

# **The Effects of Graduation Requirements on Risky Health Behaviors of High School Students**

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**Abstract:** Although previous studies have shown that years of schooling affects health behaviors, little is known about how the stringency of academic programs affects such behaviors, especially among youth. Using national survey data from the Youth Risk Behavior Surveillance System (YRBS), we study the effects of mathematics and science high-school graduation requirements (HSGR) on high school students' risky health behaviors--specifically on drinking, smoking, and marijuana use. We find that an increase in mathematics and science HSGR has significant negative impacts on alcohol consumption among high-school students, especially male students. The effects of math and science HSGR on smoking and marijuana use are also negative but not statistically significant at conventional levels in most cases. Our results suggest that curriculum design may have potential as a policy tool to curb youth drinking.

**JEL Classifications:** I12, I29

**Keywords:** high school graduation requirements; health behaviors; youth

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## 1. Introduction

Since the seminal work of Grossman (1972), the relationship between schooling and health has been well established. Years in school predicts health behaviors and outcomes strongly, with many papers providing evidence for a causal effect of schooling on health.<sup>1</sup> However, most previous work focuses on the impacts of formal schooling quantity on the health of college students or adults (or their children). There are relatively few studies about how other dimensions of education affects health.<sup>2</sup> Even less is known about how educational quality affects the health behaviors of youth.<sup>3</sup> This question is important given that drinking and smoking habits established in youth are persistent over the life cycle (Farrell and Fuchs, 1982; Wechsler et al., 1995; Arria et al., 2008); thus, deterring risky behaviors at younger ages could have significant long-term benefits (Gruber and Zinman, 2001; Auld, 2005).

In this study, we examine how high school graduation requirements (HSGR) regarding mathematics and science credits impact the health behaviors of high-school students. We focus specifically on mathematics and science because these courses have been shown to be important determinants of various future socioeconomic outcomes for youth including college

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<sup>1</sup> Readers can refer to the following papers on education and health: education and smoking (De Walque, 2007; Grimard and Parent, 2007; Park and Kang, 2008; Heckman et al., 2014), education and self-reported health (Adams, 2002; Arendt, 2005), education and mortality (Lleras-Muney, 2005; Buckles et al., 2016), education and infant health (McCrary and Royer, 2011), education and various health behaviors (Kenkel et al., 2006; Cutler and Lleras-Muney, 2010; Conti et al., 2010; Savelyev and Tan, 2014); and a literature review on the impacts of education on health (Cutler and Lleras-Muney, 2006).

<sup>2</sup> Among those, Fletcher and Frisvold (2011, 2014) find that college selectivity affects both health behaviors and health outcomes. Frisvold and Golberstein (2011) find that improvements in school quality, measured by the pupil-teacher ratio, average teachers' wages, and length of the school year, amplify the effects of education on self-rated health, smoking, obesity, and mortality. Sansani (2011) shows that school quality, measured by return to schooling, length of school term, and relative teacher wage, predicts mortality.

<sup>3</sup> Exceptions include Cowan (2011), who finds that lower college costs mitigate risky behaviors among high-school students. Jensen and Lleras-Muney (2012) show that increasing schooling and decreasing work reduce smoking among teens in the Dominican Republic.

attainment and earnings.<sup>4</sup> This paper adds to the literature by considering how the stringency of high school via changes to state-level graduation requirements affects students' drinking, smoking, and marijuana use.

There are several possible channels through which HSGR may affect risky health behaviors. The first and perhaps most important channel is through the time constraint. Stricter requirements for math and science lead students to take more courses and to enroll in higher-level courses (Clune and White, 1992; Chaney et al., 1997; Schiller and Muller, 2003; Teitelbaum, 2003; Federman, 2007). Schiller and Muller (2003) find that students in states with higher graduation requirements tend to enroll in higher level math courses as freshmen and persist in taking more advanced courses. The positive change of courses both in quantity and difficulty may leave students with less time to engage in substance use.

Second, there may be expectation effects. Since taking courses in math and science in high school has positive impacts on future college attainment and earnings, students in states with higher HSGR may have higher expectations about these future outcomes. Becker (1965) shows theoretically that an increase in expected future earnings could induce a decline in the amount of time dedicated to consumption activities because time becomes more expensive. As Cowan (2011) shows empirically, greater expectations for college attainment are associated with better health behaviors in high school. Therefore, higher HSGR may lead to a decrease in substance

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<sup>4</sup> Levine and Zimmerman (1995) find that high-school math and science courses have a positive impact on future earnings. Similarly, Rose and Betts (2004) and Joensen and Nielsen (2009) show that mathematics courses taken in high school are related to future earnings. Bottia et al. (2015) find that taking physics and attending a school with a math and science focused program are closely associated with students' choice of STEM as a major. Kim et al. (2015) show that completing an Algebra II course in high school leads to a higher chance of going to college. Federman (2007) shows higher state math and science graduation requirements lead to a higher probability of choosing a technology major in college.

use through this channel.

Using Youth Risk Behavior Surveillance System (YRBS) national survey data from 1993 to 2013, and adopting a generalized difference-in-difference (DID) framework, we show that an increase in math and science HSGR has significant negative impacts on the alcohol consumption of high-school students with no accompanying increase in the consumption of cigarettes or marijuana. The effects of HSGR are typically larger among males than females. Furthermore, our results are robust to various measures of drinking, smoking, and marijuana use.

Since more stringent HSGR may induce some students to drop out of school, and our data contains only high-school students, concerns about sample selection are natural.<sup>5</sup> One might suspect that students who engage in riskier behaviors are more likely to drop out, causing selection bias. Adopting the method proposed by Carpenter and Stehr (2008), we estimate our models using only students who are 16 years old or under. Because of compulsory schooling laws, there are very few youth absentees under 17, making selection less of a concern in this subsample. In this case, the magnitudes of our results diminish modestly, which is consistent with either larger effects of HSGR among older students or modest selection bias. Regardless, we continue to find economically and statistically significant effects of HSGR on drinking among the younger subsample, indicating that the potential selection bias cannot account for the negative impacts on drinking identified in our main regressions.

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<sup>5</sup> Lillard and DeCicca (2001) conclude that state mandated minimum course requirements cause a moderate rise in high school dropout rates. Plunk et al. (2014) similarly find that higher math and science HSGR is associated with higher odds of dropping out. In contrast, Clark and See (2011), examining the possible dropout effect of the higher graduation standard in Florida, find no effect at all.

The validity of our identification strategy is also tested. Because HSGR is a non-binary treatment and many states changed their HSGR more than once, a traditional event-study framework is not suitable in our setting. We propose a placebo analysis by examining the effects of placebo policies that are lags and leads of true changes in HSGR. The results support the notion that changes in students' health behaviors are indeed caused by HSGR.

Though comparing different policies for curbing substance use among youths is beyond the scope of our paper, our results suggest that improving the rigor of high-school education may be an attractive way to accomplish this goal. First, raising HSGR increases math and science course-taking, which is a primary goal of the education reforms since the 1980s (Clune and White, 1992; Teitelbaum, 2003). Second, raising HSGR may be more feasible than increasing taxes enough to have similar effects on risky behaviors, especially when raising the (full) price of one substance might only push youths to other substances.<sup>6</sup> However, more work is needed to ascertain the full costs and benefits of making high school education more rigorous.

## **2. Data**

Our data on the health behaviors of high-school students comes from the biannual Youth Risk Behavior Surveillance System (YRBS) national survey from 1993 to 2013. It contains 146,964 observations of high school students in 47 states. Various health behaviors, as well as demographic information on gender, age, grade, and race, are documented.

Unfortunately, the YRBS survey does not contain some potential determinants of health

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<sup>6</sup> Chaloupka and Laixuthai (1997) find that drinking among youths is negatively related to beer prices while positively related to the full price of marijuana, suggesting that beer and marijuana are substitutes among youths. DiNardo and Lemieux (2001) show that raising the minimum legal drinking age increases marijuana consumption. Crost and Guerrero (2012) find that alcohol and marijuana are substitutes in a minimum drinking age law context.

behaviors such as family income and parental education. However, the absence of these variables would only be a problem if there were different trends in these factors across treatment and control states. To address concerns about omitted variable bias, we add various state-specific economic and policy variables (and state-specific linear time trends, in some cases) as control variables in our models. These variables include median income, unemployment rate, expenditures per pupil for public elementary and secondary education (will be referred to as “public school per pupil spending”), cigarette tax, beer tax, and medical marijuana legalization status from 1993 to 2013. The data sources are described in Appendix 1. These variables are included to control for financial support for education, the full price of substances, and differences in the economic environment across states over time.<sup>7</sup>

Data on math and science HSGR is taken from the Digest of Education Statistics (DES) published by the National Center for Education Statistics (NCES). The DES reports the minimum Carnegie units of mathematics and science courses required for high-school graduation by 50 states and the District of Columbia.<sup>8</sup> Until 2001, the DES reported the first graduating class that was impacted by a change to HSGR. Starting in 2002, the DES stopped reporting this information. Hence, we collected the impact cohort information from the education board or department of each state. The final compiled dataset contains math and science HSGR from the graduation year 1989 to 2015, matched with each student using his/her

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<sup>7</sup> Previous studies have shown a relationship between alcohol taxes and youth drinking (Dee, 1999; Xuan et al., 2013), cigarette taxes and youth smoking (Carpenter and Cook, 2008; DeCicca et. al., 2008; Hansen et al., 2015), marijuana legalization and youth marijuana use (Chu, 2014; Anderson et al., 2015; Pacula et al., 2015; Wen et al., 2015), and macroeconomic conditions and health (Ruhm, 1995, 2003, 2005, 2015; Ruhm and Black, 2002).

<sup>8</sup> One Carnegie unit is defined as 120 hours of instruction time, which can be roughly translated into one academic year (two semesters) of instruction in one course.

state and predicted graduation year.<sup>9</sup> We then added the required Carnegie units of math and science courses together to get the *total number of minimum required Carnegie units in math and science courses*, which will be used in our regressions and be referred to as *HSGR* or *math and science HSGR*.<sup>10</sup> Table 1 shows the HSGR of each state for the selected graduating classes of 1993, 2003, and 2013. Our dataset indicates that from 1993 to 2013, 41 states (including the District of Columbia) changed their HSGR and 10 states remained unchanged.<sup>11</sup>

[TABLE 1 IS HERE]

Observations with at least one missing variable of interest, which include observations from a few states in which there is no state level HSGR, are dropped from our regression sample. That leaves us 115,361 total observations, including 55,812 males and 59,549 females. The summary statistics of the data we use are shown in Table 2.<sup>12</sup> The vast majority of students are

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<sup>9</sup> We assume all students graduate in 4 years. Readers can refer to Appendix 2 for further explanation.

<sup>10</sup> We also looked at the effects of math HSGR and that of science HSGR separately. The results suggest negative impacts of both math HSGR and science HSGR, with no clear evidence showing which one is more important. But since many states change math HSGR and science HSGR at the same time, separate estimations give less precise results due to the collinearity. Therefore, like Plunk et al. (2014), this study combines math HSGR and science HSGR together because they are both important in taking up students' study time and important determinants of future socioeconomic outcomes.

<sup>11</sup> State changes to HSGR have been focused on math and science courses for several decades (Teitelbaum, 2003). In fact, during our sample period, only 9 states changed the English/language arts courses requirements, and 24 states changed the social studies requirements. From 1993 to 2013, the average HSGR (unweighted) across states has gone up from 2.32 to 2.91 (in Carnegie units) for mathematics and from 2.10 to 3.26 for science, compared with an increase of HSGR from 3.85 to 3.97 for English/language arts and an increase from 2.63 to 3.02 for social studies. Data sources: Table 152, DES1993 and Table 234.30, DES2013 (<https://nces.ed.gov/programs/digest/>). Considering the lack of variation in English/language arts and social studies requirements over time, we do not include them in our regressions.

<sup>12</sup> Observations are weighted to be representative at the state level (weighting method to be introduced in the next section). The summary statistics of the unweighted data are very similar to the weighted values and available upon request. After dropping observations with missing variables, t-tests show that students in our regression sample tend to have healthier behaviors, compared with the students dropped from our sample. The comparison details are shown in Appendix 3.

between 14 and 18 years old. Students from each grade make up about a quarter of the total sample. Black and Hispanic students are over-sampled, while white students are under-sampled. The percentage of students who use each of alcohol, cigarettes, and marijuana is striking. About 45% of high school students consumed alcohol in the last 30 days. The proportions of students that binge drank, smoked, and used marijuana in the last 30 days are 28%, 25%, and 22%, respectively. During our sample period, high school students engaged in an average of 1.3 days of binge drinking, 2.7 days of drinking, 3.7 days of smoking, and 3.2 occasions of marijuana use in the last 30 days. Male students were more likely to consume these substances, and they tended to do so more frequently.<sup>13</sup>

[TABLE 2 IS HERE]

### 3. Empirical Method

The empirical specification of our model is:

$$HB_{ist} = \alpha HSGR_{ist} + X_{ist}\beta + S_{st}\gamma + \delta_s + \tau_t + \epsilon_{ist}. \quad (1)$$

In this model,  $HB_{ist}$  is individual  $i$ 's health behavior in state  $s$  at time  $t$ .  $HSGR_{ist}$  represents the math and science HSGR as defined in the previous section, which depends on a youth's state and predicted graduation year.  $X_{ist}$  contains all individual-level

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<sup>13</sup> Note that marijuana use is measured in "occasions" instead of "days" due to the YRBS survey design. Drinking days, binge drinking days, smoking days, and marijuana use occasions (in last 30 days) are categorical variables. In the YRBS national survey, students report their health behaviors by answering multiple choice questions. For example, students are asked "During the past 30 days, on how many days did you have at least one drink of alcohol?" and to choose from "A) 0 days, B) 1 or 2 days, C) 3 to 5 days, D) 6 to 9 days, E) 10 to 19 days, F) 20 to 29 days, and G) All 30 days". We take the midpoint of each group as an approximation of the actual drinking days when running OLS models (e.g., if a student chose the answer D, we label this student as having 7.5 drinking days in the last 30 days). The same method applies to other categorical measures of substance use. Alternatively, we analyze these categorical responses in ordered probit models (Appendix 7) and find similar results to our baseline OLS ones.



control variables including gender, age, grade, and race.  $S_{st}$  stands for all state-level control variables including median income, public school per pupil spending, unemployment rate, beer tax, cigarette tax, and medical marijuana legalization status dummies.  $\delta_s$  and  $\tau_t$  are state and year dummies, respectively. Our assumption for identifying  $\alpha$  is the typical DID assumption that changes to HSGR within a state over time are exogenous to youths' health behavior decisions.

As shown in Table 2, we have four measures of drinking behavior, including “did binge drink in last 30 days (1 if yes, 0 if no)”, “did drink in last 30 days (1 if yes, 0 if no)”, “number of days binge drinking in last 30 days”, and “number of days drinking in last 30 days”; two measures of smoking behavior, including “did smoke in last 30 days (1 if yes, 0 if no)” and “number of days smoking in last 30 days”; and finally, two measures of marijuana use, including “did use marijuana in last 30 days (1 if yes, 0 if no)” and “times marijuana used in last 30 days”. We use OLS to construct our baseline estimates in line with most previous studies, but we also use discrete choice models (Appendices 6 and 7), the results of which are consistent with those found in the body of the paper.

There are two major issues regarding the YRBS national survey data. First, the data is not representative at the state level, and the number of students surveyed from each state varies considerably across cohorts. Because of that, we weight our sample so that observations in each state-year pair are representative of the state's share of national public high-school students, an approximation of the proportion of total high-school students in each state among all high-

school students in the nation.<sup>14</sup> In other words, the weight for each observation is calculated by

$$Weight_{ist} = \frac{State\ Public\ High\ School\ Enrollment_{st}}{National\ Public\ High\ School\ Enrollment_t \times Observations_{st}}.^{15}$$

The second issue is the potential for sample selection. As mentioned above, previous studies show that increases in HSGR may unintentionally raise high-school dropout rates. Since YRBS data only contains high-school students who were currently enrolled, we need to address the concern that the effects of HSGR on substance use identified in our study are due to higher dropout rates of students with riskier behaviors.<sup>16</sup> Most studies that use YRBS data do not explicitly address this issue (Carpenter and Cook, 2008; Anderson, 2010; DeSimone, 2010; Disney et al., 2013; Xuan et al., 2013; Anderson and Elsea, 2015; Hansen et al., 2015). However, this selection issue is crucial in this paper because unlike previous studies, in which the covariates are fairly unlikely to affect the dropout rate, HSGR more plausibly does so.

Carpenter and Stehr (2008) propose a remedy for this problem by running the same regressions only using students who are 16 or under. The reason is that state compulsory

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<sup>14</sup> The YRBS dataset contains a weighting variable itself, which is calculated based on student sex, race/ethnicity, and grade to address nonresponse and the oversample of black and Hispanic students in order to be representative at the national level, but not at the state level. In contrast, our weighting method produces a representative dataset at the state level in terms of the state's share among national students so that it can be used to produce state-level estimates. However, our method is not able to adjust for nonresponse or demographic factors. As a result, blacks and Hispanics remain over-sampled using our weighting method. Since our main goal is to estimate state level policy effects, we believe our weighting method is more appropriate. The oversampling by race/ethnicity is addressed by adding these variables into the regressions as control variables.

<sup>15</sup> We also examined all models reported below using the unweighted YRBS data. In most cases, point estimates have the same sign but are smaller in absolute value compare with those from the weighted data. The results for drinking generally remain statistically significant at conventional levels while those for smoking and marijuana use are again not significant. These results are available upon request.

<sup>16</sup> One study by Bray et al. (2000) shows that marijuana use is positively related with dropping out from high school.

schooling laws can dictate a subgroup that has a much smaller selection problem. Over our sample period, students were required to stay in school by law until at least 16 years old in every state, with many states requiring even longer attendance.<sup>17</sup> Using U.S. Census and American Community Survey data, we calculated the school enrollment rates by different age groups for the year 1990, 2000, and 2010. The results, presented in Table 3, show there were clear gaps in the enrollment rates between 16 years old and 17 years old, and dropouts before age 17 were rare. Although the enrollment rates were not 100% even for younger individuals, restricting our sample to the younger subgroup mitigates the concern that our results are being driven by selection. Thus, our primary robustness check strategy is to only include students who are under 17 in the same regressions as in our main analysis. We show in Section 5 that the potential selection cannot account for our main results.

[TABLE 3 IS HERE]

#### **4. Main Results**

Tables 4 and 5 show the results of our baseline regressions, with the effects of HSGR on

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<sup>17</sup> In 1994, 33 states required attendance until age 16, 9 states until age 17, and 9 states until age 18. In 2013, 22 states required attendance until age 16, 9 states until age 17, and 19 states until age 18. Source: Digest of Education Statistics, National Center for Education Statistics (For compulsory schooling ages data in 1994, see: <https://nces.ed.gov/programs/digest/d95/dtab148.asp>; for data in 2013, see: [https://nces.ed.gov/programs/digest/d13/tables/dt13\\_234.10.asp](https://nces.ed.gov/programs/digest/d13/tables/dt13_234.10.asp)). Although in some states, like Florida, students are allowed to drop out when they turn 16, extra requirements like parents' consent and filing formal declaration of intent to terminate school enrollment with the school district are needed if they decide to drop out at age 16, making it harder than doing so at 17 or older. Source: Florida Department of Education (<http://www.fldoe.org/how-do-i/attendance-enrollment.shtml>).

It would be useful to control for the effects of the compulsory schooling laws in the regressions. However, we can only find compulsory schooling law information for every even year during our sample period. Considering YRBS cohorts are from odd years, matching these two sets of data is problematic. Because of this, we do not add compulsory schooling law dummies in the baseline regressions or in the main robustness check regressions. However, we did run the regressions with the nearest year law dummies added later, and the results are very similar to those without them and are available upon request.

drinking listed in Table 4 and the effects of HSGR on smoking and marijuana use listed in Table 5. All models are estimated using OLS with standard errors clustered at the state level. Column (1) of both tables shows the results from models estimated with state and time fixed effects and individual-level controls but without state-level controls. State-level control variables are added in column (2). Finally, in column (3), both state-level controls and state-specific linear time trends are included.

[TABLES 4&5 ARE HERE]

Table 4 shows consistently negative impacts of HSGR on drinking across all measures: it decreases the probability of drinking and binge drinking as well as the number of drinking days and binge drinking days. From the subgroup estimations, the magnitudes of HSGR's effects on drinking and binge drinking are larger among male students than females for every measure and every specification.

Most results in columns (1) and (2) of Table 4 are statistically significant (at the 10% level or better), except for the effects on female binge drinking days in column (2) and the effects on female drinking days in both columns. After adding state-specific linear time trends, some results lose significance in columns (3). Point estimates in columns (3) decline (usually modestly) in absolute value in most cases but still remain negative, and standard errors increase. These changes are because the state-specific time trends are correlated with HSGR and thus pick up some of the effects of HSGR. As Wolfers (2006) argues, state-specific time trends may capture the effects of policies in addition to differences in preexisting trends. Because of this multicollinearity, the results after adding state-specific time trends are not necessarily more trustworthy than those without them.

Following this argument, we treat columns (2) as our preferred specification which includes state dummies, year dummies, individual controls and state controls. Our state level controls include a broad range of factors that we believe are able to largely control for state-level heterogeneous trends. Nevertheless, the results after adding state-specific linear time trends are reported in columns (3) for the information of the readers. Throughout our study, we find that although some of the results become insignificant after adding state-specific time trends, all the estimated signs are negative and consistent with those in columns (1) and (2).

Using our preferred specification with the total sample, the point estimates of the effect of HSGR on “did binge drink in last 30 days” and “did drink in last 30 days” are both -0.016, meaning that one additional unit in math and science HSGR reduces the probability of both binge drinking and drinking by 1.6%. These drops constitute 5.8% of the students who did binge drink and 3.5% of the students who did drink in our sample.<sup>18</sup> For male students, both estimates are -0.018, constituting 5.8% of males who did binge drink and 3.8% of males who did drink. For female students, the reductions are both 1.4% for binge drinking and drinking, constituting 5.8% of females who did binge drink and 3.2% of females who did drink.

Table 4 also shows that one additional unit of HSGR reduces binge drinking days by 0.119 and drinking days by 0.171 for the total sample, which is a 9.4% drop at the mean in binge drink days and a 6.3% drop at the mean in drinking days. The estimated declines among males are 6.7% at the mean in binge drinking and 5.7% at the mean in drinking (the effects of HSGR on female binge drinking days and drinking days are insignificant at conventional levels and

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<sup>18</sup> These two numbers are calculated as  $100 \times (0.016 / 0.275) = 5.8$  percent for binge drinking and  $100 \times (0.016 / 0.454) = 3.5$  percent for drinking. Percentage changes discussed below are calculated using the same method.

not reported here).

Table 5 reports the effects of HSGR on smoking and marijuana use. The results are consistent with the results for drinking regarding the estimated signs but different in terms of statistical significance. From the top half of Table 5, the effect of HSGR on smoking is only significant in one specification for the total sample (“did smoke in last 30 days”, column (2)), and the coefficients for female students are insignificant at conventional levels in any specification. The effects on males are significant in column (2) for both smoking measures and are larger than those for females. Based on the results shown in column (2), a one-unit increase in HSGR decreases the likelihood of smoking in the last 30 days by 1.0% for the total sample and 1.3% for male students, which are equivalent to 4.0% of the total sample who did smoke and 4.8% of males who did smoke. Furthermore, one additional unit of HSGR reduces smoking days by 0.183 for male students, which is a 4.4% drop at the mean among this group. All insignificant results are not reported here, although the negative estimated signs are consistent with our earlier results on drinking.

The bottom half of Table 5 shows the effects of HSGR on marijuana use. No results are significant for either measure of marijuana use among the total sample and male students; the two significant results are for females (“did use marijuana in last 30 days”, columns (2) and (3)). Though we cannot reject the null hypothesis that the effect of HSGR on marijuana use is zero in most cases, we continue to find negative coefficients across all specifications, which at least suggests that students are not merely substituting from alcohol to tobacco or marijuana

(or vice versa) when HSGR becomes more stringent.<sup>19,20</sup>

## 5. Younger Subsamples

As discussed above, we adopt the approach of Carpenter and Stehr (2008) and restrict the sample to students who are 16 years old and under to conduct our primary robustness check. HSGR is likely to affect younger students' health behaviors through the time constraint because students facing higher HSGR tend to enroll in higher level courses from the beginning of high school study (Schiller and Muller, 2003). Since dropout rates are very low for students in this age category, the results are less likely to be contaminated by sample selection bias due to dropout. All methods and the control variables remain the same as those in the previous section. In our database, 66,074 observations out of 115,361, or 57 percent of the total observations, are under 17 years old. 56 percent of male students and 59 percent of females are under 17. Detailed descriptive statistics are listed in Appendix 5.

Table 6 shows the effects of HSGR on drinking for the younger subsample. The results are consistent with those in Table 4. Nearly all the estimated signs are negative. Point estimates for the total sample are slightly smaller in absolute value compared with those in Table 4 in most cases, and this is primarily driven by smaller effects for females rather than males. Both

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<sup>19</sup> Despite the lack of statistical significance, the estimated signs for marijuana use are consistent with those of drinking and smoking. This insignificance could come from under-reporting. Although all three substances are illegal for youth, marijuana use is arguably accompanied with harsher social criticism. Two studies also point out that people tend to under-report marijuana use (Mensch and Kandel, 1988; Bessa et al., 2010).

<sup>20</sup> In addition to drinking, smoking and marijuana use, YRBS also has measures of cocaine use including "did use cocaine in last 30 days" and "times cocaine used in last 30 days". It also records the use of heroin, methamphetamines, and other drugs. But those measures are based on lifetime consumption (instead of consumption in the past month), which are not suitable for this study. There are 4.5% of high school students who report using cocaine in the last 30 days. Appendix 4 shows the results with cocaine use as the dependent variable. The point estimates are generally insignificant and show negative signs with a few exceptions.

total sample and male sample estimates are significant in our preferred specification and most other specifications. But all results for females lose significance. These results show that the potential selection due to different dropout patterns cannot explain our main results for drinking among males or both sexes, though we cannot rule out the possibility of selection among females (alternatively, the effects of HSGR on drinking behavior may be stronger for females at higher grade levels).

[TABLES 6&7 ARE HERE]

Table 7 shows the effects of HSGR on smoking and marijuana use for students under age 17. The results are broadly consistent with their counterparts in Table 5, though they are modestly smaller. Again, nearly all coefficients in Table 7 are negative. However, most of the coefficients have lost their significance except for one measure of male smoking, suggesting that some significant results for smoking in Table 5 may be caused by selection. Although the loss of significance could be due to a smaller sample size and thus less precise estimation, according to Table 7, the effects of HSGR on marijuana are statistically indifferent from zero, and we cannot definitively conclude that HSGR negatively affects smoking.<sup>21</sup>

## 6. Placebo Analysis

To test the validity of our DID design, we construct a placebo test in this section. The goal is to mitigate the concern that the trends in risky behavior would have been different between

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<sup>21</sup> We also examined the robustness of our results by using probit models for binary dependent variables and ordered probit models for multinomial dependent variables. Regressions are performed both for all students and those under 17. In order to save space, we only report the results of our preferred specification, which includes individual controls, state controls, state and time dummies. The results are shown in Appendix 6 and Appendix 7 and they correspond to the second columns in Table 4 through Table 7. The results are consistent with their counterparts in Tables 4 through 7.



the treatment states and control states even in the absence of treatment. Traditionally, such tests are performed under an event-study framework by replacing the treatment variable with cohort-specific dummy indicators (relative to treatment) and examining the effects of each indicator. However, our data structure prevents us from adopting the typical event study framework, because HSGR is a non-binary policy and a substantial number of states (20) changed their HSGR more than once from 1993 to 2013. Simon (2016) proposes to use only large policy changes (in his case, excise tax hikes) to reduce the events that are considered to be treatments, and he limits the sample period to a certain time window to guarantee there is only one discrete event per state. Unfortunately, this method is not suitable for us given that most HSGR changes are the same size (1 or 2) and distributed fairly uniformly throughout our sample time frame.

In our placebo test, we construct 10 different placebo HSGR treatments, which are essentially 6 leads (by shifting the true HSGR 1-6 cohorts forward) and 4 lags (by shifting the true HSGR 1-4 cohorts backward) of the true HSGR. In other words, by imposing the “ $n$  cohorts ahead (after)” placebo HSGR, students of graduation year  $t$  are being treated with the HSGR of graduation year  $t \pm n$ .<sup>22</sup>

If our DID method is valid, we expect the effects of these placebo HSGR to be smaller than the effects of the true HSGR because of mismatching. In addition, the further a placebo HSGR deviates from the true HSGR, the more severe the mismatch is, and thus the smaller the effect of the placebo HSGR should be. On the contrary, if the placebo HSGR effects do not

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<sup>22</sup> We choose to use 4 lags because our HSGR data begins with the graduating cohort of 1989, 4 years prior to our first cohort (graduation year 1993) in the YRBS data. To construct the 6 HSGR leads, for those observations that would receive a placebo HSGR for a graduation year beyond 2015, we simply assign them the last HSGR available (graduation year 2015). As illustrated below, with this number of leads and lags, we find that the effects of (placebo) HSGR diminish as the placebo HSGR gets farther from the true HSGR.

show such a pattern, it would call our identification strategy into question. For example, if the effects got stronger as the placebo HSGR was shifted forward, we would have reason to believe that there were different pre-treatment trends between control and treatment groups caused by unobserved differences between the two, which would mean our baseline estimates of HSGR on risky health behaviors are likely biased upward (in absolute value).<sup>23</sup>

We only perform the placebo test on drinking behaviors since these behaviors are most affected by HSGR in our baseline models. Table 8 shows the effects of placebo HSGR's on these behaviors under our preferred specification.  $n$  cohort ahead (after) means the placebo HSGR is generated by shifting the true HSGR forward (backward) by  $n$  cohorts. The effects of the true HSGR are the same as shown in Column (2) of Table 4 (full sample) and indeed are stronger than any placebo effect in terms of both magnitude and significance. The effects of placebo HSGR's generally get smaller the further they are from the true HSGR, supporting the validity of our DID design.

[TABLE 8 IS HERE]

## 7. Conclusions and Discussions

We study the effects of high-school graduation requirements (HSGR) regarding mathematics and science on high-school students' health behaviors, specifically drinking, smoking, and marijuana use. We find that an increase in math/science HSGR has significant negative impacts on the alcohol consumption of high-school students, especially males. Estimated effects on smoking and marijuana are consistently negative though often not

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<sup>23</sup> It is important to note that our placebo HSGR's will still pick up some effects of the true HSGR because they will still partially coincide with the true HSGR, unlike a traditional event-study design in which each cohort/bin indicator "turns on" just once at a certain cohort/bin. This is one shortcoming of our design.

statistically different from zero, especially among our younger subsample.

The potential selection issue due to high-school dropout is addressed. Using observations of individuals under 17 years old, we show that either the effects of math and science HSGR are somewhat larger among older (higher grade) students, or there is indeed a modest amount of selection such that riskier youths are less likely to be in our (school based) sample. One limitation of our study is that we are unable to identify which of these explanations accounts for our findings. However, because point estimates remain economically and statistically significant when using our younger subsample, the sample selection is not nearly sufficient to account for our main results on (binge) drinking.

As mentioned above, there is empirical evidence suggesting that different substances may be substitutes among youths. For example, raising the price of alcohol by increasing its excise tax or raising the minimum drinking age is likely to decrease alcohol consumption but could increase the consumption of marijuana. Since HSGR is a constraint imposed on time, it does not seem to induce a shift from one substance to another in this way. Our results suggest that HSGR could be an attractive policy alternative to curb youth drinking, and that perhaps high-school course requirements or curriculum are an understudied means of discouraging risky behavior. However, since an increase in HSGR imposes a stricter time constraint, it is possible that it could reduce students' sleeping or exercise. The limitation of our dataset prevents us from examining the effects of HSGR on these health behaviors. Further work could explore whether the benefits of higher HSGR outweigh its costs.

### References:

1. Adams, Scott J. "Educational attainment and health: Evidence from a sample of older adults." *Education Economics* 10.1 (2002): 97-109.
2. Anderson, D. Mark. "Does information matter? The effect of the meth project on meth use among youths." *Journal of Health Economics* 29.5 (2010): 732-742.
3. Anderson, D. Mark, Benjamin Hansen, and Daniel I. Rees. "Medical marijuana laws and teen marijuana use." *American Law and Economics Review* 17.2 (2015): 495-528.
4. Anderson, D. Mark, and David Elsea. "The meth project and teen meth use: New estimates from the national and state youth risk behavior surveys." *Health Economics* 24.12 (2015): 1644-1650.
5. Arendt, Jacob Nielsen. "Does education cause better health? A panel data analysis using school reforms for identification." *Economics of Education Review* 24.2 (2005): 149-160.
6. Arria, Amelia M., et al. "High school drinking mediates the relationship between parental monitoring and college drinking: A longitudinal analysis." *Substance Abuse Treatment, Prevention, and Policy* 3.1 (2008): 1-11.
7. Auld, M. Christopher. "Causal effect of early initiation on adolescent smoking patterns." *Canadian Journal of Economics* 38.3 (2005): 709-734.
8. Becker, Gary S. "A theory of the allocation of time." *The Economic Journal* 75.299 (1965): 493-517.
9. Bessa, Marco A., et al. "Underreporting of use of cocaine and marijuana during the third trimester of gestation among pregnant adolescents." *Addictive Behaviors* 35.3 (2010): 266-269.
10. Bottia, Martha Cecilia, et al. "The relationships among high school STEM learning experiences and students' intent to declare and declaration of a STEM major in college." *Teachers College Record* 17.3 (2015): 1-46.
11. Bray, Jeremy W., et al. "The relationship between marijuana initiation and dropping out of high school." *Health Economics* 9.1 (2000): 9-18.
12. Buckles, Kasey, et al. "The effect of college education on mortality." *Journal of Health Economics* 50 (2016): 99-114.
13. Carpenter, Christopher S., and Mark Stehr. "The effects of mandatory seatbelt laws on seatbelt use, motor vehicle fatalities, and crash-related injuries among youths." *Journal of Health Economics* 27.3 (2008): 642-662.
14. Carpenter, Christopher, and Philip J. Cook. "Cigarette taxes and youth smoking: new evidence from national, state, and local Youth Risk Behavior Surveys." *Journal of Health Economics* 27.2 (2008): 287-299.
15. Chaloupka, Frank J., and Adit Laixuthai. "Do youths substitute alcohol and marijuana? Some econometric evidence." *Eastern Economic Journal* 23.3 (1997): 253-276.
16. Chaney, Bradford, Kenneth Burgdorf, and Nadir Atash. "Influencing achievement through high school graduation requirements." *Educational Evaluation and Policy Analysis* 19.3 (1997): 229-244.
17. Chu, Yu-Wei Luke. "The effects of medical marijuana laws on illegal marijuana use." *Journal of Health Economics* 38 (2014): 43-61.
18. Clark, Damon, and Edward See. "The impact of tougher education standards: Evidence from Florida." *Economics of Education Review* 30.6 (2011): 1123-1135.

19. Clune, William H., and Paula A. White. "Education reform in the trenches: Increased academic course taking in high schools with lower achieving students in states with higher graduation requirements." *Educational Evaluation and Policy Analysis* 14.1 (1992): 2-20.
20. Conti, Gabriella, James Heckman, and Sergio Urzua. "The education-health gradient." *The American Economic Review* 100.2 (2010): 234-238.
21. Cowan, Benjamin W. "Forward-thinking teens: The effects of college costs on adolescent risky behavior." *Economics of Education Review* 30.5 (2011): 813-825.
22. Crost, Benjamin, and Santiago Guerrero. "The effect of alcohol availability on marijuana use: Evidence from the minimum legal drinking age." *Journal of Health Economics* 31.1 (2012): 112-121.
23. Cutler, David M., and Adriana Lleras-Muney. *Education and health: evaluating theories and evidence*. No. w12352. National Bureau of Economic Research, 2006.
24. Cutler, David M., and Adriana Lleras-Muney. "Understanding differences in health behaviors by education." *Journal of Health Economics* 29.1 (2010): 1-28.
25. DeCicca, Philip, Don Kenkel, and Alan Mathios. "Cigarette taxes and the transition from youth to adult smoking: smoking initiation, cessation, and participation." *Journal of Health Economics* 27.4 (2008): 904-917.
26. Dee, Thomas S. "State alcohol policies, teen drinking and traffic fatalities." *Journal of Public Economics* 72.2 (1999): 289-315.
27. De Walque, Damien. "Does education affect smoking behaviors?: Evidence using the Vietnam draft as an instrument for college education." *Journal of Health Economics* 26.5 (2007): 877-895.
28. DeSimone, Jeff. "Drinking and academic performance in high school." *Applied Economics* 42.12 (2010): 1481-1497.
29. DiNardo, John, and Thomas Lemieux. "Alcohol, marijuana, and American youth: the unintended consequences of government regulation." *Journal of Health Economics* 20.6 (2001): 991-1010.
30. Disney, Lynn D., Robin A. LaVallee, and Hsiao-ye Yi. "The effect of internal possession laws on underage drinking among high school students: A 12-state analysis." *American Journal of Public Health* 103.6 (2013): 1090-1095.
31. Farrell, Phillip, and Victor R. Fuchs. "Schooling and health: the cigarette connection." *Journal of Health Economics* 1.3 (1982): 217-230.
32. Federman, Maya. "State graduation requirements, high school course taking, and choosing a technical college major." *The BE Journal of Economic Analysis & Policy* 7.1 (2007): 1-34.
33. Fletcher, Jason M., and David E. Frisvold. "College selectivity and young adult health behaviors." *Economics of Education Review* 30.5 (2011): 826-837.
34. Fletcher, Jason M., and David E. Frisvold. "The long run health returns to college quality." *Review of Economics of the Household* 12.2 (2014): 295-325.
35. Frisvold, David, and Ezra Golberstein. "School quality and the education–health relationship: Evidence from Blacks in segregated schools." *Journal of Health Economics* 30.6 (2011): 1232-1245.
36. Grimard, Franque, and Daniel Parent. "Education and smoking: Were Vietnam war draft avoiders also more likely to avoid smoking?" *Journal of Health Economics* 26.5 (2007):

896-926.

37. Grossman, Michael. "On the concept of health capital and the demand for health." *Journal of Political Economy* 80.2 (1972): 223-255.
38. Gruber, Jonathan, and Jonathan Zinman. "Youth smoking in the United States: evidence and implications." *Risky behavior among youths: An economic analysis*. University of Chicago Press, 2001. 69-120.
39. Hansen, Benjamin, Joseph J. Sabia, and Daniel I. Rees. *Cigarette taxes and youth smoking: updated estimates using YRBS data*. No. w21311. National Bureau of Economic Research, 2015.
40. Heckman, James J., et al. *Education, health and wages*. No. w19971. National Bureau of Economic Research, 2014.
41. Jensen, Robert, and Adriana Lleras-Muney. "Does staying in school (and not working) prevent teen smoking and drinking?" *Journal of Health Economics* 31.4 (2012): 644-657.
42. Joensen, Juanna Schrøter, and Helena Skyt Nielsen. "Is there a causal effect of high school math on labor market outcomes?" *Journal of Human Resources* 44.1 (2009): 171-198.
43. Kenkel, Donald, Dean Lillard, and Alan Mathios. "The roles of high school completion and GED receipt in smoking and obesity." *Journal of Labor Economics* 24.3 (2006): 635-660.
44. Kim, Jeongeun, et al. "Completing algebra II in high school: Does it increase college access and success?" *The Journal of Higher Education* 86.4 (2015): 628-662.
45. Levine, Phillip B., and David J. Zimmerman. "The benefit of additional high-school math and science classes for young men and women." *Journal of Business & Economic Statistics* 13.2 (1995): 137-149.
46. Lillard, Dean R., and Philip P. DeCicca. "Higher standards, more dropouts? Evidence within and across time." *Economics of Education Review* 20.5 (2001): 459-473.
47. Lleras-Muney, Adriana. "The relationship between education and adult mortality in the United States." *The Review of Economic Studies* 72.1 (2005): 189-221.
48. McCrary, Justin, and Heather Royer. "The effect of female education on fertility and infant health: Evidence from school entry policies using exact date of birth." *The American Economic Review* 101.1 (2011): 158-195.
49. Mensch, Barbara S., and Denise B. Kandel. "Underreporting of substance use in a national longitudinal youth cohort individual and interviewer effects." *Public Opinion Quarterly* 52.1 (1988): 100-124.
50. Orzechowski, William, and Robert Walker. "The tax burden on tobacco." *Historical compilation* 49 (2014).
51. Park, Cheolsung, and Changhui Kang. "Does education induce healthy lifestyle?" *Journal of Health Economics* 27.6 (2008): 1516-1531.
52. Pacula, Rosalie L., et al. "Assessing the effects of medical marijuana laws on marijuana use: the devil is in the details." *Journal of Policy Analysis and Management* 34.1 (2015): 7-31.
53. Plunk, Andrew D., et al. "Intended and unintended effects of state-mandated high school science and mathematics course graduation requirements on educational attainment." *Educational Researcher* 43.5 (2014): 230-241.
54. Rose, Heather, and Julian R. Betts. "The effect of high school courses on earnings." *Review of Economics and Statistics* 86.2 (2004): 497-513.

55. Ruhm, Christopher J. "Economic conditions and alcohol problems." *Journal of Health Economics* 14.5 (1995): 583-603.
56. Ruhm, Christopher J. "Good times make you sick." *Journal of Health Economics* 22.4 (2003): 637-658.
57. Ruhm, Christopher J. "Healthy living in hard times." *Journal of Health Economics* 24.2 (2005): 341-363.
58. Ruhm, Christopher J. "Recessions, healthy no more?" *Journal of Health Economics* 42 (2015): 17-28.
59. Ruhm, Christopher J., and William E. Black. "Does drinking really decrease in bad times?" *Journal of Health Economics* 21.4 (2002): 659-678.
60. Sansani, Shahar. "The effects of school quality on long-term health." *Economics of Education Review* 30.6 (2011): 1320-1333.
61. Savelyev, Peter A., and Kegan Teng Kok Tan. "Personality, education, and health-related outcomes of high-ability individuals." *Fifth Biennial Conference of the American Society of Health Economists*. 2014.
62. Schiller, Kathryn S., and Chandra Muller. "Raising the bar and equity? Effects of state high school graduation requirements and accountability policies on students' mathematics course taking." *Educational Evaluation and Policy Analysis* 25.3 (2003): 299-318.
63. Simon, David. "Does early life exposure to cigarette smoke permanently harm childhood welfare? Evidence from cigarette tax hikes." *American Economic Journal: Applied Economics* 8.4 (2016): 128-159.
64. Teitelbaum, Peter. "The influence of high school graduation requirement policies in mathematics and science on student course-taking patterns and achievement." *Educational Evaluation and Policy Analysis* 25.1 (2003): 31-57.
65. Wechsler, Henry, et al. "Correlates of college student binge drinking." *American Journal of Public Health* 85.7 (1995): 921-926.
66. Wen, Hefei, Jason M. Hockenberry, and Janet R. Cummings. "The effect of medical marijuana laws on adolescent and adult use of marijuana, alcohol, and other substances." *Journal of Health Economics* 42 (2015): 64-80.
67. Wolfers, Justin. "Did unilateral divorce laws raise divorce rates? A reconciliation and new results." *The American Economic Review* 96.5 (2006): 1802-1820.

Table 1: Mathematics and Science HSGR for graduating class  
of 1993, 2003, and 2013 (in Carnegie units)

States	1993		2003		2013	
	Math	Science	Math	Science	Math	Science
AL	2	2	4	4	4	4
AK	2	2	2	2	2	2
AZ	2	2	2	2	4	3
AR	3	2	3	3	4	3
CA	2	2	2	2	2	2
CO	---	---	---	---	---	---
CT	3	2	3	2	3	2
DE	2	2	3	3	4	3
DC	2	2	3	3	4	4
FL	3	3	3	3	4	3
GA	2	2	4	3	4	4
HI	2	2	3	3	3	3
ID	2	2	2	2	4	3
IL	2	1	2	1	3	2
IN	2	2	2	2	3	3
IA	---	---	---	---	3	3
KS	2	2	2	2	3	3
KY	3	2	3	3	3	3
LA	3	3	3	3	4	3
ME	2	2	2	2	2	2
MD	3	2	3	3	3	3
MA	---	---	---	---	---	---
MI	---	---	---	---	4	3
MN	1	1	---	---	3	3
MS	2	2	3	3	4	4
MO	2	2	2	2	3	3
MT	2	2	2	2	2	2
NE	---	---	---	---	---	---
NV	2	2	3	2	3	2
NH	2	2	2	2	3	2
NJ	3	2	3	2	3	3
NM	3	2	3	2	4	3
NY	2	2	2	2	3	3
NC	2	2	3	3	4	3
ND	2	2	---	---	3	3
OH	2	1	2	1	3	3
OK	2	2	3	3	3	3
OR	2	2	2	2	3	3
PA	3	3	---	---	---	---
RI	2	2	2	2	4	3



SC	3	2	4	3	4	3
SD	2	2	2	2	3	3
TN	2	2	3	3	4	3
TX	3	2	3	2	4	4
UT	2	2	2	2	3	3
VT	2.5	2.5	3	3	3	3
VA	2	2	3	3	3	3
WA	2	2	2	2	3	2
WV	2	2	3	3	4	3
WI	2	2	2	2	2	2
WY	---	---	3	3	3	3

Notes: "---" means that the graduating requirements are decided by local boards, so there is no state-level HSGR. In our regressions, we exclude students living in states with no state-level requirements.

Table 2: Descriptive Statistics

Variables	Total Sample		Male Only		Female Only	
	No. of Obs. =115,361		No. of Obs. =55,812		No. of Obs. =59,549	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
<b>Health Behaviors</b>						
did binge drink in last 30 days (1 if yes, 0 if no)	0.275	0.447	0.311	0.463	0.241	0.428
did drink in last 30 days (1 if yes, 0 if no)	0.454	0.498	0.470	0.499	0.438	0.496
did smoke in last 30 days (1 if yes, 0 if no)	0.252	0.434	0.273	0.446	0.231	0.421
did use marijuana in last 30 days (1 if yes, 0 if no)	0.222	0.416	0.260	0.439	0.185	0.388
number of days binge drinking in last 30 days	1.269	3.410	1.721	4.194	0.833	2.344
number of days drinking in last 30 days	2.711	5.587	3.345	6.556	2.099	4.371
number of days smoking in last 30 days	3.692	8.736	4.204	9.277	3.198	8.151
times marijuana used in last 30 days	3.209	9.184	4.445	10.91	2.018	6.932
<b>High School Graduation Requirements (HSGR)</b>						
minimum total required units (math and sciences)	5.016	1.279	5.010	1.286	5.023	1.272
<b>Individual Controls</b>						
male	0.491	0.500	1	0	0	0
age	16.13	1.279	16.18	1.293	16.08	1.263
12 years old or less	0.009	0.096	0.011	0.106	0.007	0.085
13 years old	0.001	0.033	0.001	0.031	0.001	0.035
14 years old	0.094	0.292	0.085	0.279	0.102	0.303
15 years old	0.220	0.415	0.214	0.410	0.227	0.419
16 years old	0.256	0.436	0.253	0.435	0.259	0.438
17 years old	0.260	0.438	0.261	0.439	0.258	0.438
18 years old or more	0.160	0.366	0.174	0.379	0.145	0.352
9th grade	0.236	0.425	0.234	0.424	0.238	0.426
10th grade	0.242	0.428	0.241	0.428	0.244	0.429
11th grade	0.255	0.436	0.254	0.435	0.256	0.436
12th grade	0.252	0.434	0.252	0.434	0.252	0.434
white	0.442	0.497	0.451	0.498	0.433	0.495
black	0.197	0.398	0.184	0.388	0.209	0.407
other race	0.361	0.480	0.365	0.481	0.358	0.479
Hispanic	0.272	0.445	0.270	0.444	0.273	0.445
<b>State Controls</b>						
median income (USD)	23,237	2,802	23,258	2,789	23,217	2,815
public school per pupil spending (USD)	4,426	1,095	4,435	1,082	4,417	1,108
unemployment rate (%)	6.261	2.106	6.269	2.125	6.254	2.087
medical marijuana legalization (1 if legal, 0 if illegal)	0.191	0.393	0.186	0.389	0.196	0.397
cigarette tax (cents per pack)	36.58	29.49	36.64	29.12	36.52	29.85
beer tax (cents per gallon)	13.48	8.931	13.34	8.829	13.61	9.028

Notes: Observations are weighted to be representative at the state level. Monetary figures are deflated (CPI1982-1984=100).

Table 3: School Enrollment Rates by Age

age	year		
	1990	2000	2010
13	96.48 (0.18)	98.84 (0.11)	98.39 (0.13)
14	96.29 (0.19)	98.69 (0.11)	98.16 (0.13)
15	95.63 (0.20)	97.92 (0.14)	97.98 (0.14)
16	93.33 (0.25)	95.62 (0.20)	97.10 (0.17)
17	88.12 (0.32)	90.85 (0.29)	94.39 (0.23)
18	73.52 (0.44)	75.08 (0.43)	81.02 (0.39)

Notes: Standard errors are shown in parentheses. Sample sizes are 243,552 for year 1990, 288,082 for year 2000, and 287,494 for year 2010. Data source: 1990 US Census 1% public use sample, 2000 US Census 1% public use sample and 2010 American Community Survey from Steven Ruggles, Katie Genadek, Ronald Goeken, Josiah Grover, and Matthew Sobek. Integrated Public Use Microdata Series: Version 6.0 [Machine-readable database]. Minneapolis: University of Minnesota, 2015.

Table 4: The Impact of Total Math and Science HSGR on Drinking

	(1)	(2)	(3)
did binge drink in last 30 days (1 if yes, 0 if no)			
Total Sample	-0.014*** (0.004)	-0.016*** (0.004)	-0.012** (0.006)
Male Only	-0.016** (0.006)	-0.018** (0.007)	-0.015 (0.009)
Female Only	-0.011** (0.005)	-0.014*** (0.004)	-0.008 (0.005)
number of days binge drinking in last 30 days			
Total Sample	-0.081*** (0.029)	-0.119*** (0.042)	-0.086** (0.041)
Male Only	-0.082* (0.042)	-0.115** (0.044)	-0.062 (0.052)
Female Only	-0.041* (0.022)	-0.031 (0.022)	-0.021 (0.030)
did drink in last 30 days (1 if yes, 0 if no)			
Total Sample	-0.016*** (0.004)	-0.016*** (0.004)	-0.007 (0.006)
Male Only	-0.020*** (0.006)	-0.018*** (0.007)	-0.008 (0.009)
Female Only	-0.012** (0.005)	-0.014*** (0.005)	-0.006 (0.005)
number of days drinking in last 30 days			
Total Sample	-0.130*** (0.041)	-0.171** (0.064)	-0.126** (0.061)
Male Only	-0.164** (0.065)	-0.189** (0.074)	-0.110 (0.092)
Female Only	-0.048 (0.041)	-0.045 (0.041)	-0.023 (0.048)
State Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
Individual Controls	YES	YES	YES
State Level Controls	NO	YES	YES
State Specific Linear Time Trends	NO	NO	YES

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Estimates are obtained using weighted OLS with standard errors (in parentheses) clustered by state. Individual controls include age, grade, gender, and race dummies. State level controls include median income, unemployment rate, per pupil education spending, beer tax, cigarette tax, and a medical marijuana legalization dummy. The total number of observations is 115,361, including 55,812 males and 59,549 females.

Table 5: The Impact of Total Math and Science HSGR on Smoking and Marijuana Use

Dependent Variables	(1)	(2)	(3)
did smoke in last 30 days (1 if yes, 0 if no)			
Total Sample	-0.007 (0.005)	-0.010** (0.005)	-0.007 (0.006)
Male Only	-0.011* (0.006)	-0.013** (0.006)	-0.008 (0.009)
Female Only	-0.004 (0.006)	-0.006 (0.005)	-0.005 (0.005)
number of days smoking in last 30 days			
Total Sample	-0.109 (0.123)	-0.169 (0.113)	-0.063 (0.120)
Male Only	-0.138 (0.108)	-0.183* (0.101)	-0.026 (0.131)
Female Only	-0.069 (0.155)	-0.132 (0.138)	-0.044 (0.134)
did use marijuana in last 30 days (1 if yes, 0 if no)			
Total Sample	-0.004 (0.005)	-0.007 (0.005)	-0.008 (0.006)
Male Only	-0.003 (0.006)	-0.005 (0.006)	-0.005 (0.009)
Female Only	-0.005 (0.005)	-0.009* (0.005)	-0.010* (0.005)
times marijuana used in last 30 days			
Total Sample	-0.034 (0.120)	-0.120 (0.097)	-0.194 (0.134)
Male Only	-0.040 (0.150)	-0.108 (0.131)	-0.194 (0.180)
Female Only	-0.011 (0.111)	-0.092 (0.093)	-0.136 (0.122)
State Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
Individual Controls	YES	YES	YES
State Level Controls	NO	YES	YES
State Specific Linear Time Trends	NO	NO	YES

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Estimates are obtained using weighted OLS with standard errors (in parentheses) clustered by state. Individual controls include age, grade, gender, and race dummies. State level controls include median income, unemployment rate, per pupil education spending, beer tax, cigarette tax, and a medical marijuana legalization dummy. The total number of observations is 115,361, including 55,812 males and 59,549 females.

Table 6: The Impact of Total Math and Science HSGR on Drinking, Age $\leq$ 16

Dependent Variables	(1)	(2)	(3)
did binge drink in last 30 days (1 if yes, 0 if no)			
Total Sample	-0.011*** (0.004)	-0.011*** (0.004)	-0.007* (0.004)
Male Only	-0.017*** (0.005)	-0.015*** (0.005)	-0.014** (0.007)
Female Only	-0.006 (0.005)	-0.007 (0.004)	-0.001 (0.005)
number of days binge drinking in last 30 days			
Total Sample	-0.086* (0.045)	-0.104* (0.059)	-0.092*** (0.028)
Male Only	-0.098** (0.038)	-0.092** (0.039)	-0.127** (0.048)
Female Only	-0.014 (0.020)	-0.002 (0.021)	0.005 (0.031)
did drink in last 30 days (1 if yes, 0 if no)			
Total Sample	-0.014*** (0.005)	-0.012** (0.005)	-0.003 (0.005)
Male Only	-0.020*** (0.005)	-0.017*** (0.006)	-0.006 (0.007)
Female Only	-0.009 (0.007)	-0.008 (0.006)	-0.001 (0.007)
number of days drinking in last 30 days			
Total Sample	-0.155** (0.067)	-0.160* (0.087)	-0.135** (0.052)
Male Only	-0.203*** (0.060)	-0.165** (0.069)	-0.184** (0.084)
Female Only	-0.028 (0.042)	0.002 (0.041)	-0.004 (0.047)
State Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
Individual Controls	YES	YES	YES
State Level Controls	NO	YES	YES
State Specific Linear Time Trends	NO	NO	YES

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Estimates are obtained using weighted OLS with standard errors (in parentheses) clustered by state. Individual controls include age, grade, gender, and race dummies. State level controls include median income, unemployment rate, per pupil education spending, beer tax, cigarette tax, and a medical marijuana legalization dummy. The total number of observations is 66,074, including 31,057 males and 35,017 females.

Table 7: The Impact of Total Math and Science HSGR on Smoking and Marijuana Use, Age $\leq$ 16

Dependent Variables	(1)	(2)	(3)
did smoke in last 30 days (1 if yes, 0 if no)			
Total Sample	-0.005 (0.005)	-0.005 (0.005)	-0.002 (0.008)
Male Only	-0.009* (0.005)	-0.009* (0.005)	0.001 (0.007)
Female Only	-0.002 (0.007)	-0.002 (0.006)	-0.003 (0.010)
number of days smoking in last 30 days			
Total Sample	-0.048 (0.107)	-0.062 (0.097)	-0.021 (0.128)
Male Only	-0.089 (0.095)	-0.089 (0.085)	0.019 (0.103)
Female Only	-0.005 (0.141)	-0.026 (0.136)	-0.024 (0.178)
did use marijuana in last 30 days (1 if yes, 0 if no)			
Total Sample	-0.003 (0.006)	-0.004 (0.005)	-0.006 (0.006)
Male Only	-0.002 (0.006)	-0.003 (0.005)	-0.005 (0.007)
Female Only	-0.003 (0.007)	-0.006 (0.006)	-0.006 (0.007)
times marijuana used in last 30 days			
Total Sample	-0.009 (0.114)	-0.041 (0.090)	-0.136 (0.108)
Male Only	-0.058 (0.150)	-0.052 (0.128)	-0.229 (0.147)
Female Only	0.024 (0.114)	-0.049 (0.100)	-0.040 (0.129)
State Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
Individual Controls	YES	YES	YES
State Level Controls	NO	YES	YES
State Specific Linear Time Trends	NO	NO	YES

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Estimates are obtained using weighted OLS with standard errors (in parentheses) clustered by state. Individual controls include age, grade, gender, and race dummies. State level controls include median income, unemployment rate, per pupil education spending, beer tax, cigarette tax, and a medical marijuana legalization dummy. The total number of observations is 66,074, including 31,057 males and 35,017 females.

Table 8: The Effects of Placebo HSGR on (Binge) Drinking Behaviors

	(1)	(2)	(3)	(4)
	did binge drink in last 30 days (1 if yes, 0 if no)	number of days binge drinking in last 30 days	did drink in last 30 days (1 if yes, 0 if no)	number of days drinking in last 30 days
4 cohorts after	-0.010** (0.004)	-0.028 (0.032)	-0.013*** (0.004)	-0.046 (0.051)
3 cohorts after	-0.014*** (0.004)	-0.081* (0.040)	-0.016*** (0.004)	-0.137** (0.065)
2 cohorts after	-0.013*** (0.003)	-0.077* (0.042)	-0.016*** (0.003)	-0.122* (0.066)
1 cohort after	-0.015*** (0.004)	-0.108*** (0.039)	-0.015*** (0.003)	-0.169*** (0.062)
<b>True HSGR</b>	<b>-0.016***</b> <b>(0.004)</b>	<b>-0.119***</b> <b>(0.042)</b>	<b>-0.016***</b> <b>(0.004)</b>	<b>-0.171**</b> <b>(0.064)</b>
1 cohort ahead	-0.014*** (0.004)	-0.101** (0.041)	-0.016*** (0.004)	-0.147** (0.058)
2 cohorts ahead	-0.012*** (0.004)	-0.102** (0.041)	-0.011** (0.005)	-0.132** (0.059)
3 cohorts ahead	-0.010** (0.005)	-0.107** (0.043)	-0.010* (0.005)	-0.128** (0.062)
4 cohorts ahead	-0.008* (0.004)	-0.095** (0.047)	-0.010** (0.005)	-0.099 (0.063)
5 cohorts ahead	-0.002 (0.005)	-0.067 (0.045)	-0.004 (0.005)	-0.051 (0.057)
6 cohorts ahead	-0.000 (0.005)	-0.055 (0.047)	-0.003 (0.006)	-0.025 (0.065)

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Weighted OLS with standard errors (in parentheses) clustered by state. Sample are students of both sexes and all ages. Models are estimated with state dummies, year dummies, individual controls, and state level controls. Individual controls include age dummies, grade dummies, gender, and race. State level controls include median income, unemployment rate, per pupil education spending, beer tax, cigarette tax, and medical marijuana legalization dummies. The numbers of observations of all specifications are over 114,000 and are similar with that of the true HSGR specification (They differ only at the level of thousands).



## Appendix 1: Data Sources

1. State median income. Source: U.S. Census Bureau, Historical Income Tables: Households, “Table H-8. Median Household Income by State.” (<http://www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-households.html>). Most recent date of access: Aug 20, 2016.
2. Expenditures per pupil for public elementary and secondary education. Data for the years 1993-2001 comes from NCES, “A Historical Overview of Revenues and Expenditures for Public Elementary and Secondary Education, by State: Fiscal Years 1990–2002, Adjusted current expenditures per pupil for public elementary and secondary education.” (<https://nces.ed.gov/pubs2007/npefs13years/>). Data for the years 2003-2013 comes from Census Bureau, Public School System Finances, “Per Pupil Amounts for Current Spending of Public Elementary-Secondary School Systems.” (<http://www.census.gov/govs/school/>). Most recent date of access: Aug 20, 2016.
3. Unemployment rate. Source: Annual Unemployment Rates by State. U.S. Department of Labor, Bureau of Labor Statistics. Local Area Unemployment Statistics (LAUS). Data used in this study is second-hand data that is collected and compiled by Iowa Community Indicators Program, Iowa State University. (<http://www.icip.iastate.edu/tables/employment/unemployment-states>). Most recent date of access: Aug 20, 2016.
4. Cigarette tax. Source: Orzechowski, William, and Robert Walker. “The tax burden on tobacco.” Historical compilation, 49 (2014).
5. Beer tax. Source: World Tax Database, University of Michigan's Ross School of Business for the years 1993-2002 and Tax Foundation, “State Beer Excise Tax Rates” for the years 2003-2013. We then use Alcohol Policy Information System ([https://alcoholpolicy.niaaa.nih.gov/taxes\\_beer.html](https://alcoholpolicy.niaaa.nih.gov/taxes_beer.html)) to verify the data. All tax rates are the rates on the first day of each year. Numbers are rounded up to the cent to achieve consistency of the two datasets. Based on the drinking pattern of youth, using beer taxes to approximate tax burden for youth alcohol consumption is more accurate than the liquor tax or wine tax.
6. Medical marijuana legalization year. Medical Marijuana legalization data comes from

ProCon.org. “23 Legal Medical Marijuana States and DC.” (<http://medicalmarijuana.procon.org/view.resource.php?resourceID=000881>). Most recent date of access: Aug 20, 2016. Besides medical marijuana legalization, recreational marijuana legalization will likely to affect youths’ consumption of marijuana. However, since our YRBS data ends in 2013 and all recreational marijuana legalization laws were adopted after that year, we do not include them in the regressions.

7. State and national high school student enrollment. Source: Digest of Education Statistics 1993-2015. U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD) 1993-2015.
8. CPI. Source: U.S. Department of Labor, Bureau of Labor Statistics. Consumer Price Index - All Urban Consumers. (<http://www.bls.gov/cpi/#tables>). Most recent date of access: Aug 20, 2016.

## Appendix 2: Compiling Methodology for High School Graduation Requirements

DES publishes HSGR data for the years 1990, 1993, 1996, 1998, 2001, 2002, 2004, 2006, 2008, 2011, and 2013, but not for other years within this period. DES also reports the first graduating class that is affected by a newly implemented HSGR up until 2001 (implementation of a new HSGR generally comes several years after it is first reported in DES). We compile a dataset that contains the HSGR students in each state, cohort and grade face from the graduating class of 1989 to 2015.

For example, DES1996 shows that the math and science HSGR for Alabama is 4 units for mathematics and 4 units for science. It also documents that the first graduating class for which these requirements apply is 2000. Thus, the graduating classes before 2000 are not affected by the HSGR reported in DES1996. To recover the HSGR of the graduating classes prior to 2000, we need to resort to DES reports before 1996. In DES 1993 we can find previous HSGR information (2 units for mathematics and 2 units for science) and also the first graduating class for which the old HSGR applied (in this case the graduating class of 1989). Also, we find that in DES reports following DES1996, the math and science HSGR of Alabama reported always remains as “4 units for mathematics and 4 units for science.” This means that for the state of Alabama we have recovered all relevant HSGR information: for the graduating classes of 1999 and before, the math and science HSGR is 2 units for mathematics and 2 units for science, and for the graduating classes of 2000 and after, the math and science HSGR is 4 units for mathematics and 4 units for science. To verify this information, we double-checked our procedure using each state’s legislation.

Starting in 2002, DES stops reporting the first graduating class for which a new HSGR will apply. As a result, we collect the implementation year data from the state board of education or department of education of each state when it is unclear from the DES reports.

For example, in the case of Delaware, we have the information about the math and science HSGR and which graduating class the requirements will impact until 2001 from DES (3 units in mathematics and 3 units in science). After 2001, although we can still get the information about math and science HSGR for each year from DES, there is no impact year data from DES. In this case, we turn to the website of the Delaware Department of Education. In the Delaware

state code “14 Delaware Code, Section 122(d)<sup>24</sup>”, it is stated:

**“2.0 Current Graduation Requirements**

*A public school student shall be granted a State of Delaware Diploma when such student has successfully completed a minimum of twenty-two credits in order to graduate including: 4 credits in English Language Arts, 3 credits in mathematics, 3 credits in science, 3 credits in social studies, 1 credit in physical education, 1/2 credit in health, 1 credit in computer literacy, 3 credits in a Career Pathway, and 3 1/2 credits in elective courses.*

**3.0 Graduation Requirements Beginning with the Class of 2011 (Freshman Class of 2007-2008)**

*3.1 Beginning with the graduating class of 2011, a public school student shall be granted a State of Delaware Diploma when such student has successfully completed a minimum of twenty two (22) credits in order to graduate including: four (4) credits in English Language Arts, **four (4) credits in Mathematics; three (3) credits in Science**, three (3) credits in Social Studies, one (1) credit in physical education, one half (1/2) credit in health education, three (3) credits in a Career Pathway, and three and one half (3.5) credits in elective courses.”*

From this state code, we can pin down the exact graduation class for which the new requirements apply. In this case, starting with the graduating class of 2011, the minimum required units in mathematics were changed from 3 to 4.

For some states, students are given the option to select different types of diplomas that have different sets of requirements. For example, Indiana offers students who entered school before the fall of 2007 two types of diploma (“general” and “core 40”) with two different sets of requirements. We are unable to separate students who choose the general diploma from those who choose the “core 40” diploma in YRBS. In this case, we must use our own judgment to pick a set of requirements that is applied to all students. Our criterion is to choose the least stringent of the possible sets of requirements (since we are trying to define a *minimum* course requirement) unless it is clear that the non-academic requirements associated with the least stringent set are so onerous that it is unlikely to be a choice for the vast majority of students.

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<sup>24</sup> Source: <http://regulations.delaware.gov/register/july2006/proposed/10%20DE%20Reg%2030%2007-01-06.htm>

To continue with the example from above, the Indiana General Assembly made completion of “core 40” a graduation requirement for all students beginning with those who entered high school in the fall of 2007. Therefore, for the class of 2010 and after, there is only one unique set of requirements. However, for the class of 2009 and before, there are two sets of requirements. Here we choose the requirements of the “general” diploma since this is consistent with the standard diploma requirements of other states. In addition, it is the *minimum* graduation requirement one could face.

Another example is Texas. There are 3 different programs: “recommended”, “advanced”, and “minimum”. We choose the “minimum” program requirements for the graduating class of 2007 and before as their HSGR because it is the *minimum* requirement. However, for the class of 2008 and after, we choose the “recommended” program requirements because a newly implemented law made it very difficult for most students to enroll in the minimum program. The law requires parents’ consent, age restrictions, and failing to enter grade 10 once as qualifications for a student to choose the “minimum” program.<sup>25</sup> In this sense, the “recommended” program appears to be the standard one, which is also consistent with the DES report.

For the state of South Dakota, the DES reports from different years are inconsistent with each other, and we could not find additional information from the South Dakota Department of Education to help correct the information despite our best efforts. As a result, we have to use DES data without knowledge of the implementation year even after 2001 for South Dakota’s HSGR.

Our complete compiled dataset of HSGR is available upon request.

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<sup>25</sup> Sources: 1. Texas Education Code, §§7.102, 28.002, 28.023, 28.025, 28.054, and 38.003. “Chapter 74. Curriculum Requirements Subchapter D. Graduation Requirements, Beginning with School Year 2001-2002” (<http://ritter.tea.state.tx.us/rules/tac/chapter074/ch074d.html>);

2. Texas Education Code, §§7.102(c) (4), 28.002, and 28.025. “Chapter 74. Curriculum Requirements Subchapter D. Graduation Requirements, Beginning with School Year 2004-2005” (<http://ritter.tea.state.tx.us/rules/tac/chapter074/ch074e.html>);

3. Texas Education Code, §§7.102(c) (4); 28.002; 28.00222; and 28.025. “Chapter 74. Curriculum Requirements Subchapter D. Graduation Requirements, Beginning with School Year 2007-2008” (<http://ritter.tea.state.tx.us/rules/tac/chapter074/ch074f.html>)

### Appendix 3: Comparison of the Sample Dropped and the Sample Used

Variables	Sample Used (N=115,361)		N	Sample Dropped		T-stat for mean difference
	Mean	Std. Dev.		Mean	Std. Dev.	
<b>Health Behaviors</b>						
did binge drink in last 30 days (1 if yes, 0 if no)	0.267	0.442	28,484	0.270	0.444	-1.022
did drink in last 30 days (1 if yes, 0 if no)	0.448	0.497	22,197	0.499	0.500	-13.930
did smoke in last 30 days (1 if yes, 0 if no)	0.243	0.429	25,128	0.266	0.442	-7.514
did use marijuana in last 30 days (1 if yes, 0 if no)	0.211	0.408	28,950	0.271	0.444	-20.886
number of days binge drinking in past 30 days	1.112	2.980	28,484	1.122	3.042	-0.499
number of days drinking in past 30 days	2.438	4.906	22,197	2.972	5.648	-13.163
number of days smoking in past 30 days	3.283	8.138	25,128	3.664	8.587	-6.432
times marijuana used in past 30 days	2.777	8.354	28,950	3.881	9.868	-17.525
<b>High School Graduation Requirements (HSGR)</b>						
minimum total required units (math and sciences)	5.144	1.266	17,492	5.352	1.343	-19.229
<b>Individual Controls</b>						
male	0.484	0.500	31,517	0.527	0.499	-13.552
age	16.18	1.224	31,603	16.15	1.248	3.802
9th grade	0.238	0.426	31,456	0.262	0.440	-8.633
10th grade	0.245	0.430	31,456	0.245	0.430	0.000
11th grade	0.256	0.437	31,456	0.250	0.433	2.174
12th grade	0.259	0.438	31,456	0.241	0.428	6.579
white	0.425	0.494	30,201	0.360	0.480	20.823
black	0.220	0.414	30,201	0.289	0.453	-23.978
other race	0.355	0.479	30,201	0.352	0.477	0.972
Hispanic	0.270	0.444	30,431	0.268	0.443	0.700
<b>State Controls</b>						
median income (USD)	22,643	2,905	31,161	23,686	2,826	-57.464
public school per pupil spending (USD)	4,245	1,024	31,161	4,603	968.4	-57.191
unemployment rate (%)	6.320	2.095	32,013	6.010	2.194	22.584
medical marijuana legalization (1 if legal, 0 if illegal)	0.175	0.380	31,161	0.144	0.351	13.587
cigarette tax (cents per pack)	33.63	27.73	31,161	41.73	27.81	-45.649
beer tax (cents per gallon)	14.94	10.15	31,161	11.66	8.628	57.254

Notes: Observations are unweighted in order to obtain comparability. Monetary figures are deflated (CPI1982-1984=100). T-tests

are performed using  $T - statistics = \frac{mean_1 - mean_2}{\left(\frac{std_1^2}{N_1} + \frac{std_2^2}{N_2}\right)^{\frac{1}{2}}}$ , while the subscripts “1”s refer to the sample we used, and “2”s refer to the

sample dropped.

Appendix 4: The Impact of Total Math and Science HSGR on Cocaine Use

	(1)	(2)	(3)
did use cocaine in last 30 days (1 if yes, 0 if no)			
Total Sample	0.000	-0.002	-0.004
	(0.003)	(0.003)	(0.003)
Male Only	-0.000	-0.003	-0.005
	(0.004)	(0.003)	(0.003)
Female Only	0.002	0.003	0.000
	(0.003)	(0.002)	(0.003)
times cocaine used in last 30 days			
Total Sample	-0.028	-0.115	-0.131
	(0.066)	(0.077)	(0.079)
Male Only	0.013	-0.075	-0.097
	(0.070)	(0.069)	(0.071)
Female Only	-0.011	0.019	-0.018
	(0.037)	(0.029)	(0.035)
State Dummies	YES	YES	YES
Year Dummies	YES	YES	YES
Individual Controls	YES	YES	YES
State Level Controls	NO	YES	YES
State Specific Linear Time Trends	NO	NO	YES

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Estimates are obtained using weighted OLS with standard errors (in parentheses) clustered by state. Individual controls include age, grade, gender, and race dummies. State level controls include median income, unemployment rate, per pupil education spending, beer tax, cigarette tax, and a medical marijuana legalization dummy. The total number of observations is 125,930, including 61,860 males and 64,070 females.

Appendix 5: Descriptive Statistics for Sample with Age <=16

Variables	Total Sample		Male Only		Female only	
	No. of Obs. =66,074		No. of Obs. =31,057		No. of Obs. =35,017	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
<b>Health Behaviors</b>						
did binge drink in last 30 days (1 if yes, 0 if no)	0.239	0.427	0.257	0.437	0.223	0.416
did drink in last 30 days (1 if yes, 0 if no)	0.416	0.493	0.417	0.493	0.415	0.493
did smoke in last 30 days (1 if yes, 0 if no)	0.226	0.418	0.236	0.425	0.216	0.412
did use marijuana in last 30 days (1 if yes, 0 if no)	0.202	0.401	0.232	0.422	0.174	0.379
number of days binge drinking in past 30 days	1.057	3.165	1.416	3.953	0.729	2.163
number of days drinking in past 30 days	2.341	5.195	2.870	6.266	1.859	3.913
number of days smoking in past 30 days	3.085	7.991	3.401	8.410	2.797	7.579
times marijuana used in past 30 days	2.844	8.680	3.776	10.12	1.995	7.014
<b>High School Graduation Requirements (HSGR)</b>						
minimum total required units (math and sciences)	5.075	1.311	5.065	1.322	5.084	1.302
<b>Individual Controls</b>						
male	0.477	0.499	1	0	0	0
age	15.23	0.838	15.23	0.856	15.22	0.821
12 years old or less	0.016	0.125	0.02	0.140	0.012	0.110
13 years old	0.002	0.043	0.002	0.041	0.002	0.045
14 years old	0.162	0.368	0.151	0.358	0.172	0.377
15 years old	0.380	0.485	0.378	0.485	0.380	0.486
16 years old	0.441	0.496	0.449	0.497	0.434	0.496
9th grade	0.403	0.490	0.410	0.492	0.396	0.489
10th grade	0.387	0.487	0.388	0.487	0.387	0.487
11th grade	0.190	0.393	0.179	0.383	0.201	0.401
12th grade	0.004	0.065	0.004	0.063	0.005	0.067
white	0.453	0.498	0.461	0.498	0.445	0.497
black	0.191	0.393	0.176	0.381	0.204	0.403
other race	0.356	0.479	0.362	0.481	0.351	0.477
Hispanic	0.268	0.443	0.274	0.446	0.263	0.440
<b>State Controls</b>						
median income (USD)	23,304	2,792	23,348	2,780	23,265	2,803
public school per pupil spending (USD)	4,445	1,101	4,457	1,091	4,433	1,111
unemployment rate (%)	6.297	2.159	6.302	2.194	6.292	2.127
medical marijuana legalization (1 if legal, 0 if illegal)	0.202	0.402	0.197	0.398	0.207	0.405
cigarette tax (cents per pack)	37.30	29.92	37.56	29.56	37.07	30.24
beer tax (cents per gallon)	13.41	8.887	13.21	8.760	13.59	8.998

Notes: Observations are weighted to be representative at the state level. Monetary figures are deflated (CPI1982-1984=100).



Appendix 6: Probit Model for Whole Sample and Sample with Age<=16

	Whole Sample		Sample with Age<=16	
	Probit Point Estimate	Average Marginal Effects	Probit Point Estimate	Average Marginal Effects
did binge drink in last 30 days (1 if yes, 0 if no)				
Total Sample	-0.054*** (0.014)	-0.016*** (0.004)	-0.038*** (0.013)	-0.011*** (0.004)
Male Only	-0.059*** (0.021)	-0.019*** (0.007)	-0.051*** (0.017)	-0.015*** (0.005)
Female Only	-0.048*** (0.015)	-0.014*** (0.004)	-0.026 (0.017)	-0.007 (0.005)
did drink in last 30 days (1 if yes, 0 if no)				
Total Sample	-0.042*** (0.012)	-0.016*** (0.004)	-0.032** (0.014)	-0.012** (0.005)
Male Only	-0.049*** (0.017)	-0.018*** (0.006)	-0.045*** (0.016)	-0.017*** (0.006)
Female Only	-0.035*** (0.012)	-0.013*** (0.005)	-0.021 (0.017)	-0.008 (0.006)
did smoke in last 30 days (1 if yes, 0 if no)				
Total Sample	-0.031* (0.017)	-0.009* (0.005)	-0.012 (0.018)	-0.003 (0.005)
Male Only	-0.043** (0.019)	-0.013** (0.006)	-0.027 (0.019)	-0.008 (0.005)
Female Only	-0.018 (0.018)	-0.005 (0.005)	0.001 (0.024)	0.000 (0.006)
did use marijuana in last 30 days (1 if yes, 0 if no)				
Total Sample	-0.028 (0.018)	-0.008 (0.005)	-0.020 (0.020)	-0.005 (0.005)
Male Only	-0.020 (0.021)	-0.006 (0.007)	-0.013 (0.019)	-0.004 (0.005)
Female Only	-0.036* (0.019)	-0.009* (0.005)	-0.025 (0.024)	-0.006 (0.006)

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Standard errors in parentheses are clustered by state. Control variables include state dummies, time dummies, individual controls and state controls. Individual controls include age, grade, gender, and race dummies. State level controls include median income, unemployment rate, per pupil education spending, beer tax, cigarette tax, and a medical marijuana legalization dummy. Sample sizes are the same as Table 4 and 5 for the whole sample regressions and the same as Table 6 and 7 for the regressions with age <=16.

### Appendix 7: Ordered Probit Model for Whole Sample and Sample with Age<=16

Dependent Variables		Whole Sample	Sample with Age<=16
<b>number of days binge drinking in last 30 days</b>			
	Total Sample	-0.059*** (0.014)	-0.048*** (0.016)
	Male Only	-0.060*** (0.019)	-0.054*** (0.017)
	Female Only	-0.042*** (0.015)	-0.020 (0.017)
<b>number of days drinking in last 30 days</b>			
	Total Sample	-0.047*** (0.012)	-0.041*** (0.015)
	Male Only	-0.052*** (0.017)	-0.051*** (0.017)
	Female Only	-0.031** (0.013)	-0.015 (0.016)
<b>number of days smoking in last 30 days</b>			
	Total Sample	-0.029 (0.018)	-0.008 (0.018)
	Male Only	-0.039** (0.018)	-0.023 (0.018)
	Female Only	-0.018 (0.020)	0.004 (0.025)
<b>times marijuana used in last 30 days</b>			
	Total Sample	-0.028 (0.019)	-0.018 (0.020)
	Male Only	-0.021 (0.021)	-0.014 (0.019)
	Female Only	-0.032 (0.022)	-0.021 (0.026)

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. There are 7 outcomes for the measure binge drinking days, drinking days and smoking days; and 6 outcomes for the measure marijuana use days. Numbers in the table are point estimates. Standard errors in parentheses are clustered by state. Control variables include state dummies, time dummies, individual controls and state controls. Individual controls include age, grade, gender, and race dummies. State level controls include median income, unemployment rate, per pupil education spending, beer tax, cigarette tax, and a medical marijuana legalization dummy. Sample sizes are the same as Table 4 and 5 for the whole sample regressions and the same as Table 6 and 7 for the regressions with age <=16.