0.032 (0.025, 0.040)	0.003 (-0.001, 0.006)
Positive school climate	0.037 (0.029, 0.044)	-0.006 (-0.010, -0.003)
Participates in after-school sport or club	-0.003 (-0.006, 0.000)	0.006 (0.005, 0.008)
Has friends who use drugs	0.012 (-0.003, 0.027)	0.033 (0.020, 0.045)
Marijuana Use Sample		
Feels safe at school	0.040 (0.023, 0.057)	0.001 (-0.002, 0.005)
Positive school climate	0.037 (0.015, 0.058)	-0.006 (-0.009, -0.003)
Participates in after-school sport or club	0.005 (-0.000, 0.011)	0.006 (0.005, 0.007)
Has friends who use drugs	0.018 (-0.003, 0.040)	0.034 (0.021, 0.047)
Problematic Drug Use Sample		
Feels safe at school	0.031 (0.024, 0.039)	-0.027 (-0.030, -0.023)
Positive school climate	0.035 (0.028, 0.042)	-0.006 (-0.009, -0.002)
Participates in after-school sport or club	-0.002 (-0.005, 0.000)	0.003 (0.002, 0.004)
Has friends who use drugs	0.014 (-0.001, 0.028)	0.034 (0.021, 0.046)

eTable 7: Risk differences of the effect of voucher receipt on the mediator for Sensitivity Analysis 3 that includes all sites. Marginal effects, adjusting for baseline covariates and adherence, Z.

Mediator	Boys RD (95% CI)	Girls RD (95% CI)
Feels safe at school	0.031 (0.023, 0.038)	0.001 (-0.002, 0.005)
Positive school climate	0.035 (0.028, 0.042)	-0.008 (-0.012, -0.005)
Participates in after-school sport or club	-0.003 (-0.006, 0.000)	0.006 (0.005, 0.008)
Has friends who use drugs	0.011 (-0.003, 0.026)	0.031 (0.019, 0.044)

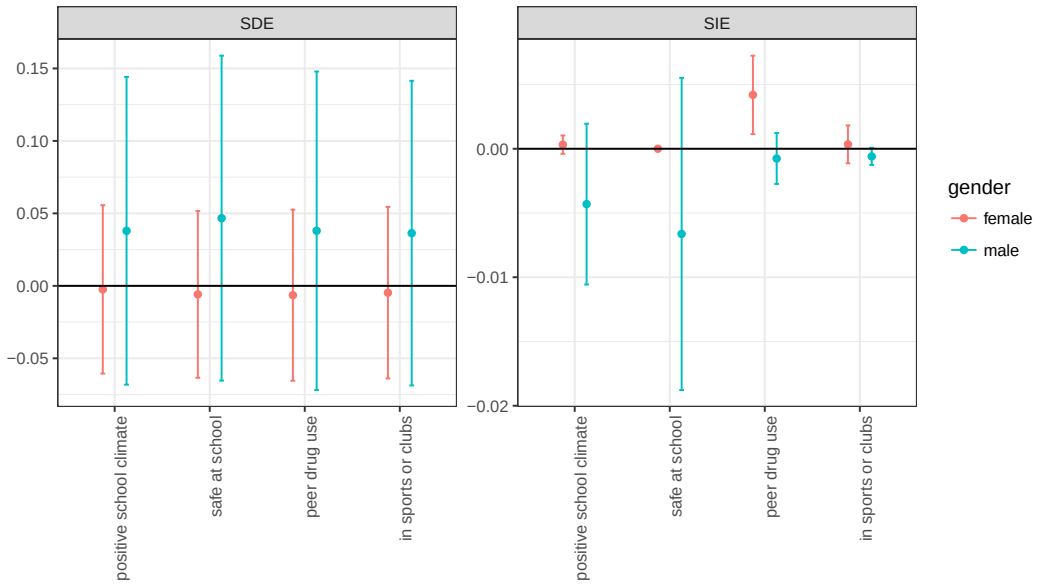
Stochastic direct and indirect effects for main analysis

eTable 8: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on substance use outcomes by mediator and gender, contrasting the voucher group to the control group.

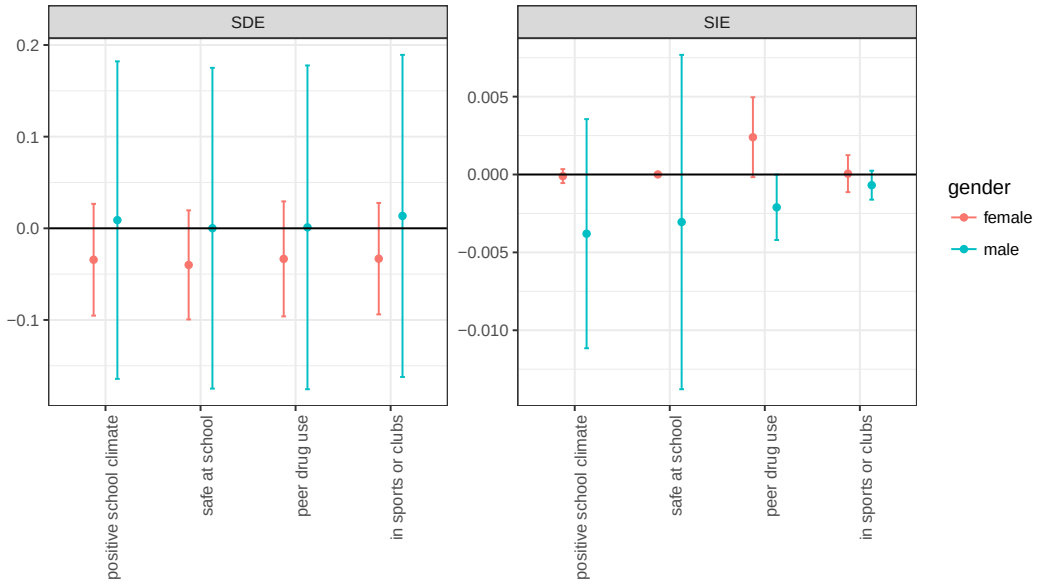
Estimand	Mediator	Gender	RD (95% CI)
Cigarette Use			
SDE	safe at school	male	4.227 (-4.526, 12.981)
SDE	positive school climate	male	4.024 (-4.276, 12.325)
SDE	in sports or clubs	male	3.548 (-4.756, 11.852)
SDE	peer drug use	male	3.580 (-5.217, 12.376)
SDE	safe at school	female	-0.590 (-6.345, 5.164)
SDE	positive school climate	female	-0.197 (-6.024, 5.631)
SDE	in sports or clubs	female	-0.511 (-6.422, 5.399)
SDE	peer drug use	female	-0.593 (-6.511, 5.324)
SIE	safe at school	male	-0.348 (-0.921, 0.225)
SIE	positive school climate	male	-0.280 (-0.713, 0.154)
SIE	in sports or clubs	male	0.027 (-0.002, 0.055)
SIE	peer drug use	male	-0.026 (-0.074, 0.022)
SIE	safe at school	female	-0.000 (-0.010, 0.010)
SIE	positive school climate	female	0.032 (-0.041, 0.104)
SIE	in sports or clubs	female	0.035 (-0.111, 0.180)
SIE	peer drug use	female	0.419 (0.111, 0.727)
Marijuana Use			
SDE	safe at school	male	1.421 (-4.734, 7.576)
SDE	positive school climate	male	1.663 (-4.531 7.857)
SDE	in sports or clubs	male	1.296 (-4.797, 7.389)
SDE	peer drug use	male	1.235 (-5.156, 7.626)
SDE	safe at school	female	-6.366 (-16.236, 3.504)
SDE	positive school climate	female	-6.064 (-16.006, 3.878)
SDE	in sports or clubs	female	-5.425 (-15.205, 4.354)
SDE	peer drug use	female	-5.585 (-15.734, 4.564)
SIE	safe at school	male	-0.066 (-0.358, 0.225)
SIE	positive school climate	male	-0.128 (-0.538, 0.283)
SIE	in sports or clubs	male	0.040 (-0.021, 0.101)
SIE	peer drug use	male	0.452 (0.118, 0.785)
SIE	safe at school	female	0.113 (-0.028, 0.253)
SIE	positive school climate	female	-0.051 (-0.132, 0.029)
SIE	in sports or clubs	female	-0.003 (-0.010, 0.003)
SIE	peer drug use	female	0.370 (-0.157, 0.898)
Problematic Drug Use			
SDE	safe at school	male	0.484 (-2.595, 3.563)
SDE	positive school climate	male	0.718 (-2.476, 3.913)
SDE	in sports or clubs	male	0.934 (-2.068, 3.936)
SDE	peer drug use	male	0.185 (-3.047, 3.417)
SDE	safe at school	female	0.144 (-1.282, 1.570)
SDE	positive school climate	female	0.180 (-1.279, 1.639)
SDE	in sports or clubs	female	-0.201 (-1.895, 1.494)
SDE	peer drug use	female	-0.138 (-1.866, 1.590)
SIE	safe at school	male	-0.016 (-0.149, 0.116)
SIE	positive school climate	male	-0.047 (-0.254, 0.161)
SIE	in sports or clubs	male	0.008 (0.001, 0.015)
SIE	peer drug use	male	0.071 (-0.009, 0.150)
SIE	safe at school	female	0.036 (-0.056, 0.128)
SIE	positive school climate	female	0.002 (-0.017, 0.021)
SIE	in sports or clubs	female	-0.002 (-0.005, 0.001)
SIE	peer drug use	female	0.100 (-0.033, 0.234)

Stochastic direct and indirect effects for sensitivity analyses

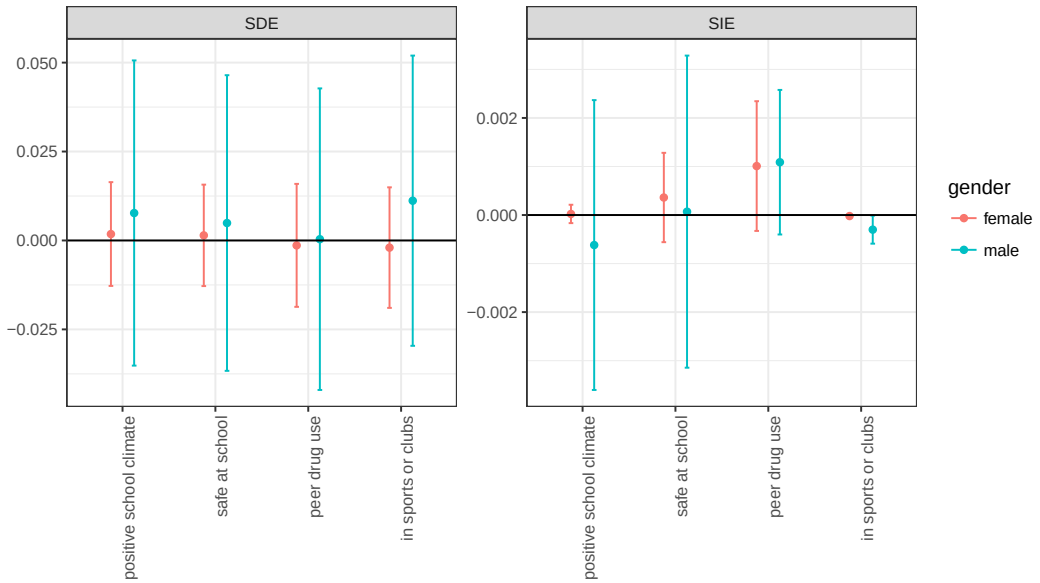
Sensitivity Analysis 1: comparing the restricted voucher group to the control group



eFigure 4: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on past 30-day cigarette use by mediator, contrasting the restricted voucher group to the control group.

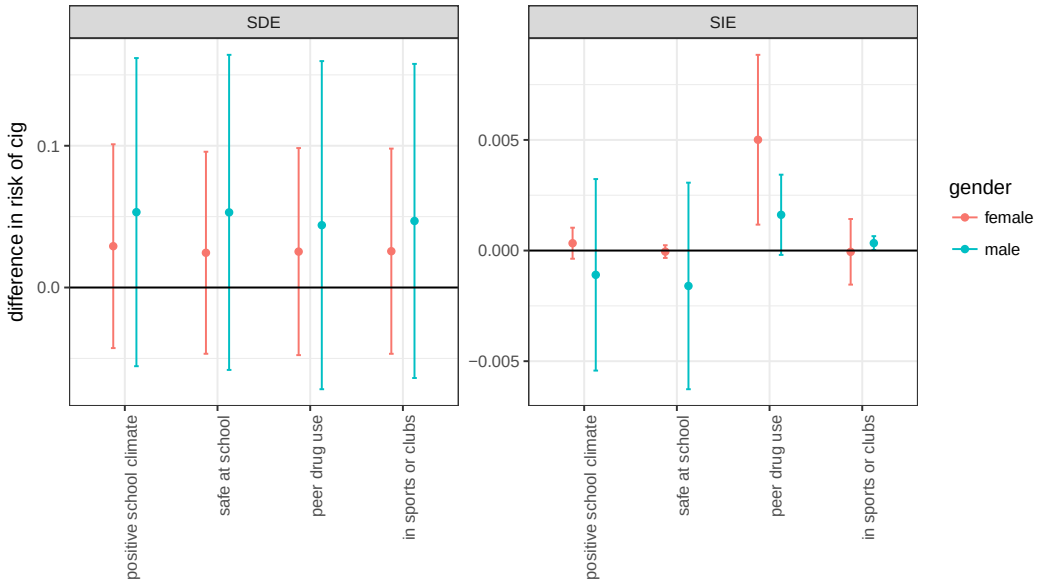


eFigure 5: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on past 30-day marijuana use by mediator, contrasting the restricted voucher group to the control group.

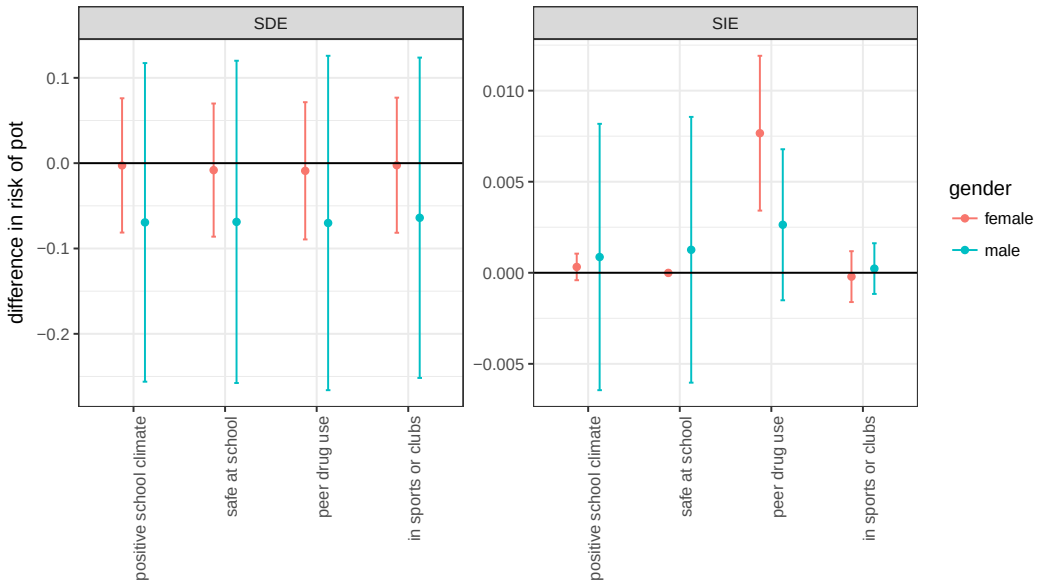


eFigure 6: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on past 30-day problematic drug use by mediator, contrasting the restricted voucher group to the control group.

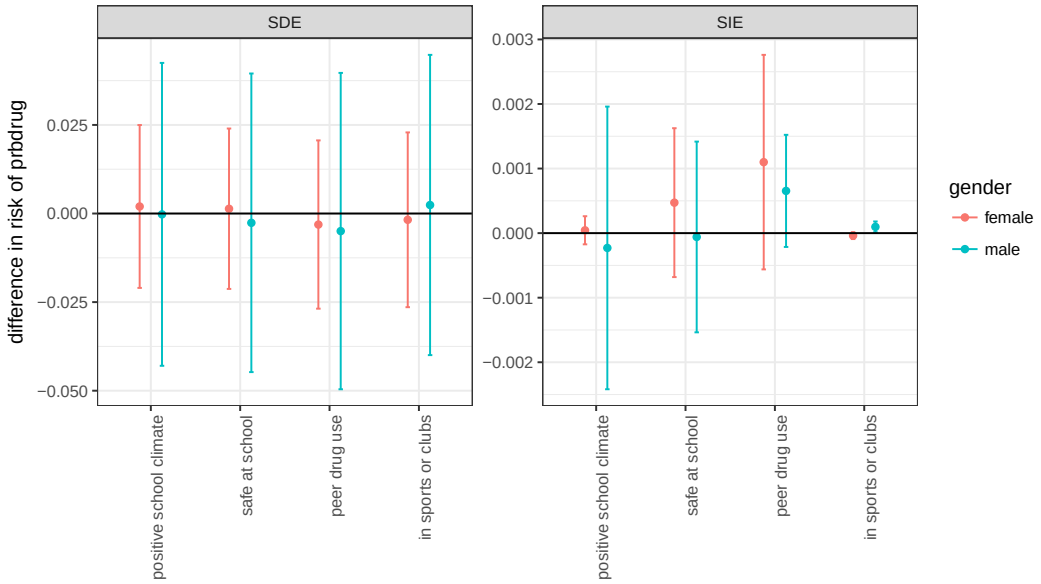
Sensitivity Analysis 2: lifetime outcome measures



eFigure 7: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on any cigarette use by mediator.

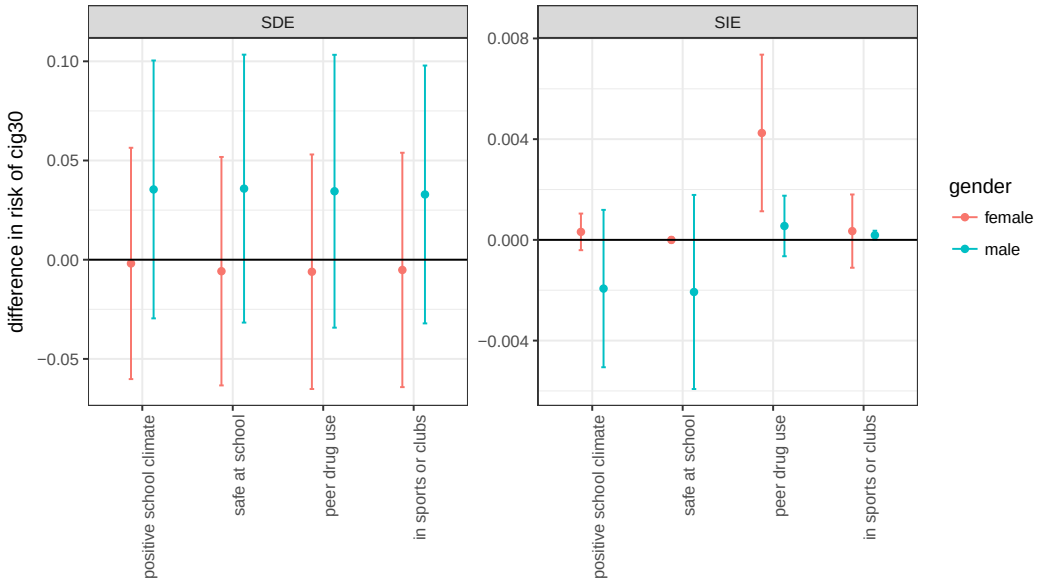


eFigure 8: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on any marijuana use by mediator, contrasting the restricted voucher group to the control group.

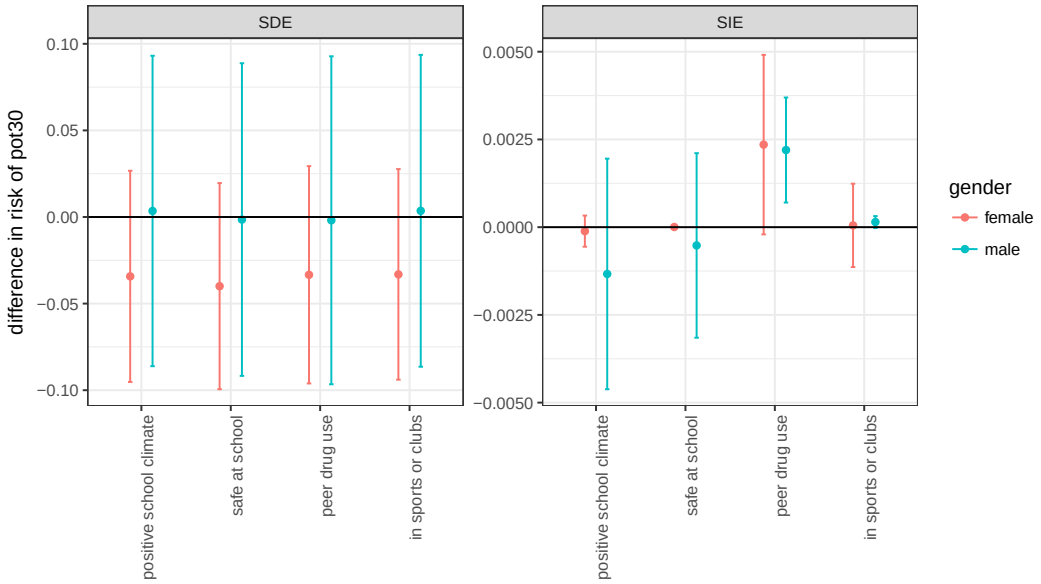


eFigure 9: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on any problematic drug use by mediator.

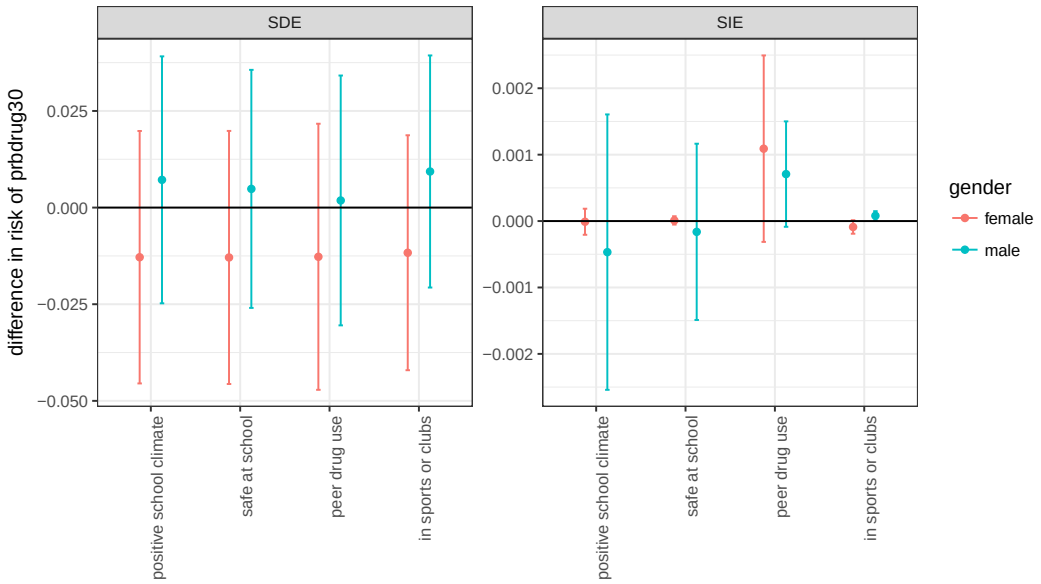
Sensitivity Analysis 3: all sites included



eFigure 10: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on past 30-day cigarette use by mediator, all sites included.



eFigure 11: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on past 30-day marijuana use by mediator, all sites included.



eFigure 12: Data-dependent stochastic direct (SDE) and indirect effect (SIE) estimates and 95% confidence intervals on past 30-day problematic drug use by mediator, all sites included.

Discussion of small, null mediation effects

The indirect effects we estimated were small—increasing or decreasing the risk of substance use by tenths or hundredths of a percent. There are likely multiple contributors to such small effects. First, the school and peer environment variables we tested may be weak or poorly measured mediators, suggesting important mediators have yet to be identified. Use of the voucher entailed moving to a new neighborhood, and the disruption of moving may have influenced children's outcomes. In other words, characteristics of the destination neighborhood may not be the only or even the primary mediators of the total effect of randomization. A goal of future research is to examine additional potential mediators, including mediation by the family environment—such as parental mental health and employment and parent-child closeness—and unexamined aspects of the school and peer environments.

Another contributor is weak first-stage effects. As seen in Table 8, receiving a voucher versus not affects the mediator by a maximum RD of 0.048 and a minimum of 0.001. These first-stage effects reflect the path $A \rightarrow Z \rightarrow M$, and thus assumes that the effect of A on M operates through Z—moving with the voucher. Although we believe this to be a reasonable assumption, incomplete measurement or mismeasurement of Z may dilute these effects. For example, a more complete measurement of adherence may include a non-binary Z that reflects compliance with the intervention over time (e.g., years in the new neighborhood) and/or include multiple Zs. Such factors suggest that an important area for future work is in extending the stochastic mediation TMLE estimator for non-binary and high-dimensional Z. Methods that can capture such a complex Z do not currently exist. Because we do not evaluate multiple Z's, we cannot know which particular aspect of intervention adherence is important in affecting mediator and outcome values.

Another potential explanation for weak first-stage effects could be that families in the voucher group may not have moved far enough away from their baseline neighborhoods to result in a change of school or change in peer social network. MTO resulted in shorter-distance moves than other housing interventions (1). Those in the restricted voucher group were more likely to move farther than those in the unrestricted voucher group, yet only 16% of those in the restricted group moved 10 miles or more (2). This contrasts with those participants in the Gautreaux study where 90% moved 10 miles or more (1; 3; 4). Unfortunately, we do not have information on change in the specific schools for the adolescents, but the majority did not change school districts; 30% of those in the voucher group changed school districts compared to 25% of controls. It is possible that moving greater distances may have strengthened effects on the mediators by affecting the extent to which ties were severed with the baseline neighborhood.

Finally, measurement error in self-reported covariates (W), incomplete measurement of the nuances of intervention adherence (Z) (discussed above), and measurement error in the self-reported mediator and outcome variables (M and Y) may have both biased our results and reduced power, thereby potentially contributing to very small indirect effects (5). Bias due to measurement error is typically given less attention in the epidemiology

literature than bias due to confounding, despite the equivalency between confounding bias and bias due to covariate measurement error (6). However, measurement error is pervasive. In this study, interviewers offered youth the opportunity to self-administer sections of the in-person computer-assisted survey that addressed sensitive behaviors, and this may have reduced measurement error for illicit behaviors for some adolescents (2). However given that the majority of youth chose not to self-administer the survey, measurement error may be a concern for the mediator and outcome variables, given they were still self-reported in an in-home interview.

Estimating potential biases due to measurement error or conducting sensitivity analyses that adjust effect estimates for the types of measurement error that realistically exist in this study is not feasible, as prior information on each mismeasured variable's measurement error model and the error's joint distribution with all the other variables in the study does not exist. Except in the simple case of ordinary least squares regression with one covariate experiencing classical measurement error, predicting the direction of the bias due to measurement error is complex (5). Consequently, our results may be biased due to measurement error with the degree of bias unknown. Such bias could be a contributing factor to null results.

Bibliography

[1] Rosenbaum JE, Zuberi A, Comparing residential mobility programs: design elements, neighborhood placements, and outcomes in mto and gautreaux. *Housing Policy Debate* 2010;20(1):27–41.

[2] Orr L, Feins J, Jacob R, et al., Moving to opportunity: Interim impacts evaluation 2003;.

[3] Keels M, Duncan GJ, DeLuca S, et al., Fifteen years later: Can residential mobility programs provide a long-term escape from neighborhood segregation, crime, and poverty. *Demography* 2005;42(1):51–73.

[4] Keels M, Second-generation effects of chicago's gautreaux residential mobility program on children's participation in crime. *Journal of Research on Adolescence* 2008; 18(2):305–352.

[5] Carroll RJ, Ruppert D, Stefanski LA, et al., *Measurement error in nonlinear models: a modern perspective*, CRC press2006.

[6] Rudolph KE, Stuart EA, Using sensitivity analyses for unobserved confounding to address covariate measurement error in propensity score methods. *American Journal of Epidemiology* 2017;In Press.