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School Social Capital and Tobacco Experimentation Among Adolescents: Evidence from a Cross-Classified Multilevel, Longitudinal Analysis.

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Abstract

Purpose: School social capital incorporates the intangible pro-social resources from social networks, including expectations and social norms, found in a school environment. School social capital may influence health behaviors such as smoking. This study examined the association of school social capital with smoking behaviors from childhood into adolescence.

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Methods: We used a cohort sampled from 3 U.S. cities for the Healthy Passages Longitudinal Study of Adolescent Health. The primary outcome was cigarette smoking at grade ten (Wave 3). The primary predictor of interest was school social capital at grade five (Wave 1). We included potential covariates at the individual-, school-, and neighborhood-levels at Wave 1. To account for simultaneous clustering in schools and neighborhoods, cross-classified multilevel models (CCMM) were employed.

Results: After exclusions and imputations for missing variables, our final sample contained 3,968 students as constituents of 118 schools and 479 neighborhoods. With adjustment for the covariates, school social capital for grade five was negatively associated with cigarette smoking in grade ten. We estimated that a one-standard deviation increase in the school average social capital for grade five is associated with an odds ratio of 0.86 (95% Credible Interval: 0.75-0.98) for school-level smoking in grade ten.

Conclusions: This study suggests that school social capital in late elementary years is associated with reduced smoking behaviors among adolescents in the United States. Influencing school social capital through enrichment of positive social norms and parent/teacher expectations may be a useful strategy to reduce adolescent smoking, with long-term implications for adult health.

Keywords

School Social Capital; Adolescents; Smoking; Cross-Classified Multilevel models

INTRODUCTION

As of 2014, smoking was causing more than 480,000 deaths annually in the United States, accounting for about one in five deaths (1). Adolescents have been particularly vulnerable to the highly addictive effects of nicotine in tobacco. Thus, not surprisingly, adult smoking behaviors often have their roots in adolescence: 40% of adult smokers try cigarettes by age 14 and 80% by age 17 (2).

A 2013 study found that every day, 700 adolescents already experimenting with cigarettes became new, regular, daily smokers (3). If current trends persist, 5.6 million Americans currently under 18 years of age, or roughly one in every thirteen children, are projected to die prematurely from smoking-related illness (1) . Developing effective preventive strategies to keep adolescents from starting to smoke may reduce long-term habitual smoking and thus tobacco-related morbidity and mortality (1).

The school environment is an important social context for shaping adolescent health behaviors, including smoking, because children and adolescents spend a large percentage of their waking hours at school (4, 5); furthermore, peer influence is critical to adoption of new behaviors (6). As the primary place where adolescents interact with friends and teachers (7), school has the potential to shape students' social relationships and behavioral patterns in stronger ways than other environmental contexts, such as neighborhoods (6).

One way that schools may influence students and their behaviors is through social capital. Especially as it relates to children, social capital was first defined in the US by Coleman (8) as a set of socio-structural resources with characteristics incorporated in a social structure,

and facilitate certain individual actions, such as student engagement and student sense of belonging, within the structure. He also noted that social capital is not inherent in individuals. School social capital is characterized by intangible pro-social resources from social networks found in school environments that include social norms within peer groups as well as expectations of parents and teachers. This capital may produce student feelings of connection to the school, promoting reciprocity or trust, and through social norms, may influence health-related behaviors including smoking. To date, much of the research examining social capital in schools has focused on the individual student's perception of their school connection (5, 9, 10), missing the opportunity to understand the contextual impact of school environments on student behavior.

When examining the possible influence of schools, and specifically, school social capital on smoking, it is important to recognize that children and adolescents simultaneously belong to multiple settings (e.g., families, schools, neighborhoods), all of which may have some protective or harmful characteristics. In the school-age population, several studies have examined the association between neighborhood context and smoking. (11, 12) Therefore, influences of both schools and neighborhoods should be considered when examining contextual influences on health behaviors.

Family, schools, and neighborhoods are the main settings that might affect student smoking behaviors (4, 5, 9, 10, 13-15); examination of all 3 simultaneously requires multi-level modeling. A traditional multilevel model requires that students are nested within schools, and schools are nested within neighborhoods. This requirement rarely corresponds to real lives, in which students from several different neighborhoods attend the same school or schools serve multiple neighborhoods. Cross-classified multi-level models (CCMM) allow for non-nested structures such that schools need not be fully contained within neighborhoods or vice versa. As a result, researchers can distinguish independent associations of smoking with school and neighborhood, even if children from the same neighborhood attend different schools.

The objective of our study was to examine the association of school social capital at grade five with smoking behaviors in grade ten in a cohort of preadolescents sampled from three U.S. metropolitan areas, while also accounting for simultaneous clustering in schools and neighborhoods. A secondary objective examined the relative strengths of the associations of school social capital, neighborhood characteristics, and family characteristics with smoking.

METHODS

We used data from the Healthy Passages Longitudinal Study of Adolescent Health, a prospective cohort study of grade five students in Birmingham, Alabama; Los Angeles, California; and Houston, Texas. Baseline data were collected from participants, their parents, and school administrators between August 2004 and September 2006 when each cohort of students was in grade five (mean [±SD] age, 11.1±0.5 years); Waves 2 and 3 were collected when most participants were in grades seven and ten. (16, 17). Additionally, geographic data from the participants were linked to available 2000 census tract data. We

used data from the baseline (Wave 1: 2004 - 2006) and the last wave of data (Wave 3: 2008 - 2010). Sampling procedures and other study details have been described elsewhere. (16, 17)

Among 11,532 grade five students enrolled in 118 sampled schools, parents of 5,752 (49.9%) students agreed to be contacted and 5,147 (89.5% of those who agreed to be contacted, and 44.6% of the potential pool) students completed an interview. Parent interviews were missing for 28 parent-child dyads, yielding a final sample of 5,119. (88.9% of those who agreed to be contacted and 44.4% of the potential pool) Both children and their primary caregivers completed computer-assisted personal interviews in English or Spanish and audio-computer-assisted self-interviews for sensitive questions, such as drug use, familial conflict, and sexual behaviors. Our research team received only de-identified data.

Measures

Outcome—Our primary outcome was tobacco use at Wave 3, which was measured with the following question: “Have you ever tried cigarette smoking, even one or two puffs? (yes or no).” Those who answered *yes* to this question included current smokers (those who smoked in the past 30 days), as well as experimenters (those who indicated that they had tried smoking, but smoked on zero days in the past 30 days) (18). We specifically included experimenters in the analyses because experimentation during adolescence often leads to long-term tobacco use. (19)

Primary predictor of interest—Our primary predictor of interest was school social capital at Wave 1. Our goal was to determine the long-term association between the Wave 1 measure of social capital and smoking. School social capital measures were aggregated from individual responses. Supplemental Table 1 summarizes the eight items measuring school social capital. Informed by prior research on social capital (20) and school connectedness (21), we created the School Social Capital Composite Index using the factor scores calculated by Principal Component Analyses (PCA) (eigenvalue 2.48), which recodes individual items to match directionality of the scales if necessary. The scale was constructed and standardized to a z-score such that higher scores indicate higher levels of school social capital and that each unit represents one standard deviation from the mean social capital.

Covariates—Variables previously shown or hypothesized to be associated with smoking in adolescents were included as covariates. We included variables at the individual-, school-, and neighborhood-levels at Wave 1 as shown in Supplemental Table 2. The survey sites: Birmingham, AL; Los Angeles, CA; and Houston, TX, were also included as a fixed effect, which absorbs all location-specific effects, such as state-level tobacco control policies.

Statistical Analyses—We excluded a total of 830 (16.2%) participants, including those lost to follow-up by Wave 3 (n=671, 13.1%), as well as those missing data on: tobacco use at Wave 3 (n=80); and race/ethnicity (n=1), marital status (n=13), household highest education (n=20), employment status (n=30), or census information (n=15) at Wave 1. We exclude them because these variables were used to impute other missing variables.

To allow for appropriate cross-classification, neighborhoods with only one student (n=321, 7.4%) were also excluded from the analyses. Other missing variables (household income,

n=265; use of public assistance, n=206; parental smoking, n=62; and school climate, n=856) were imputed using the Gaussian normal regression imputation method (22) with race/ethnicity, marital status, highest household education, employment status (employed/unemployed), median household income in neighborhood, percentage of White in neighborhood, percentage of unemployed in neighborhood, percentage of neighborhood residents with less than high-school-level education, and sites. After all exclusions and imputations for missing variables, our final analytic sample was 3,968 students nested in 118 schools and 479 neighborhoods.

Descriptive statistics of continuous variables were presented as means with standard deviations, and those of categorical variables were presented as counts and percentages. Differences between tobacco experimenters and non-experimenters were examined using t tests for continuous variables, and chi squared test for categorical variables. Descriptive statistics were computed using SAS (Version 9.4; Cary, NC, USA).

In the remaining analyses, we used cross-classified multi-level logistic regression models to examine the association of school social capital with tobacco use while accounting for student clustering within schools and neighborhoods. CCMM accounts for non-hierarchical clustering of observations to account for students who attend the same school and live in several different neighborhoods, or students who live in the same neighborhood but attend different schools. The traditional multilevel model assumes a hierarchical structure, where observations are hierarchically nested, such that students in one school live in the same neighborhood, or individuals in once neighborhood attend the same school.

Adjusted models were fitted including: 1) individual-level covariates, and 2) all individual-, school-, and neighborhood-level predictors and covariates. Site-fixed effects were included in all models.

The Median Odds Ratio (MOR), estimated in a cross-classified multi-level logistic regression model, quantifies heterogeneity between clusters, and is always greater than or equal to 1. If MOR is 1, there is no variation between clusters. If there is considerable between-cluster variation, MOR will be large (23). The MORs in the null model will quantify whether the school or neighborhood factors have greater association with the outcome, namely, the bigger MOR, the greater association.

SAS Version 9.4 PROC FACTOR was used to conduct PCA with the varimax rotation method. All other analyses were conducted in Stata: Version 12 (College Station, TX) or MLwiN (Version 2.29; Birmingham, UK) via Stata: Version 12. The software utilizes Bayesian estimation procedures using Markov Chain Monte Carlo (MCMC) methods with non-informative priors and a Metropolis-Hastings sampling algorithm allowing for simultaneous modeling of non-hierarchically nested contexts. Odds ratios and 95% credible intervals are presented for fixed effects, parameter estimates and standard errors for intercepts, and median odds ratios and 95% credible intervals for random effects. Statistical tests were performed with a two-sided alpha-level of 0.05, except for random effects, for which one-tailed tests were performed (alpha-level <0.05). A formal description of the cross-classification procedure can be found elsewhere (24).

Sensitivity Analyses—As a robustness check, we conducted four sensitivity analyses. First, we excluded students who had already smoked in fifth grade because some might express concern that smoking could have occurred before school social capital was measured. Second, the past 12-month tobacco use at Wave 3 was used as an outcome. Third, we excluded the participants who had missing data on any variables included in the model, instead of imputing the missing data. Fourth, we employed the first differencing method (25) to examine association of changes in individual student perception of school social capital on change in smoking behaviors. We used individual perception of school social capital because school identifiers necessary for school-level measures of social capital were only available at Wave 1. Additionally, neighborhood support and social scales were also used at individual-level, because we only had comparable information at school-level, which is the individual perception of school social capital, due to unavailability of school identifiers at Wave 3. This second sensitivity analysis also excluded students who had already smoked in fifth grade to provide a clearer picture of change in smoking behaviors for those indicating "never smoked" at Wave 1. The detailed model is described in Supplement file 1.

This research was approved by the RAND Institutional Review Board (IRB), with the IRB at Boston Children's Hospital deferring to RAND.

RESULTS

Among 3,968 respondents, there were 1,133 unique combinations of school and neighborhoods observed, indicating that data are well suited to CCMM analysis. The median number of students included per school was 44.5, ranging from 4 to 99 (n=118 schools). Per neighborhood, the median sample number of students was 15, ranging from 2 to 64 (n=482 neighborhoods).

Table 1 shows descriptive statistics, both overall and by tobacco use. Students indicating they had used tobacco at Wave 3 were significantly more likely to be older and male, have lower SES, have parent and friend smokers, and live with a single parent. School social capital was significantly lower for students who had used tobacco.

The cross-classified null models showed that between-level variance in smoking was associated more strongly with the school (MOR=1.42 95% CI: 1.27-1.57) than with the neighborhood (MOR=1.13, 95% CI: 1.06 - 1.27).

Table 2 presents fixed effects from the two cross-classified multilevel logistic regression models. Higher school social capital in fifth grade was statistically significantly associated with less tobacco use in grade ten. We estimated that a one school-level standard deviation increase in the school average social capital is associated with an odds ratio of 0.86 (95% CI: 0.75-0.98) for student smoking, decreasing the odds of smoking by 14%. The results also suggested that schools in the highest decile for school social capital had 0.96 times the odds of smoking on average compared to schools within other deciles of school social capital. None of the neighborhood factors had significant associations with smoking.

Results from the first sensitivity analysis, which excludes students who stated that they had smoked in fifth grade, mirrored findings from our main analysis, again showing reduced

odds of tobacco use in schools with higher school social capital. (Table 3: OR=0.82, 95% CI: 0.72-0.94) A total of 809 among 3,968 (20.4%) stated that they used tobacco in the past 12 months. Although we did not detect a statistically significant association, the direction of the point estimate of odds ratio did not change from the main analyses, i.e., the higher school social capital in fifth grade was associated with less tobacco use in grade ten. (OR=0.94, 95% CI: 0.81-1.09) We did not detect a significant association likely due to the small percentage of the past 12-month smoking experience in our cohort. After we excluded all the participants who had missing variables, our analytic sample decreased to 2,892 nested in 112 schools and 456 neighborhoods. The results of this sensitivity analysis mirrored the results from the main analyses, i.e., higher school social capital in fifth grade was statistically significantly associated with less tobacco use in grade ten. (OR=0.83, 95% CI: 0.72-0.95) Our sensitivity analysis employing a first differencing method, i.e., smoking uptake regressed on changes in individuals' perceptions of school social capital between waves 1 and 3, provided further evidence of the association between school social capital and tobacco use. Table 4 shows detailed results. We estimated that a one standard deviation increase in changes in individuals' perceptions of school social capital between waves 1 and 3 is associated with an odds ratio of 0.92 (95% CI: 0.86-0.9, $p\text{-}value < 0.01$) for changes in smoking behavior between waves 1 and 3. For every standard deviation increase in the individual student's perceptions of school social capital for those who had never smoked at Wave 1, the odds of having smoked by Wave 3 decreased by 8%.

DISCUSSION

In this study, we provide evidence that higher school social capital for fifth-grade students attending public schools in the greater Birmingham, AL; Houston, TX; and Los Angeles, CA areas is associated with less tobacco use at tenth grade. This study contributes to the literature for three reasons. First, we used an aggregated measure to represent social capital at school-level, instead of relying exclusively on individual perception of school social capital. Second, we employed CCMM to account for individual, school, and neighborhood factors simultaneously, thus avoiding our results being biased by lack of accounting for clustering in different contexts. CCMM enabled us to look at social capital across three key contexts, i.e., [1] family social capital, [2] school social capital, and [3] neighborhood social capital, and we found that school social capital is associated with smoking behavior among adolescents after adjusting for social capital in the other two contexts. Third, our sensitivity analysis, which controlled for time-invariant confounders, also suggested an association between higher school social capital and less tobacco use.

Previous studies examined individual perceptions of school social capital and its association with tobacco use. Takakura (4) employed individual-school, two-level analyses, with school social trust in the model based on aggregated individual responses at school-level. However, as the author noted, it was unclear which areas (communities, neighborhoods, or schools) students had in mind when answering trust questions. Additionally, Takakura (4) demonstrated protective associations of individual perceptions of trust with smoking prevention, but was inconclusive regarding protective associations of school social capital. Johansen et al. (5), using a traditional hierarchical multilevel model with individuals nested within schools, found that peer social network was an important correlate of smoking

behaviors, and students having difficulty talking to their parents could even encourage adoption of smoking. However, the question intended to measure peer social networks did not make clear whether social networks were in the neighborhood, school, or elsewhere. Additionally, the social network was individual-level, not school-level, as is the case with school social capital.

Although school effects are particularly important for adolescents (4), some studies focused on neighborhood effects, and conducted individual-neighborhood two-level analyses (10, 13). Our study went beyond these previous studies, using school-level measures of social capital instead of each individual's perception. Moreover, questions to measure social capital clearly focused on school trust or attachment. We were also able to adjust for key influences within the family, school, and neighborhood through cross-classified multilevel analyses. Thus, we provided evidence that school social capital has a protective association with smoking behaviors among adolescents even after adjusting for social capital in the other two important contexts. Furthermore, because Healthy Passages collected data longitudinally, we could employ the first differencing method (25) as a sensitivity analysis, and control time-invariant factors that could produce omitted variable bias, although individual perception was used for this sensitivity analysis due to unavailability of school identifiers at Wave 3.

CCMM is still rarely applied, and to our knowledge, only one study applied CCMM to examine associations of school social capital with smoking behaviors among adolescents. De Clercq et al. (15) studied school pupils in Belgium, revealing that family social capital and cognitive school social capital were associated with less regular smoking. Additionally, their study suggested that previously observed, community-level associations with adolescent smoking may be a consequence of unmeasured confounding. Nevertheless, the De Clercq et al. (15) study only examined perceptions of individual associations between school social capital and smoking behaviors. Dunn et al. (26) showed where and how results from a CCMM might deviate from a traditional multilevel model focused on a single context. In our CCMM model, the between-level variation in smoking was also more associated with school-level variation (MOR=1.42, 95% CI: 1.27-1.57) than with neighborhood-level variation (MOR=1.13, 95% CI: 1.06-1.27). The results of our current study were consistent with their results.

As De Clercq et al. (15) have pointed out, traditional hierarchical multilevel studies provided different results, and these mixed findings could be due to the different study sites (4, 10, 13-15). Therefore, it is important to explore effects of school social capital on smoking behavior among adolescents in different sites. To our knowledge, our study is the first to explore effects of school social capital on smoking behavior among adolescents in the United States.

This study defined tobacco use of any duration to include both current smokers and experimenters (18), because we believe exploring the association of school social capital with tobacco experimentation is important, given that adolescents who experiment with smoking often become regular smokers (1). Also, some adolescents experience tobacco dependence even within a day of first inhaling (27).

This study suggests that school social capital may have a protective effect on prevention of smoking behaviors among adolescents in the United States, although causality cannot be inferred from this observational data. Enriching school social capital may be a promising strategy to reduce adolescent smoking, especially since it has been reported that some intervention programs, such as Families and Schools Together (FAST), successfully build social capital among families, children, and schools.(28, 29) Our study has several limitations. First, tobacco use was self-reported. Therefore, errors or inaccuracies in self-reporting could affect our results, although previous studies using biochemical verification of self-reported smoking status in adolescents have confirmed validity of self-reporting (30, 31). Second, overall response rate for the survey was 34%. This rate of participation is similar to the rate of participation seen in other studies requiring parental consent. (32) Grove et al (33) argued that nonresponse bias in surveying students from a school or members of an organization is smaller than that in surveying among the general population. Rogelberg et al (34) demonstrated that respondents to membership surveys tend to be more attached to the organization than non-respondents. Therefore, our survey results may underrepresent students who were less attached to schools. Third, Healthy Passages was conducted at three sites, so caution should be exercised in generalizing findings to other settings (16). Fourth, the school identifier is only available at Wave 1; therefore, we could only use individual perception of school social capital for our sensitivity analysis. Furthermore, parental smoking status was only available at Wave 3, and therefore, parental smoking status could not be included in the sensitivity analysis, although parental changes in smoking status are likely to have been small between Waves 1 and 3 (35). Fifth, family social capital was measured at the individual level, but not enough information was collected for an aggregated family social capital variable. Sixth, we did not use current smokers (those who smoked in the past 30 days) at Wave 3 as an outcome due to the small number of current smokers, i.e. 464 students across 118 schools and 479 neighborhoods. Seventh, with the advent of vaping/Juuling in recent years, (36) younger smokers in particular have begun to shift from conventional cigarettes to e-cigarettes, including those that deliver nicotine. (37) Although delivery of nicotine to the developing adolescent brain results in enhanced clinical vulnerabilities, (38) longitudinal studies evaluating potential health risks of vaping/Juuling are not yet feasible, (39) and our data were collected before e-cigarettes was a factor. Therefore, this study did not examine the association with e-cigarettes, and it is unclear if the same factors would influence other tobacco-related behaviors. Eighth, our first differencing method (25) controlled time-invariant factors that could produce omitted variable bias, time-variant factors that could produce omitted variable bias still exist. For example, retail availability of tobacco products in neighborhoods could change over time, and its association with tobacco use have been reported; however, the information was not available for the analyses. (40, 41) Ninth, while the CCMM model has advantages over alternative models that do not properly account for the structure and covariance of cross-classified data, they do not incorporate sampling weights in a standard way. Fortunately, we are able to incorporate the key predictors of nonresponse and attrition in the CCMM model, making it nearly as robust to the effects of nonresponse as a weighted model with different limitations. Finally, due to the complexity of the CCMM model, our analyses used single imputation methods, rather than multiple imputation methods, in order to impute missing values.

CONCLUSION

This study suggests that school social capital may have an effect on reducing smoking initiation among adolescents in the United States. This study examined social capital across three key contexts: [1] family social capital, [2] school social capital, and [3] neighborhood social capital. We found that after considering family and neighborhood associations with smoking behaviors, school social capital appears to have the preventive association. Enriching school social capital might be a useful strategy to prevent adolescents from smoking.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Implications and contribution

School social capital in grade five was associated with lower odds of smoking in grade ten in a diverse cohort of preadolescents sampled from three U.S. metropolitan areas. Strategies to enrich school social capital may reduce adolescent smoking.

Table 1.

Descriptive statistics by tobacco use

		All n=3,968		Never smoked n=2,693		smoked before n=1,275		P value
individual level factors								
		n	**%**	**n**	**%**	**n**	**%**	
Gender	Male	1,946	49.0%	1,290	47.9%	656	51.5%	.04
	Female	2,022	51.0%	1,403	52.1%	619	48.6%	
Race	White	978	24.7%	681	25.3%	297	23.3%	.18
	Black	1380	34.8%	914	33.9%	466	36.6%	.11
	Hispanic	1396	35.2%	932	34.6%	464	36.4%	.29
	Other	214	5.4%	166	6.2%	48	3.8%	< .01
Parental smoking		335	8.4%	298	11.1%	633	49.7%	< .01
Friend smoking [a]		469	11.8%	257	9.5%	212	16.6%	< .01
Marital Status								
Married/live with partner		2,563	64.6%	1,793	66.6%	770	60.4%	< .01
Widow/separated/divorced/never married		1,405	35.4%	900	33.4%	505	39.6%	
Plan to attend college		3911	98.6%	2666	99.0%	1245	97.7%	< .01
		Mean	**SD[b]**	**Mean**	**SD[b]**	**Mean**	**SD[b]**	
Age		16.1	0.60	16.1	0.58	16.2	0.61	< .01
SES Composite Index (z-score) [c]		0	1.00	0.07	1.01	−0.15	0.97	< .01
Smoking Disapproval (z-score)		0	1.00	−0.02	1.01	0.04	0.97	.09
Family Cohesion (z-score)		0	1.00	0.03	0.99	−0.07	1.02	< .01
Parental Oversight z-score)		0	1.00	−0.03	0.98	0.07	1.04	< .01
School Level factors								
School level demographics (z-score)		0	1.00	0.06	1.02	−0.12	0.93	< .01
School Social Capital (z-score_		0	1.00	0.08	1.01	−0.17	0.94	< .01
School Climate (z-score)		0	1.00	0.08	0.99	−0.17	1.00	< .01
Neighborhood Level Factors								
Neighborhood Social exchange (z-score)		0	1.00	−0.04	1.02	0.08	0.95	< .01
Neighborhood informal social control (z-score)		0	1.00	0.05	1	−0.11	0.97	< .01
Neighborhood Demographics (z-score)		0	1.00	0.06	1.02	−0.12	0.94	< .01

[a] We used: “How many of your closest friends do you think have ever smoked cigarettes? (none, a few, or many)" and recoded the variable to have a binary outcome (none/at least some).

[b] Standard Deviation

[c] A composite index of socioeconomic indicators created from highest household education (no high school degree, high school degree, some college, and 4-year college degree or greater), annual household income (<$25,000; $25,000 - $49,999; $50,000-$99,999; and ≥$100,000), and use of public assistance (yes/no).

Table 2:

Results from the two cross-classified multilevel logistic regression models to evaluate the association between tobacco use and school social capital

		Model adjusted for individual-level factors				Model adjusted for individual-, ol-, and neighborhood-level factors			
		OR[a]	SD[b]	95% CI[c]		OR[a]	SD[b]	95% CI[c]	
Individual level									
Age in year		1.23	0.06	1.11	1.33	1.40	0.04	1.31	1.46
Male		1.13	0.08	0.97	1.30	1.11	0.09	0.96	1.29
Race/Ethnicity	White	Reference				Reference			
	Black	0.70	0.09	0.54	0.91	0.54	0.08	0.40	0.70
	Hispanic	1.00	0.13	0.75	1.26	0.85	0.13	0.62	1.12
	Other	0.68	0.13	0.46	0.95	0.59	0.12	0.39	0.85
SES composite Index[d]		0.85	0.04	0.76	0.93	0.95	0.06	0.84	1.06
Not married or living with partner		1.02	0.02	0.98	1.06	1.03	0.02	0.99	1.07
Plan to attend college		0.60	0.18	0.35	1.07	0.55	0.14	0.31	0.83
Parent Smoke		1.92	0.19	1.59	2.33	1.88	0.19	1.54	2.28
Friends Smoke		1.55	0.17	1.25	1.88	1.49	0.17	1.20	1.82
Parents Disapprove of smoking (z-score)		1.04	0.04	0.96	1.12	1.03	0.04	0.96	1.10
Family Cohesion (z-score)		0.98	0.04	0.91	1.05	0.99	0.04	0.92	1.06
Parental oversight (z-score)		1.08	0.04	1.00	1.16	1.08	0.04	1.01	1.17
School Level Factor									
School Demographics (z-score)						1.10	0.10	0.91	1.32
School Social Capital (z-score)						0.86	0.06	0.75	0.98
School Climate (z-score)						0.87	0.06	0.76	0.99
Neighborhood Factors									
Neighborhood demographics (z-score)						0.90	0.08	0.76	1.07
Neighborhood social exchange (z-score)						1.04	0.06	0.91	1.16
Neighborhood informal social control (z-score)						0.98	0.06	0.88	1.09

[a]Odds Ratio

[b]Standard Deviation

[c]Credible intervals

[d]A composite index of socioeconomic indicators created from highest household education (no high school degree, high school degree, some college, and 4-year college degree or greater), annual household income (<\$25,000; \$25,000 - \$49,999; \$50,000-\$99,999; and ≥\$100,000), and use of public assistance (yes/no).

Table 3.

Results from sensitivity analyses Cross-classified multilevel logistic regression to evaluate the association between tobacco use and school social capital

		A sensitivity analysis, which excludes the students who had smoked at 5th grade				A sensitivity analyses using past 12-month smoking experience as an outcome				A sensitivity analyses excluding students who had missing values			
		OR[a]	SD[b]	95% CI[c]		OR[a]	SD[b]	95% CI[c]		OR[a]	SD[b]	95% CI[c]	
Individual level													
Age in years		1.21	0.08	1.10	1.36	1.31	0.05	1.23	1.40	1.20	0.05	1.08	1.28
Male		1.12	0.09	0.96	1.31	1.17	0.10	0.99	1.36	1.10	0.09	0.93	1.29
Race	White	Reference											
	Black	0.52	0.07	0.4	0.66	0.52	0.08	0.37	0.70	0.54	0.08	0.41	0.71
	Hispanic	0.84	0.11	0.64	1.07	0.90	0.14	0.65	1.20	0.88	0.13	0.64	1.19
	Other	0.55	0.11	0.36	0.8	0.56	0.13	0.35	0.83	0.77	0.16	0.51	1.14
SES composite Index[d]		0.94	0.05	0.83	1.05	1.04	0.07	0.90	1.18	0.89	0.06	0.78	1.01
Not married or living with partner		1.02	0.02	0.97	1.06	1.04	0.03	0.99	1.09	1.03	0.02	0.98	1.08
Plan to attend college		0.54	0.14	0.29	0.83	0.67	0.19	0.41	1.13	0.48	0.14	0.26	0.76
Parent Smoke		1.88	0.19	1.54	2.27	1.93	0.21	1.55	2.35	1.94	0.21	1.57	2.39
Friends Smoke		1.12	0.15	0.86	1.44	1.47	0.18	1.14	1.84	1.51	0.19	1.17	1.92
Parents Disapprove of smoking		1.06	0.04	0.98	1.14	1.09	0.05	1.00	1.19	1.04	0.05	0.95	1.14
Family Cohesion		0.96	0.04	0.89	1.03	1.00	0.04	0.92	1.08	1.01	0.04	0.93	1.09
Parental oversight		1.08	0.04	1.00	1.17	1.07	0.04	0.99	1.15	1.09	0.05	1.00	1.19
School Level Factor													
School Demographics (z-score)		1.12	0.11	0.92	1.34	1.37	0.14	1.11	1.68	1.13	0.12	0.90	1.39
School Social Capital (z-score)		0.82	0.06	0.72	0.94	0.94	0.07	0.81	1.09	0.83	0.06	0.72	0.95
School Climate (z-score)		0.88	0.05	0.78	0.98	0.83	0.06	0.73	0.95	0.87	0.06	0.77	0.99
Neighborhood Factors													
Neighborhood demographics (z-score)		0.9	0.09	0.75	1.1	0.82	0.09	0.67	1.01	0.93	0.10	0.76	1.14
Neighborhood social exchange (z-score)		1.03	0.07	0.91	1.16	1.01	0.08	0.87	1.17	1.05	0.08	0.90	1.21
Neighborhood informal social control (z-score)		0.99	0.06	0.88	1.1	1.01	0.07	0.88	1.15	0.99	0.07	0.85	1.12

[a] Odds Ratio

[b] Standard Deviation

[c]Credible intervals

[d]A composite index of socioeconomic indicators created from highest household education (no high school degree, high school degree, some college, and 4-year college degree or greater), annual household income (<\$25,000; \$25,000 - \$49,999; \$50,000-\$99,999; and ≥\$100,000), and use of public assistance (yes/no).

Table 4:

The association between the individual perception of the school social capital and tobacco use

	OR[a]	SD[b]	95% CIs[c]		*p-value*
School Social Capital (z-score)	0.92	0.03	0.86	0.98	<0.01
SES composite Index[d]	0.98	0.09	0.82	1.17	0.78
Not married or living with partner	1.07	0.10	0.90	1.28	0.44
Plan to attend college	0.73	0.09	0.57	0.93	0.01
Friends Smoke	2.65	0.21	2.27	3.09	<0.01
Family Cohesion (z-score)	0.93	0.03	0.88	0.99	0.02
Parental oversight (z-score)	0.77	0.02	0.73	0.81	<0.01
Neighborhood social exchange (z-score)	1.00	0.04	0.92	1.07	0.88
Neighborhood informal social control (z-score)	0.99	0.04	0.92	1.08	0.91

[a]Odds Ratio

[b]Standard Deviation

[c]Confidence intervals

[d]A composite index of socioeconomic indicators created from highest household education (no high school degree, high school degree, some college, and 4-year college degree or greater), annual household income (<$25,000; $25,000 - $49,999; $50,000-$99,999; and ≥$100,000), and use of public assistance (yes/no).