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ABSTRACT

We use difference-in-differences models and individual-level data from the national and state Youth Risk Behavior Surveillance System (YRBSS) from 1991 to 2015 to examine the effects of e-cigarette Minimum Legal Sale Age (MLSA) laws on youth cigarette smoking, alcohol consumption, and marijuana use. Our results suggest that these laws increased youth smoking participation by 0.7 to 1.4 percentage points, approximately half of which could be attributed to smoking initiation. We find little evidence of higher cigarette smoking persisting beyond the point at which youth age out of the law. Our initial results also show little effect of the law on youth drinking, binge drinking, and marijuana use. Taken together, our findings suggest a possible unintended effect of e-cigarette MLSA laws—rising cigarette use in the short term while youth are restricted from purchasing e-cigarettes.

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1. Introduction

Teenage substance use and abuse continues to be a major public health concern. Although rates of youth smoking are declining, each day more than 3,200 youth initiate cigarette consumption and more than 2,000 transition into daily smoking (US Department of Health Human Services, 2014). Youth drinking and marijuana use is a prevalent and costly form of teenage substance use, which has been linked to poor academic performance, impaired cognitive development, and other severe health problems (National Institute on Alcohol Abuse and Alcoholism, 2016). In 2015, 33% of youth drank, 18% binge drank, and 22% used marijuana over the past month (Centers for Disease Control and Prevention (CDC), 2015). Since use of substances is often inter-related, policies reducing one form of substance use might also impact other forms.

The introduction of electronic cigarettes (e-cigarettes) presents youth with an alternative that could disrupt their use of cigarettes, marijuana, and alcohol. E-cigarettes are a particular type of vaping device within the broader class of electronic nicotine delivery systems (ENDS). They differ primarily from conventional cigarettes by permitting the inhalation of nicotine that is heated rather than combusted, substantially reducing the harm associated with combustion-related byproducts. Since their introduction into the U.S market, e-cigarettes have been advertised and positioned as alternatives to conventional cigarettes. Their popularity among adults and youth, in particular, has been rising exponentially. Within a four-year period (2011-15), e-cigarette use has increased from 1.5% to 16.0% among high school students and from 0.6% to 5.3% among middle school students, surpassing cigarettes as the most commonly used tobacco product among adolescents (Singh, 2016).[1] The most recent estimates show that over 3 million middle and high school students currently use e-cigarettes (Singh, 2016).[2]

Examining the risks of e-cigarettes, and the relative risks between e-cigarettes and conventional cigarettes, has spurred a heated policy debate and has attracted significant academic interest. A recent report issued by the British government suggests that e-cigarettes

[1] E-cigarettes were not treated as tobacco products until 2016 when FDA finalized its deeming rule.
[2] Among adults, the 2014 National Health Interview Survey shows that 12.6% had ever used e-cigarettes at least once and 3.7% currently use e-cigarettes (Schoenborn and Gindi, 2015).

are no more than five percent as harmful as conventional cigarettes (Tobacco Advisory Group of the Royal College of Physicians, 2016). Other studies have suggested that e-cigarettes can direct smokers away from smoking and possibly help them quit (Hampton, 2014, Abrams, 2014, Brandon et al., 2015, McNeill et al., 2015). However, the 2016 Surgeon General's Report warns that e-cigarettes are dangerous to adolescents because they can interfere with cognitive development and can cause nicotine addiction (US Department of Health Human Services, 2016).

A particular concern raised by the public health community is that e-cigarettes may act as a gateway towards the use of other addictive substances, such as cigarettes, alcohol, and marijuana (Gostin and Glasner, 2014, Primack et al., 2015, Mammen et al., 2016). In response, state governments passed a wave of regulations limiting youth access to e-cigarettes. A popular initiative has been the adoption of Minimum Legal Sale Age (MLSA) laws on e-cigarettes analogous to those passed for conventional cigarettes decades ago. New Jersey became the first state to implement an e-cigarette MLSA law in March of 2010, followed by four other states later within the same year.[3] Additional states adopted an e-cigarette MLSA law in each year subsequently: two in 2011, five in 2012, twelve in 2013, fifteen in 2014, eight in 2015, and two in 2016. By the time the Food and Drug Administration (FDA) mandated a federal e-cigarette MLSA law of 18 in August of 2016, all states but two had an e-cigarette MLSA law in place.

Canonical microeconomic theory suggests that youth vaping is likely to decline as costs and other components of the "full price" associated with the product rise. The magnitude of the decline in e-cigarette use caused by e-cigarette MLSA laws may be less pronounced to the extent that retailers do not abide by the law or youth bypass the law through online vendors. If e-cigarettes are economic substitutes with other tobacco products or other addictive substances, then e-cigarette restrictions may induce substitution toward smoking and other substance use, thus lessening the intended public health implication. However, relating to the public health community's concerns about e-cigarettes being a gateway to other substances,

[3] Utah, New Hampshire, Minnesota, and California enforced the law on May 11, July 31, August 1, and September 27, all in 2010, respectively.

complementarity is also possible. In this case, restricting e-cigarette access may reduce not only its own use but also the use of cigarettes, both today and in the near future, through a reduction in the addictive stock of nicotine.

In this study, we explore how e-cigarette MLSA laws affect youth smoking. Other studies exploring this question have arrived at mixed conclusions (Friedman, 2015, Pesko et al., 2016, Abouk and Adams, 2017), and our study attempts to provide further clarity to this question. Specifically, we examine the impact of these laws on youth smoking behaviors by exploiting the heterogeneity in the timing of states' adoption of e-cigarette MLSA laws using a quasi-experimental difference-in-differences research design. These analyses inform whether youth, who are constrained from purchasing e-cigarettes, are currently more likely to use conventional cigarettes.

In addition to contemporaneous effects, by affecting the addictive nicotine stock, e-cigarette MLSA laws may also have dynamic effects. We therefore extend our analyses and provide some of the first evidence on the dynamic, intertemporal relationship between e-cigarette MLSA laws and youth smoking. Specifically, we provide estimates that inform whether a policy that makes vaping less attractive today makes future smoking more or less likely when youth are no longer subject to the MSLA-based restriction.

Finally, we broaden the lens to other addictive substances and provide some of the first evidence on potential spillover effects of e-cigarette MLSA laws on other substance use. Such spillover effects are plausible given the high prevalence of co-occurring alcohol, marijuana, and tobacco use among adolescents.[4] The rest of the study is organized as follows. Section 2 provides a brief background and a review of current literature on this topic. Section 3 outlines a conceptual framework of the various channels through which e-cigarette MLSA laws may affect substance use, and also motivates our empirical specifications. Section 4 describes the dataset, and the construction of e-cigarette MLSA laws and other relevant policy variables, followed by our empirical approach in section 5. Section 6 presents the findings, followed by a discussion of the implications of our results.

[4] Data from the 2014 National Survey of Drug Use and Health (NSDUH) suggest that, among youth ages 12-17 who have used tobacco products in the past year, 88% have also consumed alcohol and 56% have used marijuana over this period.

2. Literature

A. Cigarette MLSA Laws and Youth Smoking

Over recent decades, individual states have made several efforts to tighten tobacco control regulations by prohibiting retailers from selling tobacco products to minors. Several studies have examined the efficacy of cigarette MLSA laws adopted between the 1980s and early 1990s in curbing youth smoking. Though many of these studies suggest that the laws have been effective in reducing youth smoking (Chaloupka and Pacula, 1998, Gruber and Zinman, 2001, Ahmad and Billimek, 2007, DiFranza et al., 2009), some find limited effects. Chaloupka and Grossman (1996) find little effect of youth access restrictions on youth smoking, which they attribute to the weak enforcement of the laws. DeCicca and colleagues (2002), using indices of smoking restrictions that ranged from youth access restrictions to restrictions on smoking in public places, also find limited effects of the laws. A recent study by Yoruk and Yoruk (2015) revisits the effect of cigarette MLSA laws on youth smoking using a regression discontinuity design. They find that, although the law's impact are imprecisely estimated, gaining legal access to tobacco products once youth have aged out is associated with a 2 to 3 percentage point increase in the probability of smoking. By focusing on a subsample where youth report smoking in the prior wave, the authors find that cigarette MLSA laws lead to a statistically significant increase in the probability of smoking (five percentage points) and frequency of smoking (25% increase) over the past month.

B. Relationship Between E-Cigarettes and Traditional Cigarettes

A few studies assessing the contemporaneous relationship between vaping and smoking have suggested substitutability. Using state-level aggregated data from the National Survey on Drug Use and Health (NSDUH), Friedman (2015) find that state e-cigarette MLSA laws are associated with an increase in youth smoking rate. Pesko and colleagues (2016) also analyze the effects of e-cigarette MLSA laws on adolescent smoking and other tobacco consumption using

state-level aggregated YRBSS data. In their main findings, e-cigarette MLSA laws are associated with a 0.8 percentage point increase in regular adolescent smoking, which slowed the downward trend of youth smoking. However, they do not find any strong evidence that e-cigarette MLSA laws affect use of other tobacco products in adolescents. Abouk and Adams (2017) find opposite results. Using individual-level data from Monitoring the Future (MTF), their estimates suggest that e-cigarette MLSA laws lead to a reduced smoking rates among high-school seniors. This suggests that e-cigarettes and cigarettes are economic complements, rather than substitutes as suggested by Friedman (2015) and Pesko and colleagues (2016). Abouk and Adams (2017) attribute their use of individual-level data as one possible reason for the opposite findings.

One study uses price changes[5] as the mechanism to study whether e-cigarettes and cigarettes are economic substitutes or complements. Using Nielsen scanner data, Huang and colleagues (2014) find little evidence that consumers substitute toward cigarettes when e-cigarette price increases.

C. Relationship Between Smoking, Drinking and Marijuana Use

The relationship between youth e-cigarette use and marijuana and alcohol use has not yet been clearly established. Equipment that is used for delivering nicotine may also be used to vaporize marijuana (Budney et al., 2015, Mammen et al., 2016). A study using YRBSS data suggests no relationship between e-cigarette MLSA laws and adolescent marijuana use (Pesko et al., 2016). While little is known about the relationship between vaping and drinking, many studies have explored the relationship between smoking and drinking. Dee (1999) suggests that smoking and drinking are complements among high school seniors. By exploiting variation in state cigarette excise taxes and state's adoption of minimum legal drinking age (MLDA) laws at different points in time, Dee finds that MLDA laws are negatively associated with youth smoking. However, the negative impact of cigarette taxes on youth drinking is imprecisely estimated. Using sales and household expenditure data on cigarettes and alcohol in Canada,

[5] These are prices recorded during the actual transactions.

Gruber and colleagues (2003) find partial evidence supporting complementarity between smoking and drinking. Their estimates suggest that a ten percent increase in cigarette prices is associated with a one percent drop in alcohol sales, alluding to a cross-product price elasticity of -0.1. In the same study, cigarette prices are estimated to have a positive but statistically insignificant impact on household expenditure on total alcohol consumption. Focusing on the elderly population, Picone and colleagues (2004) find that complementarity and substitutability can co-exist. Higher cigarette prices are found to increase drinking, and yet smoking bans are found to decrease both smoking and drinking. Overall, the existing literature seems to lack a consensus on the relationship between smoking and drinking.

D. Summary and Contributions

As noted above, only a handful of studies have focused specifically on the impact of e-cigarette MLSA laws on youth smoking. Two of them (Pesko et al., 2016, Friedman, 2015) find that the laws increased smoking and the third (Abouk and Adams, 2017) find the opposite effect. Friedman (2015) is based on 2-year state aggregated data from the NSDUH (spanning 2002-2013) and Pesko et al. (2016) is based on the state-aggregated data from the Youth Risk Behavioral Surveillance System (YRBSS; spanning 2007-2013). Both studies indicated that e-cigarette MLSA laws increased youth smoking by 0.8 to 0.9 percentage points. Abouk and Adams (2017) focus on high school seniors and utilize micro-level data spanning 2007-2014 from the MTF. Their study suggests that e-cigarette MLSA laws led to reduced cigarette use by about 2-3 percentage points. It is unclear whether the divergence in findings stems from the use of more granular individual-level data or from the addition of one more study period.

Our study extends this seminal work by Friedman (2015), Pesko et al. (2016), and Ahouk and Adams (2017), and contributes to this literature in several respects. First, we add to the prevailing evidence by incorporating micro-level data from both the national and the state YRBSS spanning up to 2015. This yields a substantially larger sample size (between 500,000 and 1,000,000 person-wave observations) relative to previous work. Utilizing data up to 2015, just prior to the FDA's national ban on e-cigarette sales to minors, further maximizes policy

variation (8 additional states had adopted these laws in 2015) and extends the post-policy window for the other states to disentangle dynamic effects. Second-order policy responses on youth substance use (other than e-cigarettes) are likely to be small, and hence micro-level data with large sample sizes, more cleanly-defined affected groups, and longer time windows with greater policy variation may be necessary for maximizing precision.

Second, prior work has focused only on the contemporaneous effects of e-cigarette MLSA laws on smoking behaviors. Our study is the first to consider how these laws may affect youth smoking rates once they have aged out of the restrictions and are able to purchase e-cigarettes. This is particularly relevant for assessing long-term effects on smoking rates and addressing public health concerns. Finally, we also estimate the relationship that e-cigarette MLSA laws have on other substance use. With the exception of Pesko et al. (2016), who studied and found no effects on marijuana use, prior work has mainly focused on cigarette smoking.

3. Conceptual Framework

The overall effect of e-cigarette MLSA laws on smoking, drinking, and marijuana use[6] depends on the marginal direct and indirect costs of youth obtaining e-cigarettes. Banning legal sales of e-cigarettes to minors will raise the indirect costs of obtaining the product through added inconvenience and/or associated time delays. It could also increase the direct costs of obtaining the product through additional markups or purchasers having to pay "friends" who can buy the product for them. E-cigarette MSLA laws will therefore raise the full price of e-cigarettes, which are expected to have first-order effects in the form of a decline in e-cigarette consumption. However, the predicted decrease in e-cigarette consumption may be moderated to the extent that retailers do not abide by the law or youth are able to bypass the law through online vendors.

A rise in the indirect or direct costs of purchasing e-cigarettes would also cause a *relative* increase in the cost of e-cigarettes in comparison to conventional cigarettes and other

[6] For the purpose of this paper, the substances we focus on are conventional cigarettes, alcohol, and marijuana. Ideally, we would want to incorporate e-cigarettes into the basket, but the lack of national datasets with sufficient information on e-cigarette use prevents us from doing so. Nevertheless, we present some preliminary evidence on the effects of e-cigarette MLSA laws on youth e-cigarette use later in the study to help frame our estimates on other substance use.

addictive substances. This increase in relative costs could have spillover second-order effects on the consumption of cigarettes, alcohol, and/or marijuana through complementarity or substitution.

A priori, the effects of e-cigarette MLSA laws on the use of conventional cigarettes, marijuana, and alcohol are ambiguous. One particular mechanism through which the laws may increase smoking is if e-cigarettes are being used for smoking cessation or reduction. Losing access to e-cigarettes could therefore reduce a smoker's propensity to attempt cessation. In fact, many studies have documented the success of e-cigarettes in helping smokers quit (Etter and Bullen, 2011, Brown et al., 2014, Adkison et al., 2013). E-cigarettes could also lead to smoking initiation if they generate nicotine-induced cravings that cigarettes are then able to meet. E-cigarette MLSA laws could also raise youth interest in the motive underlying the legal change and encourage them to search for health information related to e-cigarettes and possibly other substances, which could in turn change their attitudes toward consumption.

The dynamic effects of e-cigarette MLSA laws on smoking, when youth have reached the age limit, are also a priori indeterminate. However, it should be noted that once youth turn 18, they are able to purchase both e-cigarettes and conventional cigarettes legally.[7] In states that have passed an e-cigarette MLSA law, youth who age out of the laws will therefore experience a decrease in the *relative* cost of obtaining e-cigarettes, which could lead to an increase in e-cigarette use and a decrease in smoking. Hence, once youth are able to purchase e-cigarettes legally, they may substitute from smoking to vaping. However, if youth had turned to smoking when exposed to e-cigarette MLSA laws, the accumulation of the addictive stock of nicotine may make it difficult to cut down on smoking even when they are able to purchase e-cigarettes legally.

Ultimately, the impact of e-cigarette MLSA laws on smoking, drinking, and marijuana use is an empirical question, and one that we explore in this study.

4. Data

[7] In most cases, youth aged 18 are old enough to legally purchase e-cigarettes and conventional cigarettes except for a few cases where states set the minimum age at 19 or 21.

To study the impact of e-cigarette MLSA laws on youth use of cigarettes, alcohol, and marijuana, we draw on all available waves of the bi-annual national and state Youth Risk Behavior Surveillance System (YRBSS) spanning 1991–2015. The national YRBSS is conducted by the CDC and the state YRBSS is usually administered by state health departments. Many states have authorized the CDC to distribute their data for secondary analyses and for states that did not, we contacted each and received their permission to use the data. The data was limited to states that participated in the survey noting that data in a given year could be withheld from secondary analyses due to sample size constraints.[8] Appendix Table 1 shows the observation count in each state from 1991 to 2015.

The YRBSS data collection typically starts in March and ends in early June for each state. Standard demographic characteristics are consistently collected and a battery of questions relating to youth risky behaviors such as smoking, drinking, and other drug use is also included in each wave. We identify youth as current smokers, drinkers, or marijuana users using questions in the data and conventional methods in the literature.[9] To investigate the specific question of whether e-cigarette MLSA laws cause youth to newly initiate smoking, we infer initiation based on a series of responses. We first use a question in the data asking how old the individual was when he/she smoked a whole cigarette for the first time. We use that information to create a binary indicator for smoking initiation if the reported age of first cigarette smoking matches his/her current age at the time of the survey and zero otherwise. For all the following analyses, we restrict the sample to youth with no missing demographic information.

To isolate the *ceteris paribus* relationship between e-cigarette MLSA laws and youth substance use, we control for an extensive set of confounding policy shifts over this period: federal and state cigarette excise taxes, state beer taxes, an index for medical marijuana laws

[8] A common reason that states do not distribute their data for secondary analyses is that sample size is not large enough to meet the minimum weighting requirement.

[9] We define being a current smoker using a question "*During the past 30 days, on how many days did you smoke cigarettes?*" Youth are then defined as current smokers if any days of smoking are reported. Being a current drinker is defined using the question "*During the past 30 days, on how many days did you have at least one drink of alcohol?*" Being a current binge drinker is defined using the question "*During the past 30 days, on how many days did you have 5 or more drinks of alcohol in a row, that is, within a couple of hours?*" Being a current marijuana user is defined using the question "*During the past 30 days, how many times did you use marijuana?*"

(MML), state unemployment rates, and the natural logarithm of state per capita income.[10] Our index for MML is created using the law's three main provisions – overall legislative decision, home cultivation, and medical marijuana dispensary (Anderson et al., 2015, Pacula et al., 2015, Choi et al., 2016). The index equals one when states only grant the legal status of using marijuana for therapeutic purposes but not for home cultivation or marijuana dispensaries. It equals three when all dimensions are allowed. To proxy for anti-smoking sentiment at the state level, we control for an index (with a maximum value of 3) capturing the restrictiveness of indoor smoking in private workplaces in each state. We also account for anti-vaping sentiment by using an indicator for if vaping in private workplaces is banned.[11] We do not use e-cigarette taxes as a control because only Minnesota has levied taxes on e-cigarettes over our study period. We also control for zero-tolerance laws to account for a general social perception of teenage drinking at the state level.

Table 1 reports the summary statistics for the variables investigated during our study period. Column 1, 2, and 3 present the means of each variable for the full sample, a subsample of individuals younger than 18, and a subsample of individuals 18 or above, respectively. While four states (Alabama, Alaska, New Jersey, and Utah) set the purchasing age of e-cigarettes at 19 years old during the study period, age in the YRBSS is top-coded at "18 or above" and we are unable to separate out youth who are 19 years of age.[12]

As shown in Table 1, 19% of the sample were current smokers, 20% were marijuana users, 39% were current drinkers, and 23% percent were binge drinkers. The proportion of

[10] The cigarette tax data comes from the CDC STATE System and the beer tax data comes from the National Institute on Alcohol Abuse and Alcoholism (NIAAA). We use the tax rates as of March for both variables to match the period of time over which the survey was conducted. Data for state's medical marijuana laws come from the National Conference of State Legislatures (NCSL) and National Organization for the Reform of Marijuana Laws (NORML). We obtain state unemployment rates and per capita income from Bureau of Labor Statistics (BLS). Both cigarette and beer taxes are inflation-adjusted to 2005 values using the Consumer Price Index for All Urban Consumers (CPI-U), and we transform the per capital income using a natural logarithm.

[11] No partial bans on vaping in private workplaces exist. We have also experimented with including smoke-free air laws in bars and restaurants to further control for state anti-smoking sentiment, which are highly collinear with private workplace laws. Our estimate of the impact of e-cigarette MLSA laws was not materially affected by adding these additional proxy variables for anti-smoking sentiment.

[12] This will result in some individuals "18 and above" being subject to the e-cigarette MLSA laws, that is, some individuals in the control group may be treated. We found that moving these youth into column 2 does not at all change the summary statistics. Based on the 2016 American Community Survey, among current high-school enrollees nationally between the ages of 12-19, only about 2% are aged 19, and only 4.3% (based on the share of the population of the affected states, AK, AL, NJ and UT) of these 19 year olds would be misclassified as being not treated. Hence, any attenuation bias from this misclassification is negligible.

current smokers, drinkers, and marijuana users among those who are 18 or above is significantly higher than that among youth 17 or younger (10, 12, and 6 percentage points higher, respectively). Questions related to youth e-cigarette use are first included in the YRBSS in 2015. These questions indicated that 45% of high-school students have tried e-cigarettes in their lifetime, and 24% are current (past 30-day) vapors.

Figure 1 graphs the trend of youth smoking, drinking, and marijuana use over our study period from a sample restricted to those younger than 18 years of age. We use solid lines to represent states where laws were in place before or during February 2015 and dashed lines to represent states where laws have yet to be implemented. These figures suggest two things; first, the prevalence of youth smoking and drinking consistently declined over the past two decades while youth marijuana use spiked in the early 1990s, then decreased substantially, before trending slightly upwards again. Second, trends within both the treated states (solid line) and the non-treated states (dashed line) have been largely similar, yielding little graphical evidence on the impact of e-cigarette MLSA laws on youth smoking, drinking, or marijuana use. Limited graphical evidence notwithstanding, many confounding factors have not been taken into consideration in these graphical representations. Furthermore, second-order effects on smoking and other substance use may be small and difficult to disentangle from other confounding trends. For this reason, we turn to more rigorous quasi-experimental evidence to investigate the policy effects of e-cigarette MLSA laws on youth use of these substances.

5. Empirical Specification

Our baseline model employs the standard difference-in-differences (DD) framework, exploiting differences in the timing of policy adoption across states to identify the effects of the e-cigarette MLSA laws on youth substance use behaviors. Specifically, we estimate the following reduced-form demand function, relating substance use directly to the e-cigarette MLSA laws.

$$P(DV_{i,s,t} > 0) = \sum_{i} \Gamma \mathbf{X}_{\mathrm{i,s,t}} + \mathbf{b_1}\mathrm{MLSA}_{\mathrm{s,t}} + \mathbf{b_2}\mathbf{Z}_{s,t} + \boldsymbol{\gamma}_s + \boldsymbol{\lambda}_t\,[+\boldsymbol{\gamma}_s t] + \varepsilon_{i,s,t}, (1)$$

In specification (1), $DV_{i,s,t}$ is one of the three indicators for youth substance use at the current time. For instance, when $DV_{i,s,t}$ indicates smoking, $P(DV_{i,s,t} > 0)$ denotes the probability that the youth is a current smoker. Our key variable of interest, $\mathrm{MLSA}_{\mathrm{s,t}}$, is an indicator for whether the state had an e-cigarette MLSA law in place. To reflect the typical data collection time in YRBSS, this variable is set equal to one if the law was effective by the end of February of that year and all the subsequent time periods and zero otherwise. The parameter of interest is $\mathbf{b_1}$, which captures the average reduced-form effect of e-cigarette MLSA laws on youth smoking, drinking, or marijuana use, including through all reinforcing and/or competing pathways as discussed earlier. The vector $\mathbf{X}_{\mathrm{i,s,t}}$ contains a full vector of interactions across youth demographic characteristics, and the vector $Z_{s,t}$ represents the time-varying, state level policy variables (inflation-adjusted cigarette and beer taxes expressed in dollars, a three-value index for the medical marijuana law, restrictions on vaping and smoking in private workplaces, an indicator for the existence of zero-tolerance laws, state unemployment rate, and the natural log transformed state per capita income). We include state and year fixed effects, denoted by $\boldsymbol{\gamma}_s$ and $\boldsymbol{\lambda}_t$ respectively, to account for time-invariant state heterogeneity and unobserved national trends. In some specifications, we also add state-specific linear time trends, denoted by $\boldsymbol{\gamma}_s t$, to account for the unobserved state-level factors, evolving at a linear rate. All specifications are estimated as linear probability models via OLS.[13] Standard errors are clustered at the state level where the variable of interest varies (Bertrand et al., 2004).

We extend the baseline specification in several ways to address specific issues. First, to examine dynamic impacts of the policy on youth substance use and explicitly assess the parallel trends assumption between the reform and non-reform states, we transform specification (1) into an event study design. In particular, we decompose $\mathrm{MLSA}_{\mathrm{s,t}}$ in model (1) into $\mathrm{MLSA}_{\mathrm{s,-3}}$, $\mathrm{MLSA}_{\mathrm{s,0}}$, and $\mathrm{MLSA}_{\mathrm{s,1}}$ that capture a series of policy "leads", or "placebo" laws. $\mathrm{MLSA}_{\mathrm{s,-3}}$ takes the value of 1 if an e-cigarette MLSA law will be passed, but not within 3 years (0 otherwise). $\mathrm{MLSA}_{\mathrm{s,0}}$ takes the value of 1 in the year when the law is de facto effective (0 otherwise). $\mathrm{MLSA}_{\mathrm{s,1}}$ takes the value of 1 if a law has been in effect for one or more years (0 otherwise). Our

[13] Our results and conclusions are not materially affected if the specification is estimated via logit or probit regression.

omitted category, or the reference group, is an MLSA law coming into effect 1-2 years later. The new specification takes the form:

$$P(DV_{i,s,t} > 0) = \sum_i \Gamma \mathbf{X}_{\mathrm{i,s,t}} + \boldsymbol{\alpha_1} \mathrm{MLSA}_{\mathrm{s,-3}} + \boldsymbol{\alpha_2} \mathrm{MLSA}_{\mathrm{s,0}} + \boldsymbol{\alpha_3} \mathrm{MLSA}_{\mathrm{s,1}} + \mathbf{b_2} \mathbf{Z}_{s,t} + \boldsymbol{\gamma}_s + \boldsymbol{\lambda}_t \, [+\boldsymbol{\gamma}_s t] + \varepsilon_{i,s,t} \quad (2)$$

where all other variables besides the MLSA variable are defined as before. The parameter $\boldsymbol{\alpha_2}$ captures the contemporaneous policy effect on teen substance use and $\boldsymbol{\alpha_3}$ captures the lagged policy effect one or more years after the law's implementation. Hence, $\boldsymbol{\alpha_1}$ provides evidence of parallel or differential pre-treatment period time trends. If this coefficient is statistically distinguishable from zero, it would suggest that the treatment and control states had differential trends prior to policy adoption, which may undermine the interpretation of the DD effect as causal. Explicitly controlling for the lead effects as in the event study can also help to partly account for any non-parallel trends.

Second, we build upon the above specifications and assess the margin at which smoking is potentially affected. Specifically, we consider whether, and to what extent, e-cigarette MLSA laws have impacted youth smoking initiation and take-up.

Third, we further assess inter-temporal responses by estimating how being exposed to an e-cigarette MLSA law when underage affects smoking behaviors once youth have aged out and are able to purchase e-cigarettes. We do so by restricting the sample to those who are currently over the e-cigarette MLSA age limit and then follow three approaches.

In the first approach, we construct an indicator (denoted $\mathrm{MLSA\_Minor}$) that is set equal to one if an e-cigarette MLSA law was effective when the individual was underage and to zero otherwise.[14] For instance, an e-cigarette MLSA law was effective on January 1st, 2013 in the state of New York. Therefore, a youth aged 18 in 2014 from New York would have been exposed to the law in 2013. By the same analogy, a youth aged 18 or 19 in 2015 would have also been exposed to the law two years ago. Based on this construct, restricting the sample to youth who are not currently impacted by the law based on their age, we estimate the following specification:

[14] For states where no e-cigarette MLSA laws were enacted during the study period, this variable also takes on value zero.

$$P(Smk_{i,s,t} > 0) = \sum_i \Gamma \mathbf{X}_{\mathrm{i,s,t}} + \mathbf{b_1}\mathrm{MLSA\_Minor} + \mathbf{b_2}\mathbf{Z}_{s,t} + \boldsymbol{\gamma}_s + \boldsymbol{\lambda}_t\,[+\boldsymbol{\gamma}_s t] + \varepsilon_{i,s,t}\,, (3)$$

where the dependent variable denotes the probability that the youth is a current smoker, and the other variables are as defined above.

Alternately, we use the same sample of those currently aged out of e-cigarette MLSA laws, wherein MLSA_1Pass denotes an indicator for whether the e-cigarette MLSA law has been in effect in the youth's state of residence for at least one or more years.[15]

$$P(Smk_{i,s,t} > 0) = \sum_i \Gamma \mathbf{X}_{\mathrm{i,s,t}} + \mathbf{b_1}\mathrm{MLSA\_1Pass} + \mathbf{b_2}\mathbf{Z}_{s,t} + \boldsymbol{\gamma}_s + \boldsymbol{\lambda}_t\,[+\boldsymbol{\gamma}_s t] + \varepsilon_{i,s,t}\,(4)$$

Building upon model (4), we further decompose $\mathrm{MLSA\_1Pass}$ into responses to a law that has been in effect for one year and responses to a law that has been in effect for two or more years. In each of these specifications, parameter $\mathbf{b_1}$ captures how youth exposure to the e-cigarette purchase restriction, at any point in time when the youth was underage (model 3) or when the law was passed one or more years ago when the youth was underage (model 4), affects their current smoking behaviors when the youth is no longer a minor.

In alternate specifications, we conduct additional checks to assess heterogeneous responses across gender and race. Finally, we implement a falsification check, assessing effects of the e-cigarette MLSA law on youth who should not be constrained or affected by the policy.

6. Results

A. Effects on Smoking

Table 2 presents estimates of the effects of e-cigarette MLSA laws on youth smoking among those under the age of 18. Panel A reports baseline effects from the difference-in-differences (DD) model specified in Equation (1). Model 1 suggests a 1.3 percentage point increase in smoking participation among youth exposed to an e-cigarette MLSA law, a 7% increase relative to the sample mean. The model utilizes the full sample window from the

[15] Using the same example as above, MLSA_1Pass takes on value one in year 2014 and 2015.

YRBSS, spanning 1991-2015. Though maximizing the number of pre-policy periods[16] can reduce the residual variance and improve the precision in estimating pre-policy trends within the DD framework, extending the pre-policy window too far back may introduce additional confounding. We therefore assess the sensitivity of the estimates to alternately restricting the sample window to 2005-2015 (Model 3), 2007-2015 (Model 5), and 2009-2015 (Model 7). The estimates remain quite robust and indicate a 1.0 to 1.1 percentage point increase in the probability of being a current smoker.

While all models control for additional tobacco, alcohol, and marijuana policies, we further control for state-specific linear trends in even-numbered models, in order to capture remaining time-varying state heterogeneity and potential policy endogeneity. The effect magnitudes in even-numbered models range from 0.7 to 1.4 percentage points and generally remain statistically significant. In some cases, standard errors become smaller, which may point to the presence of marked state trends, which once controlled reduces the residual variance (and hence the standard errors). One possible limitation of using state-specific trends is that it reduces the amount of identifying variation, which may be less credible (Neumark et al., 2014). Furthermore, fitting such state-specific linear trends may exacerbate bias, particularly for sample periods and pre-policy windows where trends in smoking (or other substance use) are far from linear. We therefore exercise care as the case warrants. Taking this into consideration, we continue to present models with and without state trends in all subsequent analyses.

Panel B decomposes the timing of the DD effects and presents estimates from a formal event study design. In keeping with the biennial sampling scheme of the YRBSS, these models control for indicators for the full year of policy enactment, 2 or more years post-adoption, 2 or more years pre-adoption (reference category) and 4 or more years pre-adoption. While we report models both with and without state-specific trends for completeness, we emphasize results from the latter. Wolfers (2006) cautions against adding state-specific linear trends in such timing analyses where the policy is modeled as pre-post implementation since such trends

[16] As noted earlier, NJ was the first state to enact an e-cigarette MLSA law in March of 2010.

may confound both the state-specific time-varying unobservable as well as any dynamic effects of the policy itself.[17] Nevertheless, both sets of specifications show largely similar patterns.

The results from the event study design underscore three points. First, e-cigarette MLSA laws appear to have a significant "contemporaneous" effect during the full year of enactment, about 1.3 percentage points on average. Owing to YRBSS' biennial sampling frame, the enactment year indicator is defined such that it turns on if the policy took effect anytime since March of the previous wave and February of the current year.[18] This ensures that the policy was active for at least 12 months, though it would also pick up some lag in the policy effect for up to 2 years. Second, as the lag increases, the response to policy becomes larger, on the order of 2-3 percentage points. This compounding of the policy effect over time is consistent with an interactive age response. Smoking participation generally increases with age among adolescents; current smoking participation among 16-year-olds is 10.2% compared to 5.0% among 14-year-olds. Hence, an e-cigarette MLSA law in effect when the adolescent was, for instance 14 years of age, would be expected to have a stronger "bite" as he/she ages and becomes more likely to contemplate smoking (or use other forms of tobacco) in the future. Third, the lead effects are generally small and insignificant, providing some validation of the research design and confirming that the policy is orthogonal to pre-adoption trends in smoking.

While our conceptual framework is agnostic about the direction of the effects given the potential for cigarette smoking to either substitute or complement e-cigarette use, the pattern of results that we find – suggesting an increase in smoking participation – is ex post validating when contrasted with unconditional declining trends in youth smoking over the sample period. As shown in Figure 1, unconditional trends suggest a decrease in youth smoking as e-cigarettes entered the market (2007) and e-cigarette MLSA laws proliferated across states (starting in 2010). Thus, if our models are simply reflecting this decline in smoking as states passing more e-cigarette MLSA laws, then the DD effects would have suggested (possibly spuriously) that the laws have reduced youth smoking. However, finding increases in smoking from the policy,

[17] Hence, it is not surprising that, in disentangling the timing of the effects and separating out the lead vs. lagged responses, the estimates are more sensitive to the inclusion of state-specific trends.

[18] For instance, for respondents interviewed in the 2013 YRBSS, the enactment indicator would equal 1 in 2013 if the state they lived in adopted the policy anytime between March 2011 and February 2013.

despite this declining secular trend, adds some confidence that these estimates are not just reflecting the falling smoking rates.

Estimates in Table 2 suggest that when faced with e-cigarette MLSA laws, underage youth may be more likely to turn to cigarette smoking. This may prima facie seem counter-intuitive since they are also restricted from purchasing cigarettes; hence, it would appear that underage youth are turning from one restricted substance to another. However, since all youth face purchase restrictions for cigarettes over the sample period, the implementation of e-cigarette MLSA laws would increase the *relative* costs of accessing e-cigarettes (relative to cigarettes), affecting the demand for these substances. Because cigarettes have been in the market for a long time, most youth who smoke may have found alternative ways to bypass the purchase restrictions and obtain their cigarettes through secondary sources, such as "bumming" or borrowing from a friend or adult (Katzman et al., 2007, Hansen et al., 2013).[19] Thus, it is conceivable that these youth are increasing their participation in the secondary cigarette market when purchasing e-cigarettes is prohibited. The secondary market for e-cigarettes, however, may be less well-developed, particularly when recent estimates suggest that only 3.7% of adults vape (Schoenborn and Gindi, 2015). That said, adults may be a less reliable source of e-cigarettes for teenagers in secondary markets than cigarettes.[20]

In Table 3, we evaluate whether an increase in smoking persists after youth are no longer constrained by the purchasing restrictions. Thus, all models are estimated for youth who have aged out of the e-cigarette MLSA laws.[21] For models reported in Panel A, we define an indicator for whether a youth was exposed to an e-cigarette MLSA law at any time while he/she

[19] A dollar increase in cigarette taxes is estimated to decrease the probability of youth getting cigarettes through a secondary market by 5 or 6 percent, but cigarette taxes had little impact on youth obtaining cigarettes through borrowing or taking from a store or family member. This may suggest that they have alternative ways to bypass the rising costs of cigarettes.

[20] See https://www.cdc.gov/nchs/products/databriefs/db217.htm. Furthermore, while it may be relatively easier for a youth to borrow or "bum" a combustible cigarette from a friend or adult, which by definition is disposed after use, the long-lasting properties of e-cigarettes (e.g. even one disposable e-cigarette can last up to 400 puffs or equivalent to one pack of cigarettes) makes it more difficult to borrow or bum from another user.

[21] Age in the YRBSS is top-coded as 18 or above and four states (AL, AK, NJ, and UT) set the age for legally purchasing e-cigarettes at 19. We restrict the sample to youth with age top-coded as 18 or above, which may still include a few who are not old enough to buy e-cigarettes. We thus ran the same model by further excluding these four states. Our results for the variable of interest remained virtually the same.

was underage.[22] There is little evidence from these specifications to suggest that exposure to an e-cigarette MLSA law when underage is associated with smoking behaviors when he/she has aged out. Models in Panels B and C are more explicit in specifying the timing of underage exposure. Specifically, Panel B separately assesses the effects of being exposed to an e-cigarette MLSA law both one year and two or more years ago (when the youth is below the e-cigarette MLSA age limit) on youth current smoking participation once they aged out of the law. Panel C assesses the combined effects of underage exposure to e-cigarette MLSA laws one or more years prior. Specifications that control for state-specific trends and are limited to shorter pre-policy windows (models 6 and 8) are weakly suggestive of some decline in smoking (about the same magnitude as Table 2 indicated, but in the opposite direction). However, large standard errors make the confidence intervals wide and difficult to rule out nil effects. In any case, we do not find any strong evidence that the increase in smoking persists as youth age out of e-cigarette MLSA laws. These models suggest that any effects on underage smoking, among youth exposed to an e-cigarette MLSA law, fade when they aged out of the law and are able to purchase e-cigarettes legally.[23]

The smoking participation margin among adolescents combines first-time smoking, smoking experimentation, regular smoking, and use of multiple tobacco products including cigarettes. Table 4 presents a parallel set of models for smoking initiation to those presented in Table 3 for smoking participation. Panel A reports estimates for the baseline DD specification, and Panel B reports estimates from the event study design. We have restricted the sample to youth who have initiated smoking in the given year and youth who are non-smokers; thus youth who are current smokers but had initiated their smoking habits in prior years are excluded. As noted earlier, a youth is defined as a first-time smoker if his/her age at the time of interview matches the reported age when he/she first tried smoking. These results should be interpreted with care since smoking initiation in the YRBSS is likely coupled with recall errors in

[22] Since the YRBSS is not longitudinal, this requires the implicit assumption that the youth has not changed their state of residence. Data from the 2001-2015 American Community Surveys show that, on average, about 1.3% of high-school students ages 14-18 change state of residence from one year to the next. Thus, any measurement error from assuming stable state of residence will be minimal; based on the average inter-state migration rate, only about 5% of 18 year olds may be misclassified when assigning a state of residence to when they were underage.

[23] Most smokers initiate smoking during adolescence, with 16 years of age being the mode among ever-smokers (based on the 2013 National Survey on Drug Use and Health). Hence, accumulation of the addictive smoking stock is still relatively low.

the reported age at which smoking was initiated as well as the mismatch between age and wave year.[24] These estimates are generally insignificant and imprecise, though we note that these estimates may be biased downwards from measurement error. At best, they may suggest some positive lagged effects on smoking initiation of about 1 to 2 percentage points, derived from models that control for state-specific linear trends. These magnitudes represent about half of the smoking participation effect identified in Table 2. Thus, the caveats regarding measurement error notwithstanding, it appears that the positive effects of e-cigarette MLSA laws on smoking among underage youth depicted Table 2 might have reflected some increase in initiation as well as movement across smoking and vaping in former initiates.[25]

B. Magnitude of the Smoking Effect

Our estimates thus far suggest that when faced with e-cigarette MLSA laws, underage youth may be more likely to turn to cigarette smoking, at least until they age out of these laws. Models in Table 2 suggest a 1.0 to 1.4 percentage point increase in smoking post-policy adoption, which is consistent with findings reported by Friedman (2015) and Pesko et al. (2016).[26] To place this magnitude in context, it should be noted that the DD effect we estimate is an intention-to-treat (ITT) effect. Most adolescents in the population would not be affected by e-cigarette MLSA laws, and thus the estimated reduced-form smoking response is an average across two groups – those who are potentially affected by e-cigarette MLSA laws and those who are not. It is unlikely that e-cigarette MLSA laws would have a direct effect on smoking behaviors, independent of their effect on e-cigarette use. If e-cigarette MLSA laws had no effect on e-cigarette use, we should expect no effects on other substance use behaviors as well.

[24] For instance, a 15-year-old surveyed in 2013 who reported that they initiated smoking at age 15 would be coded as having initiated smoking in 2013. However, the youth may have initiated smoking in 2012 while still 15 years of age.
[25] It should be noted that adolescents aged 14-17 who are current smokers are likely to have initiated very recently; hence, any change in the smoking margin for this age group may still reflect initiation, experimentation, and trying out different substances.
[26] Both studies find about a one percentage point increase in smoking among underage youth, based on data up to 2013. Our slightly larger estimate (up to 1.4 percentage points in some models) reflect the one additional wave of data (YRBSS spanning up to 2015) in conjunction with the evidence from Table 3 that the lagged policy response is generally larger over time.

Hence, establishing the first-stage effect of how e-cigarette MLSA laws may have impacted youth e-cigarette use can help frame what the maximal effect should be for spillover responses into smoking (and other substance use) given that these individuals represent the affected group. However, estimating effects on e-cigarette use due to these policies has been a challenge because of data limitations; youth-based surveys, including the YRBSS and the MTF, have only recently started asking respondents regarding their e-cigarette use, yielding only one wave of data. Abouk and Adams (2017), for instance, estimate that the e-cigarette MLSA law is associated with a significant 10 percentage point decline in e-cigarette use among high school seniors, which may be an upper bound estimate given that it is based on cross-sectional evidence from only the 2014 MTF wave out of necessity.

The YRBSS started fielding questions on e-cigarette use in the latest 2015 wave. For suggestive evidence, we estimate a similar specification to equation (1) for outcomes related to e-cigarette use (ever use and current use) based only on the 2015 YRBSS.[27] Appendix Table 2 suggests that, among underage youth, e-cigarette MLSA laws reduced current use by about 1.2 percentage points (6% decline relative to the sample mean of 21% vaping participation), and ever use (as a proxy for initiation) by about 4.4 percentage points (10% decline relative to the sample mean of 40% ever vaping). Similar to Abouk and Adams (2017), the effects (not shown) are somewhat larger for older adolescents (11th and 12th graders). We previously found evidence that the laws increased youth smoking by 1.0 to 1.4 percentage points, and so we calculate a back-of-the-envelope treatment-on-the-treated (TOT) effect of 0.3 using the law's impact on ever vaping. We use ever vaping for this calculation to better match the longer duration of data available for smoking. In other words, about 1 in 3 youth may have increased their smoking as they reduced their e-cigarette use in response to the e-cigarette MLSA. These estimates should be interpreted with caution and are meant to be suggestive due to the inherent difficulties in obtaining the first-stage effect of the laws on e-cigarette use. Nevertheless, they can prove useful in gauging the credibility of the magnitudes on the second-order effects.

[27] Given the single wave of data, we are not able to control for state fixed effects, and year fixed effects are not necessary. Instead, we include census region fixed effects to account for unobserved heterogeneity at this geographic level. Models are saturated with all other state-level policy controls.

C. Effects on Drinking and Marijuana Use

Next we examine whether exposure to e-cigarette MLSA laws has an effect on other substance use behaviors among underage youth. In Table 5, DD estimates are presented separately for current drinking and current binge drinking, showing little evidence of any meaningful or consistent effect on alcohol use, though these average effects may mask heterogeneity in their timing. Hence, Table 6 presents models for these drinking outcomes based on the event study design. When separating out the lead and lags, the results are more sensitive to the addition of state-specific linear trends. When considering any current alcohol participation two or more years post-policy adoption, estimates that do not control for state trends suggest nil to minor negative effects. The lagged decrease in drinking becomes stronger by 1-3 percentage points (representing 4-9% relative to the sample mean) when state trends are added. For binge drinking, the variance in the estimates is greater from models with and without state trends. Lead effects are generally close to 0 and insignificant in all models, as are the contemporaneous effects. However, there appears to be a suggestively stronger response in binge drinking over time, similar to the patterns observed for smoking participation. Estimates conditional on state trends indicate about a 1.1 to 1.7 percentage point decrease in binge drinking two or more years post policy adoption. However, estimates that do not control for state trends generally show a nil (to weakly positive but insignificant) effect on binge drinking. While there is weak evidence that binge drinking may be negatively affected with some lag, standard errors are large and we cannot reject the null in most cases. Overall, the results in Tables 5 and 6 suggest no effects of e-cigarette MLSA laws on any youth drinking.

Table 7 presents estimates of the effect of e-cigarette MLSA laws on youth current marijuana use. Only one specification, model 8, which is limited to a narrow time window spanning 2009-2015 and which controls for state linear trends, suggests a significant decline in participation. This model indicates there is on average a 0.9 percentage point decline in marijuana use post e-cigarette MLSA laws. This relationship showed a stronger response over time with a 1.4 percentage point decline within 2 years post-enactment, and a 1.8 percentage

point decline two or more years post-enactment. However, these results are not robust enough to change in the sample frame or the omission of state trends.

We note that effects on substances other than tobacco are third-order effects, and so it is not surprising that they are quite weak. Various estimates in Tables 6 and 7 are suggestive of declines in binge drinking and marijuana use in association with e-cigarette MLSA laws, though the weight of the evidence confirms that the effects are expectedly quite small or nil. Hence, while our results suggest that restricting the purchase of e-cigarettes among underage youth may have spilled over into higher smoking participation, we find little evidence of additional substitution into drinking or marijuana use.

D. Placebo Checks and Heterogeneous Effects

Given that e-cigarette MLSA laws are by definition binding only for underage youth, this suggests a natural falsification test. The policy should have no causal effect on any addictive behaviors among youth who have aged out and who were not exposed to the policy while underage. That is, even if a state enacted an e-cigarette MLSA law of 18 in 2010, youth aged 18 or older in 2010 (19 years of age or older in 2011; etc.) should not be affected since they were never exposed to the restriction even when they were underage. Table 8 carries out this falsification, defining the sample as youth that have aged out of e-cigarette MLSA laws and were never exposed while underage, for each specification and substance use outcome. All of these estimates, most notably for current smoking participation, which earlier models suggested a significant effect among affected underage youth, are generally statistically insignificant and close to zero in magnitude.[28]

In Tables 9-12, we assess whether the response in smoking behaviors is different across gender and race. Panel A of Table 9 shows the baseline DD estimate of the effects of an e-cigarette MLSA on current smoking among underage youth, separately for males and females. Panel B shows corresponding estimates from the event study. While the DD effects tend to suggest that males may be more responsive in terms of increasing their smoking participation

[28] Only 2 out of the 32 are significant at the 10% level, to be expected within the probability of a Type I error.

when restricted from purchasing e-cigarettes, the event study suggests that these differences may reflect the timing of the effects. The short-term response (within two years of policy enactment) tends to be slightly higher for males relative to females. This may suggest that the average age of smoking initiation for female smokers is almost one year higher than for male smokers. Over an extended period of time (two or more years post-enactment) both genders appear to be equally responsive and we find significant lagged increases in smoking participation among both males and females.

When we stratify by race (white vs. non-white) in Table 10, the effects tend to be larger among non-whites, both in terms of the absolute magnitude as well as the relative increase since baseline smoking rates tend to be lower among non-white adolescents. In the event study results for white youth, an e-cigarette MLSA law is associated with at most a 1-2 percentage point increase in current smoking within 2 years of enactment and a 2-4 percentage point increase 2 or more years post-enactment. These findings can be compared to a 2-3 percentage point increase in the short-term and about a 3-5 percentage point increase over the longer term for non-white youth. Similar to females, some of this differential pattern may be related to a higher mean age of smoking initiation among non-white youth. The differential policy impact on youth smoking between white and non-white may seem puzzling since white youth tend to use e-cigarettes at a higher rate than non-white youth and one may expect the e-cigarette MLSA laws to be more binding on white youth. We therefore further decompose the non-white sample into African American, Hispanic, and Other races and see if the policy impact was clustered among Hispanic youth who are also likely to use e-cigarettes at a higher rate.[29] Appendix Table 3 confirms that Hispanic youth and other race are much more likely to increase their smoking in response to e-cigarette MLSA laws than African Americans, confirming our hypothesis. In particular, an e-cigarette MLSA law is associated with a 1.7–3.0 percentage point increase in smoking among Hispanic youth, compared to a 1.4–2.7 percentage point increase in smoking among all non-white youth.

[29] According to the 2015 national YRBSS, the prevalence of having ever used e-cigarettes among Hispanic, white, and black youth is 52%, 43%, and 42% respectively. The prevalence of current e-cigarette use among Hispanic, white, and black youth is 26%, 25%, and 18%

Tables 11-12 consider the heterogeneity across gender and race, respectively, for the inter-temporal effect of being exposed to an e-cigarette MLSA law. Using the models depicted in Table 11, we find no consistent differences across males and females, suggesting that exposure to an e-cigarette MLSA law when underage does not appear to have any persistent effects on smoking when the youth is no longer subject to the restrictions. However, with respect to race (Table 12), there appears to be some marked differences in these effects. Our findings show that the increase in current smoking persists even when youth are no longer subject to the age-based e-cigarette purchase restrictions for non-whites, suggesting a 2-3 percentage point increase in smoking participation. In contrast, white adolescents are less likely to smoke if exposed to an e-cigarette MLSA law when underage, once they have met the legal age. The racial difference in the inter-temporal effects mirrors that in the "contemporaneous" response while the youth is underage (Table 10). As non-white youth were significantly more likely to turn to smoking when constrained from purchasing e-cigarettes, we find that this increase persists even when the youth have aged out. However, the increase in smoking does diminish in magnitude compared to the underage effects in Table 10. For white youth, we found smaller increases in smoking when underage, and the results in Table 11 suggest that white youth reduce their smoking participation (presumably substituting to e-cigarettes) when they are no longer constrained from purchasing e-cigarettes.

7. Conclusion:

Economic theory suggests that e-cigarette MLSA laws may reduce e-cigarette use, and we find suggestive evidence of this using a single cross-section of data. Using MTF data, Abouk and Adams (2017) reached a similar conclusion. We also find strong evidence that e-cigarette MLSA laws increased the probability of youth smoking conventional cigarettes by approximately 1 to 1.4 percentage points (8-12 % relative to the mean smoking rate). In particular, youth who have not smoked in the past but initiated their first cigarettes due to the e-cigarette MLSA laws may have contributed to about half of the increase in smoking participation. The other half of the smoking increase may have come from smokers continuing to smoke rather than using e-cigarettes to quit smoking due to the restrictions. The positive

effect of e-cigarette MLSA laws on youth smoking appear to fade once youth have aged out of the law, implying that these youth eliminated their smoking once they could legally buy e-cigarettes again. Our estimates of the effect of the laws on youth smoking are slightly larger than estimates from Friedman (2015) and Pesko et al. (2016), who both found that the laws increased smoking participation by roughly 0.9 percentage points. Our slightly larger estimate reflects two additional years of data in conjunction with the evidence we find that the lagged policy response tends to be stronger than the contemporaneous response. We find some heterogeneity in these average responses based on gender and race. However, our finding that e-cigarette MLSA laws increased cigarette use is different from findings by Abouk and Adams (2017). Given that both our study and Abouk and Adams (2017) use individual-level data, this alone does not appear to account for the differences in results. Given the disagreement in the literature on if e-cigarette MLSA laws increase or decrease smoking, further research exploring this relationship is warranted.

While federal regulations require all states to have a cigarette MLSA law of at least 18, some states have made the age limit for purchasing both cigarettes and e-cigarettes higher. As of the 4th quarter of 2016, four states had an MLSA of 19 and three states (California, D.C., and Hawaii) had MLSA laws of 21. Our results suggest some caution in raising MLSA laws for both cigarettes and e-cigarettes to 21. It may be preferable to raise cigarette MLSA laws to 21, but keep e-cigarette MLSA laws at 18 to encourage youth to quit smoking using e-cigarettes. Preventing them from legally buying e-cigarettes until age 21 may harden preferences for cigarettes and make quitting at that age more difficult.

We find little evidence that e-cigarette MLSA laws impact alcohol or marijuana use. Given that alcohol or marijuana is less related to e-cigarettes than conventional cigarettes, the null results we found for youth use of these two substances are somewhat expected.

In sum, results from our study suggest that it is unclear if e-cigarette MLSA laws have a positive impact on public health. It appears that some portion of the decrease in e-cigarette use, about 30% based on crude TOT estimates, may come at the cost of higher conventional cigarette use, at least in the short-term until the youth has aged out of the restrictions. If e-cigarettes are only 5% as harmful as traditional cigarettes (Tobacco Advisory Group of the Royal

College of Physicians, 2016), then e-cigarette MLSA laws leading to increased smoking may cause greater harm than benefits. However, such net costs need to be balanced against other considerations such as the potential use of e-cigarettes for smoking cessation among older youth and among longer-term smokers.

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Table 1 Summary Statistics

	Full Sample	Youth younger than 18	Youth 18 or above
Youth substance use			
Current smoker	0.19 [0.40]	0.18 [0.39]	0.28 [0.45]
Current drinker	0.39 [0.49]	0.38 [0.48]	0.50 [0.50]
Current binge drinker	0.23 [0.42]	0.22 [0.41]	0.33 [0.47]
Current marijuana user	0.20 [0.40]	0.19 [0.40]	0.25 [0.44]
Youth demographic characteristics			
Females	0.51 [0.50]	0.52 [0.50]	0.45 [0.50]
White	0.58 [0.49]	0.58 [0.49]	0.57 [0.49]
Black	0.15 [0.36]	0.15 [0.36]	0.17 [0.38]
Hispanics	0.14 [0.35]	0.14 [0.35]	0.15 [0.35]
Other races	0.12 [0.33]	0.12 [0.33]	0.11 [0.31]
Grade = 9^{th}	0.28 [0.45]	0.32 [0.47]	0.01 [0.08]
Grade = 10^{th}	0.27 [0.44]	0.30 [0.46]	0.01 [0.11]
Grade = 11^{th}	0.24 [0.43]	0.26 [0.44]	0.11 [0.31]
Grade = 12^{th}	0.21 [0.41]	0.12 [0.32]	0.87 [0.33]
Merged state-level policies			
E-cigarette MLSA Laws	0.20 [0.40]	0.21 [0.41]	0.15 [0.36]
Cigarette taxes	1.75 [1.04]	1.78 [1.05]	1.59 [0.98]
Beer taxes	0.29 [0.25]	0.29 [0.25]	0.31 [0.26]
Medical Marijuana Law	0.57 [1.04]	0.59 [1.04]	0.50 [1.00]
State unemployment rate	5.92 [1.92]	5.91 [1.91]	5.95 [1.98]
Natural log of per capita income	10.43 [0.19]	10.44 [0.19]	10.40 [0.18]
Indoor cig restrictions in private workplaces	1.60 [1.32]	1.63 [1.32]	1.42 [1.30]
Indoor E-cig restrictions in private workplaces	0.01 [0.09]	0.01 [0.09]	0.01 [0.10]
Zero-tolerance law	0.30 [0.46]	0.30 [0.46]	0.28 [0.45]

Notes: Means and standard deviation (in bracket) are reported. Youth substance use variables are defined in the text. E-cigarette MLSA Laws and cigarette taxes data come from CDC STATE System. Beer taxes come from NIAAA. State unemployment rate and per capita income data come from Bureau of Labor Statistics. Indoor cigarette use restrictions in private workplaces are created as a three-value index ("0"–no restriction; "1"–partial restriction; "2"–full restriction) Indoor e-cig restrictions in private workplaces and zero-tolerance laws are created as indicators. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Figure 1 Youth Substance Use Trends from 1991-2015

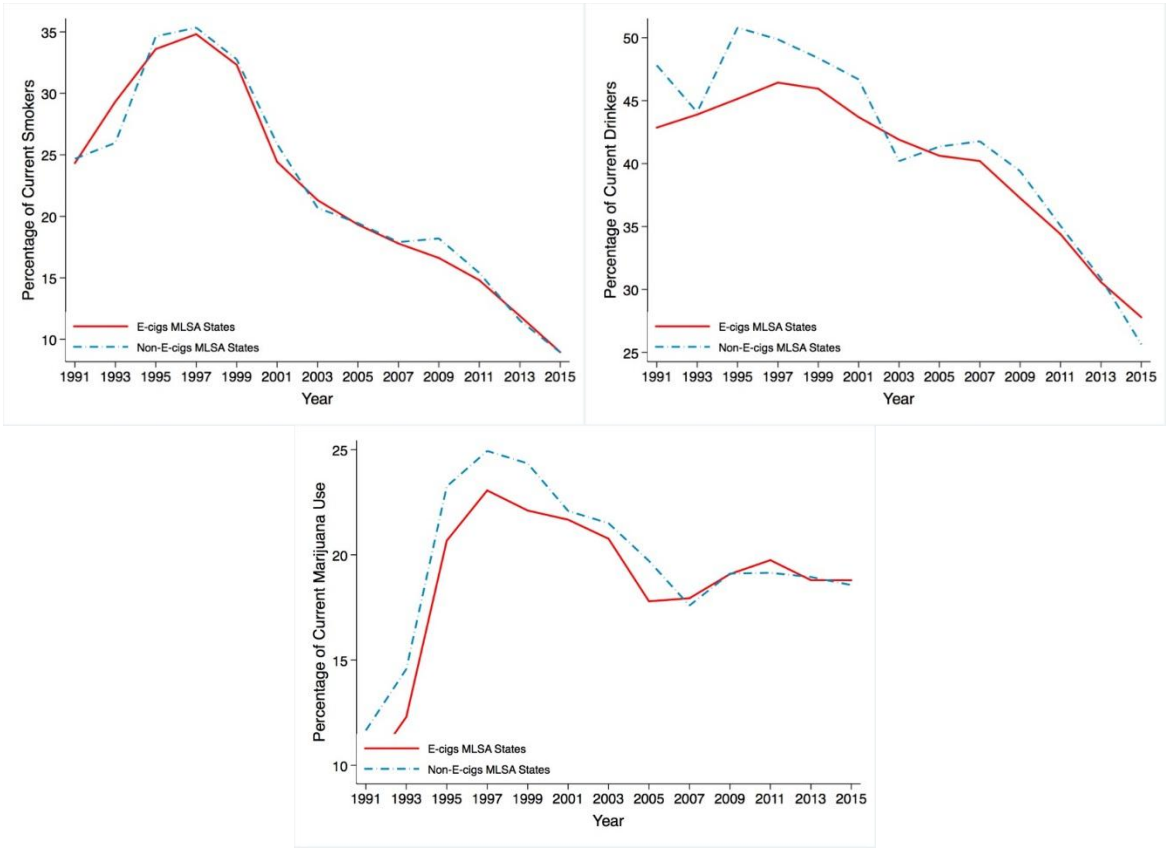

Table 2 – E-cigarette MLSA Laws and Youth Smoking

National and State YRBSS

Panel A: Difference-in-Difference								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.013*	0.013*	0.010^{+}	0.014**	0.010^{+}	0.011**	0.011*	0.007
	(0.005)	(0.006)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)
Panel B: Event Study Design								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.004	-0.012*	-0.004	-0.008^{+}	-0.004	-0.006	-0.009	-0.003
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)
E-cig MLSA Law	0.012*	0.017*	0.011^{+}	0.019***	0.011^{+}	0.014*	0.014*	0.004
	(0.005)	(0.007)	(0.006)	(0.005)	(0.006)	(0.007)	(0.006)	(0.007)
E-cig MLSA Law 1yr Post	0.022*	0.033*	0.023*	0.030*	0.023*	0.017	0.027*	-0.006
	(0.010)	(0.013)	(0.010)	(0.011)	(0.011)	(0.015)	(0.012)	(0.016)
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015
Mean of DV	0.18	0.18	0.14	0.14	0.13	0.13	0.12	0.12
Observations	1,075,651	1,075,651	724,413	724,413	634,364	634,364	543,510	543,510

Note: Standard errors, clustered at the state level, are in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

The sample has been restricted to youth younger than 18 years of age.

E-cig MLSA Law is set equal to one if the law was effective before February of that year and all the subsequent years.

Table 3 — Inter-temporal Relationship Between E-cigarette MLSA Laws and Youth Smoking

National and State YRBSS

Panel A:								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA_Minor	0.005	0.009	0.005	0.006	0.004	0.000	0.007	0.004
	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.010)	(0.008)	(0.014)
Panel B:								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 Yr Ago	-0.004	-0.006	-0.004	-0.004	-0.003	-0.015	-0.004	-0.019
	(0.010)	(0.014)	(0.010)	(0.015)	(0.011)	(0.016)	(0.011)	(0.015)
MLSA Passed 2 or more Yrs Ago	0.012	0.017^{+}	0.013	-0.002	0.014	-0.012	0.013	-0.032**
	(0.013)	(0.009)	(0.011)	(0.010)	(0.010)	(0.013)	(0.010)	(0.010)
Panel C:								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 or more Yrs Ago	0.005	0.007	0.006	-0.003	0.007	-0.013	0.005	-0.026*
	(0.010)	(0.010)	(0.009)	(0.010)	(0.009)	(0.011)	(0.009)	(0.011)
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015
Mean of DV	0.28	0.28	0.23	0.23	0.22	0.22	0.22	0.22
Observations	148,593	148,593	89,728	89,728	77,566	77,566	64,854	64,854

Note: Standard errors, clustered at the state level, are in parentheses.

** $p < 0.01$, *** $p < 0.001$

All models include controls for gender, race, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Youth is defined as a current smoker if he/she reported smoking at least one day in the past 30 days

The sample has been restricted to youth aged 18 or above.

In Panel A, the policy variable "MLSA_Minor" is set equal to one if an e-cigarette MLSA law was effective when the youth was underage, but he/she has now aged out of the restriction.

In Panel B, the policy variable "MLSA Passed 1 Yr Ago" is set equal to one if e-cigarette MLSA laws have been in effect for one year.

In Panel C, the policy variable "MLSA Passed 1 or more Yrs Ago" is set equal to one if e-cigarette MLSA laws have been in effect for one or more years.

Table 4 – E-cigarette MLSA Laws and Youth Smoking Initiation

National and State YRBSS

Panel A: Difference-in-Difference								
DV: Yth is a first-time smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.005	0.003	0.003	0.003	0.003	-0.000	0.004	-0.004
	(0.005)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)
Panel B: Event Study Design								
DV: Yth is a first-time smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.004	-0.006	-0.004	-0.007^{+}	-0.005	-0.008*	-0.007	-0.005
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
E-cig MLSA Law	0.004	0.002	0.003	0.008^{+}	0.003	0.006	0.004	0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
E-cig MLSA Law 1yr Post	0.002	0.002	-0.000	0.018*	0.001	0.019*	0.005	0.010
	(0.006)	(0.007)	(0.006)	(0.008)	(0.007)	(0.008)	(0.009)	(0.008)
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015
Mean of DV	0.10	0.10	0.08	0.08	0.08	0.08	0.08	0.08
Observations	725,311	725,311	530,574	530,574	469,598	469,598	405,568	405,568

Note: Standard errors, clustered at the state level, are in parentheses.

$^{+}$ $p < 0.10$, * $p < 0.05$

All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Youth is defined as a first time smoker if his/her age at the time of the survey matches his/her age of first-time smoking cigarettes; Youth never smoked a cigarette are coded zero and youth who initiated smoking when he/she was younger than the time of the survey were excluded. Age≤12 and ≥18 are dropped due to perfect collinearity.

Table 5 – E-cigarette MLSA Laws and Youth Drinking (DD)
National and State YRBSS

DV: Yth is a current drinker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.014*	-0.003	0.004	0.002	0.002	0.002	0.002	-0.002
	(0.006)	(0.008)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Mean of DV	0.38	0.38	0.34	0.34	0.33	0.33	0.31	0.31
DV: Yth is a binge drinker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.015**	-0.001	0.007	0.002	0.004	0.001	0.005	-0.002
	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)
Mean of DV	0.22	0.22	0.19	0.19	0.19	0.19	0.18	0.18
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015
Observations	1,034,886	1,034,886	683,964	683,964	594,461	594,461	507,232	507,232

Note: Standard errors, clustered at the state level, are in parentheses
* $p < 0.05$, ** $p < 0.01$
All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.
Youth is defined as a current drinker if he/she reported drinking at least on day in the past 30 days
Youth is defined as a current binge drinker if he/she, in at least 1 day of the past 30 days, drank 5 or more drinks of alcohol in a row within a couple of hours
The sample has been restricted to youth younger than 18 years of age

Table 6 – E-cigarette MLSA Laws and Youth Drinking (Event Study Design)
National and State YRBSS

DV: Yth is a current drinker	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.019**	-0.009	-0.009	-0.009	-0.008	-0.005	-0.012	-0.019*
	(0.006)	(0.006)	(0.006)	(0.009)	(0.007)	(0.009)	(0.009)	(0.010)
E-cig MLSA Law	0.012*	-0.006	0.003	-0.001	0.001	-0.002	0.002	0.006
	(0.006)	(0.007)	(0.007)	(0.009)	(0.007)	(0.010)	(0.008)	(0.007)
E-cig MLSA Law 1yr Post	0.014	-0.025*	-0.006	-0.014	-0.009	-0.014	-0.003	0.012
	(0.008)	(0.012)	(0.011)	(0.020)	(0.012)	(0.021)	(0.014)	(0.016)
Mean of DV	0.38	0.38	0.34	0.34	0.33	0.33	0.31	0.31
DV: Yth is a binge drinker	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.012*	-0.006	-0.005	-0.003	-0.004	0.002	-0.006	-0.001
	(0.005)	(0.004)	(0.005)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)
E-cig MLSA Law	0.014**	-0.002	0.007	-0.001	0.005	-0.004	0.006	-0.006
	(0.004)	(0.004)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
E-cig MLSA Law 1yr Post	0.024***	-0.011	0.011	-0.012	0.007	-0.016	0.011	-0.017
	(0.006)	(0.007)	(0.009)	(0.014)	(0.008)	(0.014)	(0.009)	(0.013)
Mean of DV	0.22	0.22	0.19	0.19	0.19	0.19	0.18	0.18
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015
Observations	1,034,886	1,034,886	683,964	683,964	594,461	594,461	507,232	507,232

Note: Standard errors, clustered at the state level, are in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.
Youth is defined as a current drinker if he/she reported drinking at least on day in the past 30 days
Youth is defined as a current binge drinker if he/she, in at least 1 day of the past 30 days, drank 5 or more drinks of alcohol in a row within a couple of hours
The sample has been restricted to youth younger than 18 years of age

Table 7 – E-cigarette MLSA Laws and Youth Marijuana Use

National and State YRBSS

Panel A: Difference-in-Difference								
DV: Yth is a current MJ user	1	2	3	4	5	6	7	8
E-cig MLSA Law	-0.004	-0.001	-0.004	-0.006	-0.004	-0.004	-0.004	-0.009[+]
	(0.005)	(0.006)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
Panel B: Event Study Design								
DV: Yth is a current MJ user	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.009[*]	-0.011	-0.005	-0.002	-0.004	-0.006	-0.006	0.005
	(0.004)	(0.006)	(0.003)	(0.006)	(0.004)	(0.006)	(0.005)	(0.005)
E-cig MLSA Law	-0.005	0.003	-0.004	-0.006	-0.003	0.002	-0.002	-0.014[+]
	(0.004)	(0.007)	(0.004)	(0.008)	(0.004)	(0.007)	(0.005)	(0.008)
E-cig MLSA Law 1yr Post	0.007	0.018	0.006	-0.006	0.005	0.015	0.007	-0.018
	(0.007)	(0.014)	(0.007)	(0.018)	(0.008)	(0.015)	(0.008)	(0.016)
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015
Mean of DV	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Observations	1,096,105	1,096,105	731,805	731,805	639,619	639,619	547,068	547,068

Note: Standard errors, clustered at the state level, are in parentheses.

[+] $p < 0.10$, [*] $p < 0.05$

All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Youth is defined as a current marijuana user if he/she reported using marijuana at least once in the past 30 days

The sample has been restricted to youth younger than 18 years of age

Table 8 – Falsification Tests

National and State YRBSS

Panel A:								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.011	0.020^{+}	0.011	0.011	0.010	0.005	0.011	0.007
	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)	(0.015)
Mean of DV	0.28	0.28	0.23	0.23	0.22	0.22	0.22	0.22
N	148,593	148,593	89,728	89,728	77,566	77,566	64,854	64,854
Panel B:								
DV: Yth is a current drinker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.012	-0.014	-0.006	-0.017	-0.008	-0.013	-0.011	-0.019
	(0.012)	(0.013)	(0.013)	(0.016)	(0.013)	(0.016)	(0.014)	(0.016)
Mean of DV	0.50	0.50	0.47	0.47	0.46	0.46	0.45	0.45
N	114,634	114,634	72,924	72,924	62,881	62,881	52,542	52,542
Panel C:								
DV: Yth is a binge drinker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.018^{+}	-0.008	-0.001	-0.011	-0.004	-0.010	-0.005	-0.014
	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)	(0.009)
Mean of DV	0.34	0.34	0.31	0.31	0.30	0.30	0.29	0.29
N	114,634	114,634	72,924	72,924	62,881	62,881	52,542	52,542
Panel D:								
DV: Yth is a marijuana user	1	2	3	4	5	6	7	8
E-cig MLSA Law	-0.002	-0.003	-0.005	-0.014	-0.009	-0.009	-0.010	-0.016
	(0.010)	(0.011)	(0.010)	(0.012)	(0.010)	(0.012)	(0.009)	(0.011)
Mean of DV	0.25	0.25	0.26	0.26	0.26	0.26	0.27	0.27
N	113,482	113,482	74,812	74,812	65,032	65,032	54,457	54,457
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015

Note: Standard errors, clustered at the state level, are in parentheses

$^{+}$ $p < 0.10$

All models include controls for gender, race, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

The sample has been restricted to youth aged 18 or above.

Table 9 – E-cigarette MLSA Laws and Youth Smoking (stratified by gender)

National and State YRBSS

Panel A: Difference-in-Difference								
Male								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.016**	0.018**	0.013*	0.018**	0.012*	0.017**	0.016**	0.015*
	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)
Mean of DV	0.19	0.19	0.15	0.15	0.14	0.14	0.14	0.14
Female								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.009+	0.008	0.008	0.009*	0.007	0.006	0.007	0.001
	(0.006)	(0.006)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)	(0.004)
Mean of DV	0.18	0.18	0.13	0.13	0.12	0.12	0.12	0.12
Panel B: Event Study Design								
Male								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.002	-0.010+	-0.002	-0.004	-0.001	-0.001	-0.006	0.002
	(0.005)	(0.006)	(0.004)	(0.005)	(0.004)	(0.006)	(0.006)	(0.006)
E-cig MLSA Law	0.016*	0.021**	0.014*	0.021**	0.014*	0.016+	0.018*	0.008
	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)
E-cig MLSA Law 1yr Post	0.026*	0.035**	0.024+	0.026+	0.022+	0.014	0.029*	-0.009
	(0.010)	(0.012)	(0.012)	(0.015)	(0.012)	(0.019)	(0.013)	(0.018)
Mean of DV	0.19	0.19	0.15	0.15	0.14	0.14	0.14	0.14
Female								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.007	-0.014*	-0.006+	-0.012*	-0.007	-0.010+	-0.011*	-0.008
	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)	(0.006)	(0.006)	(0.006)
E-cig MLSA Law	0.009	0.012	0.009	0.017**	0.009	0.011	0.011	0.001
	(0.005)	(0.008)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.008)
E-cig MLSA Law 1yr Post	0.019+	0.029*	0.022*	0.033*	0.023*	0.019	0.025+	-0.003
	(0.011)	(0.014)	(0.010)	(0.013)	(0.011)	(0.015)	(0.013)	(0.017)
Mean of DV	0.18	0.18	0.13	0.13	0.12	0.12	0.12	0.12
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015

Note: Standard errors, clustered at the state level, are in parentheses

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Youth is defined as a current smoker if he/she reported smoking at least one day in the past 30 days

The sample has been restricted to youth younger than 18 years of age.

Table 10 – E-cigarette MLSA Laws and Youth Smoking (stratified by race)

National and State YRBSS

Panel A: Difference-in-Difference								
White								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.004	0.003	-0.000	0.009^{+}	-0.001	0.007	0.001	0.001
	(0.007)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)
Mean of DV	0.21	0.21	0.16	0.16	0.15	0.15	0.14	0.14
Non-white								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.027**	0.020***	0.024***	0.018***	0.023***	0.016**	0.024***	0.014**
	(0.008)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)
Mean of DV	0.15	0.15	0.12	0.12	0.11	0.11	0.11	0.11
Panel B: Event Study Design								
White								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.006	-0.010^{+}	-0.006	-0.012*	-0.007^{+}	-0.013*	-0.006	-0.007
	(0.006)	(0.005)	(0.004)	(0.005)	(0.004)	(0.006)	(0.004)	(0.006)
E-cig MLSA Law	0.003	0.006	0.001	0.018**	0.001	0.015*	0.002	0.001
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.010)
E-cig MLSA Law 1yr Post	0.010	0.020	0.008	0.037**	0.009	0.029^{+}	0.007	-0.004
	(0.011)	(0.013)	(0.009)	(0.012)	(0.010)	(0.016)	(0.011)	(0.020)
Mean of DV	0.21	0.21	0.16	0.16	0.15	0.15	0.14	0.14
Non-white								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
E-cig MLSA Law 3yr Prior	-0.003	-0.010^{+}	-0.003	-0.003	-0.002	0.001	-0.010	-0.003
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
E-cig MLSA Law	0.027**	0.025***	0.026***	0.020*	0.025***	0.013^{+}	0.029***	0.012^{+}
	(0.008)	(0.005)	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)	(0.007)
E-cig MLSA Law 1yr Post	0.040*	0.044***	0.042**	0.024	0.040**	0.008	0.049***	0.004
	(0.017)	(0.010)	(0.013)	(0.017)	(0.013)	(0.017)	(0.013)	(0.017)
Mean of DV	0.15	0.15	0.12	0.12	0.11	0.11	0.11	0.11
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015

Note: Standard errors, clustered at the state level, are in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Youth is defined as a current smoker if he/she reported smoking at least one day in the past 30 days

The sample has been restricted to youth younger than 18 years of age.

Table 11 — Inter-temporal Relationship Between E-cigarette MLSA Laws and Youth Smoking (stratified by gender)

National and State YRBSS

Panel A:								
Male								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA_Minor	0.003	0.009	0.002	0.008	0.004	-0.005	0.008	-0.002
	(0.010)	(0.012)	(0.011)	(0.013)	(0.011)	(0.014)	(0.010)	(0.019)
Female								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA_Minor	0.008	0.009	0.009	0.004	0.005	0.007	0.006	0.011
	(0.012)	(0.012)	(0.011)	(0.011)	(0.011)	(0.012)	(0.010)	(0.013)
Panel B:								
Male								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 Yr Ago	-0.006	-0.017	-0.010	-0.013	-0.007	-0.033	-0.009	-0.044^{+}
	(0.015)	(0.019)	(0.015)	(0.022)	(0.016)	(0.023)	(0.017)	(0.026)
Female								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 Yr Ago	-0.000	0.006	0.003	0.008	0.003	0.007	0.001	0.014
	(0.014)	(0.015)	(0.012)	(0.019)	(0.012)	(0.022)	(0.013)	(0.018)
Panel C:								
Male								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 or more Yrs Ago	0.001	0.000	-0.001	-0.007	0.002	-0.025	0.003	-0.039*
	(0.011)	(0.012)	(0.011)	(0.015)	(0.011)	(0.017)	(0.011)	(0.017)
Female								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 or more Yrs Ago	0.010	0.014	0.015	0.004	0.013	0.001	0.010	-0.010
	(0.013)	(0.011)	(0.011)	(0.013)	(0.011)	(0.014)	(0.011)	(0.014)
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015

Note: Standard errors, clustered at the state level, are in parentheses.
$^{+}$ $p < 0.10$, * $p < 0.05$
All models include controls for gender, race, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.
Youth is defined as a current smoker if he/she reported smoking at least one day in the past 30 days
The sample has been restricted to youth aged 18 or above.

Table 12 — Inter-temporal Relationship Between E-cigarette MLSA Laws and Youth Smoking (stratified by race)

National and State YRBSS

Panel A:								
White								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA_Minor	-0.004	0.001	-0.007	-0.005	-0.008	-0.010	-0.007	-0.018
	(0.013)	(0.014)	(0.013)	(0.012)	(0.013)	(0.012)	(0.012)	(0.016)
Non-white								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA_Minor	0.019^{+}	0.025^{+}	0.022*	0.018	0.020^{+}	0.018	0.022*	0.028^{+}
	(0.011)	(0.013)	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)	(0.014)
Panel B:								
White								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 Yr Ago	-0.013	-0.026	-0.018	-0.029	-0.017	-0.037^{+}	-0.017	-0.060**
	(0.018)	(0.023)	(0.019)	(0.020)	(0.019)	(0.021)	(0.019)	(0.019)
Non-white								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 Yr Ago	0.016	0.022	0.018	0.019	0.019	0.007	0.014	0.027
	(0.014)	(0.015)	(0.013)	(0.017)	(0.013)	(0.017)	(0.012)	(0.021)
Panel C:								
White								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 or more Yrs Ago	-0.006	-0.007	-0.007	-0.016	-0.005	-0.030*	-0.005	-0.051***
	(0.013)	(0.013)	(0.012)	(0.012)	(0.012)	(0.014)	(0.012)	(0.014)
Non-white								
DV: Yth is a current smoker	1	2	3	4	5	6	7	8
MLSA Passed 1 or more Yrs Ago	0.021^{+}	0.026*	0.023*	0.002	0.022^{+}	0.001	0.017	0.003
	(0.011)	(0.013)	(0.010)	(0.015)	(0.011)	(0.015)	(0.011)	(0.018)
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015

Note: Standard errors, clustered at the state level, are in parentheses.

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

All models include controls for gender, race, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Youth is defined as a current smoker if he/she reported smoking at least one day in the past 30 days

The sample has been restricted to youth aged 18 or above.

Appendix Table 1 National and State YRBSS Observation Counts

State	1991	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	2015	Total
Alabama	2,444	5,120	3,917	4,421	2,099	1,862	1,721	1,026	483	2,528	1,654	1,845	1,810	30,930
Alaska			1,596				1,439		1,268	1,218	1,279	1,183	1,343	9,326
Arizona		435		1,107	131	408	3,714	3,502	3,545	2,846	3,876	1,744	2,698	24,006
Arkansas		395	2,536	2,336	1,435	1,670	281	1,503	1,979	1,927	1,327	1,802	2,746	19,937
California	1,742	1,974	1,202	1,985	2,479	2,198	1,730	1,553	2,110	2,802	1,877	2,463	5,779	29,894
Colorado	141	259	101	268		658				193	297	304	270	2,491
Connecticut			242	1,887				2,442	1,997	2,319	2,000	2,377	2,429	15,693
Delaware			214		2,131	2,863	3,333	2,633	2,357	2,257	2,421	2,590	2,638	23,437
D.C			508								316			824
Florida	1,177		547	675	863	5,130	5,461	4,982	5,098	5,591	7,409	6,840	6,854	50,627
Geogia	2,728	2,491	445	344	811	486	2,469	3,579	2,744	3,146	2,033	2,278	402	23,956
Hawaii		1,550	1,231	1,382	1,531			1,627	1,148	1,692	4,172	4,467		18,800
Idaho	4,107	3,970				1,843	1,702	1,667	1,384	2,102	1,921	2,090	2,050	22,836
Illinois	416	4,272	3,303		230	440	315	492	2,956	4,432	4,500	3,793	4,022	29,171
Indiana	269					178	2,061	1,682	2,653	1,473	3,062	824	2,057	14,259
Iowa			242	2,284				1,588	1,666		1,513			7,293
Kansas		171		204			340	1,909	1,692	2,196	2,133	2,089		10,734
Kentucky			354	1,455			1,563	3,766	3,842	1,726	1,973	2,257	2,465	19,401
Louisiana			768	6,039	624		691	158	1,299	1,437	1,115	1,063		13,194
Maine		249	1,528	2,060	198	1,525	1,830	1,325	1,267	8,445	9,079	8,343	9,112	44,961
Maryland	214	145		823			261	1,398	1,486	1,590	2,793	51,769	54,356	114,835
Massachusetts		370	274	1,632		255	213	257	718		289		264	4,272
Michigan	766	144	1,110	4,385	3,134	3,864	3,772	3,479	3,723	3,636	4,711	4,627	4,879	42,230
Minnesota		322						95		188		292	745	1,642
Mississippi	479	1,749	1,746	1,827	2,178	2,133	1,471		1,923	1,763	1,846	2,144	2,040	21,299
Missouri	247	183	5,386	1,459	2,175	2,095	1,798	1,963	1,865	1,681	344	1,825	1,594	22,615
Montana		2,489	2,493	2,402	2,820	2,810	2,678	2,987	3,846	1,785	4,022	4,745	4,308	37,385
Nebraska	2,426	3,560					2,913	3,706			3,719	1,824	1,634	19,782
Nevada		2,005	1,507	1,453	1,652	1,676	1,947	1,529	1,729	2,403	207	2,069	1,787	19,964
New Hampshire	252	2,662	2,072				1,298	1,249	1,581	1,450	1,359	1,590	14,310	27,823
New Jersey	454			737	235	2,324	305	1,800	689	2,203	1,730	2,027	208	12,712
New Mexico	3,259	661		280		155	104	5,417	2,780	5,495	5,685	5,325	8,486	37,647
New York	373	491	273	4,043	3,995	309	9,987	9,939	13,688	15,335	13,161	10,409	10,406	92,409
North Carolina		2,712	1,873	339	509	3,191	2,522	4,466	3,975	5,550	3,324	2,171	5,891	36,523
North Dakota			1,509		1,789	1,580	1,649	1,710	1,722	1,767	1,863	1,919	2,064	17,572
Ohio	135	524	553	556	564	224	299	279				158	227	3,519
Oklahoma				223		397	1,366	1,923	2,842	1,397	1,136	1,465	1,934	12,683
Oregon		188				184		268		247				887
Pennsylvania	488	362	671	272	487		316	423	210	1,067	450	264	483	5,493
Rhode Island				1,494	75	1,361	1,775	2,316	2,133	3,106	3,814	2,357	4,004	22,435
South Carolina	6,020	4,619	5,434	6,003	5,313		887	1,567	1,206	1,070	1,437	1,553	1,311	36,420
South Dakota	1,638	1,336	1,177	1,589	1,643	1,596	2,100	1,567	1,577	2,122	1,502	1,273	1,257	20,377
Tennessee		3,735		578	265	611	1,919	1,924	2,182	2,176	2,874	1,847	4,371	22,482
Texas	2,517	1,358	1,198	949	2,715	9,022	2,628	5,821	4,906	4,766	5,841	3,479	1,226	46,426
Utah	4,513	4,338	3,144	1,349	1,479	1,042	1,537	1,710	2,097	1,544	1,657	2,118		26,528
Vermont	141				6,868	6,967	6,184	6,997	5,744	8,190	8,267		20,151	69,509
Virginia	687		64		746		245	349	439	98	1,603	7,776	4,310	16,317
Washington	422	376	83	108		54		101		246	167	195	102	1,854
West Virginia		3,107	2,071	1,808	1,308	261	1,719	1,549	1,598	2,071	2,375	1,753	1,803	21,423
Wisconsin		3,272		1,603	1,855	2,327	2,278	2,593	2,234	3,074	3,615	2,776		25,627
Wyoming			1,674	2,033	1,590	2,684	1,507	2,455	2,174	2,802	2,439	2,924	2,317	24,599
Total	38,055	61,594	53,046	64,392	55,927	66,383	84,328	107,271	108,555	127,152	136,187	171,026	203,143	1,277,059

Appendix Table 2 – Cross-sectional Relationship Between E-cigarette MLSA Laws and Youth Use of E-cigarettes

National and State YRBSS

	Ever used e-cigarettes	Current vapor
E-cig MLSA Law	-0.044**	-0.012
	(0.016)	(0.015)
Mean of DV	0.40	0.21
Full controls	Yes	Yes
Census Region FEs	Yes	Yes
Year	2015	2015
N	145,950	178,444

Note: Standard errors, clustered at the state level, are in parentheses

** p < 0.01

All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Youth is defined as a current vapor if he/she reported using e-cigarettes at least one day in the past 30 days

The sample has been restricted to youth younger than 18

E-cig MLSA Law is set equal to one if the law was effective before February 2015.

Appendix Table 3 – E-cigarette MLSA Laws and Youth Smoking

(Stratified non-white sample)

National and State YRBSS

Difference-in-Difference (***DV: Yth is a current smoker***)

African American	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.013^{+}	0.007	0.009	0.013^{+}	0.009	0.014*	0.010	0.012*
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.006)	(0.007)	(0.005)
Mean of DV	0.11	0.11	0.08	0.08	0.07	0.07	0.07	0.07
Hispanic	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.030***	0.029***	0.028***	0.020**	0.027**	0.018**	0.028***	0.017*
	(0.006)	(0.008)	(0.008)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)
Mean of DV	0.17	0.17	0.14	0.14	0.13	0.13	0.13	0.13
Other races	1	2	3	4	5	6	7	8
E-cig MLSA Law	0.036***	0.025**	0.031***	0.023**	0.031**	0.021*	0.031**	0.016*
	(0.009)	(0.008)	(0.009)	(0.009)	(0.010)	(0.008)	(0.010)	(0.008)
Mean of DV	0.18	0.18	0.14	0.14	0.13	0.13	0.12	0.12
Full Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trend	No	Yes	No	Yes	No	Yes	No	Yes
Time span	1991–2015	1991–2015	2005–2015	2005–2015	2007–2015	2007–2015	2009–2015	2009–2015

Note: Standard errors, clustered at the state level, are in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

All models include controls for gender, race, age, grade, cigarette and beer taxes, zero tolerance laws, smoke-free air laws, indicator for comprehensive restrictions on e-cigarette use in private work places, state unemployment rate, and natural log of state per capita income. Both cigarette and beer taxes are inflation-adjusted using CPI-U.

Youth is defined as a current smoker if he/she reported smoking at least one day in the past 30 days

The sample has been restricted to youth younger than 18 years of age.