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Taxation reduces smoking but may not reduce smoking disparities in youth

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Abstract

This study examines the extent to which cigarette taxes affect smoking behavior and disparities in smoking among adolescents by gender, socioeconomic status (SES), and race/ethnicity. We used US nationally-representative, repeated cross-sectional data from the 2005-2016 Monitoring the Future study to evaluate the relationship between state cigarette taxes and past 30-day current smoking, smoking intensity, and first cigarette and daily smoking initiation using modified Poisson and linear regression models, stratified by grade. We tested for interactions between tax and gender, SES, and race/ethnicity on the additive scale using average marginal effects. We found that higher taxes were associated with lower smoking outcomes, with variation by grade. Across nearly all of our specifications, there were no statistically significant interactions between tax and gender, SES, or race/ethnicity for any grades/outcomes. One exception is that among 12th graders, there was a statistically significant interaction between tax and college plans, with taxes being

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associated with a lower probability of 30-day smoking among students who definitely planned to attend college compared to those who did not. We conclude that higher taxes were associated with reduced smoking among adolescents, with little difference by gender, SES, and racial/ethnicity groups. While effective at reducing adolescent smoking, taxes appear unlikely to reduce smoking disparities among youth.

Keywords

disparities; priority/special populations; prices; taxes

Disparities in smoking are pervasive among adolescents in the United States. Adolescents from lower socioeconomic status (SES) households and those who do not plan to attend college have worse smoking outcomes than their more affluent peers [1-3]. Important disparities in smoking also exist among adolescents across gender and race/ethnicity. High school males are more likely to smoke than females [4]. Adolescent non-Hispanic Blacks (hereafter, Blacks) have lower smoking prevalence and probability of initiation than Hispanics and non-Hispanic Whites (hereafter, Whites), although these differences have narrowed over time [4] and non-smoking Hispanic and Black youth have higher susceptibility to future smoking than Whites [2]. Asian Americans have the lowest smoking prevalence [4], probability of initiation [4], and susceptibility to smoking [2].

Despite the well-documented disparities in youth smoking, there is limited evidence on how tobacco policies affect these disparities—especially among adolescents. Prior studies have found that cigarette taxes reduce smoking among adolescents [5-25], although the effectiveness of taxes may be waning in more recent years [26]. However, relatively few studies have examined whether the associations of taxation vary by SES, race/ethnicity, or gender. Despite continued higher smoking rates among low SES youth, studies have found that lower SES youth are generally more price responsive [21, 27], as has been found among low SES adult smokers [28, 29], and therefore should be more likely to be influenced by taxes. Results by race/ethnicity have been mixed: several studies found that racial minority youth were more price responsive than their White counterparts [21, 24, 25, 30], although another study found White adolescents to be more price responsive than Blacks [22]. Results by gender are also mixed, with some studies finding that male adolescents are more price responsive [30, 31], whereas others find the opposite [21, 22, 24].

Prior literature has found mixed results in terms of the effectiveness of taxation on smoking behavior by SES, race/ethnicity, and gender, and few studies have been conducted using data from more recent years. To address these gaps, we used data from the 2005-2016 Monitoring the Future (MTF) surveys to assess the relationship between state cigarette taxes and price, cigarette smoking, and disparities in smoking by SES, race/ethnicity, and gender, stratified by grade.

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METHODS

Sample

We obtained restricted access to MTF data from 2005-2016 that included information on each respondent's smoking behavior, parental education, college plans for 12th graders, mother's employment status, race/ethnicity, gender, state of residence, and school zip code. Since 1991, MTF has collected nationally representative cross-sections from the 48 contiguous states of 8th, 10th, and 12th graders [3, 32]. While the data are nationally representative, they are not state representative. We used data between 2005 to 2016 to focus on the effects of recent changes in tax on smoking disparities. Analytic sample sizes varied by outcome variable and grade. Due to the use of de-identified data, the University of Michigan Institutional Review Board deemed this research exempt.

Adolescent smoking

The primary dependent variables were past 30-day cigarette smoking (did vs. did not smoke at least one cigarette in the past 30 days); the number of cigarettes smoked per day among respondents who reported any smoking (conditional intensity); initiation for first time smoking in current grade (smoked first cigarette in current grade vs. never smoked a cigarette); and initiation for daily smoking in current grade (started smoking daily in current grade vs. never smoked daily). First cigarette and daily smoking initiation were only assessed among respondents who had not smoked prior to the current grade.

Cigarette taxes and price

The key independent variables were state cigarette taxes and average cigarette sale price (per pack of 20 cigarettes) from the Tax Burden on Tobacco (TBT) [33]. MTF surveys were administered in the spring each year, and students were asked retrospectively about smoking during their current grade. Therefore, we constructed tax and price variables to reflect taxes and prices that students would have been exposed to over the academic year. State and federal cigarette taxes (recorded each year in the TBT for fiscal years ending June 30) were matched to students based during the same year they were surveyed. For prices (recorded on November 1), we used the average of the prices from the November before and after students were surveyed. All dollar amounts were adjusted for inflation to 2016 dollar values using an implicit price deflator [34].

Gender, socioeconomic status, and race/ethnicity

Gender was coded as male or female. We included two markers for SES: parental education and plans to attend college for a four-year degree (12th grade sample only). Parental education was the highest education attained by either of the respondent's parents coded as: less than high school, high school graduate, some college, or college or higher. For plans to attend college, 12th graders were classified into "definitely will," "probably will/won't," and "definitely won't" based on their response to whether they expect to attend a four-year college program [3]. Plans to attend college is not a traditional marker of SES and may be correlated with individual time preferences [35]; however, more traditional markers of SES, such as parental education, occupation, and income, affect students' plans to attend college

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[36, 37]. Race and ethnicity were self-reported and combined into a single variable defined as non-Hispanic White, non-Hispanic Black, Hispanic, Asian, and other non-Hispanic (including mixed race).

Covariates

To control for individual factors other than gender, SES, and race/ethnicity, we included variables for living arrangements (living alone, with mother or father only, or with both parents), mother's employment status (grade 8/10: no, part-time, full-time currently, grade 12: no, some, most, all of time growing up), and type of high school (prep, general, or vocational).

To control for time-varying state-level factors that might affect adolescent smoking and exposure to higher state cigarette tax/price, we included variables for state/year unemployment and poverty rates from University of Kentucky's Center for Poverty Research [38], percent Hispanic and Black population calculated from Survey of Epidemiology and End Results population estimates [39], and percent high school graduates (age 25+) and college graduates (25+) from the American Community Survey [40]. To control for other factors in the tobacco policy environment, we included the percentage of residents covered by workplace and hospitality laws at the county level [41]. To control for anti-smoking sentiment, we used the percentage of adults in each state with home smoking bans, and the percentage by state supporting bans on smoking in bars, calculated from the Tobacco Use Supplement to the Current Population Survey with linear interpolation between survey waves [42, 43]. Finally, we included covariates to control for the four census regions (Northeast, Midwest, South, and West) and year.

Statistical analysis

All analyses were stratified by grade due to variation in price sensitivity by age [22, 44, 45] and interactions between tax and/or price for several outcomes, and accounted for MTF's complex survey design using strata, school cluster, and individual sample weights. Because MTF does not sample states as a first stage, we did not cluster at the state level. To examine the relationships between cigarette tax and price with smoking participation (past 30-day) and initiation (both first cigarette and daily), we calculated risk ratios using modified Poisson regression with a sandwich-type variance estimator [46]. Linear regression was used to examine conditional smoking intensity. We then separately tested for interactions between either tax or price and gender, SES, and race/ethnicity. We tested interactions on the additive scale by predicting marginal probabilities for our population with covariates at their measured values (known as average marginal effects, AME) [47-49]. We plotted AMEs of tax/price on smoking for each category of gender, SES, or race/ethnicity where the interactions were statistically significant after adjusting for multiple testing using the false discovery rate of Benjamini-Hochberg at 5% [50]. Finally, we calculated elasticities by grade and by sociodemographic subgroups within grades.

Data were missing for 2% to 12% of the variables across samples, particularly for parental education (9% overall, 7%-12% by grade) and gender (4% overall, 3%-7% by grade). To correct for missing values, we performed multiple imputation using IVEware 0.3 [51] using

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sequential regression imputation under the missing at random assumption [52]. In total, 10 datasets were imputed separately by grade using all covariates (except region) shown in Table 1, as well as indicators for year, school type, ever smoked, smoking participation in last 30 days, first cigarette smoked in current grade, began smoking daily in current grade, ≥5 drinks in a row over last 2 weeks, and marijuana use in last 30 days.

In additional analyses, we examined differences in the source of cigarettes for students by grade using a question in the MTF survey regarding if respondents had bought cigarettes in the past 30 days via friends or relatives, from vending machines, through the mail, in stores where you bring cigarettes to the check-out, in stores where clerks hand you the cigarettes, or in some other way.

In sensitivity analyses we evaluated models that additionally controlled for past 30-day alcohol use, past 30-day marijuana use, and past 2-week binge drinking (i.e., 5 or more drinks in a row) together in one model. We also investigated the potential non-linearity of the associations between tax or price and the four outcome variables using interactions between each year and tax or price.

All analyses were conducted using Stata version 15.0.

RESULTS

Descriptive statistics

Table 1 presents descriptive statistics for 8^{th}, 10^{th}, and 12^{th} graders in the entire population (analytic sample for 30-day smoking participation) and in the analytic sample for smoking intensity for years 2005 to 2016. Smoking participation increased across grades with 6% of 8^{th} graders, 11% of 10^{th} graders, and 17% of 12^{th} graders smoking any cigarettes in the past 30 days. The average inflation-adjusted state and federal cigarette tax in our sample was approximately $1.40 and average sale price was approximately $5.70.

The conditional intensity analytic samples were restricted to those with any smoking participation in the past 30 days, and the initiation samples were restricted to those who had not initiated first cigarette or daily smoking before their current grade (Appendix Table 1). Among past 30-day smokers, average cigarettes smoked per day ranged from approximately 4 to 5. First cigarette smoking initiation ranged from 2% to 4% by grade, and daily smoking initiation ranged from 1% to 2%. Descriptive statistics for the imputed sample are shown for comparison in Appendix Table 2.

Main associations

Table 2 presents the main associations of tax and price on each of the adolescent smoking outcomes for 8^{th}, 10^{th}, and 12^{th} graders after adjusting for individual characteristics, state-level controls, region, and year fixed effects. Findings for tax and price were similar, so we focus on tax below.

Among 8^{th} graders, a $1 increase in cigarette tax was associated with a 0.7 percentage point lower probability of smoking in the past 30 days (AME = −0.007; 95% CI: −0.010, −0.003),

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a 0.4 percentage point lower probability of smoking a cigarette for the first time (AME = −0.004; CI: −0.006, −0.002), and a 0.3 percentage point lower probability of starting daily smoking (AME = −0.003; CI: −0.004, −0.001). Tax was not associated with the number of cigarettes smoked per day among 8th graders.

Among 10th graders, there were no statistically significant associations between cigarette tax or price and smoking participation, first cigarette initiation, or daily smoking initiation. A $1 increase in tax or price was marginally associated with smoking 0.2 fewer cigarettes per day among smokers.

In models of smoking participation for 12th graders, a $1 increase in cigarette tax was associated with a 0.9 percentage point lower probability of smoking in the past 30 days (AME = −0.009; 95% CI: −0.015, −0.003), fewer cigarettes smoked per day (change in mean = 0.30; CI: −0.49, −0.11), and lower daily smoking initiation (AME = −0.003; 95% CI: −0.006, 0.000), but was not associated with first cigarette initiation.

To further understand differences in the taxation/smoking associations, we examined differences in the source of cigarettes for students by grade. Using additional MTF questions, we found 12th graders more often purchased their own cigarettes than 10th and 8th graders (64% from a store clerk vs 24% and 16%, respectively), while 8th and 10th graders more often acquired cigarettes from other sources, such as websites, vending machines, through the mail, or from friends or relatives.

Differential associations of taxation and smoking outcomes by SES, race/ethnicity, and gender

After adjusting for multiple testing, student's college plans significantly modified the association between taxation and 30-day smoking among 12th graders (Appendix Table 3; P <0.001). Specifically, taxation was associated with lower 30-day smoking probability among students who definitely planned to attend college, while students who did not plan to attend college had no relationship between taxation and 30-day smoking; students who probably planned to attend college fell in between (Figure 1). Although not statistically significant after adjusting for multiple testing, parental education exhibited a similar relationship to that of college bound: students who had at least one parent with a college education had a lower probability of smoking in the past 30 days than students whose highest parental education level was lower (Appendix Figure 1). We found no other interactions by SES, race/ethnicity, or gender for any of the other outcomes in any of the other grades after correcting for multiple testing.

We also report tax elasticities overall by grade, as well as stratified by parental education, college bound, race/ethnicity, and gender (Appendix Table 4). Eighth graders were tax responsive for 30-day smoking participation, first cigarette initiation, and daily smoking initiation, while 12th graders were tax responsive for smoking participation, conditional intensity, and daily smoking initiation. Students whose parents had a college education showed greater elasticities than their less educated counterparts for smoking participation (8th and 12th graders), first cigarette initiation (8th graders), and daily smoking initiation (12th graders). Twelfth graders who definitely planned to attend college had stronger tax

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elasticities than students with other college plans for smoking participation and daily smoking initiation.

In the sensitivity analyses additionally controlling for other substance use, we found similar results. We also investigated the potential non-linearity of the associations between taxation or price and the four outcome variables, and found no evidence of differences in the associations with time (results not shown).

DISCUSSION

Our study found that higher state cigarette taxes and average cigarette price per pack were associated lower 30-day smoking, first cigarette smoking initiation, and daily smoking initiation among 8th graders, lower intensity among 10th grader smokers, and lower 30-day smoking participation and intensity among 12th graders. Our findings are consistent with prior literature finding that taxation reduced smoking participation [5-22, 26, 53], smoking intensity [5, 7, 11, 12, 22-24, 26], and smoking initiation [22, 25] among youth. Interestingly, we found that taxation reduced initiation among 8th graders only, while affecting 30-day smoking among 8th and 12th graders, and intensity among 10th and 12th graders. From our analysis of differences in cigarette sources by grade, 12th graders may more acutely feel the effects of price since they are doing more of their own purchasing, which may help explain why taxation has a stronger association for 30-day smoking among 12th than 10th graders. Regarding stronger associations between taxation and 30-day smoking and initiation for 8th graders compared to 10th graders, it may be that 8th graders are more likely to obtain cigarettes from their parents, whereas 10th graders may be more likely to get cigarettes from their friends. The survey questions could not distinguish between these possibilities, but prior literature suggests that family influence is more important than peer influence on smoking for younger ages [54].

For most taxation/smoking outcome relationships, we saw no heterogeneity of association by SES, race/ethnicity, or gender. Only the relationship between taxation and 30-day smoking participation differed by plans to attend college for 12th graders, and in a direction that indicates an *increase* in disparities, rather than a decrease. This seems to contradict two studies using older data that found that students whose parents had less than a college degree were more price responsive than students whose parents had a college degree or greater [21, 27], as well as adult studies that have found greater price responsiveness by among low SES adults [28, 29]. However, our results are consistent with the national surveys that show continued disparities in youth smoking by SES. In addition, although we did not find statistically significant differences by parental education in any of the tax/smoking relationships after correction for multiple testing, the pattern for parental education for 12th graders showed a similar pattern to plans to attend college: students whose parents had attended college had lower 30-day smoking participation.

Plans to attend college is not a traditional measure of SES, and another possible interpretation is that students who plan attend college have higher preference for the future. Thus, an increase in cigarette taxes increased the cost of smoking addiction in the future and induced individuals who value the future more to not smoke or smoke less—consistent with

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forward-looking smoking behavior [55, 56]. Although we do not rule out a time preference interpretation, we think it is more likely that plans to attend college is a SES proxy, given that it is strongly associated with parental education, income, and occupation [36, 37]. Moreover, other studies have shown differences in time preferences do not explain much of differences in health behaviors [57] or the relationship between education and health behaviors [58].

We did not find differences in the association of taxation on smoking outcomes by race/ethnicity or gender, which is in contrast to earlier studies. Several older studies found Black and/or Hispanic youth to be more price responsive than White youth [21, 24, 25, 30], with some variation by gender [30]. However, an analysis of the 2009 federal tax increase found White adolescents were more price responsive than Black adolescents [22]. Previous results were also mixed for gender, with male adolescents more price responsive than female adolescents for smoking prevalence [30] and smoking initiation [31] in some studies, with opposite findings in others for smoking prevalence [21, 22, 24], intensity [21], and initiation [22]. Differences between these studies and our findings could again be due to using newer data, looking at a wider range of outcomes, and examining differences by grade.

Overall, the smoking participation and conditional intensity elasticities that we estimated were smaller than elasticities estimated by prior studies using MTF data from earlier years. A study using MTF data from 1976-1998 had the highest elasticity for smoking participation at −1.41 [24], while studies using MTF data from the 1990s [7, 23, 27, 30] estimated participation elasticities ranging from −0.311 [27] to −0.675 [23] and conditional intensity elasticities ranging from −0.029 [27] to −0.638 [23] when pooling across grades and not differentiating by sociodemographic factors. More recently, a study using MTF data from 1991 to 2010 estimated the participation elasticity at −0.259 and the conditional intensity elasticity at −0.187 [21]. Using data from 2005 to 2016, we found smoking participation elasticities for 8^{th} and 12^{th} graders were −0.28 and −0.13 (respectively), and that the conditional intensity elasticity for 12^{th} graders was −0.12, with other results by grade not statistically significant. The elasticities we estimated may have been smaller than previous in previous papers if youth price-responsiveness has declined over time; decades after the harms of cigarettes were exposed, today's youth may not be as price-elastic.

This research is subject to several limitations. We examined repeated cross-sectional data, so our findings should not be extrapolated to reflect longitudinal changes within individuals. The substance use data are self-reported, which may lead to reporting bias. However, school-based youth samples typically have less bias than home-based youth samples for substance use reporting [59, 60], and measures of self-reported drug use have been validated within MTF [3]. We examined taxation and smoking behavior over a time period when tobacco control policies were changing and new tobacco products were being introduced. However, we controlled for the changing tobacco control landscape by adjusting for smoke-free policies over time, as well as other state-level characteristics that may be associated with tobacco control policies and smoking behavior. We also tested for changes in the association between taxation and smoking behavior by adding in interaction terms for each year, with the concern that taxation may have become less effective as new products, such as electronic cigarettes, were introduced into the market. We found no evidence of differences in the

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taxation/smoking relationships over time. However, we acknowledge that the patterns we observed may change due to the increase of e-cigarette use and other products among youth over time, and additional policies implemented to address these changes. Although prior research has also controlled for state fixed effects [18, 26], we did not because MTF data are representative at the national level, but not the state level. Moreover, the number and types of communities sampled within states change over time, and not all states are sampled every year. We did control for several state-level sociodemographic variables to adjust for differences between states, but acknowledge that residual state-level confounding may remain. Local level tax rates were not considered in this analysis, and we did not have data on actual price at point of sale, which may vary within states.

In conclusion, taxation continues to be a useful tobacco control tool for reducing smoking among youth, particularly for 8th and 12th graders in our analysis. However, taxation may not be effective in improving health equity among youth. There is a need for longitudinal analyses to further elucidate these findings as youth transition into adulthood.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What this paper adds

Cigarette taxes are effective in reducing smoking, and there is evidence that lower socioeconomic status adults are the most price sensitive.

There is little evidence on how taxes impact adolescent smoking disparities, particularly in recent years.

Our findings suggest that cigarette taxes, while effective at reducing smoking among youth, appear unlikely to reduce smoking disparities.

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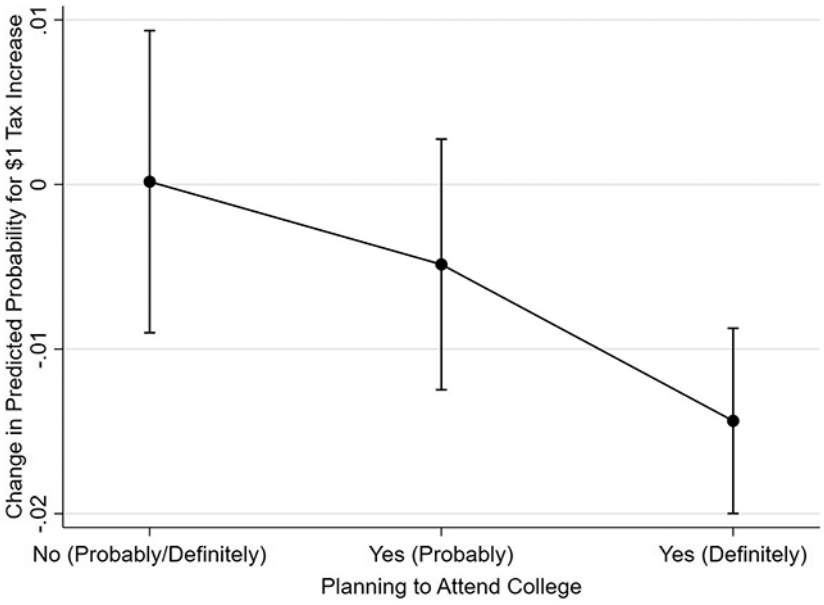

Figure 1.

Differential Associations of Tax on Smoking Participation Over Prior 30 Days Among 12th Graders, by Plans to Attend College, Monitoring the Future, 2005-2016. Results Shown are Using Imputed Data (m=10).

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Table 1.

Weighted Descriptive Statistics for all 8th, 10th, and 12th Graders, Monitoring the Future Data, 2005-2016.

	Entire Population (30-day Smoking Participation Analytic Sample)			Population of Past 30 Day Smokers (Conditional Intensity Analytic Sample)		
Variables	**Grade 8 wt. %**	**Grade 10 wt. %**	**Grade 12 wt. %**	**Grade 8 wt. %**	**Grade 10 wt. %**	**Grade 12 wt. %**
Gender						
Female	49%	49%	48%	49%	47%	42%
Male	47%	48%	45%	46%	50%	51%
Missing	4%	3%	7%	5%	3%	7%
Race/Ethnicity						
Non-Hispanic White	50%	57%	57%	56%	67%	69%
Non-Hispanic Black	13%	11%	12%	8%	6%	6%
Hispanic	18%	14%	14%	16%	11%	11%
Non-Hispanic Asian	4%	4%	4%	1%	2%	2%
Non-Hispanic Other	11%	10%	9%	15%	11%	9%
Missing	4%	3%	5%	4%	2%	4%
Education, Parents' Highest						
Less than High School	8%	7%	8%	13%	9%	8%
High School	16%	17%	18%	23%	22%	21%
Some College	14%	17%	19%	17%	19%	21%
College or Greater	50%	53%	47%	35%	43%	44%
Missing	12%	7%	8%	12%	6%	7%
College Plans (Grade 12)						
No, Probably/Definitely			16%			26%
Yes, Probably			21%			24%
Yes, Definitely			55%			42%
Missing			8%			8%
Living Arrangement						
Neither Mother or Father in Household	4%	4%	6%	8%	7%	9%
Lives with Father	4%	4%	5%	7%	7%	7%
Lives with Mother	18%	18%	21%	23%	21%	22%
Lives with Father and Mother	71%	73%	64%	58%	63%	58%
Missing	3%	2%	5%	3%	2%	4%
Mother's Current Employment (Grade 8/10)						
Not Employed	21%	21%		24%	22%	
Part Time	19%	16%		17%	14%	
Full Time	57%	61%		55%	61%	
Missing	4%	3%		4%	2%	
Mother's Past Employment (Grade 12)						
None			13%			12%

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Variables	Entire Population (30-day Smoking Participation Analytic Sample)			Population of Past 30 Day Smokers (Conditional Intensity Analytic Sample)		
	Grade 8 wt. %	Grade 10 wt. %	Grade 12 wt. %	Grade 8 wt. %	Grade 10 wt. %	Grade 12 wt. %
Sometimes			18%			18%
Most of Time			17%			18%
All the Time			47%			48%
Missing			5%			4%
High School Program						
College Prep.	33%	46%	49%	20%	31%	38%
General	17%	24%	32%	20%	31%	38%
Vocational/Technical	4%	4%	5%	7%	8%	7%
Other/Don't Know	41%	23%	9%	48%	28%	11%
Missing	5%	3%	6%	5%	2%	6%
Census Region						
Northeast	17%	20%	18%	13%	18%	18%
Midwest	22%	24%	23%	24%	27%	27%
South	38%	33%	37%	46%	38%	38%
West	23%	23%	22%	17%	17%	17%
Smoking Participation (past 30 day)						
No	91%	86%	79			
Yes	6%	11%	17%			
Missing	3%	3%	3%			
Smoking Intensity (cigarettes/day)						
Mean (SE), range				4.0 (8.3), 0.5-40.0	4.1 (7.4), 0.5-40.0	5.0 (7.9), 0.5-40.0
0.5				58%	52%	45%
2.5				27%	30%	30%
10				7%	10%	14%
20				3%	4%	7%
30				2%	1%	2%
40				3%	2%	2%
State tax (mean $ (SE), range)	1.4 (1.0), 0.1-4.7	1.4 (0.9), 0.1-4.7	1.4 (1.0), 0.1-4.7	1.2 (0.8), 0.1-4.7	1.3 (0.9), 0.1-4.7	1.3 (0.9), 0.1-4.7
State price (mean $ (SE), range)	5.8 (1.4), 3.6-10.5	5.7 (1.3), 3.6-10.5	5.8 (1.4), 3.6-10.5	5.4 (1.2), 3.6-10.5	5.5 (1.2), 3.6-10.5	5.6 (1.3), 3.6-10.5
Smoke-free workplace law county coverage (mean %, (SE), range)	52.3 (46.5), 0-100	50.9 (46.9), 0-100	(46.8), 0-100	(46.7), 0-100	43.0 (46.9), 0-100	47.0 (47.2), 0-100
Smoke-free hospitality law county coverage (mean %, (SE), range)	62.7 (46.1), 0-100	65.3 (46.0), 0-100	62.9 (46.6), 0-100	47.9 (47.9), 0-100	55.1 (48.0), 0-100	53.8 (48.0), 0-100
State Unemployment (mean %, (SE), range)	6.6 (2.1), 2.6-13.7	6.7 (2.3), 2.6-13.7	6.7 (2.2), 2.6-13.7	6.6 (2.2), 2.6-13.7	6.7 (2.3), 2.6-13.7	6.7 (2.2), 2.6-13.7
State Poverty (mean %, (SE), range)	13.8 (2.9), 5.6-23.1	13.6 (3.0), 5.4-23.1	13.9 (2.8), 5.4-23.1	14.1 (3.0), 5.6-23.1	13.7 (3.1), 5.4-23.1	13.9 (2.9), 5.4-23.1

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Variables	Entire Population (30-day Smoking Participation Analytic Sample)			Population of Past 30 Day Smokers (Conditional Intensity Analytic Sample)		
	Grade 8 wt. %	Grade 10 wt. %	Grade 12 wt. %	Grade 8 wt. %	Grade 10 wt. %	Grade 12 wt. %
State bar smoking opposition (mean %, range)	49.9 (10.2), 26.7-74.5	50.8 (10.2), 27.2-74.0	50.1 (10.3), 26.7-74.5	46.3 (9.6), 26.7-74.5	47.7 (10.4), 27.2-74.0	47.9 (10.3), 27.2-74.5
State % with smoke-free home rules (mean %, (SE), range)	82.8 (6.6), 59.1-93.8	82.7 (7.0), 59.1-96.9	82.5 (6.7), 59.1-93.8	80.5 (6.8), 59.1-93.8	80.7 (7.3), 59.1-96.9	80.8 (6.9), 59.1-93.8
State % Black (mean %, (SE), range)	12.8 (8.1), 0.6-51.9	12.3 (7.7), 0.6-48.6	13.0 (8.0), 0.6-54.4	13.8 (8.8), 0.6-51.0	12.6 (7.8), 0.6-48.6	13.2 (8.0), 0.6-54.4
State % Hispanic (mean %, (SE), range)	16.1 (12.6), 1.0-47.8	16.0 (13.0), 1.0-48.5	16.1 (13.0), 1.1-48.2	13.6 (12.2), 1.0-47.8	14.0 (12.6), 1.0-48.5	14.1 (12.4), 1.1-48.2
State % HS grad (age 25+) (mean %, (SE), range)	85.6 (3.5), 77.8-93.5	85.6 (3.6), 78.4-93.5	85.4 (3.5), 77.8-93.5	85.1 (3.5), 77.8-93.5	85.3 (3.6), 78.4-93.5	85.4 (3.5), 77.8-93.5
State % college grad (age 25+) (mean %, (SE), range)	28.3 (4.7), 16.6-56.7	28.5 (4.5), 16.6-55.0	28.3 (4.6), 17.3-56.7	26.8 (4.5), 16.6-50.1	27.5 (4.5), 16.6-55.0	27.7 (4.7), 17.3-56.7
Unweighted N	**193,570**	**185,943**	**171,019**	**11,501**	**20,019**	**29,667**

Abbreviations: Weighted (wt), standard error (SE)

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Table 2.

Average Marginal Effects of Cigarette Tax (State/Federal) and Average Sale Price on Adolescent Smoking by Grade, Monitoring the Future, 2005-2016. Results Shown are Using Imputed Data (m=10).

	8th graders		10th graders		12th graders	
	[a]AME (95% CI)	*P*	[a]AME (95% CI)	*P*	[a]AME (95% CI)	*P*
Smoking participation						
Tax	−0.007 (−0.010, −0.003)	<0.001	0.003 (−0.001, 0.008)	0.156	−0.009 (−0.015, −0.003)	0.002
Price	−0.007 (−0.010, −0.003)	<0.001	0.002 (−0.002, 0.007)	0.298	−0.011 (−0.016, −0.005)	<0.001
N	*193570*		*185943*		*171019*	
Conditional intensity						
Tax	0.09 (−0.31, 0.50)	0.649	−0.22 (−0.44, 0.00	0.053	−0.30 (−0.49, −0.11)	0.002
Price	−0.02 (−0.38, 0.34)	0.925	−0.23 (−0.43, −0.03)	0.021	−0.27 (−0.44, −0.09)	0.003
N	*11501*		*20019*		*29667*	
First cigarette initiation						
Tax	−0.004 (−0.006, −0.002)	<0.001	0.000 (−0.002, 0.003)	0.820	−0.002 (−0.006, 0.003)	0.389
Price	−0.004 (−0.006, −0.002)	<0.001	0.001 (−0.002, 0.003)	0.701	−0.001 (−0.006, 0.003)	0.474
N	*163427*		*138073*		*53933*	
Daily smoking initiation						
Tax	−0.003 (−0.004, −0.001)	0.002	0.002 (−0.006, 0.009)	0.646	−0.003 (−0.006, −0.000)	0.043
Price	−0.003 (−0.004, −0.001)	0.003	0.002 (−0.004, 0.008)	0.541	−0.002 (−0.005, 0.000)	0.104
N	*186398*		*171541*		*74231*	

Abbreviations: Average marginal effects (AME), confidence interval (CI)

[a]Each average marginal effect is estimated from a single model with either tax or price as the independent variable. Average marginal effects are the average change in predicted probability of the outcome, associated with a one-dollar increase in tax or price. In addition to tax or price, all Poisson models included all variables shown in Table 1 for each grade as well as a year indicator and a state random effect. Conditional intensity was investigated using linear models, adjusted for the same covariates as the Poisson models; interpretation is for a change in the mean cigarettes per day. The initiation questions were only asked for half of the 12th grade forms so sample size is halved.