Multiple Levels of Influence That Impact Youth Tobacco Use

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Abstract

Objective—Multiple levels of influence interplay to impact youth tobacco use. We work towards understanding important policy and environmental strategies that are associated with youth tobacco use behaviors.

Methods—We utilized data from participants of the Monitoring the Future (MTF) study and linked national data from multiple sources to assess correlates of youth tobacco use behaviors across individual, family, school, community, and state-level policy influences.

Results—Higher cigarette prices had the strongest association with youth tobacco use behaviors. Demographic and socio-economic characteristics at the individual, familial, and community/school-levels were associated with youth tobacco use behaviors.

Conclusions—In the present study, we confirm that higher cigarette prices could help to reduce youth tobacco use behaviors. Several states are still lagging behind in terms of their low cigarette tax and they should enact tax policies to reduce youth tobacco use.

Keywords

smoking; nicotine; adolescent; tobacco

Despite great progress on curbing tobacco use in the United States (US), it is still the leading cause of preventable morbidity and mortality.[1,2] Whereas cigarette smoking in the past month decreased from 28% in 1975 to 8% in 2014, the increasing use of non-cigarette tobacco products among youth (eg, e-cigarettes, hookah) is worrisome and their use may lead to cigarette smoking and/or poly-tobacco use behaviors.[3–9] Because the vast majority of adult regular smokers (90%) initiate tobacco use by age 18 years, it is important for tobacco prevention efforts to target the prevention and reduction of tobacco use among adolescents.[10]

Formative biological and social transitions occur in adolescence, and researchers have put forth extensive effort toward understanding both the risk and protective factors that impact tobacco use behaviors during this critical time of development.[11–17] There is consensus that social forces from one's family and peers interact in a dynamic and complex way to influence youth tobacco use behaviors.[15,18–21] Even more distal influences (ie, further from the individual), such as anti-tobacco policies and anti-tobacco efforts delivered in schools, like-wise can influence youth tobacco use behaviors.[22–27] Thus, a multidimensional ecological framework that accounts for the complexity in overlapping and interacting determinants of tobacco use behaviors is a more comprehensive model than ones that focus on a specific aspect (eg, SES) of a particular life domain (eg, family).[28–30]

The aforementioned youth tobacco use behaviors are impacted by proximal levels of influence including one's socio-demographic characteristics (eg, sex, age, racial/ethnic minority status) and family status.[31,32] For instance, young people living in single-parent households and/or with lower socioeconomic status have increased risk for tobacco use.[32–35] In addition, the average US student will spend 180 days in a school setting, meaning that for approximately half the year, adolescents have the opportunity to interact with peers at school on a daily basis.[36] Therefore, school characteristics, although more distal than individual and familial factors, are important predictors of tobacco use because they depict the social surroundings where youth spend most of their daily lives.[37–39]

Anti-tobacco control policies and campaigns delivered at a population level are desirable for their potential to reach a mass audience despite their distal relation to youth.[40–42] For instance, higher cigarette prices and smoke-free indoor air policies have been well documented as effective strategies for preventing the uptake of tobacco use as well as reducing the cigarette smoking behaviors of youth.[43–45] Similarly, media campaigns delivered through television, radio, print, and billboards are costly for reaching a mass population but can be a worthwhile expense for reducing cigarette smoking uptake among young people.[46–50] Correspondingly, mass media campaigns are considered to be an integral component of a comprehensive tobacco control program.[51–53]

There is a vast amount of literature that examines specific risk and protective factors for tobacco use behaviors.[15,18–21] Yet, understanding how multiple levels of influence interplay to impact youth tobacco use is challenging because of the unique and numerous data sources

that must be linked to analyze different levels of the social hierarchy simultaneously. As such, there is a paucity of research utilizing an ecological approach despite its value for comprehensively explaining youth tobacco use behaviors. In response, the present study utilizes nationally representative data to study the integrated effects of individual, family, school, community, and state-level influences on youth cigarette and smokeless tobacco use behaviors. In essence, we aimed to work towards understanding important policy and environmental strategies for reducing tobacco use behaviors among young people using a comprehensive and theoretically relevant approach. Based on extant evidence, we hypothesized that the multiple levels of influence we examined in our models would exhibit varying levels of associations with youth tobacco use behaviors. We expected to find strong associations between individual and family-level variables and tobacco use because they are proximate mechanisms. We also expected to find effects of varying strengths among school, community, and state-levels and tobacco use behaviors given their distal levels of influence.

METHODS

The present study utilized data from 2000–2006 because these are the years when data at a national level on 2 primary independent variables were available (ie, anti-tobacco media campaigns and school tobacco policies).

Data Source and Respondents

We utilized data on 8th, 10th, and 12th grade students from the Monitoring the Future (MTF) study, an ongoing national study (since 1975) of the substance use behaviors of adolescents conducted by the Institute for Social Research at the University of Michigan and sponsored by the National Institute on Drug Abuse.[54] Students complete one of 4 different surveys for 8th and 10th graders or one of 6 different surveys for 12th graders. The forms are dispersed to participants in an ordered sequence that guarantees equally random subsamples.

Dependent Variable

The dichotomous dependent variables included cigarette smoking and smokeless tobacco use in the last 30 days and *daily use* of cigarettes. Current cigarette smoking was assessed by an item that queried participants on frequency of cigarette smoking in the past 30 days. Participants who responded positively to any cigarette smoking in the past 30 days were defined as *a current cigarette user*. Similar methods were used to define a *current smokeless tobacco user*. Participants who endorsed at least 1 cigarette per day in the past 30 days were defined as *daily cigarette smokers*.

Primary Independent Variables. Individual, Familial, and School-level Characteristics

We controlled for student-level demographic variables including sex, age, race/ethnicity, parents' educational attainment (neither parent achieved a high school diploma versus having at least one parent who completed and/or achieved more than a high school diploma), and number of parents that currently live in the home (none/one/both). We also controlled for type of school (public/private), school size (based on the number of students from the targeted grade eligible for the survey), percent of students receiving free or reduced cost lunch, and percent of students who are black or Hispanic, and population density.

Primary Independent Variables. State-level Policies

State excise tax per pack of cigarettes—We utilized a historical compilation of annual state cigarette excise tax data from "The Tax Burden on Tobacco" to measure increases in cigarette prices.[55] For this analysis, the reported results were adjusted for inflation to reflect dollars from 2012. This adjustment was made using the Bureau of Labor Statistics (www.bls.gov/cpi/) consumer price index.

Smoke-free indoor air (SFA) policies—We used state-specific policy data from the ImpacTeen State-Level Tobacco Legislative Database to examine SFA policies, PUP penalties, and youth access to tobacco laws. For SFA policies, 3 key policies are considered that include those covering private worksites, restaurants, and bars. For this rating system, there are 3 key levels for each policy that range from no restrictions (score 0) to a complete ban (score 2) resulting in composite scores ranging from 0 to 6.

Possession/use/purchase (PUP) penalties—PUPs include consequences such as fines, tobacco cessation classes, and community service and/or driver license suspension. States were coded for the presence or absence of a state law prohibiting minors from (1) possessing, (2) using, and/or (3) purchasing tobacco products. A PUP index was calculated as the sum of the number of possession, use, and/or purchase laws in each state in a given year (possible values: 0 = no PUP laws; 1 = 1 PUP law present; 2 = 2 PUP laws present; 3 = all 3 PUP laws present).

Youth access to tobacco laws—For youth access to tobacco laws, we used a rating system developed by Alciati et al,[56] which measures the extensiveness of state tobacco control youth access laws. Nine state laws that prohibit youth access to tobacco were coded and summed to establish the total youth access to tobacco score. The composite score ranges from 0 to 31 with a higher score indicating stricter policies.

Synar retailer violation rate (%)—We obtained state retailer violation rates from Substance Abuse and Mental Health Services Administration for the years 2000–2006 as a way to quantify compliance with laws prohibiting the sale of tobacco to youth. Lower rates are indicative of fewer retailer violations statewide.

Acres of tobacco harvested—Although not a state policy, we included the number of acres of tobacco harvested per state as a covariate in our models to account for a culture that may be supportive of tobacco use. These data were obtained from the US Department of Agriculture, National Agricultural Statistics Service.[57] The number of tobacco acres harvested per state was only available for the years 1997, 2002, and 2007; thus, data for the remaining years needed for our study were estimated using linear interpolation.

Primary Independent Variables. School-level Policies

School-level policy variables to deter youth tobacco use came from the Youth, Education, & Society (YES) Surveys of School Principals, a cross-sectional nationally representative study of US secondary schools also participating in MTF. The 2 school-based tobacco policies that were assessed in the current study included monitoring compliance to the

school's tobacco policy and the severity of students' punishment when caught violating the tobacco policies.

The level of monitoring compliance to the school's tobacco policy was measured by averaging 7 items that assess students' compliance in school (5 items) and at school-sponsored events (2 items). School administrators indicate on a 5-point scale (1 = *not at all strictly* to 5 = *very strictly*) how strictly they monitor tobacco use during the school day in school buildings, parking lots, playing fields, school grounds, and school buses, in addition to school-sponsored sporting and social events.

School administrators also reported on items related to the actions that they take when students were found to be in violation of the tobacco use policy. Using similar methods published elsewhere,[58] schools were assigned scores according to severity of their punishments to misbehaviors, taking into consideration whether the student's violation was the first, second, or third (or more) time. Fifteen possible disciplinary actions were rated on a 7-point scale where 1 = *least severe* and 7 = *most severe*. Data on the severity of consequences for violating school tobacco policies were only available through 2003.

Primary Independent Variables. Anti-tobacco Media Campaigns

Commercial ratings purchased from Nielson Media Research were used to examine average audience exposure to anti-tobacco campaigns that are representative of those that were shown on any of the Nielsen Monitor-Plus monitored network and cable television distributors nationally and for local spot, clearance, and syndication television across the largest 75 media markets (called *designated market areas*) in the US for the years 2000–2006. These 75 markets accounted for most of the viewing households in the US (78%). We used Nielson's Targeted Rating Points (TRPs) to specifically examine exposure in adolescents who are ages 12–17 over a 4-month period. The Nielsen data were linked to individual-level data from the MTF based on state and county Federal Information Processing Standard (FIPS) code of the respondents' schools. TRP values estimate the reach and frequency of advertising to a targeted group. One hundred (100) TRPs are equal to one exposure. A depreciated sum of mean exposure to anti-tobacco advertising over 4 months (survey month plus the 3 preceding months) was calculated using existing methods.[59] For the purposes of analysis, we created 2 dummy variables (reference group = 0 TRPs): (1) greater than zero but less than one mean exposure; and (2) one or more mean exposures.

Statistical Analysis

Logistic regression was used to model the likelihood of each dichotomous tobacco outcome (current cigarette use, daily cigarette use, current use of smokeless tobacco) in 2000 through 2006. Participants that were included in the analysis were those students participating in the MTF survey 2000–2006 whose schools also participated in the YES survey, and who were in the top 75 designated market areas (thus had anti-smoking advertising data). The models were built in 2 steps. First state tobacco policies (including smoke-free air score, cigarette excise tax, PUP index, youth access to tobacco score, and Synar retailer violation rates), level of school tobacco policy monitoring, and exposure to anti-smoking advertising, were each examined separately as independent variables, adjusting for individual, familial, and

school characteristics as well as state tobacco acres harvested and survey year. Results from this first stage of model development are discussed only briefly, and results are shown in Appendix A. Second, full models were run including all covariates. Each grade level (8th, 10th, and 12th grades) was modeled separately because effects of factors influencing substance use may differ between older and younger teens.[60,61] In addition, past MTF studies have examined substance use outcomes separately by grade level;[60–64] therefore, we opted to utilize a similar approach. Separate models also were run for 2000 through 2003, including the above independent variables, as well as severity of punishment for violation of the school's tobacco policy (this variable was not available after 2003). Parameter estimates and standard errors were calculated using the SAS (Version 9.2, SAS Institute, Cary, NC) procedure "surveylogistic," employing state (the highest level of nesting) as the clustering unit and applying sampling weights to adjust for differential selection probabilities due to the survey's multi-stage complex sample design. Adjusted odds ratios and 95% confidence intervals are reported. Analyses were restricted to students for whom both school tobacco policy data and Nielsen data on anti-smoking advertising exposure were available (8th grade weighted N = 55,520, 10th grade weighted N = 51,614, and 12th grade weighted N = 46,514).

RESULTS

Demographic Characteristics and Tobacco Use

Characteristics of the 8th, 10th, and 12th graders for 2000–2006 in our sample are presented in Table 1. Past 30-day cigarette use was lowest among 8th graders (10%), followed by 10th graders (17%), and 12th graders (26%). The percent of current smokers who smoked daily was approximately 46%, 54%, and 62% for 8th, 10th, and 12th grade, respectively. Rates of smokeless tobacco use were much less than rates of current cigarette use (smokeless tobacco use 8th graders 4%, 10th graders 5%, 12th graders 7%). A little over half of the sample for each grade was female, the majority was non-Hispanic white, most lived in a house with 2 parents, and over 70% had at least one parent with education higher than high school. Additional demographic characteristics and school characteristics are shown in Table 1.

Median tobacco policy monitoring scores were approximately 4.5 for all grades and the median state cigarette excise tax students were exposed to was $0.69 to $0.77 for the 3 grades. Medians for exposure to other state tobacco policies are also shown in Table 1. Regarding exposure to anti-smoking advertising, across grades nearly one-fourth of students were in media markets with no exposure (8th graders 24%, 10 graders 25%, 12th graders 19%). Over half of the students were in media markets with greater than zero but less than one mean exposure (8th graders 56%, 10th graders 62%, 12th graders 62%), and only 1 in 5 were in markets with one or more mean exposures.

Eighth Grade Multivariable Models

Models that examined tobacco use as a function of each policy and anti-smoking advertising variable separately (adjusting for individual, familial and school characteristics) among 8th graders are shown in Appendix A, Table S1. Higher cigarette excise taxes were significantly associated with decreased odds of current and daily cigarette use as well as current

smokeless tobacco use. Stronger SFA policies were associated with decreased odds of daily cigarette use. Greater exposure to anti-smoking advertising was associated with decreased likelihood of current cigarette and smokeless tobacco use.

Results from full multivariable logistic regression models including all independent variables are provided in Table 2. Regarding individual-level demographic variables, male students had decreased odds of current cigarette use but increased odds of smokeless tobacco use. Participants who were age 14 or older had increased odds of all 3 tobacco use outcomes. Black students had decreased odds of all current and daily cigarette use, but Hispanic students had increased odds of current cigarette use. Family-related factors also impacted tobacco use. Students with at least one parent with more than a high school degree were at decreased risk for all 3 tobacco outcomes, whereas those without both parents in the home were more likely to use tobacco.

Regarding school/community characteristics, students whose school had a higher percent of students receiving free/reduced cost lunch were more likely to use tobacco, and those in schools with higher percentages of black or Hispanic students had decreased odds of all 3 tobacco use outcomes. Students in public schools had greater odds of daily smoking. Students in small or medium sized schools (versus large schools) had decreased odds of current smoking and daily smoking, and students in SMSAs had decreased odds for smokeless tobacco use.

The only state tobacco policy significantly associated with reduced tobacco use among 8th graders was cigarette taxes. Whereas higher cigarette taxes appeared protective of current and daily cigarette use, this level did not reach statistical significance. However, higher cigarette taxes were associated with decreased odds of current use of smokeless tobacco. Living in a state with a $1 higher cigarette tax reduced the odds of smokeless tobacco use by approximately 30%. School monitoring for tobacco policies was not significantly associated with any of the outcomes.

Being in media markets with >0 mean exposure to anti-smoking advertising was significantly protective of current use of cigarettes and current use of smokeless tobacco. Compared to 8th grade students in media markets with no exposure to anti-smoking advertising, exposure to < 1 TRP was associated with 15% reduced odds of current cigarette use, and 31% reduced odds of current smokeless tobacco use. Exposure to ≥ 1 TRP reduced the odds even more so, with 24% reduced odds for current cigarette use and 45% reduced odds for smokeless tobacco use.

Tenth Grade Multivariable Models

When we examined each policy and anti-smoking advertising variable in separate models, higher PUP index was associated with increased odds of smokeless tobacco use (results shown in Appendix A, Table S2) among 10th graders. No other policies or advertising exposure were significantly associated with tobacco use in these models.

Results of full multivariable models among 10th graders including all independent variables are shown in Table 3. Variables with strong associations with tobacco use were individual,

familial, and school-level characteristics. Tenth grade boys were less likely than girls to use cigarettes, but more likely to use smokeless tobacco. Those who were 16 or older had increased odds for all 3 tobacco outcomes. Black or Hispanic students were less likely to use tobacco. Students with at least one parent with more than a high school education had decreased odds of all 3 tobacco outcomes, whereas those without both parents in the home were more likely to use tobacco. Those in public schools were more likely to be daily smokers, and those in schools with a higher percentage of students receiving free/reduced cost lunch were more likely to use smokeless tobacco. Students whose school had a higher percentage of Hispanic students, and those living in a SMSA were less likely to use tobacco.

None of the state tobacco policies were significantly associated with any of the tobacco use outcomes. Students in states with greater number of harvested tobacco acres were at increased odds of current cigarette use and current smokeless tobacco use. Living in media markets with > 0 TRP exposure to anti-smoking advertising was not significantly associated with any of the tobacco use outcomes, nor was school tobacco policy monitoring.

Twelfth Grade Multivariable Models

When we examined each policy and anti-smoking advertising variable in separate models (shown in Appendix A, Table S3), higher cigarette taxes and SFA scores were associated with reduced odds of all 3 tobacco use outcomes. In addition, higher Synar retailer violation rates were significantly associated with increased odds of all 3 tobacco use outcomes.

Table 4 provides results from 12th grade models including all independent variables. Twelfth grade males were slightly more likely to be current users of cigarettes, and were much more likely to use smokeless tobacco. Those who were 18 or older had increased odds of current cigarette or smokeless tobacco use. Black and Hispanic students were less likely to use cigarettes or smoke daily; black students also were less likely to use smokeless tobacco. Not having both parents in the home increased odds of current cigarette use and daily smoking, and having more educated parents decreased the odds of these outcomes and smokeless tobacco use. Students in schools with a higher percentage of Hispanic students had decreased odds of all 3 tobacco outcomes. Those in small schools (vs large) were more likely to be daily smokers, and those in medium size schools were more likely to use smokeless tobacco.

Higher cigarette excise taxes were significantly protective of current cigarette use and current use of smokeless tobacco. Living in a state with $1 higher cigarette tax reduced the odds of these outcomes by 16% to 33%. Higher smoke-free air scores were associated with reduced odds of smokeless tobacco use (1 point higher score associated with 10% reduced odds of use). Unexpectedly, a higher youth access to tobacco score was associated with slightly increased odds of smokeless tobacco use. School tobacco policy monitoring and living in media markets with >0 TRP for exposure to anti-smoking advertising were not significantly associated with any of the tobacco use outcomes.

Severity of Consequences for Violating School Tobacco Policies

Data on the severity of consequences for violating school tobacco policies were only available through 2003. Median severity of consequences scores during 2000–2003 were 4.9

(inter-quartile range [IQR] 4.3–5.9) for the 8th graders, 4.7 (IQR 4.0–5.9) for 10th graders, and 4.9 (IQR 4.2–5.6) for 12th graders. Models restricted to years 2000–2003 included the same independent variables as models presented in Tables 2–4, but also including the score for severity of consequences for violating school tobacco policies as a predictor. In each grade, there were no statistically significant associations between school severity of consequences and any of the tobacco outcomes.

DISCUSSION

This study makes important contributions to tobacco research and tobacco control policy by using linked national data from multiple sources for a simultaneous examination of the relative contributions of proximal and distal factors that are known to be associated with youth tobacco use behaviors. Additionally, our study spans the entire spectrum of adolescence by examining data from middle-school through high-school. Our analyses showed that Caucasian youth have the highest risk for tobacco use with the exception of 8th graders where Hispanics had the most risk. Related, we found that schools with a higher percentage of minority students tended to be a protective factor for youth tobacco use behaviors. For the most part, our findings corroborate the well-documented findings that report African-American and Hispanic young adults use tobacco less and initiate tobacco use later in life compared to their Caucasian counterparts.[65,66] Still, despite their delayed onset of tobacco use versus Caucasian youth, members of minority groups have demonstrated consistently higher smoking-related illness and mortality rates.[67] Therefore, whereas our findings make important progress towards signaling who is at risk for youth tobacco use and when this risk occurs, reducing youth tobacco use behaviors across all individual-level characteristics should stay a public health priority.

Correspondingly, familial-level factors were also strong correlates of tobacco use behaviors, specifically parental educational attainment and number of parents in the household. In addition, tobacco use was higher at times when participants attended schools with more students receiving free or reduced cost lunch. It is widely recognized that one's life circumstances can profoundly impact one's tendency to engage in risk behaviors and it may be that the family and school characteristics that we measured are indicative of home-life and/or community/school conditions (eg, socio-economic status).[26] Thus, our findings support the contention that tobacco control advocates should work towards reaching young people whose social and/or economic situations may be influencing their decisions to engage in tobacco use.

Our study found that higher cigarette prices were also strongly associated with reduced youth tobacco use behaviors even after controlling for influential proximal and distal factors but this occurred only among 12th graders. Our findings corroborate other studies that have similarly found that the cigarette use behaviors of older teens are more responsive to price when compared to younger teens.[68–70]

Existing studies have posed numerous reasons to explain this price sensitivity including their limited access to disposable income and short-history of tobacco use potentially creating a response to even small price increases in cigarettes.[71,72] In any case, our results carry

important implications for several states that are lagging behind in terms of their low cigarette tax. For instance, state-level cigarette taxes vary widely with a range from 17 cents per pack in Missouri to $4.35 in New York. In addition, our findings are relevant for targeting high school seniors who are at a critical period in their development when tobacco use behaviors often transition into addictive patterns.

We found that higher smoke-free indoor air (SFA) policy scores reduced the odds of tobacco use, but only in models that did not include other state and school policies or exposure to anti-smoking advertising. When including all of these covariates, significance was lost, perhaps because the effects were confounded by cigarette taxes, which tend to have a stronger effect.[73] That effect notwithstanding, continued support for smoke-free air legislation is encouraged because of its success in reducing secondhand smoke exposure and modifying social norms regarding the permissibiliy of smoking.[74]

We found fewer significant associations between other tobacco control policies and youth tobacco use. In the case of PUP tobacco laws, they have been criticized for a number of reasons including their endorsement by tobacco companies and the low likelihood of detection among youth.[75] Nevertheless, efforts that strive to prevent and decrease tobacco use at a population-level are relevant to sustain because of the messages they may send to youth about tobacco-related harms and their benefits to society (ie, smoke-free air laws).

Exposure to anti-tobacco media campaigns was associated with reduced likelihood of cigarette smoking and smokeless tobacco use behaviors, but these effects were limited to the youngest students (8th graders) in our sample. It may be that the tobacco attitudes of younger students are more malleable versus their older counterparts, and that the 8th graders responded more readily to the anti-tobacco media messages.[76] On the other hand, our findings may be due to the low exposure to anti-tobacco media campaigns across all youth in our study. A related factor may be that exposure to anti-tobacco campaigns are captured on the population level, not the individual level, which limits the precision of the ratings. Similarly, we found that the level of monitoring of the school tobacco-related policies and the severity of punishment for students who were caught violating these policies have minimal to no impact on reducing youth tobacco use behaviors. A significant barrier hindering the efficacy of school-based and media campaigns that deliver anti-tobacco messages is their inability to compete with other, more salient environmental influences, namely pro-tobacco messages delivered by the media and peers.[77–80] Still, anti-tobacco campaigns, whether delivered in schools or via the media, continue to be an essential part of a comprehensive tobacco control program; it is important to refine the salient school and media-based strategies that have the potential to impact youth tobacco use behaviors.

Among the limitations of this project is our use of cross-sectional data, which leaves us unable to make direct causal inferences. In addition, although the implications of our study are significant for tobacco control efforts, we acknowledge that our data are relatively dated, and therefore, do not account for more temporal changes in the tobacco culture, including an emergence of new tobacco that may appeal to young people. Nevertheless, in the present study, we utilize an ecological approach to work towards comprehensively explaining youth tobacco use behaviors, and in doing so, we highlight how such rigorous analysis could be

valuable for understanding how multiple levels of influence interplay to impact youth tobacco use. Additionally, MTF is a school-based survey that does not include data from high school dropouts or adolescents schooled at home. We further acknowledge that in-school surveys can underestimate the substance use of certain populations but note that our findings will be highly relevant for the majority of youth in this country (~90%) and for school-based prevention programs. In addition, measures of enforcement beyond the Synar retailer violation rate are important to consider, but are not currently available, and were therefore, omitted from analyses. Nielsen data only account for 78% of the US markets, which could omit US regions where tobacco use behaviors among young people is prevalent (eg, rural areas), and it is possible that omitting these areas from our analysis could account for the null findings. Likewise, although we evaluate multiple levels of influence, it is beyond the scope of any study to examine every known determinant of youth tobacco use. Therefore, it is possible that unmeasured variables are influencing our models and future studies should continue to explore the causal pathways to tobacco use behaviors (for eg, understanding how higher cigarette prices reduce smokeless tobacco use behaviors). Similarly, we focus our analyses on state and school-level policies and programs where prevention initiatives are usually decided upon and implemented versus at more regional levels.

Despite the limitations, the implications that are derived are significant for tobacco use prevention efforts. Our findings show that multiple levels of influence are important to consider for potentially impacting youth tobacco use, especially demographic and socio-economic characteristics at the individual, familial, and school-levels. Communities have the potential to reinforce tobacco-related norms of families who reside there, and we found that community characteristics, namely racial/ethnic makeup, may also influence youth tobacco use behaviors. In addition, from the numerous tobacco control policies that we examined, higher cigarette prices had the strongest association with youth tobacco use behaviors, and this has important implications for the states in this country where cigarette taxes remain considerably low. Furthermore, anti-tobacco media effects demonstrate success with reducing youth tobacco use but we found that 25% of students had no exposure to anti-tobacco media and overall exposure was low.

IMPLICATIONS FOR TOBACCO REGULATION

This study takes important steps towards delineating the multiple levels of influence that are strong correlates of youth tobacco use behaviors and should be considered as part of a comprehensive tobacco control agenda. Increasing taxes on cigarettes and other tobacco products should be enacted but do fall outside US Food and Drug Administration (FDA) authority. Thus, we conclude by acknowledging a number of available options to the FDA that could limit the appeal of tobacco products to young people. For instance, the use of graphic warning labels and plain packaging are effective strategies for reducing tobacco use in other countries,[81–84] but they have not yet been implemented in the US. In addition, limiting the marketing novel tobacco products (ie, hookah and electronic cigarettes) is essential for preventing their initiation among young people. Furthermore, public health campaigns addressing the harms of tobacco use, especially the use of emerging tobacco products, should continue to remain a high priority.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1

Characteristics of Participants, 2000–2006

Variable	8th graders Overall weighted N = 55,520 Weighted N (weighted %)	10th graders Overall weighted N = 51,614 Weighted N (weighted %)	12th graders Overall weighted N = 46,514 Weighted N (weighted %)
Tobacco use			
Currently uses cigarettes	5676 (10.2)	8754 (17.0)	12,113(26.0)
Smokes daily	2600 (4.7)	4766 (9.2)	7558(16.2)
Currently uses smokeless tobacco[a]	944 (3.6)	1286(5.2)	532 (6.9)
Individual-level characteristics			
Sex			
Male	26,637 (48.0)	25,398 (49.2)	22,101 (47.5)
Female	28,883 (52.0)	26,216(50.8)	24,414(52.5)
Age			
13 years	23,287(41.9)	-	-
14 years	32,233(58.1)	-	-
15 years	-	22,264(43.1)	-
16 years	-	29,351 (56.9)	-
17 years	-	-	20,586 (44.3)
18 years	-	-	25,929 (55.7)
Race			
Non-Hispanic White	36,117(65.1)	35,880 (69.5)	34,001 (73.1)
Non-Hispanic Black	7322 (13.2)	6243(12.1)	4313(9.3)
Hispanic	5605(10.1)	4748 (9.2)	4198(9.0)
Other	6476(11.7)	4743 (9.2)	4002 (8.6)
Familial-level characteristics			
Parent's education			
Both parents high school	15,743 (28.4)	13,575 (26.3)	12,217(26.3)
At least one parent >high school	39,777(71.6)	38,040 (73.7)	34,298 (73.7)
Number of parents in the home			
None	1833 (3.3)	1697(3.3)	2360(5.1)
One	11,499(20.7)	10,542 (20.4)	10,751(23.1)
2	42,188(76.0)	39,375 (76.3)	33,403 (71.8)
School-level characteristics			
Type of school			
Public	50,550(91.1)	45,864(88.9)	41,180(88.5)
Private	4970 (9.0)	5750(11.1)	5334(11.5)
School size			
Small (1–99 students in targeted grade)	11,597(20.9)	3891 (7.5)	7182(15.4)
Medium (100–199 students in targeted grade)	30,151(54.3)	34,820 (67.5)	28,470(61.3)

Variable	8th graders Overall weighted N = 55,520 Weighted N (weighted %)	10th graders Overall weighted N = 51,614 Weighted N (weighted %)	12th graders Overall weighted N = 46,514 Weighted N (weighted %)
Large (200 students in targeted grade)	13,772 (24.8)	12,903 (25.0)	10,862 (23.4)
% of students on subsidized lunch, median (IQR)	27.0(13.0–50.0)	20.0 (6.3–38.0)	20.0 (7.6–37.0)
% of students Black, median (IQR)	3.5(1.0–17.4)	4.3(1.6–16.0)	4.0(1.0–14.0)
% of students Hispanic, median (IQR)	2.0(1.0–9.0)	2.0(1.0–9.0)	3.0(1.0–9.0)
Population density: Standard Metropolitan Statistical Area (SMSA)			
Non SMSA	12,146(21.9)	7429 (14.4)	8968(19.3)
Other SMSA	22,879(41.2)	25,480 (49.4)	21,004(45.2)
Large SMSA (self-representing)[b]	20,495 (36.9)	18,705 (36.2)	16,542 (35.6)
State tobacco acres, median (IQR)	79.6 (0–3290)	715.2(0–4405)	214.4 (0–4405)
State tobacco policies median (IOR)			
Smoke-free air score	2 (0–3)	2 (0–3)	2 (0–3)
Cigarette excise tax ($)	0.69(0.41–1.25)	0.77(0.41–1.42)	0.74(0.41–1.39)
PUP score	2(1–3)	2(1–3)	2(1–3)
Youth access to tobacco score	16(12–25)	15(11–20)	15(11–25)
Synar retailer violation rate (%)	13.0(96–18.1)	13.4(10.2–18.1)	13.5(10.0–18.5)
School tobacco policy median (IOR)			
Tobacco Policy Monitoring Score	4.6 (4.0–5.0)	4.6 (4.0–5.0)	4.5 (4.0–5.0)
Exposure to anti-smoking advertising			
0 TRP	13,027(23.5)	12,765 (24.7)	8,55(18.8)
< 1 TRP	30,784(55.5)	31,737(61.5)	28,774(61.9)
1 TRP	11,709(21.1)	7112(13.8)	8985 (19.3)

Note. IQR = inter-quartile range

[a]Not all respondents were asked if they used smokeless tobacco. Total weighted N for 8th graders 25,968, 10th graders 24,849, 12th graders 7721.

[b]Self-representing SMSAs are always included in the MTF sample.

Eighth Grade Multivariable Logistic Regression Models Predicting Tobacco Use, 2000–2006

Variable	Current cigarette use (Weighted N = 55,520) aOR (95% CI)	Daily cigarette use (Weighted N = 55,520) aOR (95% CI)	Current smokeless tobacco use (Weighted N = 25,968) aOR (95% CI)
Individual-level characteristics			
Sex			
Male	0.90 (0.83, 0.98)	0.99(0.88, 1.11)	4.30 (3.30, 5.60)
Female	Ref.	Ref.	Ref.
Age			
13 years	Ref.	Ref.	Ref.
14 years	1.59(1.45, 1.74)	1.88(1.68,2.10)	1.33(1.08, 1.64)
Race			
Non-Hispanic White	Ref.	Ref.	Ref.
Non-Hispanic Black	0.43 (0.35, 0.54)	0.25(0.18,0.34)	0.57(0.32, 1.01)
Hispanic	1.16(1.04, 1.29)	0.97(0.78, 1.21)	1.27(0.94, 1.71)
Other	0.95 (0.84, 1.08)	0.85(0.66, 1.10)	0.81(0.60,1.11)
Familial-level characteristics			
Parent's education			
Both parents ≤ high school	Ref.	Ref.	Ref.
At least one parent >high school	0.67(0.61,0.72)	0.59(0.51,0.68)	0.72(0.61,0.86)
Number of parents in the home			
None	2.74(2.35,3.18)	3.14(2.50,3.94)	1.79(1.10,2.93)
One	1.76(1.62, 1.93)	1.93(1.73,2.15)	1.01 (0.79, 1.28)
2	Ref.	Ref.	Ref.
School-level characteristics			
Type of school			
Public	1.20(0.94, 1.53)	1.52(1.004,2.30)	0.97(0.47,2.01)
Private	Ref.	Ref.	Ref.
School size			
Small (1-99 students in targeted grade)	0.78(0.61,0.98)	0.67(0.51,0.88)	0.91 (0.64, 1.31)
Medium (100–199 students in targeted grade)	0.84(0.76,0.93)	0.81(0.71,0.93)	0.76(0.58,0.98)
Large (200 students in targeted grade)	Ref.	Ref.	Ref.
% of students on subsidized lunch	1.013(1.010, 1.015)	1.016(1.010, 1.021)	1.011(1.004, 1.018)
% of students Black	0.993 (0.989, 0.996)	0.994 (0.988, 0.999)	0.990(0.981,0.999)
% of students Hispanic	0.988 (0.983, 0.993)	0.981(0.971,0.991)	0.981 (0.969, 0.993)
Population density: Standard Metropolitan Statistical Area (SMSA)			
Non SMSA	Ref.	Ref.	Ref.
Other SMSA	0.96(0.76, 1.21)	0.96(0.75, 1.23)	0.65(0.38, 1.10)
Large SMSA (self-representing)	0.90(0.70, 1.15)	0.87(0.64, 1.19)	0.50(0.30,0.81)
State tobacco policies			

Variable	Current cigarette use (Weighted N = 55,520) aOR (95% CI)	Daily cigarette use (Weighted N = 55,520) aOR (95% CI)	Current smokeless tobacco use (Weighted N = 25,968) aOR (95% CI)
Cigarette excise tax ($)	0.89(0.76, 1.05)	0.83 (0.66, 1.04)	0.69(0.51,0.94)
Smoke-free air score	0.99(0.94, 1.04)	0.97(0.91, 1.03)	1.03(0.93, 1.14)
PUP score	1.01 (0.94, 1.09)	0.99(0.89, 1.10)	1.08(0.92, 1.27)
Youth access to tobacco score	1.00(0.99, 1.01)	1.00(0.98, 1.01)	1.02(1.002, 1.03)
Synar retailer violation rate (%)	1.00(0.99, 1.01)	1.00(0.99, 1.01)	0.99(0.97, 1.01)
School tobacco policy			
Tobacco Policy Monitoring Score	1.00(0.92, 1.09)	0.99(0.90, 1.09)	1.05 (0.86, 1.29)
Exposure to anti-smoking advertising			
0 TRP	Ref.	Ref.	Ref.
< 1 TRP	0.85 (0.75, 0.96)	0.91 (0.78, 1.06)	0.69(0.52,0.91)
1 TRP	0.76 (0.58, 0.98)	0.82(0.60, 1.12)	0.55 (0.34, 0.89)
State tobacco acres (per 1000)	1.000(0.999, 1.002)	1.000(0.997, 1.002)	1.000(0.995, 1.004)
Survey year	0.91(0.87,0.94)	0.92 (0.88, 0.96)	0.99 (0.92, 1.07)
Model c-statistic	0.679	0.722	0.752

Table 3

Tenth Grade Multivariable Logistic Regression Models Predicting Tobacco Use, 2000–2006

Variable	Current cigarette use (Weighted N = 51,614) aOR (95% CI)	Daily cigarette use (Weighted N = 51,614) aOR (95% CI)	Current smokeless tobacco use (Weighted N = 24,849) aOR (95% CI)
Individual-level characteristics			
Sex			
Male	0.90(0.81,0.99)	0.87(0.79,0.96)	8.05(6.41, 10.10)
Female	Ref.	Ref.	Ref.
Age			
15 years	Ref.	Ref.	Ref.
16 years	1.23(1.16, 1.30)	1.33(1.21, 1.46)	1.26(1.07, 1.47)
Race			
Non-Hispanic White	Ref.	Ref.	Ref.
Non-Hispanic Black	0.30 (0.24, 0.37)	0.22(0.16,0.30)	0.53(0.35,0.81)
Hispanic	0.77 (0.64, 0.93)	0.62 (0.47, 0.83)	0.89(0.63, 1.27)
Other	0.67(0.56,0.80)	0.72 (0.59, 0.89)	0.70 (0.52, 0.95)
Familial-level characteristics			
Parent's education			
Both parents high school	Ref.	Ref.	Ref.
At least one parent >high school	0.67(0.63,0.72)	0.56(0.52,0.61)	0.81(0.72,0.92)
Number of parents in the home			
None	2.42(2.15,2.73)	3.04(2.63,3.52)	2.32(1.68,3.20)
One	1.56(1.46, 1.66)	1.83(1.72, 1.96)	1.28(1.08, 1.51)
2	Ref.	Ref.	Ref.
School-level characteristics			
Type of school			
Public	1.15(0.88, 1.50)	1.60(1.11,2.29)	0.94(0.65, 1.36)
Private	Ref.	Ref.	Ref.
School size			
Small (1–99 students in targeted grade)	1.11(0.92, 1.34)	1.19(0.94, 1.49)	0.98(0.69, 1.41)
Medium (100–199 students in targeted grade)	1.04(0.96, 1.13)	1.10(0.97, 1.25)	1.01 (0.74, 1.37)
Large (200 students in targeted grade)	Ref.	Ref.	Ref.
% of students on subsidized lunch	1.002(0.999, 1.006)	1.003 (0.999, 1.007)	1.012(1.006, 1.017)
% of students Black	0.999 (0.996, 1.002)	1.000(0.996, 1.004)	0.982 (0.975, 0.990)
% of students Hispanic	0.988 (0.983, 0.993)	0.981 (0.975, 0.988)	0.970 (0.962, 0.978)
Population density: Standard Metropolitan Statistical Area (SMSA)			
Non SMSA	Ref.	Ref.	Ref.
Other SMSA	0.78 (0.66, 0.93)	0.81(0.68,0.96)	0.60 (0.44, 0.80)
Large SMSA (self-representing)	0.77(0.63,0.93)	0.79 (0.65, 0.95)	0.75 (0.53, 1.04)
State tobacco policies			

Variable	Current cigarette use (Weighted N = 51,614) aOR (95% CI)	Daily cigarette use (Weighted N = 51,614) aOR (95% CI)	Current smokeless tobacco use (Weighted N = 24,849) aOR (95% CI)
Cigarette excise tax ($)	0.97(0.88, 1.07)	0.96(0.87, 1.06)	0.92(0.74, 1.14)
Smoke-free air score	0.99(0.95, 1.03)	0.98(0.93, 1.03)	0.96(0.89, 1.04)
PUP score	0.97(0.91, 1.03)	0.97(0.90, 1.06)	1.09(0.98, 1.22)
Youth access to tobacco score	1.00(0.99, 1.01)	1.00(0.99, 1.02)	1.00(0.99, 1.02)
Synar retailer violation rate (%)	1.01 (0.998, 1.01)	1.01 (0.999, 1.02)	1.00(0.98, 1.02)
School tobacco policy			
Tobacco Policy Monitoring Score	1.03(0.96, 1.11)	1.01 (0.94, 1.08)	0.99(0.85, 1.15)
Exposure to anti-smokine advertising			
0 TRP	Ref.	Ref.	Ref.
< 1 TRP	1.04(0.91, 1.18)	1.05(0.91, 1.20)	0.88(0.72, 1.09)
1 TRP	0.98(0.83, 1.15)	0.94(0.76, 1.17)	0.82(0.57, 1.17)
State tobacco acres (per 1000)	1.001 (1.000, 1.002)	1.001 (1.000, 1.002)	1.003(1.001, 1.005)
Survey year	0.93 (0.90, 0.96)	0.91(0.89,0.94)	1.01 (0.93, 1.09)
Model C-statistic	0.645	0.687	0.791

Table 4

Twelfth Grade Multivariable Logistic Regression Models Predicting Tobacco Use, 2000–2006

Variable	Current cigarette use (Weighted N = 46,514) aOR (95% CI)	Daily cigarette use (Weighted N = 46,514) aOR (95% CI)	Current smokeless tobacco use (Weighted N = 7721) aOR (95% CI)
Individual-level characteristics			
Sex			
Male	1.09(1.02, 1.17)	1.07(0.99, 1.16)	14.18(8.79,22.88)
Female	Ref.	Ref.	Ref.
Age			
17 years	Ref.	Ref.	Ref.
18 years	1.09(1.03, 1.15)	1.07(0.99, 1.14)	1.48(1.14, 1.92)
Race			
Non-Hispanic White	Ref.	Ref.	Ref.
Non-Hispanic Black	0.29 (0.23, 0.36)	0.21(0.16,0.28)	0.13(0.05,0.36)
Hispanic	0.84(0.75,0.93)	0.74 (0.64, 0.86)	0.78(0.36, 1.70)
Other	0.77 (0.66, 0.90)	0.77 (0.66, 0.89)	0.54(0.32,0.93)
Familial-level characteristics			
Parent's education	Ref.	Ref.	Ref.
Both parents high school	0.88(0.82,0.94)	0.78 (0.72, 0.84)	0.79 (0.63, 0.996)
At least one parent >high school			
Number of parents in the home			
None	1.80(1.54,2.11)	2.26(1.92,2.65)	1.20 (0.65, 2.20)
One	1.38(1.29, 1.47)	1.53(1.43, 1.63)	0.80(0.59, 1.09)
2	Ref.	Ref.	Ref.
School-level characteristics			
Type of school			
Public	0.97(0.81, 1.16)	1.07(0.88, 1.31)	0.78(0.49, 1.23)
Private	Ref.	Ref.	Ref.
School size			
Small (1–99 students in targeted grade)	1.14(0.96, 1.34)	1.27(1.06, 1.52)	1.29 (0.83, 2.00)
Medium (100–199 students in targeted grade)	1.01(0.91, 1.12)	1.06(0.94, 1.20)	1.37(1.06, 1.77)
Large (200 students in targeted grade)	Ref.	Ref.	Ref.
% of students on subsidized lunch, median (IQR)	0.999 (0.995, 1.002)	1.002 (0.997, 1.006)	1.001 (0.994, 1.009)
% of students Black, median (IQR)	0.997(0.992, 1.001)	0.998 (0.994, 1.002)	0.988 (0.975, 1.000)
% of students Hispanic, median (IQR)	0.994 (0.990, 0.998)	0.988 (0.982, 0.993)	0.987(0.975,0.995)
Population density: Standard Metropolitan Statistical Area (SMSA)			
Non SMSA	Ref.	Ref.	Ref.
Other SMSA	0.97(0.84, 1.13)	0.99(0.83, 1.18)	0.92(0.58, 1.46)
Large SMSA (self-representing)	1.00(0.85, 1.18)	1.04(0.87, 1.25)	0.63 (0.37, 1.06)
State tobacco policies			

Variable	Current cigarette use (Weighted N = 46,514) aOR (95% CI)	Daily cigarette use (Weighted N = 46,514) aOR (95% CI)	Current smokeless tobacco use (Weighted N = 7721) aOR (95% CI)
Cigarette excise tax ($)	0.84(0.73,0.97)	0.86(0.73, 1.01)	0.67(0.51,0.87)
Smoke-free air score	0.98(0.95, 1.02)	0.99(0.95, 1.03)	0.90(0.82, 1.00)
PUP score	1.00(0.94, 1.07)	0.99(0.92, 1.08)	0.95 (0.83, 1.09)
Youth access to tobacco score	1.00(0.996, 1.01)	1.00(0.99, 1.01)	1.03(1.01, 1.05)
Synar retailer violation rate (%)	1.01 (1.00, 1.02)	1.01 (0.998, 1.02)	1.01 (0.99, 1.02)
School tobacco policy			
Tobacco Policy Monitoring Score	1.01(0.93, 1.10)	1.02(0.93, 1.12)	1.04(0.88, 1.22)
Exposure to anti-smoking advertising			
0 TRP	Ref.	Ref.	Ref.
< 1 TRP	0.98(0.87, 1.10)	0.95 (0.83, 1.08)	0.80(0.61, 1.05)
1 TRP	0.95 (0.82, 1.09)	0.94(0.81, 1.08)	1.06(0.78, 1.46)
State tobacco acres (per 1000)	1.000 (0.999, 1.002)	1.001 (1.000, 1.002)	1.002 (0.999, 1.005)
Survey year	0.95 (0.92, 0.98)	0.93 (0.90, 0.96)	1.05(0.97, 1.13)
Model C-statistic	0.627	0.656	0.825