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Multilevel Analysis of the Impact of School-Level Tobacco Policies on Adolescent Smoking: The Case of Michigan

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ABSTRACT

BACKGROUND: In efforts to curb and prevent youth smoking, school tobacco policies have become an important and effective strategy. This study explores the degrees and types of tobacco-free school policy (TFSP) enforcement that are associated with adolescent smoking.

METHODS: A multilevel analysis was performed using 983 students who are nested in 14 schools. The individual-level data are drawn from the 2009 Michigan Youth Risk Behavior Survey. The school-level data are drawn from the 2008 School Health Profiles survey.

RESULTS: Two factors are associated with lower adolescent smoking: greater punishment for TFSP violation and more tobacco control communication efforts. By contrast, the factors associated with higher adolescent smoking are designation of a tobacco-free school zone and school-level smoking.

CONCLUSIONS: This study theoretically and methodologically guides researchers to test TFSP effectiveness in other states. Three strategic implications emerge: (1) schools should provide a consistent antismoking message in smoke-free environments; (2) schools should integrate TFSP into a comprehensive tobacco control initiative, including community-wide tobacco control programs and messages; and (3) the way a specific TFSP is promoted and communicated could determine how effective it is.

Keywords: tobacco-free school policy; adolescent smoking; social ecological model; tobacco control.

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Even after decades of nationwide tobacco control efforts, smoking remains the leading cause of preventable death in the United States.[1] Among the methods for reducing tobacco use, one of the most sustainable and cost-efficient is to prevent youths from smoking. Four of 5 smokers begin smoking before age 18, and its addictiveness poses severe difficulties for once-established smokers to quit.[2,3] Because adolescents spend much of their time at school, where they are exposed to risk factors associated with smoking,[4] the Centers for Disease Control and Prevention (CDC) recommends that each school develops and enforces a tobacco-free school policy (TFSP) to curb youth smoking.[2]

A TFSP is a crucial means for controlling adolescent smoking because it influences the school's social environment, the key place where adolescents create and reinforce their attitudes, beliefs, and behaviors.[5] Informed by this reasoning, the Pro-Children Act (PCA) of 2001 prohibits smoking in any indoor facility that was built to provide services for people under age 18 and funded either directly or indirectly by federal government agencies.[6] Such services include kindergarten, elementary or secondary education,

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libraries, health facilities, day care services, or early childhood development.

Researchers have noted that there are limitations to implementing TFSPs.[4] For example, they are difficult to enforce if they have not been clearly communicated and promoted.[7,8] Also, some policies are not comprehensive enough to maintain a tobacco-free environment that applies to everyone on school grounds.[9] Instead, they allow adults to smoke in designated areas or in areas where students cannot observe them. The existence of such areas, though, may undermine school tobacco policy as it applies to students.[10] As for determining whether enforcement is successful, school tobacco policies can be assessed according to the number of punishments that are applied to tobacco-related violations, such as fines, detentions, and suspensions.[11] However, these strictly punitive policies may be ineffective or even counterproductive if they fail to change students' attitude toward smoking.[10]

Another limitation is that a comprehensive TFSP merely forces students to use tobacco off school property. As a result, even if policies reduce tobacco use on school property, they may have no impact on overall tobacco use among adolescents who simply find other places to smoke—particularly where they may be more inclined to smoke owing to peer pressure.[12] As an ironic result, policies may end up creating alternative social environments where peer pressure exerts a greater influence on individual smoking behavior than the policies themselves do. Supporting this claim, a study of elementary school students found that when they see other students smoking near school and in school, they are more likely to take up smoking; by contrast, when students who are subject to strict rules about smoking see other students punished for doing so, they are not significantly more likely to begin smoking.[13]

There continue to be various ambiguities and uncertainties about TFSP effectiveness because existing studies show mixed findings. For this reason, more empirical research is needed. In this context, *effectiveness* refers to the degree to which a given TFSP's goals are achieved. The goal could be not only attitudinal (eg, get students to develop negative attitudes toward smoking) but also behavioral (eg, get students to refrain from or quit smoking). Although results of some studies support the effectiveness of TFSP,[10,12,14-16] others do not.[7,8,17-20] These mixed findings may be due to (1) differences in the measurement of outcome variables, for example, types and levels of adolescent smoking; (2) relative comprehensiveness, rigor, and reach of school tobacco control policies; (3) presence or absence of programs that accompany and support the policies, for example, community or school education, intervention, and regulation programs; (4) differences in efforts to publicize and communicate the policies; and (5) differences in school and student characteristics.[5]

Specifically related to this study's theoretical and methodological approaches, another reason for the mixed findings may be insufficient understanding of how the broader community and sociocultural environment can influence what happens in schools. Several theoretical approaches, notably the social ecological model (SEM), emphasize the importance of understanding social and regulatory environments to predict individuals' health behavior.[21-24] In particular, 3 of SEM's core assumptions are especially relevant for examining school tobacco policy. First, individual health and well-being are always affected by a combination of personal behaviors on one hand and environmental conditions on the other hand. Second, analyses of health and health promotion should address the multidimensional and complex nature of human environments. Third, human actors and their environments can and should be studied at varying levels, from the individual to the institutional to the communal and societal. However, even though SEM has received increased attention, the methods associated with it have not sufficiently caught up to its theoretical aims. To begin overcoming this deficiency, this study performs multilevel modeling well suited to assessing the effectiveness of school-level tobacco policy and contingent programs (school-level variables) on adolescent smoking (individual-level variable).

Another deficiency in this line of research is that most existing studies have been conducted in non-US settings.[7,14,19,20,25] Although there have been some US-based studies conducted during the early stages of TFSP, one investigated only key school stakeholders' opinion about adopting the policy in North Carolina, and another simply reviewed existing school policy documents in New York.[26,27]

Guided by existing literature and theoretical approaches, this study examines the level and types of TFSPs and their impact on adolescent smoking in Michigan. Even though the smoking rate among adults in the United States has decreased, the rate among youths remains unacceptably high.[28] In the case of Michigan, in 2007, 51% of high school students had smoked a cigarette at least once in their lifetime.[29] Although the rate decreased to 46% in 2009, it is almost identical to the high percentage among US high school students.[30,31] In addition, other smoking statistics among high school students are comparable between Michigan and the United States in terms of the percentage of students who smoked cigarettes on at least 1 day during the 30 days before the survey (19% vs 20%) and the percentage of students who tried to quit smoking (54% vs 51%).[30,31] In response, Michigan high schools have made deliberate efforts to improve tobacco control. For example, the 2010 Michigan School Health Profiles (SHP) report indicates

that 64% of Michigan high schools taught 15 key tobacco prevention topics in required courses, whereas only 47% of all US high schools covered an average of 17 tobacco prevention topics in required health education courses.[30,31]

The Tobacco Section of the Michigan Department of Community Health has issued a 5-year strategic plan for preventing and reducing tobacco use. As the number one strategy for achieving its goal, the plan cites the implementation of ''24/7'' TFSP in all Michigan schools. By definition, a 24/7 TFSP prohibits the use of any tobacco products at all times on school property, including school vehicles, and at all on- and off-campus school-sponsored athletic and extramural events. Now that some form of TFSP has been implemented in most Michigan public schools, we focus on the following questions: (1) How can varying degrees of enforcement of the policy affect adolescent smoking? (2) How can other school-level tobacco control and communication efforts implemented together with TFSP affect adolescent smoking?

METHODS

Data

To begin answering these research questions, this study merges individual-level with school-level data. The individual-level data are drawn from the 2009 Michigan Youth Risk Behavior Survey (MiYRBS). The school-level data are drawn from the 2008 SHP survey in Michigan.

The MiYRBS is part of a nationwide survey that the CDC conduct to monitor students' health risks and behaviors in 6 categories that have been identified as most likely to result in adverse outcomes, one of which is tobacco use. Because the data are collected every other year, we analyzed the 2009 data so that there is a clear time order between TFSP as predictors (measured in 2008) and individual students' smoking (measured in 2009) as an outcome variable. All regular public schools containing grades 9, 10, 11, or 12 were included in the sampling frame. Schools were selected systematically with probability proportional to enrollment in grades 9 through 12 using a random start. Then, systematic equal probability sampling was used to select classes from each school that participated in the survey. The overall response rate of MiYRBS is 69% for the 2009 data (86% for the schools and 80% for the students; N = 3411). The overall response rate was calculated using the following formula: (number of participating schools/number of eligible sampled schools) × (number of usable questionnaires/number of eligible students sampled).

The SHP is ''a system of surveys assessing school health policies and practices in states, large urban school districts, territories, and tribal governments.''[32] It is conducted biennially to monitor the status of various school health education requirements and content, as well as school health policies related to HIV/AIDS, tobacco use prevention, and nutrition. On the topics of physical activity and nutrition, several studies have analyzed the data collected in Maine, Utah, and selected states.[33-35]

For our study, we used the 2008 SHP collected from Michigan public school principals and health education teachers for grades 6 through 12, and we analyzed the survey questions that are relevant to policies banning tobacco use on school grounds and to other contingent school tobacco programs.

The data represent school-level characteristics because the school is the unit of analysis. To select schools for the survey, systematic equal probability sampling with a random start was used consistently. Schools were sorted by estimated enrollment in the target grades within the school grade segment (middle schools and junior/senior high schools) before sampling. The response rate was 83% for the 2008 data (N = 333).

These 2 data sets have a unique school ID (BCODE) that allowed us to identify individual students nested within each school. The merged data indicate that 1088 students were nested within 14 high schools in the state. The number of students nested within each school ranged from 38 to 101. Demographic characteristics of the students are as follows: female = 46.5%, male = 52.9%; 9th grade = 17.6%, 10th = 33.4%, 11th = 24.6%, and 12th = 23.3%; White = 64.2%, Black = 18.7%, and Hispanic = 6.6%; ever smoked = 49% and daily smoker = 12%.

Measures

Individual-level variables. The dependent variable was smoking behavior, which was measured by an averaging index of frequency and amount because they were highly correlated ($r = .931$, $p < .001$). *Frequency* was asked as follows: ''During the past 30 days, on how many days did you smoke cigarettes?'' 1 = ''0 days,'' 2 = ''1 or 2 days,'' 3 = ''3 to 5 days,'' 4 = ''6 to 9 days,'' 5 = ''10 to 19 days,'' 6 = ''20 to 29 days,'' 7 = ''all 30 days.'' *Amount* was asked as follows: ''During the past 30 days, on the days you smoked, how many cigarettes did you smoke per day?'' 1 = ''None,'' 2 = ''Less than 1 cigarette,'' 3 = ''1 cigarette,'' 4 = ''2 to 4 cigarettes,'' 5 = ''6 to 10 cigarettes,'' 6 = ''11 to 20 cigarettes,'' 7 = ''More than 20 cigarettes.'' There were 106 missing cases for both (1) frequency and (2) amount. After listwise deletion, the final sample size was 983.

Individual characteristics that served as level-1 predictors include sex (female as a reference), age (ordinal scale with 1 = ''12 years old or younger'' to 7 = ''18 years old or older''), and race (Black and White as dummy coded).

School-level variables. The SHP data contain multiple questions related to school-level tobacco policy and programs, including the following: (1) adoption of a policy prohibiting tobacco use; (2) prohibition of various kinds of tobacco products; comprehensive prohibition of tobacco use are in terms of (3) hours and (4) places; (5) communication of tobacco policy to students, faculty/staff, and visitors; (6) a person in charge of enforcing tobacco policy; (7) designation of a tobacco-free school zone; (8) other antismoking communications; (9) tobacco cessation services; (10) actions taken for students who are caught smoking cigarettes; and (11) stringency of tobacco policy enforcement.

Table 1 presents descriptive statistics for the schools from the SHP data, which include grades 9 through 12 and are comparable to the schools participating in the MiYRBS data. The mean comparison tests between the 169 schools in the SHP and the 14 schools of our inquiry show little statistical difference in terms of the descriptive statistics of the tobacco policy and control programs described above. In addition, most of the schools that participated in the survey show close to 100% adoption of various school tobacco policies, resulting in little variance across schools. Based on these preliminary results and exploratory analysis for potential school-level factors of adolescent smoking, the following school-level factors were included in our multilevel analysis: stringency of tobacco policy enforcement, designation of a tobacco-free school zone, and other antismoking communications. Existing research has also shown some differential impact of school tobacco policy on individual students' smoking according to these school-level factors.[5,7,8,10,11]

Stringency of tobacco policy enforcement was measured with 6 question items: ''When students are caught smoking cigarettes, how often is each of the following actions taken? (1) placed in detention; (2) not allowed in extra-curricular activities; (3) given in-school suspension; (4) suspended from school; (5) expelled from school; and (6) reassigned to alternative school.'' The response options for these items were on a 4-point ordinal scale. To create one index of stringency of tobacco policy enforcement, the items were recorded into yes (sometimes, always, or almost always = 1) and no (never or rarely = 0), and then the ''yes'' response was counted.

Designation of a tobacco-free school zone was measured with 1 binary question: ''Does your school post signs marking a tobacco-free school zone, that is, a specified distance from school grounds where tobacco use is not allowed?'' (1 = yes, 0 = no).

The other antismoking communications variable was measured with 2 binary items: (1) ''During the past two years, has your school gathered and shared information with students and families about mass-media messages or community-based tobacco-use prevention efforts?''; (2) ''During the past two years, has your school worked with local agencies or organizations to plan and implement events or programs intended to reduce tobacco use?'' (1 = yes, 2 = no). The number of ''yes'' answers for the two questions was counted to serve as the other antismoking communications variable.

In addition to the school-level tobacco policy variables, the individual students' smoking variable served as a school-level contextual variable (ie smoking rate) that was measured by aggregating individual students' smoking nested in the schools. Descriptive statistics for individual- and school-level variables are reported in Table 2.

Analysis

Hierarchical linear modeling (HLM) was performed with an estimation of restricted maximum likelihood across the 2 levels (individuals nested in schools). HLM is often more appropriate than ordinary least squares (OLS) regression methods because it acknowledges a unique error structure at each level, which the OLS procedure does not do automatically.[36,37]

To examine whether a multilevel model is appropriate—that is, whether any variance is detected at the multilevel structure—intraclass correlation (ICC) was computed from the empty model, which denotes the null model that has no variable introduced with only random error allowed to be free. Thus, the ICC captures the multilevel variance.

ICC indicates that about 4% of the variation is accounted for at the group level. Because ICC values in educational research are commonly between .05 and .20,[37] the value in this study is rather small. However, demonstrating an ICC larger than 0 means that a group effect exists. Indeed, the variance component of intercept (U0) was statistically significant ($U0 = 0.07$, χ^2 $(13) = 47.71$, $p < .001$), implying that there is significant variability in terms of the mean score of adolescent smoking across schools.

Considering the sensitive and complex nature of multilevel modeling, this study starts from an empty model and goes to a random coefficient model step-by-step, introducing level-1 (individual) and level-2 (school) variables. When there are no strong theories concerning which variables play significant roles as level-2 predictors, it is recommended to perform the procedure by starting with the simplest possible model and including the various types of parameters step-by-step.[27,38] At each step, the results should be inspected to see which parameters are significant and how much residual error is left at the 2 distinct levels for optimal hypothesis testing. The likelihood ratio test (or deviance test) was performed between the 2 models to examine whether more complex models involving

Table 1. **Descriptive Statistics of Tobacco Policy Questions From the School-Level Data (SHP)**

	% (N)		
	2008 SHP (N = 169)	**2009 MiYRBS (N = 14)**	$\chi^{2\dagger}$
Adoption of school tobacco policy			
School adopted a policy prohibiting tobacco use	97.6 (164)	100 (14)	0.34
Types of prohibiting tobacco products			
Prohibit use of cigarettes-students	98.8 (159)	100 (13)	0.16
Prohibit use of cigarettes-faculty	98.8 (158)	100 (13)	0.16
Prohibit use of cigarettes-visitors	96.3 (154)	100 (13)	0.51
Prohibit use of smokeless-students	98.8 (159)	100 (13)	0.16
Prohibit use of smokeless-faculty	94.4 (151)	92.3 (12)	0.09
Prohibit use of smokeless-visitors	87.5 (140)	92.3 (12)	0.26
Prohibit use of cigars-students	93.8 (151)	84.6 (11)	1.58
Prohibit use of cigars-faculty	93.7 (149)	84.6 (11)	1.53
Prohibit use of cigars-visitors	85.2 (144)	84.6 (11)	0.48
Prohibit use of pipes-students	93.8 (151)	84.6 (11)	1.58
Prohibit use of pipes-faculty	93.8 (150)	84.6 (11)	1.55
Prohibit use of pipes-visitors	85.8 (145)	84.6 (11)	0.49
Hours of prohibiting tobacco use			
Prohibit use during school hours-students	98.8 (159)	100 (13)	0.16
Prohibit use during school hours-faculty	97.5 (157)	100 (13)	0.33
Prohibit use during school hours-visitors	96.9 (156)	100 (13)	0.42
Prohibit use during nonschool hours-students	86.4 (146)	100 (13)	1.33
Prohibit use during nonschool hours-faculty	79.5 (128)	100 (13)	3.29
Prohibit use during nonschool hours-visitors	75.0 (120)	92.3 (12)	1.99
Places of prohibiting tobacco use			
Prohibit use in school buildings-students	98.8 (159)	100 (13)	0.16
Prohibit use in school buildings-faculty	98.7 (157)	100 (13)	0.17
Prohibit use in school buildings-visitors	98.7 (157)	100 (13)	
Prohibit use outside on school grounds-students	98.8 (159)	100 (13)	0.16
Prohibit use outside on school grounds-faculty	95.6 (151)	100 (13)	0.60
Prohibit use outside on school grounds-visitors	86.7 (137)	92.3 (12)	0.34
Prohibit use on school buses or other vehicles-students	98.1 (158)	92.3 (12)	1.82
Prohibit use on school buses or other vehicles-faculty	98.1 (156)	92.3 (12)	1.78
Prohibit use on school buses or other vehicles-visitors	95.6 (151)	92.3 (12)	0.29
Prohibit use at off-campus, school-sponsored events-students	97.5 (155)	100 (13)	0.33
Prohibit use at off-campus, school-sponsored events-faculty	85.7 (132)	100 (13)	2.14
Prohibit use at off-campus, school-sponsored events-visitors	62.7 (96)	92.3 (12)	4.61*
Communication of tobacco policy			
School inform prohibit use to students	99.4 (160)	100 (13)	0.08
School inform prohibit use to faculty and staff	92.5 (149)	92.3 (12)	0.00
School inform prohibit use to visitors	84.3 (129)	92.3 (12)	0.60
Prevention policy include actions the school should take when students are caught smoking cigarettes	98.1 (158)	100 (13)	0.25
Person in charge of enforcing tobacco policy			
None	43.0 (64)	36.4 (4)	1.90
Principal	36.2 (54)	27.3 (3)	
Assistant principal	19.5 (29)	36.4 (4)	
Other school administrator	1.3 (2)	.0 (0)	
Designation of a tobacco-free school zone	68.3 (114)	78.6 (11)	0.64
Other antismoking communications			
Gathered and shared information about community tobacco-use prevention efforts	34.9 (59)	35.7 (5)	0.00
Worked with local agencies to reduce tobacco use	36.5 (61)	35.7 (5)	0.00
Tobacco cessation services			
For faculty and staff	1.3 (17)	14.3 (2)	0.22
For students	24.4 (41)	21.4 (3)	0.06
For faculty and staff not on school property	18.9 (31)	3.8 (4)	1.07
For students not on school property	41.8 (69)	53.8 (7)	0.71
	Mean (SD)		***t***
Actions taken for Students who are caught smoking cigarettes[‡]			
Parent/guardian informed	3.98 (0.13)	3.93 (0.27)	1.32

Table 1. **Continued**

	% (N)		
	2008 SHP (N = 169)	**2009 MiYRBS (N = 14)**	$\chi^{2\dagger}$
	Mean (SD)		***t***
Referred to school counselor	2.69 (0.89)	2.43 (0.94)	1.06
Referred to administrator	3.98 (0.24)	4.00 (0.00)	−0.36
Encouraged to attend cessation program	2.62 (0.94)	2.36 (1.15)	0.99
Required to attend cessation program	1.88 (0.90)	1.93 (1.00)	−0.18
Referred to legal authorities	2.72 (0.91)	2.93 (1.07)	−0.81
Stringency of tobacco policy enforcement‡			
Placed in detention	2.21 (1.14)	1.79 (0.97)	1.34
Not allowed in extracurricular activities	3.45 (0.84)	3.23 (0.83)	0.93
Given in-school suspension	2.15 (1.11)	1.92 (1.00)	0.72
Suspended from school	3.52 (0.73)	3.79 (0.43)	−1.35
Expelled from school	1.47 (0.74)	1.38 (0.65)	0.42
Reassigned to alternative school	1.40 (0.68)	1.29 (0.61)	0.61

*$p < .05$.
SHP, School Health Profiles; MiYRBS, Michigan Youth Risk Behavior Survey.
†df = 1.
‡Four-point scale ranging from 1 = never to 4 = always or almost always.

Table 2. **Descriptive Statistics at Individual and School Level**

Variables	Minimum	Maximum	Mean	SD
Individual-level (N = 983)*				
Age	1.00	7.00	5.13	1.16
Sex (female = 1; male = 2)	1.00	2.00	1.52	0.50
Race				
White	0.00	1.00	0.16	0.37
Black	0.00	1.00	0.68	0.47
Smoking behavior†	1.00	7.00	1.57	1.38
School-level (N = 14)				
Stringency of tobacco policy enforcement	1.00	4.00	2.29	.99
Designation of a tobacco-free school zone	0.00	2.00	0.36	0.74
Other antismoking communications	0.00	2.00	0.71	0.91
School smoking rate‡	1.03	1.99	1.54	1.32

*There were a number of missing cases across the variables, which were listwise deleted in the analysis.
†The dependent variable is smoking behavior at the individual level.
‡The smoking variable was aggregated per school and served as a school-level variable in our analysis.

more parameters have a better fit than a less complex model. After fitting, a random intercept and random slope model was explored using all the school-level factors interacting with any of the individual-level factors (cross-level interaction).

Model Fitting

After the empty model was fitted, a random intercept model was fitted with student characteristics (age, sex, and race) as level-1 factors and with tobacco policy and contingent programs (designation of a tobacco-free school zone [TFZSIGN], stringency of tobacco policy enforcement [PUNISH], other antismoking communications [ANTSMKCOM], and school-level smoking [AG_SMK]) as school-level factors. The random intercept model showed that the random effects remained significant only for the 2 dummy race variables (for Black, variance component $(U2) = 1.29$, $\chi^2\ (11) = 30.67$, $p = .002$; for White, $U3 = 0.13$, $\chi^2\ (11) = 19.45$, $p = .053$). However, none of the school-level factors examined in this study served as a statistically significant factor interacting with either of the 2 individual-level variables (ie, cross-level interaction). Thus, our final model was determined as a random intercept model as follows:

Level-1 Model

$$Y = B0 + B1*(Q1) + B2*(BLACK) + B3*(WHITE) + B4*(MALE) + R$$

Level-2 Model

$$B0 = G00 + G01*(TFZSIGN) + G02*(PUNISH) + G03*(AG\_SMK) + G04*(ANTSMKCOM) + U0$$
$$B1 = G10 + U1$$
$$B2 = G20 + U2$$
$$B3 = G30 + U3$$
$$B4 = G40 + U4$$

Statistical significance was determined at a p-value of .10 because the school-level sample size was only 14. This significance level is not uncommon in multilevel research.[39,38]

Last, we performed several analyses to guard against biased estimates. Our analysis includes testing the differences between schools included versus excluded in this analysis (Table 1) and checking outliers, standardized residuals, and normality assumptions for variables at both levels, using approaches similar

Table 3. **Estimates of Fixed Effects on Smoking Behavior**

	Empty Model		Random Intercept Model	
	Coefficient	**SE**	**Coefficient**	**SE**
Mean intercept (γ_{00})	1.54***	0.08	−0.56*	0.21
Designation of a tobacco-free school zone (γ_{01})†			0.05#	0.02
Stringency of tobacco policy enforcement (γ_{02}) †			−0.02#	0.01
School smoking rate (γ_{03}) ‡			1.09***	0.05
Other antismoking communications (γ_{04}) †			−0.04#	0.02
Slope coefficient				
Age (γ_{10})			0.08*	0.03
Black (γ_{20})			0.08	0.03
White (γ_{30})			−0.15	0.13
Male (γ_{40})			0.09	0.08
Deviance	3412.80		3380.05	
No. of parameter	2		16	
χ^2D test (dfD)			36.21 (14)***	

#p < .10, *p < .05, **p < .01, ***p < .001.
Significance test follows *t*-ratio distribution.
†School-level predictors.
‡Smoking rate is an aggregated score of an individual-level variable.

to existing literature.[40] None of these examinations detected that our missing information is nonignorable or that our variables violate normality assumptions. As long as information is missing at random (MAR), or missing completely at random (MCAR), and not nonignorable (NI), HLM is likely to producing unbiased estimates.[36] These analyses lead us to conclude that our own HLM would likely guard against biased estimates. Table 3 presents the results.

RESULTS

The Impact of Individual-Level Factors on Adolescent Smoking

At an individual level, only age seemed to be a significant factor for high school students' smoking ($\gamma 10 = 0.08$, $p < .05$); older high school students seemed to smoke more. By contrast, neither race nor sex was a statistically significant factor for smoking.

The Impact of School-Level Tobacco Control Variables on Adolescent Smoking

First, designation of a tobacco-free school zone was significantly positively related to smoking ($\gamma 01 = 0.05$, $p = .065$). Second, stringency of tobacco policy enforcement was negatively related to individual students' smoking: the higher the level of punishment, the less likely individual students smoke ($\gamma 02 = -0.02$, $p = .096$). Third, a high level of smoking at schools was strongly and positively related to individual students' smoking ($\gamma 03 = 1.09$, $p < .001$). Last, the other antismoking communications variable was negatively related to individual students' smoking ($\gamma 04 = -0.04$, $p = .069$).

DISCUSSION

The school-level data (SHP) show that most Michigan public schools have adopted TFSPs. These policies, moreover, are comprehensive because they prohibit the use of various types of tobacco products under all of the following circumstances: during school and nonschool hours; inside the school, outside on school grounds, and off-campus at school-related events; and among students, faculty/staff, and visitors. In contrast to earlier studies that explored the adoption process for TFSPs in North Carolina school districts,[26] this study shows some significant improvement in terms of adopting the policies, at least in Michigan.

There was a key difference in the comprehensiveness of school tobacco policy between the 169 schools that included grades 9 through 12 in the SHP data and the 14 schools that participated in the MiYRBS survey. The difference was that about 63% of the schools in the SHP data prohibited tobacco use at off-campus school-sponsored events among visitors, whereas 92.3% of the 14 schools in the MiYRBS data prohibited tobacco use among visitors. One possible explanation for this different proportion is an actual increase of high schools in Michigan that adopted a TFSP from the year of 2008, when the SHP data used in this study were collected, to 2009, when the MiYRBS data used in this study were collected. As part of a 2009-2013 5-year strategic plan for tobacco use prevention and reduction, the Tobacco Section of the Michigan Department of Community Health recommended a ''24/7'' TFSP that prohibits the use of any tobacco products at all times both on and off school properties. This strategic effort could conceivably have improved TFSP implementation over the

course of 1 year. However, this explanation is merely speculative, and it would need to be confirmed by a follow-up study on whether each of the schools have indeed improved TFSP implementation over time and, if so, what impact such improvements have had on students' smoking.

Literature shows that the comprehensiveness of a TFSP is related to a lower level of adolescent smoking.[5] It is important to have a comprehensive policy that broadly covers a school's physical place, time of operation, and people because the key idea behind TFSP is to direct the existing impact of social environments onto specific adolescent behaviors such as smoking. This strategy is supported by another study which claims that the long-term success of 24/7 TFSP depends on the ability to maintain a school environment in which no teachers, staff, and students use tobacco products.[26]

If adolescents are provided with comprehensive tobacco-free environments, they will be less exposed to smoking and more likely to acquire the perception that smoking is unacceptable.[27] Compared to the issue whether TFSP is implemented, a more important issue at this point is *how* it is implemented in conjunction with other school tobacco programs.

Our data show that some of the methods and degrees of TFSP implementation affect adolescent smoking. Most notably, the stringency of tobacco policy enforcement seems to have an intended impact on high school students' smoking because the level of individual students' smoking is lower in schools that punish TFSP violations more strictly. This finding is consistent with existing literature.[5,12,14] For example, a study among grades 10-11 in Canada reported that students tended to smoke more in schools where they perceive they will not be punished for doing so.[5] That study, though, was based on adolescents' *perceptions* about punishment regardless of the *actual* level of punishment implemented by the schools. By contrast, this study assessed the impact of the stringency of TFSP enforcement on high school students' smoking as reported by school principals and teachers. In addition to the utility of TFSP enforcement, another implication based on previous research is that it is important for schools to clearly communicate to students what kinds of punishment they will receive when they violate the TFSP.[7]

Furthermore, our data support existing arguments that TFSP should be implemented in conjunction with other school tobacco control programs. Students were less likely to smoke in schools where they share information with students and families about antismoking media messages or community tobacco control programs, including those for not only prevention but also cessation of any kind of tobacco use. Adolescents are surrounded by a variety of risk factors, and a TFSP alone may not be sufficient to ward them all off. A review of school tobacco policies in the State of New York suggested that schools should be open to and use feedback from various stakeholders from their communities, and that they should learn about and use the additional resources that are available to assist them in developing and implementing TFSP and other health-related policies.[27]

Notably, one unintended result this study found was the positive association between designation of a tobacco-free school zone and high school student smoking. A possible reason for this association may lie in the adolescent tendency to rebel against authority. Much research has documented that this rebelliousness is one of the key tendencies that lead adolescents to take up smoking, largely because smoking itself symbolizes rebelliousness.[3,41] Also well documented is that adolescents with risk-taking, rebellious, and sensation-seeking tendencies are more likely to use illicit substances.[42] Accordingly, high school students who see a designated tobacco-free school zone may view it as a temptation to transgress. Another possible reason for this unexpected association might stem from a more fundamental communication issue—students' lack of awareness about the extent of TFSP. There is evidence that students are often unaware of school rules and penalties associated with TFSP.[43] Because our school-level data were collected from school administrators, there could be discrepancies between how they perceive TFSP and how students do. If students are oblivious to such policies, it is reasonable to expect they would have difficulty complying with them.

In addition, the finding that students are more likely to smoke in schools where a high number of students smoke supports the idea that broader social environments need to be considered and, to the extent possible, controlled. This finding is also consistent with existing literature, which documents that students are more likely to smoke in schools where they perceive a relatively high number of student smokers.[5] A key implication of this finding is that, alongside efforts to influence individual psychology, schools also need to make comprehensive efforts to improve and mobilize environmental resources, community settings, and policies.[4,22,44]

Limitations

Even though school tobacco policies are growing in importance, few data are available that could enable researchers to systematically investigate and empirically test such policies' effectiveness on individual students' smoking—particularly in conjunction with other school tobacco control programs. Although we believe that SHP and MiYRBS are the best available

statewide data for the purpose of our study, there are a few limitations that arise from the general scarcity of data.

First, while these 2 data sets incorporate several variables that are related to adolescent smoking, they lack many others. For example, at the individual level, various psychological factors such as sensation seeking, as well as environmental factors such as peer smoking and family smoking, may play a significant role in individual students' smoking. At the school level, individual students' smoking may also be affected by sociodemographic, geographic, and other contextual factors. Accordingly, our study is limited because it was bound by questions already on the survey. Future research would be warranted for developing and implementing a survey that asks various and more detailed questions about school tobacco policies and tobacco-related education programs. Along with a survey, observational studies that actually measure degrees of TFSP enforcement could enhance our understanding of how TFSPs are implemented and whether they are effective.

Second, and related to the first limitation, the statistically significant importance of the TFSP and program factors should be considered exploratory and preliminary in nature because the HLM procedure is sensitive to inclusion and omission of variables. Although we performed analyses testing the nature of missing information (ie, schools included in, as opposed to excluded from, the study) and checking outliers and residuals, a sensitivity analysis would be a useful addition for more robust and accurate model testing.

Third, the school-level sample size was small, which resulted in a small ICC coefficient and weaker statistical significance. Nevertheless, the fact that significant variance was detected across schools in the empty model should not be disregarded. In addition, because of the small sample size, another limitation lies in having to adopt the statistical significance level of $p < .10$. A systematic effort should be made to collect larger statewide and nationally representative data, via multistage sampling, to replicate and expand our findings and to explore the effectiveness of TFSP further.

Fourth, the nature of survey data does not allow for rigorous testing of causality. Thus, the significant relationships between TFSP variables and individual students' smoking should be understood as correlational rather than causal. Well-designed TFSP interventions with communication and other conditions manipulated could further advance knowledge of TFSP effectiveness.

Last, it should be noted that our findings are specific to Michigan and limited in their generalizability to other states and to the United States as a whole because of differences in geography, smoking norms and regulations, and tobacco control expenditures.

IMPLICATIONS FOR SCHOOL HEALTH

Some existing studies have noted that adoption of TFSPs alone may not be sufficient in preventing and curbing adolescent smoking.[18] In addition to adopting TFSPs, it would be just as important to identify more effective ways of implementing the policies and clearly communicating them to adolescents. In particular, some of the mixed findings on TFSP effectiveness suggest 2 key implications: (1) schools should provide a consistent antismoking message in smoke-free environments and (2) schools should integrate TFSPs into a comprehensive tobacco control initiative, including community-wide tobacco control programs and messages.[18] Existing research that systematically reviews school-based tobacco control programs supports a comprehensive and multifaceted tobacco control approach that would pursue the following aims: protecting adolescents from exposure to tobacco, preventing them from using tobacco, helping them quit using tobacco, and developing messages that portray tobacco use as abnormal.[45,46]

Also, our unexpected findings imply that, when implementing TFSP, policymakers and enforcers should try to develop effective methods of communication that could avoid provoking rebelliousness. Two of these methods are to use target-specific message features based on pretesting and to develop messages that are not overtly coercive or authoritarian.[41] Moreover, given the strong impact of peer influence among adolescents, school tobacco policies could even be promoted by students themselves, for example, in their informal everyday interactions and conversations, or in the group communication afforded by social media, or even through formal communication events such as video contests. The advantage of using such channels to promote TFSPs is that students would be more likely to communicate the policies to their peers in a less authoritarian and more relatable fashion. Regardless of which method works, though, it is important to make sure, ideally through message testing, that students understand the policy accurately. In particular, a major task for health communication researchers is to find out more about communication strategies that could effectively promote TFSP. As an initial step in this direction, a North Carolina-based study suggested several health communication strategies, including: (1) develop a positive message to promote TFSP as a prevalent norm; (2) share successful stories across a wide array of schools; and (3) involve adolescents through their personal stories and positive experiences regarding TFSP.[47] Informed by such suggestions, a media campaign could also serve as a communication strategy for promoting TFSP.

Conclusion

As the adolescent smoking rate continues to fluctuate, school policy makers who need to find more effective ways to prevent and curb adolescent smoking should try to understand multilevel factors. Such an understanding could inform more concerted efforts to integrate policy implementation and other tobacco control programs.

Human Subjects Approval Statement

This study was based on secondary data collected under the auspices of the US Centers for Disease Control and Prevention and the Michigan Department of Community Health and is thereby exempt from institutional review board approval.

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