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Abstract

E-cigarette licensure laws (ELLs) require retailers to obtain a state license to sell e-cigarettes over the counter. This study is the first to comprehensively explore the effect of ELL adoption on youth and adult tobacco product use. Using data from the State Youth Risk Behavior Survey (YRBS) and a difference-in-differences approach, we find no evidence that ELL adoption reduces overall youth ENDS use. The precision of our estimates allows us to rule out, with 95 percent confidence, ELL-induced prior-month youth ENDS use declines of more than 3.4 percent. The pattern of null findings persists when we examine ELLs that impose (1) higher penalties for retailer non-compliance, (2) higher renewable licensure fees, and (3) criminal as compared to civil penalties. However, we do uncover evidence that adoption of ELLs with higher penalties associated with a modest reduction in ENDS use among Black teens. We conclude that ELLs have only limited success in curbing access to ENDS.

Keywords: ENDS licensure laws; e-cigarette use; combustible tobacco product use.

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1. Introduction

The introduction of electronic nicotine delivery systems (ENDS) products to the United States tobacco market in the late 2000s and early 2010s had a substantial impact on youth tobacco use. From 2011 to 2019, past 30-day use of ENDS among high school students increased from 1.5 percent to over 20 percent, reaching a peak of 27.5 percent in 2019 (National Youth Tobacco Survey, 2023). This increase prompted the U.S. Surgeon General to assess high rate of ENDS use among teenagers to be an "epidemic," and policymakers have adopted various regulations to restrict their access (U.S. Surgeon General, 2018). In part due to tobacco control initiatives (Abouk, Courtemanche, et al., 2023; Hansen et al., 2023), as well as possible effects of the COVID-19 pandemic, prior-month ENDS use among teens fell to 14.7 percent by 2022. Nonetheless, ENDS use among teenagers remains an important public health concern.

Public health advocates contend that increased access to ENDS products encourages e-cigarette use among teenagers who would not otherwise use tobacco (Dai et al., 2018). Such tobacco use could lead to large adverse health effects, particularly if e-cigarettes act as a "gateway" to further nicotine addiction through increased smoking of combustible tobacco products (Scheier & Griffin, 2021; U.S. Department of Health Human Services, 2016; Zhong et al., 2016).

On the other hand, if, in the absence of e-cigarettes, youths do not abstain from all tobacco products, but rather consume combustible tobacco, then restricting access to ENDS may have unintended consequences for youths that harm health. Indeed, there is evidence that the adoption of ENDS taxes (Abouk & Adams, 2017a; Abouk, Courtemanche, et al., 2023; Anderson et al., 2020; Pesko & Warman, 2022) and minimum legal purchasing ages (MLPA) for e-cigarettes (Friedman, 2015) induces substitution toward cigarettes among youths.[1] To the extent that e-

[1] Such evidence has also been detected among adults. For example, Pesko et al. (2020) find that a $1.00 increase in the ENDS tax rate increases adult daily smoking propensity by 5.3 percent and the probability of "dual use" (i.e., consuming both ENDS and cigarettes) by 24.4 percent. Considering the experience of Minnesota, which adopted the first in the

cigarettes generate less tobacco-related health harm than combustible tobacco products (Dave et al., 2019; National Academies of Sciences, 2017; Saffer et al., 2020), ENDS use may be an effective tobacco harm reduction strategy.

While many policies designed to curb youth ENDS use have focused on demand-side factors such as using taxes to raise prices faced by consumers, policymaker attention has also been paid to regulating sellers. Since 2011, 33 states and the District of Columbia have adopted e-cigarette licensure laws (ELLs). ELLs require sellers to obtain a state license to sell e-cigarettes over the counter (Public Health Law Center, 2023b) and generally impose penalties (e.g., suspension or revocation of the license and occasionally criminal as compared to civil penalties) and fines up to $25,000 for violations. These laws are designed to regulate sales, increase compliance with state tobacco regulations (i.e., MLPAs), and reduce the supply of e-cigarettes available to consumers, in particular youth. Thus, ELLs expose retailers to greater scrutiny by state regulators through compliance checks, for example, to ensure enforcement of MLPAs. Many public health advocates see ELLs as a vital anti-vaping policy tool (see, for example, Tobacco Control Legal Consortium (2016)). Indeed, in 2018 the U.S. Surgeon General issued an advisory recommending that states and communities implement e-cigarette licensing laws as part of a comprehensive approach to curbing youth vaping (U.S. Surgeon General, 2018).

State ELLs vary in their comprehensiveness, including the costs they impose on vendors, both in terms of direct fees for the right (license) to sell e-cigarettes and in terms of regular compliance checks and associated fines and penalties for violations. ELLs also vary in the extent to

nation ENDS tax in August 2010, Saffer et al. (2020) find that adult smoking increases following an ENDS tax hike. Friedman and Pesko (2022) study the effect of ENDS taxes on young adults ages 18-25 finding that young adults use ENDS and cigarettes nearly interchangeably. In addition, emerging evidence on ENDS flavor restrictions suggests that there is some substitution between flavored e-cigarette consumption and combustible cigarette use (Friedman et al., 2023; Friedman, 2021; Yang et al., 2020).

which they offer "support" to retailers, with some ELLs including regular, or available on request, opportunities for vendors to meet with regulators onsite to ask questions about selling e-cigarettes and ensure proper signage. The most comprehensive of these statutes require retailers to pay a licensure fee (including fees for annual renewal) and impose mandatory penalties (including fines and prison-related criminal sanctions) for non-compliance.

ELL adoption could affect youth ENDS use either (1) by enabling better enforcement of other e-cigarette laws, or (2) by influencing key market variables such as price and availability. First, ELLs allow the government to keep track of which vendors sell e-cigarettes, thereby enabling compliance checks, while also spelling out penalties for violating MLPAs and other regulations. The threat of these checks and associated penalties strengthens retailers' incentive to comply with state laws including the MLPA, which may result in reduced youth access to e-cigarettes. Contact between state health agents and e-cigarette retailers can offer opportunities for retailers to become better informed about how to correctly follow state laws, which can promote enforcement of the MLPA and other regulations. Indeed, the literature on combustible tobacco, marijuana, and alcohol suggests that stricter enforcement of MPLAs can reduce youth use of these products.[2] This finding is in line with the e-cigarette literature noted earlier in this section that shows adoption (and presumably also enforcement) of state-level e-cigarette MLPAs reduces youth e-cigarette use.

Additionally, ELLs involve a licensing fee, either upon first receiving the license, at regular intervals such as annually, or both. These licensing fees represent fixed costs of selling e-cigarettes. According to standard economic theory, fixed costs influence firm entry and exit decisions but do not directly affect prices. Therefore, on the margin, licensing fees could reduce the number of retailers selling e-cigarettes, which may increase time and travel costs to alternative vendors. This

[2] See, for example, (Abouk & Adams, 2017b; Feng & Pesko, 2019; George et al., 2021; Grube et al., 2018; Grucza et al., 2013; Holmila et al., 2010; Schelleman-Offermans et al., 2012; Schweitzer et al., 2017; Scribner & Cohen, 2020).

increase in cost might disproportionately impact youths, since they are generally more transportation-constrained than adults. Moreover, if licensing fees reduce the number of retailers selling e-cigarettes, this change could indirectly increase local prices through a negative supply shock. Additionally, evidence suggests that retailers often *do* raise prices in response to increased fixed costs, in spite of economic theory, and Kamphorst et al. (2020) show that this can actually be optimal under certain conditions. Finally, other miscellaneous fixed or marginal costs of compliance (e.g., staff training, signage, higher wages to attract more qualified staff) could also lead to higher prices.[3] If prices do rise, youths may be particularly affected given that they are, on average, more income-constrained than adults.

On the other hand, if the cost of obtaining a license is relatively low (Patel et al., 2020) or if the ELL does not promote better enforcement of e-cigarette law provisions such as the MLPA, ELL adoption may have little effect on market prices of or local access to e-cigarettes, resulting in a trivial impact on youth consumption. Moreover, if informal social markets (e.g., friends to whom youths can turn to borrow or "bum" e-cigarettes) or online markets insulate youths from the effects of local ENDS regulations such as ELLs, then ELLs may have little effect on youth ENDS use. Illicit markets may also offer an alternative outlet through which youths can purchase ENDS as access through (licit) e-cigarette retailers is curtailed.

Importantly, while ELLs are designed to affect e-cigarette use, if ELLs are effective in achieving this primary objective, then there may be spillovers to combustible tobacco consumption that reinforce or undermine policymakers' goals. If e-cigarettes and combustible tobacco products (e.g., cigarettes or cigars) are economic complements, perhaps because e-cigarettes lead teens down a path to nicotine addiction, licensure laws could increase youth combustible tobacco product

[3] There is evidence that ENDS taxes are nearly fully passed along to consumers in the form of higher prices (Cotti et al., 2022), which would be consistent with retailers passing on these costs to consumers – although the fact that taxes are marginal rather than fixed costs is an important distinction.

consumption. Alternatively, if e-cigarettes and combustible tobacco products are substitutes, ELLs may have the unintended effect of inducing an increase in teens' use of combustible tobacco.

This study is, to our knowledge, the first to comprehensively examine the causal effects of ELL adoption on youth and adult tobacco use. Our work contributes to several economic literatures, including a broader literature that has explored the intended and unintended effects of supply-side interventions regulating addictive goods (Alpert et al., 2018; Evans et al., 2019; Kim, 2021), as well as health and public economics literatures that has explored the impacts of ENDS regulation (i.e., ENDS taxes, MLPAs, and indoor vaping and flavor restrictions) on tobacco and non-tobacco-related public health (Dave et al., 2024; Dave et al., 2022).

Using data from the State Youth Risk Behavior Surveys (YRBS) and a generalized difference-in-differences approach, we find no evidence that the adoption of an ELL leads to economically meaningful or statistically significant reduction on overall youth ENDS use. The precision of our estimates is such that we can rule out, with 95 percent confidence, ELL-induced ENDS use declines of less than 0.67 percentage-points (3.4 percent). This null finding persists when we examine ELLs with relatively higher penalties (i.e., larger fines and misdemeanor criminal penalties) and regular (i.e., annual) renewable licensure fees. Event-study analyses, including those generated using estimates from the Sun and Abraham (2021) procedure to account for potential bias in two-way fixed effects (TWFE) estimates caused by heterogeneous and dynamic treatment effects with a staggered policy roll-out, are consistent with this null finding.

However, our demographic heterogeneity analysis uncovers an important racial minority population for whom ELLs do seem modestly effective: Black teens. We find that adoption of a higher penalty ELL is associated with a two percentage-point reduction in Black teens' ENDS use and a larger significant reduction in the longer-run. This finding is consistent with multiple hypotheses, including (1) heightened targeted enforcement of ELLs for Black teens or retailers

operating in the Black community, a result consistent with discrimination in government policy enforcement and provision of social services (Asiedu et al., 2012; Burch, 2015; Hoekstra & Sloan, 2022; Monk, 2019); (2) higher relative ELL compliance costs for small businesses in Black neighborhoods (Asiedu et al., 2012); or (3) racial differences in sensitivity to prices or time costs (Nonnemaker & Farrelly, 2011).

Auxiliary analyses of data from the Behavioral Risk Factor Surveillance Survey (BRFSS) shows that ELL adoption has little effect on ENDS use for adults above the MLPA for tobacco products (age 21, following December 2019 Federal Tobacco-21 law). There is some weak evidence that young adults under the MLPA may see a modest decline in everyday ENDS use, though sample sizes are quite small and thus we interpret these findings with some caution. There is no clear pattern of effects of ELLs on use of combustible tobacco products, which is to be expected if there is not a clear impact on vaping. We conclude that the tobacco-related health benefits of state ELLs are, as yet, limited in scope.

2. Background

2.1 E-cigarettes and Youth Tobacco Use

The sharp increase in e-cigarette consumption between 2011 and 2019 — from 1.5 percent of 12-18-year-olds in 2011 to 27.5 percent in 2019 (Park-Lee, 2022) — raised many concerns among tobacco control advocates, policymakers, and the public. While ENDS consumption among adults has been relatively modest over the last two decades,[4] and has been accompanied by some tobacco-related health benefits such as reductions in combustible tobacco product use (Brown et al., 2014;

[4] Rates of ENDS product use among adults has increased from 3.3 percent in 2010 to 4.4 percent in 2014 and 5.1 percent in 2020 (Boakye et al., 2022; King et al., 2015). Most major U.S. health surveys of adults did not include questions related to ENDS use until 2011. The Tobacco Use Supplement to the Current Population Survey added a question in 2011 but ENDS questions were not added to the National Health Interview Survey until 2014 and the BRFSS until 2016.

Dave et al., 2019; Hajek et al., 2019; Tuchman, 2019; Zhuang et al., 2016), high rate of ENDS use among youth remains a major public health concern. This concern persists despite declines in youth ENDS use between 2019 and 2022 (from 27.5 percent to 14.1 percent, according to the National Youth Tobacco Survey), in part due to a federal Tobacco-21 law, new restrictive ENDS policies, and the COVID-19 pandemic (see *Section 2.2* for a discussion of the policy environment).

Increased access to e-cigarettes has been found to curb combustible tobacco product use, including among youth (Abouk & Adams, 2017a; Abouk, Courtemanche, et al., 2023; Anderson et al., 2020; Pesko & Warman, 2022), which may be an effective tobacco harm-reducing strategy (Dave et al., 2019; National Academies of Sciences, 2017; Saffer et al., 2020). Combustible tobacco product use is the leading cause of preventable death in the U.S. Use of these products is associated with 480,000 deaths each year (U.S. Department of Health and Human Services, 2014) and causes 40 percent of all cancer diagnoses (Centers for Disease Control and Prevention, 2019). Thus, policies targeting e-cigarettes that have the unintended effect of inducing substitution toward combustible cigarettes and other tobacco products could result in substantial public health harm and work against a decades long decline in smoking in the U.S. (Cummings & Proctor, 2014).

Despite the potential benefit of decreasing combustible tobacco consumption, public health advocates worry that increased access to ENDS may have "gateway" effects that increase smoking of combustible cigarettes and even other substance use (e.g., marijuana use) (Gorman, 2016; U.S. Department of Health Human Services, 2016). Because of these concerns and some tobacco control advocates' goal of eliminating any form of tobacco use, regulations aimed at reducing access to ENDS products have been increasing over time.

2.2 U.S. E-cigarette Policy Environment

The regulatory environment for ENDS products is rapidly evolving.[5] Policymakers have undertaken several demand- and supply-side strategies to curb ENDS use, with particular attention to youths and those who might have abstained from all tobacco products had ENDS access been limited. Among the most high-profile policy strategies include (1) MLPAs for e-cigarettes, (2) ENDS taxes, (3) the extension of clean indoor air laws to include e-cigarette aerosol or vapor, (4) internet-based e-cigarette sales shipping bans, (5) ENDS flavor restrictions, and (6) ELLs.

As e-cigarettes entered the U.S. tobacco market in the late 2000s and early 2010s, states and localities began regulating the age at which consumers could legally purchase e-cigarettes. New Jersey was the first state to enact an e-cigarette MLPA of 18 (on March 12, 2010) to match the federal MLPA for combustible tobacco products at that time. By 2016, all states (and the District of Columbia) had implemented an MLPA of 18 or higher. While there is evidence that e-cigarette MLPAs reduced youth e-cigarette use (Abouk & Adams, 2017a; Pesko, 2023), some work suggests that these laws induced substitution toward combustibles (Dave et al., 2019; Friedman, 2015; Pesko, 2023). In contrast, there is evidence that state Tobacco-21 (T-21) laws, which raised the MLPA of all tobacco products (i.e., ENDS, combustible tobacco products, smokeless tobacco products) to age 21, reduced both youth e-cigarette and cigarette use (Abouk et al., 2024; Friedman & Pesko, 2024; Friedman & Wu, 2020; Hansen et al., 2023).[6]

[5] The Food and Drug Administration (FDA), which is the federal administration with the authority to regulate tobacco products including e-cigarettes in the U.S., has rejected millions of premarket tobacco product applications (PMTAs) for e-cigarettes (Food and Drug Administration, 2023). As of March 2023, the FDA approved just 23 products out of approximately 26 million submitted PMTAs. Key reasons for denials are incomplete applications and not meeting FDA safety and public health requirements. The FDA continues to review PMTAs at the time of writing. Through this authority, the FDA has the ability to effectively determine the size and composition of the commercial e-cigarette market in the U.S., and the extent to which the FDA uses this authority to shape the e-cigarette market will likely have important implications for ENDS use, both among youth and adults. These reviews by the FDA, which began in 2021, occur after the end of our study period and thus do not impact our findings, but exploring the implications of these FDA actions is an interesting and policy-relevant avenue for future research.

[6] On December 20, 2019, a federal law was adopted that raised the MLPA for all tobacco products to age 21 nationwide. However, the extent to which this law is enforced is unclear.

In addition, by the end of 2022, 17 states and the District of Columbia had adopted clean indoor air laws that extended to ENDS (Centers for Disease Control and Prevention, 2023). There is evidence that these laws have been found to reduce both e-cigarette and cigarette use among youths and adults (Friedman et al., 2021).

Moreover, given that youths may be attracted to e-cigarettes due to the availability of a variety of flavors and novel design features of these products (Dubé et al., 2023), seven states and over 375 localities (i.e., counties, cities, and towns) adopted ENDS flavor restrictions by November 2023 (Campaign for Tobacco-Free Kids, 2023). These laws impose sales restrictions on flavored non-cigarette tobacco products. Preliminary studies show that any public health benefits of reducing ENDS use attributable to flavor bans may be offset due to substitution toward combustible cigarette consumption (Friedman et al., 2023; Friedman, 2021; Yang et al., 2020).[7]

One of the most popular policy strategies designed to curb ENDS use has been ENDS taxes. As of December 15, 2023, 33 states and the District of Columbia had adopted an ENDS tax, with some states adopting ad valorem taxes and others adopting excise taxes (per mL of liquid nicotine) (Public Health Law Center, 2023a). Higher ENDS taxes are associated with a reduction in ENDS use among both youths (Abouk, Courtemanche, et al., 2023) and adults (Pesko et al., 2020). However, there is also evidence that ENDS taxes lead to an increase in combustible tobacco

[7] Yang et al. (2020) use data from the Amazon Mechanical Turk. In particular, of the authors sample San Francisco residents aged 18–34 years and surveyed respondents about their tobacco product use both before and after the flavor ban in that city. The authors find that overall flavored tobacco use decreased from 81 percent and 85 percent to 69 percent and 76 percent for respondents 18–24 years and 25–34 years old, respectively. The prevalence of flavored e-cigarettes decreased from 57 percent and 56 percent to 45 percent and 48 percent for those 18–24 years old and 25–34 years old, respectively. The prevalence of cigar use was reduced as well. However, cigarette smoking increased, although the finding was not statistically significant among 25–34 years old. Friedman (2021) uses data from the 2011-2019 YRBS and a difference-in-differences approach to estimate changes in recent smoking in San Francisco relative to other districts, before vs after the flavor ban effective date. The author finds that San Francisco's partially implemented flavor ban was associated with higher odds of recent smoking among underage high school students relative to concurrent changes in other districts (adjusted odds ratio, 2.24 [95 percent CI, 1.42-3.53]). Friedman et al. (2023) use new data on U.S. localities and states that adopted permanent restrictions on sales of flavored e-cigarettes and find a tradeoff of 15 additional cigarettes for every one less 0.7 mL ENDS pod sold due to ENDS flavor restrictions. Further, cigarette sales increase even among brands disproportionately used by underage youth.

consumption (Abouk, Adams, et al., 2023; Abouk, Courtemanche, et al., 2023; Cotti et al., 2022; Pesko et al., 2020), consistent with these products being economic substitutes.

Finally, there is concern among policymakers that some tobacco users, especially youths, may turn to the internet to circumvent local ENDS regulations (Cullen et al., 2018; U.S. Surgeon General, 2018; Williams et al., 2011; Williams et al., 2018; Williams et al., 2017). As a result, five states have adopted internet sales shipping bans for e-cigarettes (Williams et al., 2011). Nonetheless, the enforcement of laws against online sellers remains costly and complicated compared to the enforcement costs for brick-and-mortar vendors; hence, there is limited evidence that these internet sales laws have affected youth e-cigarette access (Nali et al., 2021).

2.3 E-cigarette Licensure Laws

This section offers an overview of ELLs. There are at least 380,000 tobacco retailers in the United States (Centers for Disease Control and Prevention, 2024a). As of March 31, 2023, 33 states and the District of Columbia have enacted laws that require retailers to have a state-issued license to sell e-cigarettes over the counter. The majority of states (26) that have adopted an ELL require retailers to pay a license fee to the state and many require fee-based license renewals.[8] Minimum license fees range from trivial amounts (e.g., $5 in Montana) to more substantial fees (e.g., $800 in Connecticut). Licenses can be suspended or revoked for failure to comply with licensure requirements in 30 states, and in 31 states failure to comply with state ELLs is considered a criminal or civil offense which, if the retailer is found guilty, can lead to incarceration and/or fines. Thus, retailers in states with ELLs are likely incentivized to follow state ENDS regulations, including enforcement of the MLPA. Further, following the ELLs (e.g., paying licensure fees and purchasing

[8] Seven states (Alabama, Colorado, Hawaii, Idaho, New Mexico, Oregon, and Rode Island) do not require a minimum licensure fee.

technology to accurately check consumer identification cards and training staff) could impose financial costs on retailers, which they may pass on to consumers or, in some cases, decide to exit/not enter the e-cigarette market. The median maximum fine for an ELL among the states under study in this paper was $1,000.

Three prior public health studies of which we are aware have examined the association between ELLs and ENDS use (Azagba et al., 2020; Du et al., 2020; Jun & Kim, 2021). Two of these papers focus on adults. Jun and Kim (2021) use data from the 2017 BRFSS and exploit cross-state variation in ELLs to study their association with adult e-cigarette consumption. They find ELL adoption is associated with lower odds of e-cigarette initiation. Along the same lines, Du et al. (2020) use data from the 2016 and 2017 BRFSS and, exploiting both within and cross-state variation in ELLs (i.e., state fixed effects are not included in the regressions), find that ELL adoption is associated with a reduction in the odds of adult e-cigarette use. However, given the cross-sectional nature of the identification strategies used in these studies, policy endogeneity and state-level unobserved variables (such as anti-nicotine vaping sentiment) may be important sources of bias.

Finally, Azagba et al. (2020) use data from the 2015–2017 State YRBS to explore the effect of Pennsylvania's 2016 ELL. Using a difference-in-differences approach that relies on New York and Virginia as counterfactuals (two geographically similar states), the authors find that Pennsylvania's licensure law was associated with a 5.2 to 7.4 percentage-point (21.6 to 30.7 percent) decline in youth e-cigarette use. While important, the study offers little evaluation of the common trends assumption (e.g., tests of parallel pre-treatment trends) and evaluates a single treatment state, thereby (1) limiting generalizability of the findings, and (2) and rendering statistical inference problematic without adjustment beyond bootstrapping.

2.4 Contributions of the Current Study

This study makes three important contributions to the above-noted literature. First, we provide the first quasi-experimental examination of the average effects of ELLs adopted nationwide. The papers noted above are either cross-sectional in design or focus on a single case study. Specifically, we identify the effects of ELLs on youth tobacco use in a generalized dynamic difference-in-differences framework that account for a staggered policy variable roll-out. We carefully probe the parallel trends assumption and subject our results to numerous sensitivity analyses. While our primary focus is teens, we also conduct auxiliary analyses for adults. Second, we explore heterogeneity in the effects of ELLs by the strength of the statute, demographic characteristics, and the usual source of e-cigarettes in an effort to shed light on the potential mechanisms through which ELLs impact ENDS use. Third, this study is the first to explore spillover effects of ELLs on consumption of combustible tobacco products, which is critical to fully assessing the laws' public health effects.

3. Data

3.1 Youth Risk Behavior Surveys

Our primary analyses use repeated cross-sectional data drawn from the State YRBS spanning the period 2015-2021 to study ENDS use. The analysis sample is then also extended to 2011-2021 to study combustible tobacco product use. The time period for e-cigarettes is shorter because those are the only waves in which e-cigarette variables are available. The State YRBS is a biennial school-based survey collected by State Departments of Health and Human Services and coordinated by the Centers for Disease Control and Prevention (CDC). In these surveys, students are asked questions about their health and health behaviors, including risky and illicit behaviors. When weighted, each state's survey is designed to be representative of that state's high school students attending 9th through 12th grades. An important advantage of using these data is that they are representative of state-level trends in youth ENDS and tobacco use, important when conducting state policy analysis.

In addition, pooled data from all states can then be weighted to be representative of the U.S. population of high school-aged teenagers (ages 14-18 years) using state-by-year estimates of the population of 14-18-year-olds from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER).

In addition, we supplement our analysis of State YRBS data with a complementary analysis of the national YRBS data. The national YRBS is not designed to be representative of each state's high school-aged population. Instead, when weighted, the survey is designed to be nationally representative of high school students (rather than high school-aged teens). The number of observations in the national YBRS is much smaller than that of the State YRBS — our national YBRS sample is just 8.8 percent of our State YBRS analysis sample, and the latter data are designed to be representative of state-level changes in e-cigarette use.[9] These differences lead us to use the State YRBS as our primary data set.

Our analysis begins with the e-cigarette outcomes. A*ny E-cigarette Use*, designed to capture current consumption of ENDS among teenagers, is a dichotomous variable set equal to one if the respondent reported having used "an electronic vapor product" at least once during the prior month, and zero otherwise.[10] In our analysis sample, 20.3 percent of teens reported prior-month ENDS use (Table 1). We also generate two measures of ENDS consumption designed to capture heavier use. *Frequent E-cigarette Use* is set equal to one if the respondent reported having used "an electronic vapor product" for 20 or more days during the prior month, and zero otherwise; *Daily E-cigarette Use* is set equal to one if the respondent reported having "use an electronic vapor product"

[9] While we present separate policy estimates using the National and State YRBS separately, another approach could be to combine these datasets to maximize identifying variation in our key policy variables across treatment states. This approach has been used by several economics studies examining risky behaviors (Anderson et al., 2015; Anderson et al., 2019; Anderson et al., 2020; Bass, 2016; Hansen et al., 2017; Rees et al., 2022; Sabia & Anderson, 2016; Sabia & Bass, 2017), using constructed weights (Sabia & Anderson, 2016). Estimates obtained from the combined YRBS are qualitatively similar to those obtained across separate datasets and reported as a robustness check.

[10] To aid in answering the question, YRBS respondents are given examples of electronic vapor products, including e-cigarettes, e-cigars, e-pipes, vape pipes, vaping pens, e-hookahs, and hookah pens.

every day during the prior month, and zero otherwise. We find that 5.0 percent of teens reported frequent ENDS use during the prior month and 3.5 percent reported daily ENDS use (Table 1).[11]

Panel (a) of Appendix Figure 1 shows trends in e-cigarette use among youth during the 2015-2021 period. E-cigarette use modestly declines between 2015 and 2017 before rising substantially as JuuL's presence on the market expanded. By 2021, following the adoption of a federal Tobacco-21 law (and many other ENDS regulatory policies) and in the wake of the COVID-19 pandemic, youth ENDS use declined.

We then turn to combustible tobacco product use, defined for our purposes as cigarette and cigar consumption in the prior month. We examine youth combustible tobacco use over the same period during which we measure e-cigarette use (2015-2021) as well as over the longer window of 2011-2021. The shorter window yields results that are more directly comparable to those for e-cigarettes, while the longer window enables the utilization of additional identifying variation in EELs. Respondents to the YRBS are asked, "During the past 30 days, on how many days did you smoke cigarettes?" as well as "During the past 30 days, on how many days did you smoke cigars, cigarillos, or little cigars?" Over the 2015-2021 period, we find that with 7.2 percent of respondents reported any cigarette smoking in the prior month (*Any Cigarette Use*), 1.9 percent reported frequent cigarette smoking (20 or more days), and 1.4 percent reported daily use (*Daily Cigarette Use*). 6.7 percent reported smoking cigars at least once during the previous month (*Any Cigar Use*) while 0.9 percent reported frequent cigar smoking (*Frequent Cigar Use*), and 0.7 percent reported daily use (*Daily Cigar Use*).

[11] Table 1 reports descriptive statistics for the 2015-2021 sample period. Appendix Table 1A reports descriptive statistics for the YRBS for 2011-2021 and Appendix Table 1B shows descriptive statistics for the BRFSS.

Panel (b) and (c) of Appendix Figure 1 documents cigarette and cigar consumption among teens during the 2011-2021 period, showing evidence of a sharp decline in combustible tobacco use over the sample period.

3.2 ENDS Licensure Law Data

We collect information on ELLs, our policy of interest, from the Center for Disease Control and Prevention public database for the period 2011 to 2021.[12] Figure 1 shows geographic and temporal variation in ELL adoption over the sample period. The first state to adopt an ELL was Kansas in 2012; followed by Iowa, Louisiana, and Vermont in 2014; and Utah, Indiana, and Arkansas in 2015. Four additional states implemented an ELL in 2016 and one in 2017. An additional 17 states and the District of Columbia implemented an ELL between 2019 and 2021.[13]

In Appendix Figure 2, we explore the timing of ELL adoption by strength of the statute. We define law strength in three ways using CDC data. First, we measure high and low penalty ELLs. By 2021 Q4, 16 states had adopted an ELL that imposed on businesses (1) a maximum penalty for non-compliance of at least $1,000 dollars (the median fine among ELL adopters over the sample period), and (2) an additional penalty for non-compliance that includes revocation of the business license, suspension of the business license, or both. For these states, the variable *High Penalty EEL* is set equal to one; it is set equal to zero otherwise. *Low Penalty ELL* characterizes the remaining states. By 2016 Q4, 25 states that had adopted an ELL included a possible criminal (misdemeanor) penalty as compared to civil fine or infraction.[14] For these states, *Criminal Penalty ELL* is set equal to one; it is

[12] These data may be collected from the Centers for Disease Control and Prevention (2024b).

[14] The following penalties are classified as criminal in nature (*Criminal Penalty ELL = 1*): "class E crime: fine; imprisonment," "class III misdemeanor: fine or imprisonment, or both," "fine or imprisonment," "misdemeanor: fine or imprisonment, or both," "misdemeanor: fine or imprisonment, or both," "misdemeanor; fine or imprisonment or both," "misdemeanor; imprisonment or fine or both," "class B misdemeanor: fine, imprisonment," "fine," "class A infraction," "class A misdemeanor," "class C misdemeanor; fine," "fine; class A misdemeanor," "fine; misdemeanor," and "misdemeanor; fine." The remaining are classified as *Civil or No Penalty ELL*: "administrative penalty," "civil fine," "civil penalty," "civil penalty, fine," "fine/civil penalty," "fine; injunction," and "no provision."

set equal to zero otherwise. *Civil Penalty ELL* is set equal to one when there is no criminal and only a civil penalty.[15] Finally, *Renewable High Fee ELL* is set to one if the state requires an annual renewable fee of more than $160, which corresponds to the 75th percentile of the distribution of fees among ELL adopting states. A total of six states adopted a renewable high fee ELL over the sample period.

Finally, 40 states and the District of Columbia require retailers to have a license to sell conventional tobacco products over the counter. The vast majority of these laws were adopted by states prior to 2015.[16]

4. Empirical Methods

We begin by estimating a TWFE regression of the following form:

$$Y_{ist} = \gamma_0 + \gamma_1 ELL_{st} + \boldsymbol{X_{ist}\beta} + Z_{st}\boldsymbol{\delta} + \alpha_s + \theta_{rt} + \varepsilon_{ist}, \quad (1)$$

where *i* indexes the individual youth, *s* indexes the youth's state of residence, *r* indexes the census region, and *t* indexes the wave of the YRBS survey (we use the term "wave" as the YRBS is fielded every two years). $\boldsymbol{Y_{ist}}$ measures our tobacco-related outcomes of interest (e.g., prior-30-day e-cigarette, cigarette, or cigar use) and we align the timing of the State YRBS Survey with the timing of the policy.[17] Our key policy of interest is $\boldsymbol{ELL_{st}}$, which is defined as an e-cigarette retail licensure law. In supplemental analyses, described below, we also examine ELLs that are arguably relatively strong in nature with respect to penalties, renewable licensure fees, and criminal vs civil penalties.

The vector $\boldsymbol{X_{ist}}$ is a set of individual demographic variables, including gender, age, grade in school, and race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Other); the vector

[15] In results discussed below, we recode "fine: class A infraction," and "fine: injunction" as being civil as opposed to criminal in nature.
[16] In our sample, the variation in the tobacco products licensure laws is identified by the five states (Colorado, Georgia, Illinois, New Mexico, and Oregon) that introduced such law after 2011.
[17] The CDC provides information on the seasonality of the State YRBS (by state and year) between 2011 and 2021. This information is available via the CDC by emailing: yrbsdatareq@cdc.gov.

$\boldsymbol{Z}_{st}$ is a set of state-level, time-varying controls including (1) tobacco-related policies (T-21 laws, cigarette tax, e-cigarette tax, ENDS MLPA, clean indoor laws for smoking and vaping, combustible tobacco licensure law, e-cigarette flavor restriction, and menthol cigarette flavor restriction), (2) other substances policies (beer tax, recreational marijuana law, medical marijuana law); and (3) macroeconomic conditions and COVID-19 shocks (unemployment rate, per capita income and COVID-19 cumulative death rate).[18] Descriptive statistics for our dependent and independent variables are shown in Table 1. Finally, α_s is a time-invariant state effect and θ_{rt} is a census region-by-wave fixed effect. Regressions are weighted using the sample weights described above and standard errors are clustered at the state level. All monetary values are converted to 2021 dollars using the Consumer Price Index – Urban Consumers.

Our key parameter of interest, γ_1, is the partial effect of an ELL on youth tobacco product use. The estimated policy impact will be unbiased if the control states capture how treated states' tobacco use would have evolved in the absence of ELL adoption. While testing this assumption is not possible given the unobservability of the counterfactual, we take several approaches to provide descriptive support of the identifying assumptions. First, to test for parallel pre-treatment trends (and to descriptively test for reverse causality, whereby differential pre-treatment trends in youth

[18]State T-21 laws (prior to the enactment of the Federal law in December 2019) are available from the Preventing Tobacco Addiction Foundation (https://tobacco21.org/). Cigarette taxes, ENDS MLPA, clean indoor laws for smoking and vaping, and combustible tobacco licensure laws are available from the Centers for Disease Control and Prevention (CDC). The closed system e-cigarette tax (dollar per mL of nicotine) data were shared with the authors by Chad Cotti and Erik Nesson. E-cigarette flavor restrictions and menthol cigarette flavor restrictions were obtained from the Public Health Law Center at Mitchell Hamline School of Law (https://www.publichealthlawcenter.org/sites/default/files/resources/US-sales-restrictions-flavored-tobacco-products.pdf) and Campaign for Tobacco Free Kids (https://assets.tobaccofreekids.org/factsheets/0398.pdf) as well as the authors' own searches of statutes for jurisdictions of at least 200,000 persons. Beer tax data are obtained from the Alcohol Policy Information System (https://alcoholpolicy.niaaa.nih.gov/apis-policy-topics/beer/30). Recreational marijuana law and medical marijuana law data are obtained from Anderson and Rees (2023). Per capita income and the unemployment rate are obtained from the Bureau of Labor Statistics. The COVID-19 death rate is from the New York Times digital coronavirus data repository. Controls are available at the state-by-quarter level.

tobacco product use drive ELL adoption), we estimate event-studies where we decompose the ELL effect over time:

$$Y_{ist} = \gamma_0 + \sum_{j=\underline{J}}^{\bar{J}} \pi^j D_{st}^j + \boldsymbol{X}_{ist}\boldsymbol{\beta} + Z_{st}\boldsymbol{\delta} + \alpha_s + \theta_{rt} + \varepsilon_{ist}, \qquad (2)$$

where D_{st}^j is a dichotomous variable measuring ELL adoption occurring *j* years from *t*.[19] $\bar{J}$ and $\underline{J}$ represent the least lead (five or more years prior to adoption) and lag (two or more years after adoption) respectively. The πs are the coefficient estimates on the treatment effect, while the reference period is *j=-1 or -2*, 1-2 years prior to ELL adoption. This two-year reference bin is due to the YRBS survey being a biennial survey. If the coefficient estimates of the πs for the periods prior to the policy implementation (j < -1 or -2) are equal to 0, this would provide evidence in support of the parallel trends assumption.

Another potential source of bias would be if there were unobserved state-by-year shocks correlated with ELL adoption and youth tobacco product use. To minimize this possibility, we control for a rich set of tobacco control policies (related to both e-cigarettes and combustible tobacco products) that may have been implemented around the same time as ELLs (described earlier in this section). In addition, in a series of robustness checks, we also explore the sensitivity of our estimates to control for additional spatial heterogeneity.

Finally, in the presence of heterogeneous and dynamic treatment effects, estimates of γ_1 in equation (1) may be biased (Goodman-Bacon, 2021), as might event-study coefficients in equation (2) (Sun & Abraham, 2021). To account for this possibility, in a series of sensitivity checks, we

[19] Treatment indicators are binned at the "endpoints" (the last lead and lag variables).

restrict the set of counterfactuals to never adopters of ELLs and implement event-studies using the Sun and Abraham (2021) procedure that produces estimates robust to these sources of bias.[20]

5. Results

Our main findings appear in Tables 2 through 10 and in Figures 2 through 9. Supplemental analyses appear in the appendix, as described below.

5.1 ELL Adoption and Youth E-cigarette Use

Table 2 shows TWFE estimates of the effect of ELLs on youth ENDS use over the 2015-2021 period. Panel I focuses on the outcome of *Any E-cigarette Use*. Controlling for state and wave fixed effects and demographic characteristics (column 1), we find that ELL adoption is associated with a statistically insignificant 0.9 percentage-point (4.5 percent) *increase* in youth ENDS use. The addition of controls for macroeconomic conditions and COVID-19, as well as allowing wave fixed effects to vary by region (to capture unmeasured macroeconomic and COVID-19 shocks) (column 2), and other tobacco control policies had little effect on the estimated treatment effect (column 3). In our fully-specified model, which also includes controls for other substances (i.e., alcohol and marijuana) policies (column 4), we find that ELL adoption is associated with a statistically insignificant 1.3 percentage-point (6.6 percent) *increase* in youth ENDS use. With 95 percent confidence, the precision of our coefficient estimates allows us to rule out ELL-induced declines in ENDS use of 0.67 percentage-points (3.4 percent).[21]

[20] Our Sun and Abraham (2021) estimates exclude census region-by-wave fixed effects to avoid controls for time-varying spatial heterogeneity (and just include state and wave fixed effects); estimates from a Sun and Abraham (2021) specification that includes region-by-wave fixed effects produce findings that are qualitatively similar.
[21] Furthermore, considering the low means of frequent and daily ENDS usage, we find that these estimates remain robust when employing a non-linear probit regression model, as demonstrated in Appendix Table 2.

An examination of frequent (panel II) and everyday (panel III) ENDS use generates a similar pattern of findings. For instance, with respect to frequent ENDS use (panel II), the precision of our estimated treatment effect – our coefficient estimate implies a 0.7 percentage-point increase in the frequency of ENDS use – in column (4) allows us to rule out, with 95 percent confidence, ELL-induced declines in ENDS use of 0.29 percentage-points (7.1 percent).

Figure 2 shows event-study analyses using TWFE regression, while Figure 3 uses the Sun and Abraham (2021) procedure that mitigates bias in TWFE estimators that arises from dynamic heterogeneity in treatment effects with a staggered policy roll-out. For the latter estimates, our counterfactuals include never adopters of an ELL by 2021 Q4, which will allow us to avoid "bad comparisons" that use early adopters as controls for later adopters.

We note that because of the limited number of waves available in the YRBS for our e-cigarette analyses (2015, 2017, 2019, and 2021), our event-study window is relatively short and includes annual event time.[22] Nonetheless, the pattern of findings is consistent with parallel pre-treatment trends and with a largely null finding in the post-treatment period.

5.2 Robustness Checks

Thus far, we have shown that the null results from our baseline regressions are not sensitive to the exclusion of certain categories of covariates, and that they do not appear to be driven by problematic pre-treatment trends. This section discusses results from additional sensitivity checks.

[22] Given the biennial nature of the YRBS survey, this may be problematic to the extent that coefficients on each yearly lead or lag are identified off of different treatment states (depending on whether the ELL adoption year is positive or negative). An alternative strategy is to use biennial event time (grouped two-year bins) to ensure less selection on treatment states that identify each event-study coefficient. However, this involves an event window that is outside the span of years available for a single treatment (or control) state during the 2015-2021 window. Thus, there are important tradeoffs. In Appendix Figure 3, we show the results from event-studies (using TWFE estimates) with grouped two-year bins for lead and lag windows. The pattern of event-study estimates is qualitatively similar to those shown in Figure 2.

First, in Table 3, we control for census division (vs. region-)-specific wave fixed effects (panel I), state-specific linear time trends (panel II),[23] and seasonality effects (semester of survey interview) (panel III). The results show that our null findings are robust to the inclusion of these additional controls.

In Table 4, we turn to an analysis of the national YRBS. Panel I shows results from the baseline model with the full set of controls, akin to Column (4) of Table 2. There is again not a single statistically significant estimate for ELL. For *Frequent E-cigarette Use* and *Daily E-cigarette Use*, the coefficient estimates are close to zero. For *Any E-cigarette Use*, the estimated treatment effect is negative and non-trivially sized. However, the sample size is just 8.8 percent of that from the State YRBS, and accordingly, the standard error is quite large. While we cannot rule out a large reduction in the likelihood of a teen using any ENDS products, we also cannot rule out the positive point estimate obtained from the analogous model using the State YRBS. As noted earlier, the small sample size of the national YRBS is one reason we view the state YRBS as our primary data set.

Given this ambiguity, we explore further in the remaining panels of the table. Panel II adds census division-by-wave fixed effects, while Panel III adds state-specific linear time trends. In both cases, for *Any E-cigarette Use* the point estimate declines by more than half, while for *Frequent E-cigarette Use* and *Daily E-cigarette Use* the estimates remain close to zero. Additionally, in Panel IV we combine the national and State YRBS datasets and re-estimate the baseline specification (i.e., comparable to Panel I). All coefficient estimates are small and statistically insignificant. Therefore, the apparent sizeable reduction in *Any E-cigarette Use* from ELLs observed with the main specification in the national YRBS data appears to be driven by either sampling error or geography-specific trends, as opposed to a true causal effect. Accordingly, our main takeaway from Table 4 is that there is again no clear evidence that ELLs affect any of the vaping outcomes.

[23] In particular, we interact each state fixed effect with a linear time trend based on survey wave.

Next, we address the possibility that the null results could be attributable to spatial spillovers, with people purchasing e-cigarettes across the border in a state that does not have an ELL. Results presented in Table 5 show that the relationship between border state ELLs and teen e-cigarette use is small and statistically insignificant.

Finally, we examine whether our null finding for most teens is driven by a specific treatment state using a leave-one-treatment-state-out-at-a-time analysis. The results, shown in Appendix Figure 4, suggest this is not the case.

5.3 Heterogeneity in ELLs by Demographic Characteristics, Strength of Statute, and Usual Source of E-cigarettes

In Figure 4, we explore whether our null ELL effects on the combined sample of teenagers is masking an important effect for a particular demographic group. There are stark differences in vaping prevalence rates by gender, race/ethnicity, and age among American youth. For example, girls are more likely to vape than boys (Kong et al., 2017), and some non-White youth are more likely to vape than White youth (Cambron, 2023). Given these differences in vaping rates, we might expect differences in responses to ELLs. To explore such possible heterogeneity, in Figure 4, we show 95 percent confidence intervals around the estimated treatment effect by age, race/ethnicity, or gender.[24] Our results show insignificant positive effects for all demographic groups. However, the pattern for non-Hispanic Blacks is noticeably different. Here, we find that ELL adoption is associated with a statistically insignificant, but non-trivially-sized 1.3 percentage-point (9.9 percent) reduction in prior-month ENDS use. Event-study analyses generated using the Sun and Abraham (2021) procedure (results reported in Figure 5) are consistent with parallel pre-treatment trends and a longer-run significant reduction in ENDS use among young Black teens that emerges over time.

[24] These estimates are obtained from separate regressions of demographic sub-samples (thus allowing the coefficient estimates on each of the right-hand side controls to differ across each group).

Sun and Abraham (2021) estimates of ELL adoption and Black teens' ENDS use are shown in Appendix Table 3A.

What could explain these race-specific findings? One explanation could be that Black teens or Black communities are more likely to be targeted for stricter enforcement of ELLs, which could occur for several distinct reasons. The first is racial discrimination/targeting of vendors located in Black neighborhoods by state enforcement agencies or retailers disproportionately checking identification among Black teens. Discrimination against Black Americans has been documented by governments and businesses in many settings (Atkins et al., 2022; Gooden, 2004; Hoekstra & Sloan, 2022; Lang & Spitzer, 2020; Monk, 2019). The second is an intentional effort by the government to reverse the damage done by large tobacco companies in the 20th Century in predominantly Black, low-income communities (Healton & Nelson, 2004). A third possible reason for clearer effects about Black teens is that compliance costs associated with ELLs (relative to profit margin) are higher for small businesses such as e-cigarette retailers in Black neighborhoods which tend to have lower profit margins (Fairlie & Robb, 2007) and less access to credit (Atkins et al., 2022). Additionally, sensitivity to changes in prices and access might be relatively strong in predominantly Black communities where residents are disproportionately likely to be low-income and face heightened transportation barriers. Black teens may be more responsive to changes in price and access relative to other groups of teens (Nonnemaker & Farrelly, 2011). These possible channels are not mutually exclusive and may instead act in conjunction with one another. In any case, racial differences in impacts imply that ELLs may have an important distributional effect.

In Table 6, we examine whether our (largely) null finding could be explained by heterogeneity in the strength of the licensure statute. Here, we replace our overall ELL variable with heterogeneous types of laws ("low intensity" vs "high intensity" laws, which are included in the same regression. Panels I through III present results for our three definitions of the strength of

the law: (1) ELLs with high business penalty for non-compliance vs ELLs with low business penalty for non-compliance (panel I); (2) high renewable fee ELLs vs low fee or non-renewable ELLs (panel II); and (3) laws with criminal penalties for non-compliance vs law with civil/administrative penalty for non-compliance (panel III). The validity of our null findings is confirmed when considering stronger versions of the law, as estimated coefficients are generally positive (i.e., wrong-signed) and insignificant. For instance, with respect to high penalty ELLs, our null finding allows us to rule out high penalty ELL-induced declines in youth ENDS use of less than 3.4 percent. The only negative, though statistically insignificant, estimated effects appear in the panel III, which evaluates the effect of criminal vs. civil penalties, and are approximately 0.3 to 1.0 percentage-points. When we redefine ambiguous fine structures across states to classify more "fine only" states as having a civil as compared to criminal penalty, we find consistently null results (see Appendix Table 3B).

Figure 6 displays event-study analyses of high penalty ELLs and youth ENDS using the Sun and Abraham (2021) procedure with never-adopters of high penalty ELLs as serving as counterfactuals, and Appendix Figure 5A shows event-studies using TWFE estimates. Our findings show little support for the hypothesis that high penalty ELLs significantly affect youth ENDS use.

The results of demographic heterogeneity (Figure 7) analyses provide no evidence that stricter, more comprehensive ELL adoption affects youth ENDS use, again with one exception: Black teenagers. The TWFE estimate shows that high penalty ELLs are associated with a marginally significant 2.1 percentage-point (16.4 percent) decline in Black youths' ENDS use (p-value = 0.071). Sun and Abraham (2021) estimates in Appendix Table 3A show stronger evidence of significant effects of higher penalty EEL adoption on young Black teens' ENDS use. Moreover, event-study estimates of high penalty ELLs and Black teens' ENDS using the Sun and Abraham (2021) procedure show a relative decline in ENDS use (with a lag) in treatment versus control

states, particularly for frequent and everyday ENDS use, where evidence for parallel pre-treatment trends is stronger (Figure 8). For the post-treatment period, Sun and Abraham (2021) coefficient estimates point to a high penalty ELL-induced decline in Black teens' ENDS use of approximately 1-2 percentage-points.

Finally, in Table 7, we explore whether ELLs influence how youths typically obtain their e-cigarettes. When youth are less able to access e-cigarettes through retailers, for instance due to increased enforcement of MLPAs, they may procure these products through social or illicit markets, which could have implications for safety. For example, in late 2019, there was an outbreak of lung injuries among consumers, many youth, who tampered with e-cigarette devices and added illicit substances to the product, leading to severe injuries, hospitalizations, and deaths (Centers for Disease Control and Prevention, 2021).

To explore whether the effects of ELLs on youth ENDS use differ by usual source of obtaining e-cigarettes, we use a multinomial logistic framework and report marginal effects from five outcome categories: purchase ENDS products in a store, buy ENDS products online, taking or buying ENDS products from another person, and other source. These data are only available in the YRBS over the period 2017-2021, so the findings should be regarded tentatively. We do not find much evidence that ELLs significantly reduce ENDS use among those youths who typically obtain their e-cigarettes from a vendor. However, ELL adoption is associated with a 1.1 percentage-point increase in the probability of obtaining ENDS from someone else, suggesting that alternative sources for e-cigarettes may help to insulate teens from the full effects of these laws. In addition to safety concerns associated with non-commercially purchased e-cigarettes, if teens are purchasing e-cigarettes from the illicit market, these purchases may lead to greater involvement in crime, either in terms of crime commission through more frequent interactions with illicit markets or victimization if teens are viewed as "easy targets."

5.4 ELL Adoption and Adult E-cigarette Use

Next, we turn to the 2016-2021 BRFSS to conduct an auxiliary analysis of adults. These data are designed to be representative of all U.S. adults aged 18 and older, though they are not representative of each age sub-group. Specifically, we examine those aged 18-20 and 21 and older (at or older than the federal MLPA). We note that an important limitation of using the BRFSS is that we have a relatively small sample size when focusing on specific age groups (i.e., those aged 18-20) and the BRFSS are not designed to be representative of individuals of such sub-groups at the state level even when weighting. As such, we are cautious in the conclusions we draw from the BRFSS for such groups (and also present unweighted regression coefficient estimates in the appendix, our main regressions use survey weights provided by BRFSS administrators).

A priori, we expect that ELL effects for adults (ages 21 and older) may be weaker than for young adults (aged 18-20) to the extent that ELLs lead to greater enforcement of MLPAs for tobacco. The main pathways through which ENDS use of adults aged 21 and older might be affected by ELLs are likely prices and number of retailers selling e-cigarettes.

In Table 8, we consider two e-cigarette use measures: any e-cigarette use (columns 1 and 2) and daily e-cigarette use (columns 3 and 4).[25] Panel I focus on ELL adoption while panel II focuses on the stronger, comprehensive ELLs that impose a relatively higher penalty for non-compliance. We find that ELL adoption is associated with a statistically insignificant 2.1 percentage-point (15.6 percent) increase in any ENDS use among individuals aged 18-to-20 and a statistically insignificant 0.2 percentage-point (4.2 percent) reduction in any ENDS use among individuals aged 21 and

[25] Appendix Table 4 show unweighted estimates from the BRFSS and Appendix Table 5 shows estimates for high fee renewable ELLs as compared to low fee or non-renewable ELLs in the BRFSS. With respect to the latter coefficient estimates, the findings show support for the hypothesis that renewable high fee ELLs may reduce ENDS use among adults ages 21 and older, suggesting some scope for more comprehensive laws to curb adult ENDS use.

older. ELLs with higher penalties also have little economically significant or important effect on any prior-month ENDS use among adults.

An examination of everyday ENDS use, however, suggests some scope for more comprehensive ELLs to restrict access to ENDS for more habitual users. That is, with respect to individuals aged 18-to-20 (column 3), we find that the implementation of stronger ELLs induces a 1.3 percentage-points (36.1 percent) decline in ENDS use among younger individuals aged 18-to-20. The absence of effects for those ages 21 and older is consistent with the hypothesis that the intensive margin of ENDS use may be affected by ELLs through greater enforcement of the minimum legal purchasing age for tobacco products.[26]

5.5 Combustible Tobacco and Dual Use

We next explore the impacts of ELLs on the use of combustible tobacco products. Theoretically, the most plausible mechanism through which combustible tobacco products would be affected is by serving as substitutes or complements for e-cigarettes. Since we observed little evidence that ELLs decreased vaping, substantial spillovers seem unlikely. Nonetheless, ELLs could still plausibly influence smoking of combustible tobacco to at least some extent. First, ELLs may lead retailers to change enforcement of MLPA for all tobacco products which could impact youth combustible use even among those whose level of vaping does not change. Second, if ELLs impact vaping along margins that we cannot measure in the YRBS (e.g., types of e-cigarettes purchased, level of nicotine in purchased products), there could be spillovers to combustibles. Finally, we demonstrated earlier that ELLs increase the propensity of teens obtaining e-cigarettes through an

[26] Appendix Table 7 shows results for Black 18-20-year-olds and Blacks aged 21 and older. We find little support for the hypothesis that ELLs affect ENDS use among Black adults.

"other" source, which may lead to changes in combustible smoking. For example, if youth are purchasing e-cigarettes through illicit markets, these products may be bundled with combustibles.

In Table 9 and Figure 9, we explore spillover effects of ELL adoption on combustible tobacco product use.[27] We use data covering the period 2011-2021.[28] The results for teens, derived from the State YRBS, are displayed in columns (1)-(4) of Table 9, while findings for adults in the BRFSS appear in columns (5)-(8).[29] We find little evidence to support the hypothesis that ELL adoption affects cigar use among all teens (column 1 of Table 9 and panel a of Figure 9). For Black teens (column 3), however, we find that ELL adoption reduces cigar use by about 1.5 percentage-points (17.6 percent). This finding is consistent with the hypothesis that e-cigarettes and cigars may be complements for Black teens.[30]

For cigarettes, however, there is stronger evidence to suggest a positive association between ELL adoption and combustible cigarette use (columns 2 and 4). However, an examination of event-studies in Figure 9 suggests that at least some of this positive association may be explained by a persistent (across pre- and post-treatment periods) difference in cigarette use between treatment and comparison states. Nonetheless, the result could suggest some modest shifting to more frequent cigarette use, particularly for higher penalty ELLs (panel d of Figure 9).

With respect to adults, the evidence of spillover effects of ELL adoption on cigarette use (columns 5-8) is much weaker than in the YRBS. We conclude that evidence for spillover effects of ELLs on cigarettes is, at most, mixed.

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[27] Appendix Figure 5B shows event-study estimates of ELLs and combustible tobacco product use using TWFE estimates.

[28] Event-study estimates corresponding to the 2015-2021 period are shown in Appendix Figure 6 for a comparison to the "first-stage" ENDS use results.

[29] In a manner similar to our approach in the ENDS analysis, we examine the policy differences between high and low renewable fee ELLs. The findings are presented in Appendix Table 6.

[30] Event-study analyses in Appendix Figure 7 suggest that going back to five years prior to an ELL, some of this negative association could be explained by a pre-treatment trend, though the pre-treatment trend is common over the period from four years prior to the adoption of an ELL.

Finally, in Table 10, we examine the effects of ELLs on use of any tobacco product (columns 1-2) and dual use of ENDS and combustible tobacco products among youths (columns 3-4). Corresponding findings for those ages 18-20 and 21 and older are shown in Appendix Table 8. Our findings provide little support for the hypothesis that the adoption of an ELL or of a higher penalty or fee-based ELL had a significant impact on any or dual tobacco use. In most cases, the estimated treatment effect is positive and statistically indistinguishable from zero. Together, these findings suggest that while there are some demographic groups whose access to ENDS may be curtailed due to ELL adoption, for the vast majority of teens and adults, these laws do not appear to have an economically important impact on overall tobacco consumption.

6. Conclusion

Concern about high rate of ENDS use among teenagers has prompted several policy initiatives to curb consumption. One recent policy designed to reduce youth access to e-cigarettes is ENDS licensure laws, which require retailers to obtain a state license to legally sell ENDS products over the counter, and expose retailers to greater scrutiny from state regulators in terms of compliance checks and also offer opportunities for retailers to meet with regulators to discuss issues related to correct enforcement of e-cigarette laws. This study comprehensively explores the effects of e-cigarette licensure laws on youth tobacco use, with particular attention to statute heterogeneity and spillover effects to combustible tobacco products.

Using data from the Youth Risk Behavior Surveys, we find no evidence that ELL adoption is associated with a statistically significant or economically important change in the probability of youth ENDS use among all teens. Specifically, we find that ELL adoption is associated with a statistically insignificant 1.3 percentage-point *increase* in youth ENDS use. Given the precision of

our estimated treatment effect, we can rule out, with 95 percent confidence, ELL-induced prior-month ENDS use declines of more than 0.67 percentage-points (3.4 percent).

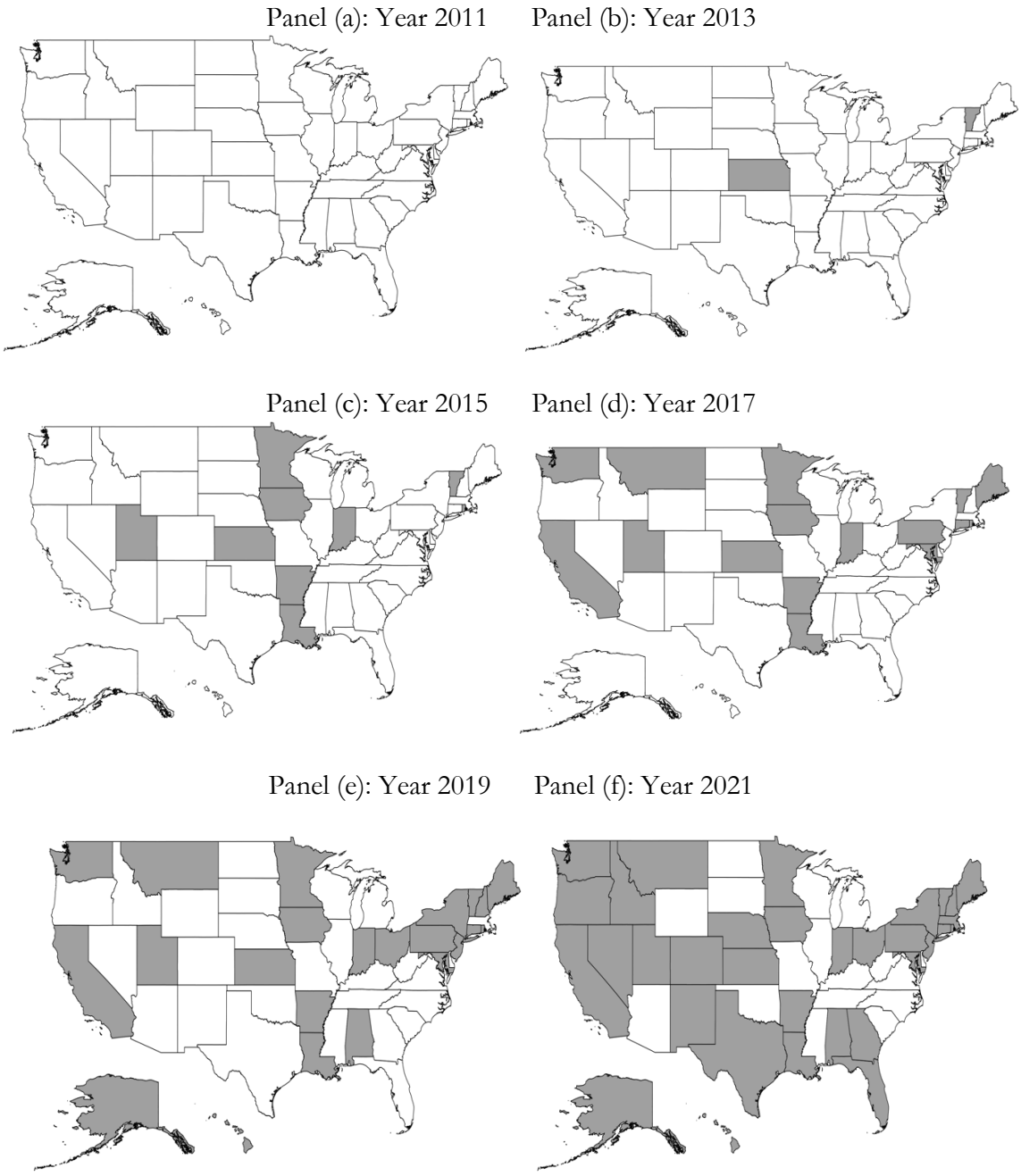
When we further explore tougher licensure statutes — including those with higher non-compliance penalties, renewable license fees, and criminal repercussions for non-compliance — we find little evidence that these laws are effective in achieving their primary objective of reducing vaping. For instance, with 95 percent confidence, we can rule out higher penalty ELL-induced declines in youth ENDS use of less than 0.66 percentage-points (3.4 percent).

Only one demographic group among teenagers appears to be affected by ELLs: Black youth. For this group, we find that the adoption of higher penalty ELLs is associated with a decline in ENDS use by approximately two percentage-points. This result could be indicative of enhanced enforcement of ELLs in the Black community or higher relative compliance costs on small businesses in Black neighborhoods, attempts by government to offset the harms of tobacco on the Black community, or higher price/access sensitivity among Black youth. Turning to adults in our BRFSS analysis, we find no evidence that ELLs impact vaping among adults 21 years and older but some modest evidence that higher penalty ELLs may induce a small reduction in ENDS use among those under the MLSA for tobacco products, those ages 18-20. Finally, we find little evidence that ELL adoption affects the probability of any tobacco product use (e-cigarette or combustible cigarette) or dual tobacco product use among youths, which is in line with the (null) findings we document for ELL impacts on vaping outcomes among youth.

Together, our findings suggest that, despite policymakers' hope that ELLs would reduce access to e-cigarettes for youths, to date such laws have been relatively ineffective. While a comprehensive welfare analysis is beyond the scope of this paper, the lack of clear benefits combined with the fact that ELLs impose costs on businesses and government imply that the net welfare effect of such laws, as currently practiced, could be negative. With that said, our results do

not imply that ELLs that are accompanied by even greater higher financial or criminal penalties for non-compliance would not affect public access to ENDS, nor do they imply that enhanced state monitoring of e-cigarette sellers would not impact ENDS use. However, our findings from Table 7 suggest that informal social sources, including the illicit market, could help to insulate youths from restrictions of this type. This change in e-cigarette source could lead youth to consume more harmful e-cigarettes and/or connect youth to illicit markets, both of which could lead to negative outcomes such as consuming corrupted e-cigarettes (Centers for Disease Control and Prevention, 2021) or involvement in crime. By 2021, only one-fifth of ENDS users obtained their e-cigarettes through direct purchase from a retailer. Thus, understanding how and why youths obtain access to ENDS will be important for effective policy strategies to curb consumption.

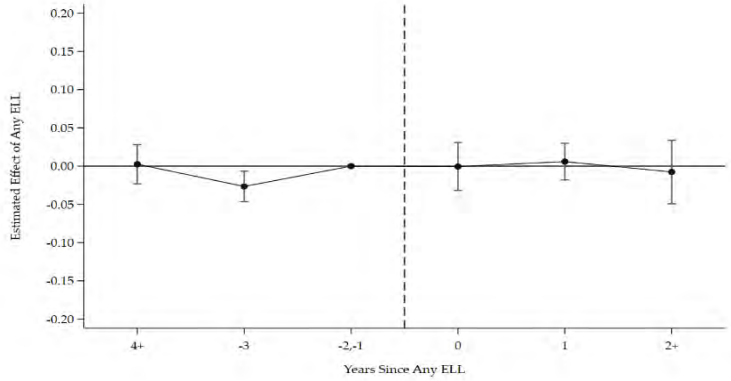
Figure 1. Geographic and Temporal Variation in ENDS Licensure Laws



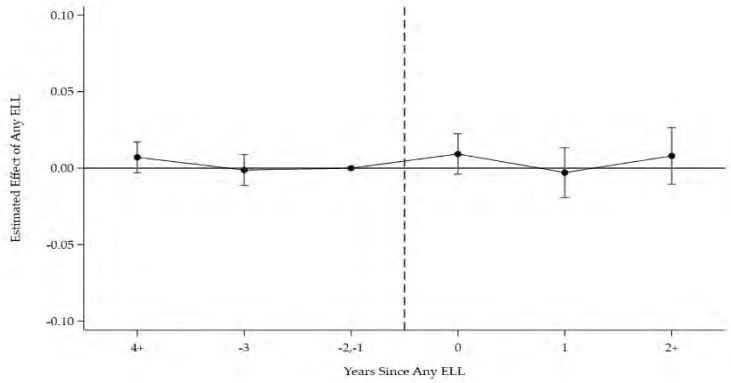
Notes: Data on ENDS licensure laws are obtained from State Tobacco Activities Tracking and Evaluation (STATE) system at the Centers for Disease Control and Prevention. The above maps show states in which an ENDS licensure law is enacted at any point during the year.

Figure 2. Event-Study Analysis of ELLs and Prior-30 ENDS Use, Using TWFE Estimates, 2015-2021

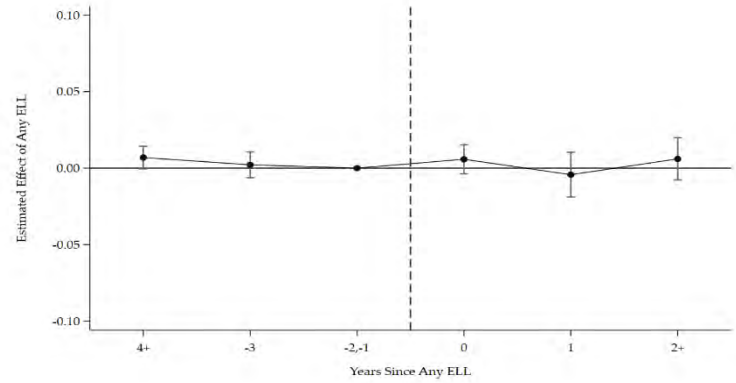
Panel (a): Any ENDS Use



Panel (b): Frequent ENDS Use

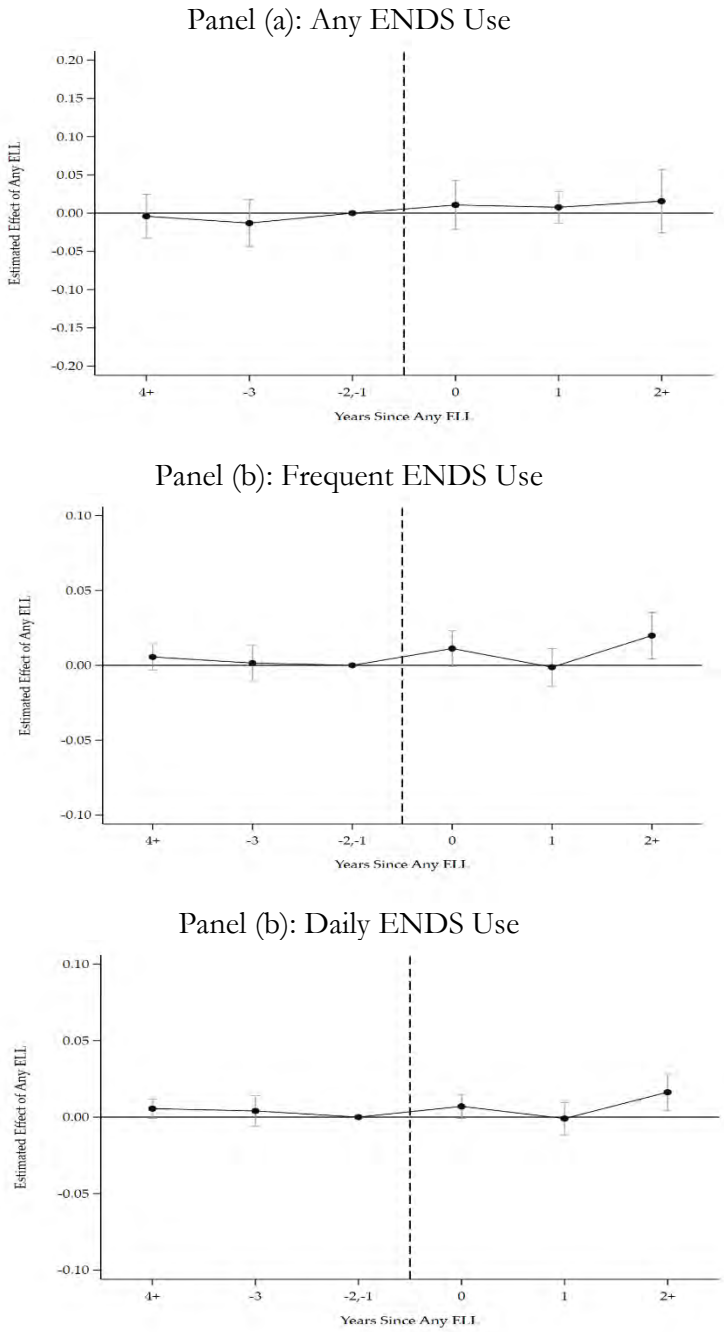


Panel (b): Daily ENDS Use



Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-specific wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

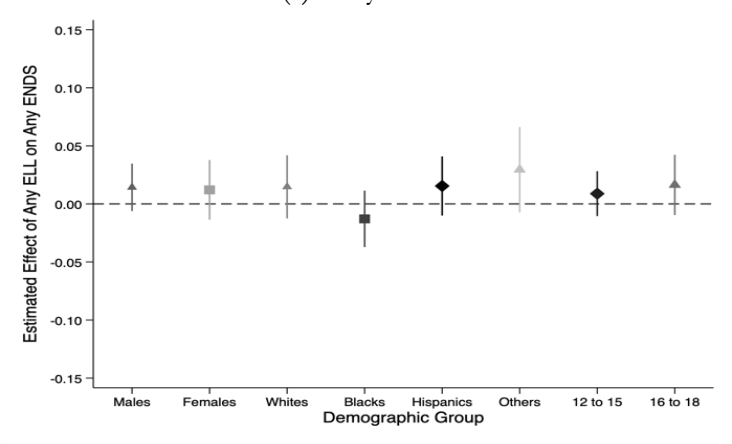
Figure 3. Event-Study Analysis of ELLs and Prior-30 ENDS Use, Using Sun and Abraham Estimates, 2015-2021



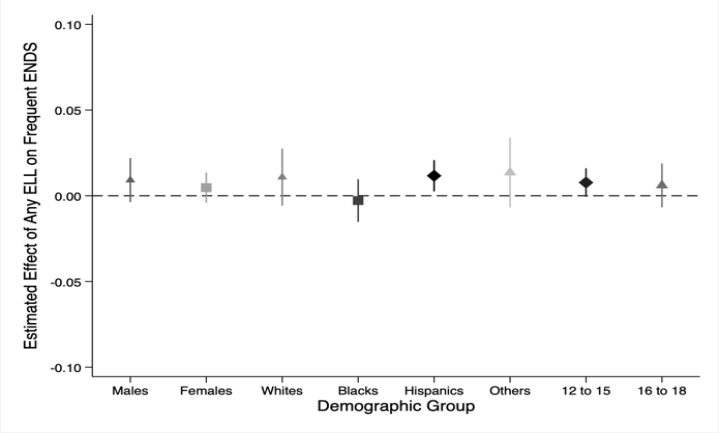
Notes: Estimates are generated via Sun and Abraham event-study using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Counterfactuals are never adopters of any ELL. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Figure 4. Heterogeneous Effects of ELLs, by Demographic Group, 2015-2021

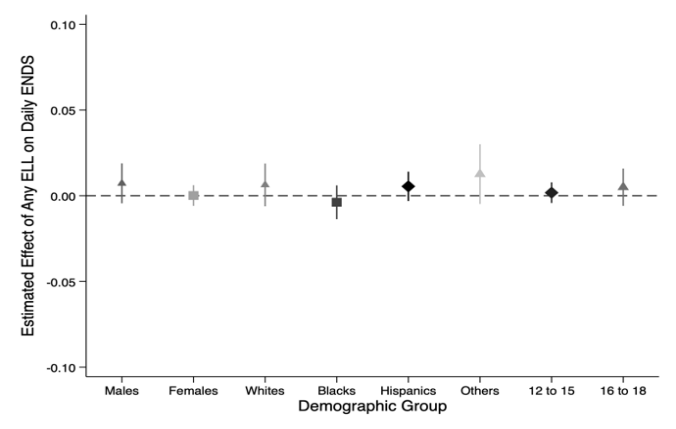
Panel (a): Any ENDS Use



Panel (b): Frequent ENDS Use



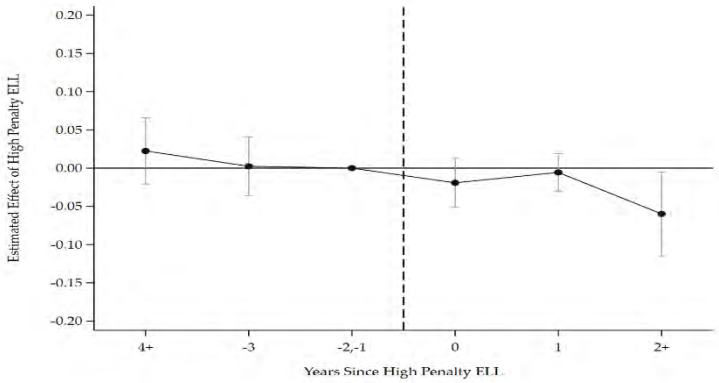
Panel (c): Daily ENDS Use



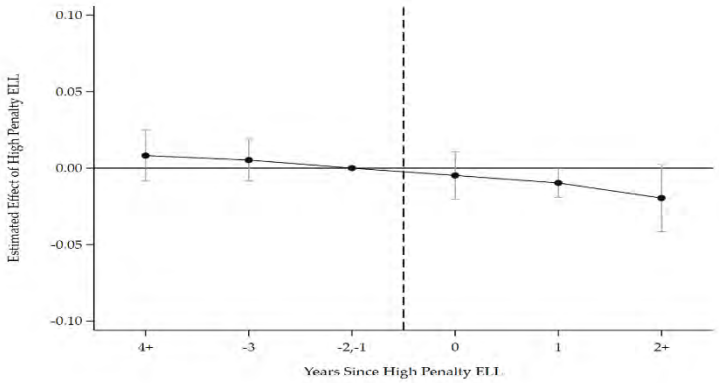
Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-specific wave fixed effects, demographics, macroeconomic conditions COVID-19 controls, tobacco policy controls, and other substances policy controls. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Figure 5. Event-Study Analysis of ELLs and ENDS Use Among Black Teenagers, Using Sun and Abraham Estimates

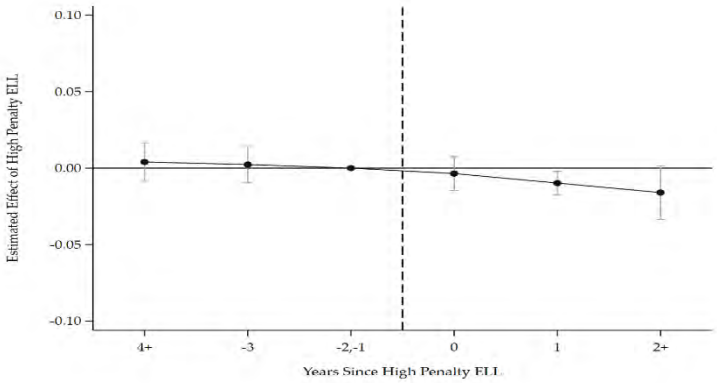
Panel (a): Any ENDS Use



Panel (b): Frequent ENDS Use



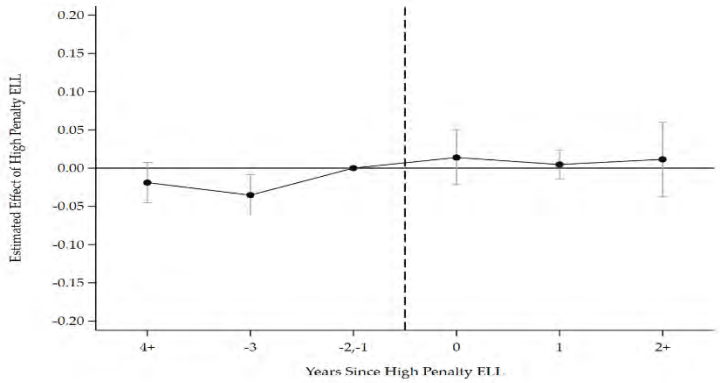
Panel (c): Daily ENDS Use



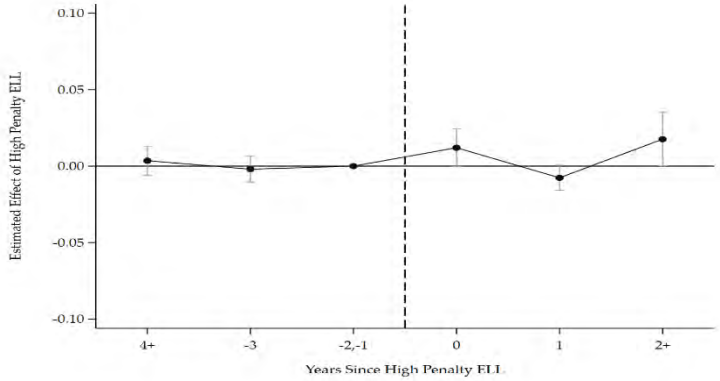
Notes: Estimates are generated via Sun and Abraham event-study using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Counterfactuals are never adopters of any ELL. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Figure 6. Event-Study Analysis of Higher Penalty ELLs and Youth ENDS Use, Using Sun and Abraham Estimates

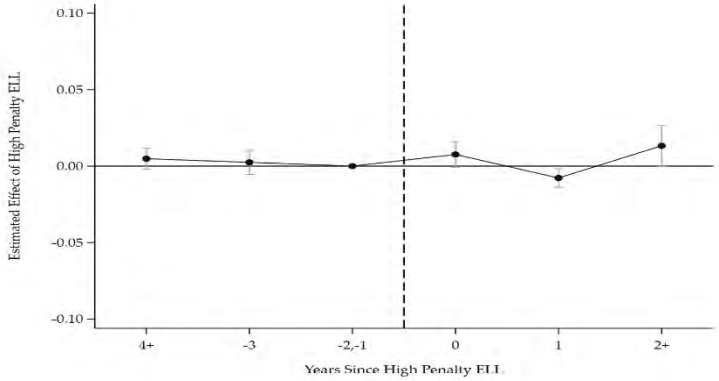
Panel (a): Any ENDS Use



Panel (b): Frequent ENDS Use



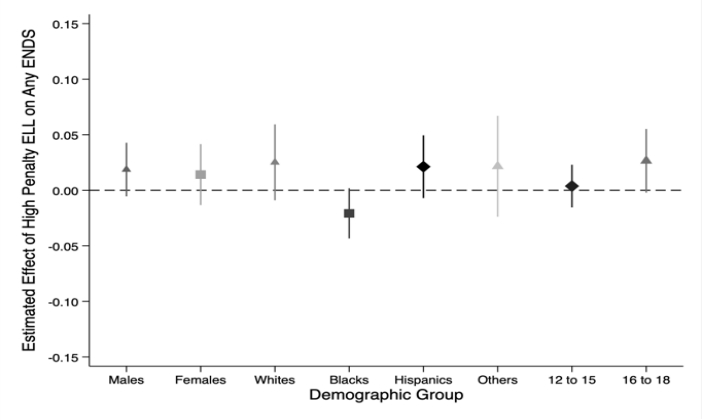
Panel (c): Daily ENDS Use



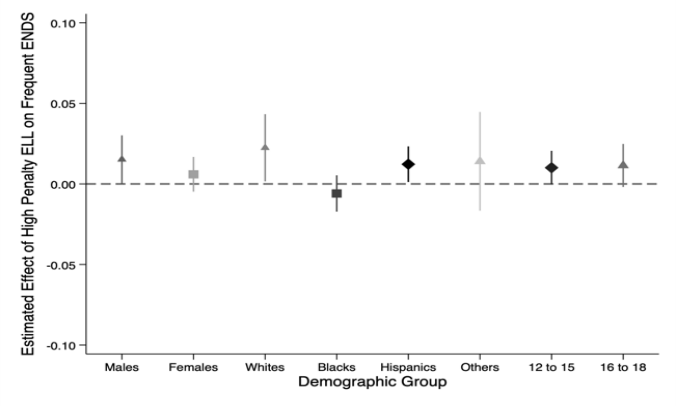
Notes: Estimates are generated via Sun and Abraham event-study using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Counterfactuals are never adopters of any high penalty ELL. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Figure 7. Heterogeneous Treatment Effects of Higher Penalty ELLs, by Demographic Group, 2015-2021

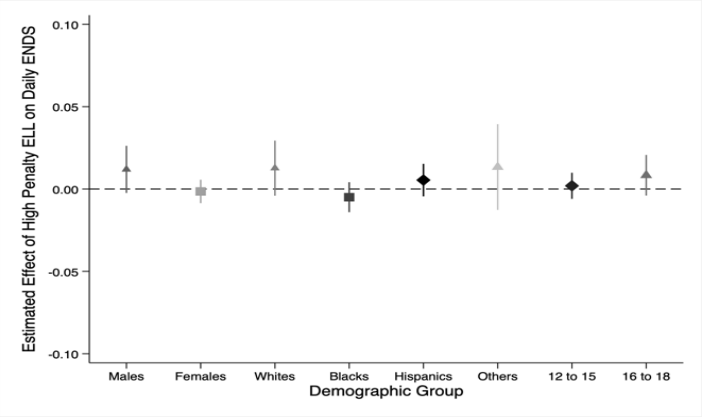
Panel (a): Any ENDS Use



Panel (b): Frequent ENDS Use



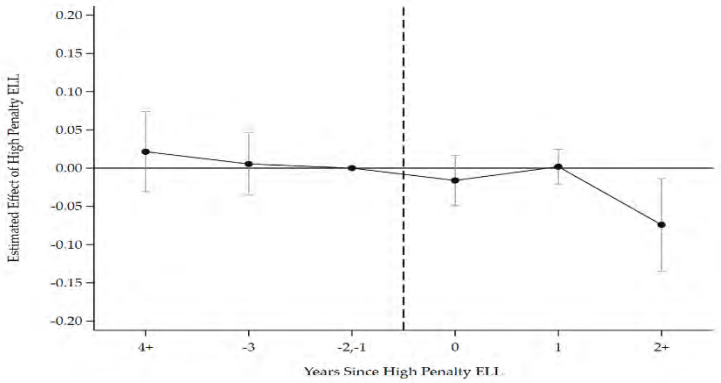
Panel (c): Daily ENDS Use



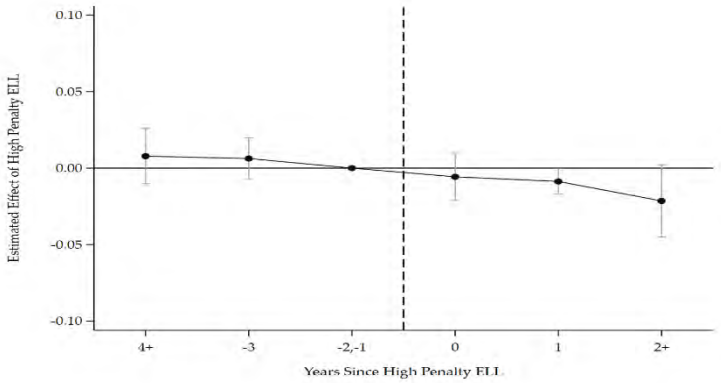
Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-specific wave fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Figure 8. Event-Study Analysis of High Penalty ELLs and ENDS Use Among Black Teenagers, Using Sun and Abraham Estimates

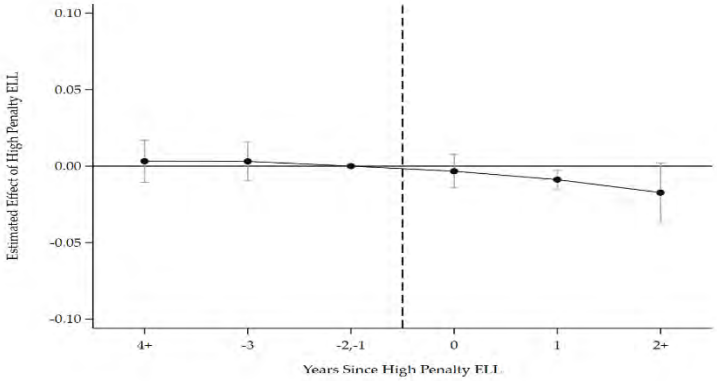
Panel (a): Any ENDS Use



Panel (b): Frequent ENDS Use



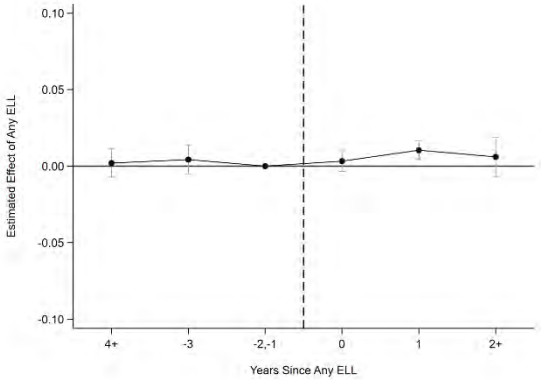
Panel (c): Daily ENDS Use



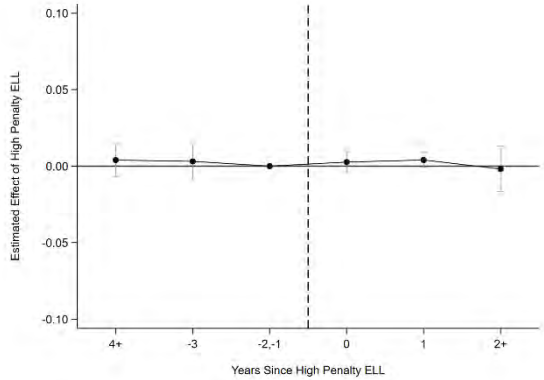
Notes: Estimates are generated via Sun and Abraham event-study using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Counterfactuals are never adopters of any high penalty ELL. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Figure 9. Event-Study Analysis of ELLs and Prior-30 Day Cigarette and Cigar Use, Using Sun and Abraham Estimates, 2011-2021

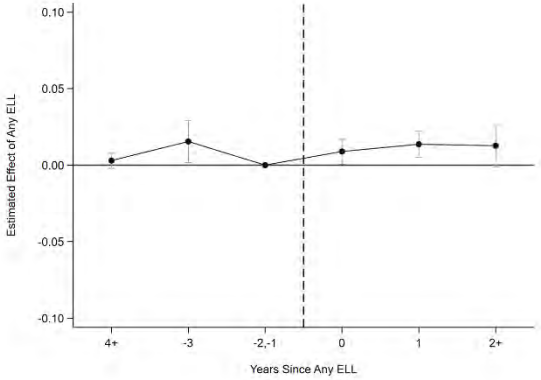
Panel (a): Any Cigar Use, ELL



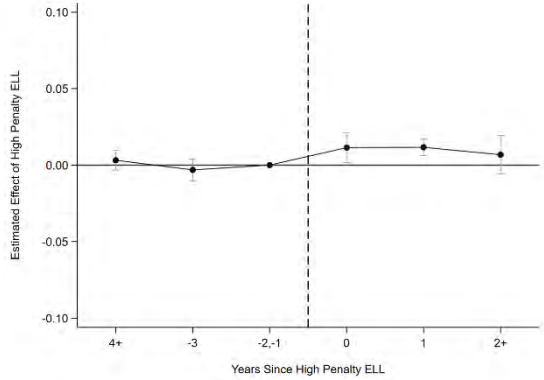
Panel (b): Any Cigar Use, Higher Penalty ELL



Panel (c): Any Cigarette Use, ELL



Panel (d): Any Cigarette Use, Higher Penalty ELL



Notes: Estimates are generated via weighted least squares using the 2011-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substance policy controls. Counterfactuals are never adopters of any ELL in panels a and c, and never adopters of any high-penalty ELL in panels b and d. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Table 1. Summary Statistics, State YRBS, 2015-2021

	Mean	Std. Dev.	N
Outcome Variables			
Any ENDS Use	.203	.402	622122
Frequent ENDS Use	.05	.217	622122
Daily ENDS Use	.035	.184	622122
Any Cigarette Use	.072	.258	622122
Frequent Cigarette Use	.019	.138	622122
Daily Cigarette Use	.014	.119	622122
Any Cigar Use	.067	.25	622122
Frequent Cigar Use	.009	.097	622122
Daily Cigar Use	.007	.084	622122
Individual Demographic Characteristics			
Female	.509	.5	622122
Age 12	.002	.049	622122
Age 13	.003	.058	622122
Age 14	.167	.373	622122
Age 15	.271	.444	622122
Age 16	.258	.438	622122
Age 17	.218	.413	622122
Age 18	.08	.272	622122
White	.56	.496	622122
Black	.128	.334	622122
Hispanic	.171	.376	622122
Other Race	.141	.348	622122
Grade 9	.286	.452	622122
Grade 10	.269	.443	622122
Grade 11	.243	.429	622122
Grade 12	.202	.401	622122
State Tobacco Policies			
ENDS Licensure Law	.393	.487	622122
ELL Lower Penalty	.204	.403	622122
ELL Higher Penalty	.189	.39	622122
ELL Lower Fee	.372	.482	622122
Renewable ELL Higher Fee	.02	.141	622122
ELL Criminal Penalty	.376	.483	622122
ELL Civil/No Penalty	.017	.128	622122
ENDS Tax (in $2021)	.27	.636	622122
Minimum Legal Purchasing Age for ENDS	.932	.251	622122
ENDS Clean Indoor Laws	.229	.419	622122
ENDS Flavor Restrictions	.065	.245	622122
Tobacco-21 Law	.249	.432	622122
Cigarette Tax (in $2021)	2.292	1.094	622122
Combustible Tobacco Licensure Law	.83	.375	622122
Cigarette Clean Indoor Laws	.887	.316	622122
Menthol Cigarette Restriction	.00006	.001	622122
	Mean	**Std. Dev.**	**N**

Macroeconomic Controls			
Unemployment Rate	4.233	1.082	622122
Per Capita Income (in $2021)	59258.999	7839.632	622122
Covid Control			
Covid Death Rate	.0004	.001	622122
Other Substances Policies			
Beer Tax (in $2021)	.29	.269	622122
Recreational Marijuana Law	.153	.36	622122
Medical Marijuana Law	.822	.381	622122

Notes: Outcome variables and demographic characteristics use data from the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data.

Table 2. Effect of ELLs on Prior-Month Youth ENDS Use, State YRBS, 2015-2021

	(1)	(2)	(3)	(4)
Panel I: Any ENDS Use				
ELL	.009	.014	.014	.013
	(.011)	(.011)	(.011)	(.010)
Pre-Treat. Mean of DV	*0.198*	*0.198*	*0.198*	*0.198*
N	622122	622122	622122	622122
Panel II: Frequent ENDS Use				
ELL	-.001	.002	.008	.007
	(.006)	(.005)	(.005)	(.005)
Pre-Treat. Mean of DV	*0.040*	*0.040*	*0.040*	*0.040*
N	622122	622122	622122	622122
Panel III: Daily ENDS Use				
ELL	-.002	.001	.005	.004
	(.004)	(.004)	(.004)	(.004)
Pre-Treat. Mean of DV	*0.028*	*0.028*	*0.028*	*0.028*
N	622122	622122	622122	622122
Controls:				
State and Wave FE?	Yes	Yes	Yes	Yes
Demographic Controls?	Yes	Yes	Yes	Yes
State and Census Region-by-wave FE?	No	Yes	Yes	Yes
Macroecon, COVID-19 & Spatial Controls?	No	Yes	Yes	Yes
Tobacco Policy Controls?	No	No	Yes	Yes
Other Substances Policy Controls?	No	No	No	Yes

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Standard errors are clustered at the state level and are reported in parentheses. Regressions control for state and census region-specific wave fixed effects other than column (1) which includes state and wave fixed effects. Demographic controls include gender, age, grade and race dummies. Macroeconomic, COVID-19, and spatial controls include the state unemployment rate, state per capita income (in $2021), cumulative state COVID-19 death rate, and census region-specific wave fixed effects. Tobacco policy controls include tobacco 21 laws, cigarette taxes (in $2021), any tobacco licensure laws, indoor smoking restrictions, menthol cigarette restrictions, ENDS taxes (in $2021), minimum legal sales age laws for ENDS, indoor vaping restrictions, and ENDS flavor restrictions. Other substances policy controls include the state beer tax (in $2021), medical marijuana laws, and recreational marijuana laws.

Table 3. Sensitivity of ELL Estimates to Use of Census Division-Specific Wave Fixed Effects, State-Specific Linear Time Trends, and Seasonality Effects, State YRBS

	(1) Any ENDS Use	(2) Frequent ENDS Use	(3) Daily ENDS Use
Panel I: Census Division-by-Wave Fixed Effects			
ELL	.003	.003	.001
	(.010)	(.006)	(.005)
Panel II: State-Specific Linear Time Trends			
ELL	.002	.008	.005
	(.018)	(.008)	(.006)
Panel III: Seasonality (Semester) Fixed Effects			
ELL	.013	.007	.004
	(.010)	(.005)	(.004)
Pre-Treat. Mean of DV	*0.198*	*0.040*	*0.028*
N	622122	622122	622122

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions in Panel I control for state and census division-specific wave fixed effects, and regressions in Panel II and III control for state and census region-specific wave fixed effects. Demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Table 4. Sensitivity of ELL Estimates in Table 3 to Use of National YRBS

	(1) Any ENDS Use	(2) Frequent ENDS Use	(3) Daily ENDS Use
Panel I: Baseline Model			
ELL	-0.040	-0.009	-0.002
	(0.030)	(0.016)	(0.012)
Panel II: Census Division-by-Wave Fixed Effects			
ELL	-.018	.004	.009
	(.025)	(.015)	(.015)
Panel III: State-Specific Linear Time Trends			
ELL	-.018	-.027	.02
	(.067)	(.034)	(.026)
Pre-Treat. Mean of DV	*0.259*	*0.053*	*0.035*
N	54441	54441	54441
Panel IV: Baseline Model, Combined State and National YRBS			
ELL	.0002	.012	.014*
	(.013)	(.009)	(.007)
Pre-Treat. Mean of DV	*0.230*	*0.047*	*0.032*
N	676563	676563	676563

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the National Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and reported in parentheses. Data in Panels I, II, and III are weighted by YRBS-provided weights. Data in Panel IV are weighted by person-specific sample weights calculated as the product of the normalized State YRBS person weight (renormalized to sum to one in each state-wave) and the state-by-wave-by race/ethnicity-by gender population data on 14- to-18-year-olds from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER). Regressions in Panels I, III, and IV control for state and census region-specific wave fixed effects. Regressions in Panel II controls for state and census division-specific wave fixed effects. Regressions control for demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Table 5. Sensitivity of Estimates in Table 2 to Border State ELL Policy

	(1)	(2)	(3)
	Any ENDS Use	Frequent ENDS Use	Daily ENDS Use
	Panel I: Excluding ELL States		
Border State ELL	-.002	.010	.005
	(.013)	(.013)	(.009)
Pre-Treat Mean of DV	*0.256*	*0.058*	*0.043*
N	125853	125853	125853
	Panel II: Excluding High Penalty ELL States		
Border State High Penalty ELL	-.013	.010	.006
	(.012)	(.010)	(.007)
Pre-Treat Mean of DV	*0.244*	*0.055*	*0.040*
N	301067	301067	301067

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Table 6. Exploration of High Penalty, High Fee, and Criminal Penalty ELLs and Youth ENDS Use, State YRBS, 2015-2021

	(1) Any ENDS Use	(2) Frequent ENDS Use	(3) Daily ENDS Use
	Panel I: High Penalty ELL vs Low Penalty ELL		
Low Penalty ELL	.005	-.002	-.0002
	(.014)	(.008)	(.006)
High Penalty ELL	.017	.011*	.005
	(.012)	(.006)	(.005)
Pre-Treat. Mean of DV for Low ELL	*0.209*	*0.041*	*0.029*
Pre-Treat. Mean of DV for High ELL	*0.196*	*0.040*	*0.028*
N	622122	622122	622122
	Panel II: High Fee Renewable ELL vs Low Fee or Non-Renewable		
Low Fee or Non-Renewable ELL	.006	.007	.005
	(.011)	(.006)	(.005)
Renewable High Fee ELL	.027*	.007	.002
	(.015)	(.007)	(.005)
Pre-Treat. Mean of DV for Low Fee	*0.222*	*0.046*	*0.031*
Pre-Treat. Mean of DV for High Fee	*0.182*	*0.037*	*0.026*
N	622122	622122	622122
	Panel III: Criminal Penalty ELL vs Civil or No Penalty ELL		
Civil or No Penalty ELL	.015	.008	.005
	(.01)	(.005)	(.004)
Criminal Penalty ELL	-.010	-.003	-.007
	(.019)	(.007)	(.005)
Pre-Treat. Mean of DV – Civil	*0.208*	*0.046*	*0.032*
Pre-Treat. Mean of DV - Criminal	*0.194*	*0.038*	*0.027*
N	622122	622122	622122

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Table 7. Multinomial Logit Estimates of Effect of ELLs on Usual Sources of E-Cigarettes, State YRBS, 2017-2021, Marginal Effects

	(1) Bought in Store	(2) Bought Online	(3) Get from Someone Else	(3) Other
		Panel I: Any ELL		
ELL	-.0027	-.00014	.0108**	.0047
	(.0053)	(.0017)	(.0055)	(.0042)
Pre-Treat. Mean of DV	*0.036*	*0.007*	*0.108*	*0.020*
	Panel II: High Penalty ELL vs Low Penalty ELL			
Low Penalty ELL	-.005	.002	.0012	.008
	(.007)	(.001)	(.008)	(.005)
High Penalty ELL	-.002	-.0007	.011	.004
	(.006)	(.002)	.007	(.005)
Pre-Treat. Mean of DV for Low ELL	*0.023*	*0.009*	*0.106*	*0.024*
Pre-Treat. Mean of DV for High ELL	*0.037*	*0.007*	*0.109*	*0.019*
N	376,520	376,520	376,520	376,520

***significant at 1% level **at 5% level *at 10% level

Notes: Average marginal effect estimates are generated via multinomial logit estimation using the 2017-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Table 8. Exploring Effects of ELLs on Adult ENDS Use, BRFSS, 2016-2021

	(1)	(2)	(3)	(4)
	Aged 18-20	Aged 21+	Aged 18-20	Aged 21+
	Any ENDS Use		Daily ENDS Use	
	Panel I: Any ELL			
ELL	.021	-.002	-.005	-.0003
	(.021)	(.002)	(.007)	(.001)
Pre-Treat. Mean of DV	*0.135*	*0.048*	0.043	*0.019*
	Panel II: High Penalty ELL vs Low Penalty ELL			
Low Penalty ELL	.023	-.0007	.010	.0035**
	(.025)	(.002)	(.011)	(.00137)
High Penalty ELL	.020	-.003	-.013*	-.00208
	(.026)	(.003)	(.007)	(.00183)
Pre-Treat. Mean of DV for Low ELL	*0.164*	*0.055*	*.042*	*0.022*
Pre-Treat. Mean of DV for High ELL	*0.124*	*0.045*	*.036*	*0.018*
N	38086	1548893	38086	1548891

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2016-2021 waves of the Behavioral Risk Factor Surveillance System (BRFSS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted by BRFSS-provided weights. Regressions control for state, year, (seasonality) quarter, and census region-specific year fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Table 9. Spillover Effects of ELLs on Combustible Tobacco, State YRBS and BRFSS, 2011-2021

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Any Cigar Use	Any Cigarette Use	Any Cigar Use	Any Cigarette Use	Any Cigarette Use	Any Cigarette Use	Any Cigarette Use	Any Cigarette Use
	All	All	Black	Black	Aged 18-20 All	Aged 18-20 Black	Aged 21+ All	Aged 21+ Black
	YRBS				**BRFSS**			
				Panel I: Any ELL				
ELL	.005	.013***	-.015*	.007	.002	-.005	.0007	.002
	(.004)	(.004)	(.007)	(.004)	(.005)	(.02)	(.00191)	(.005)
Pre-Treat. Mean of DV	*0.100*	*0.099*	*.085*	*.060*	*.072*	*.041*	*.150*	*.171*
				Panel II: High Penalty ELL vs Low Penalty ELL				
Low Penalty ELL	.006	.007	-.019	.026***	.003	.012	-.002	-.003
	(.007)	(.006)	(.016)	(.007)	(.007)	(.016)	(.002)	(.005)
High Penalty ELL	.004	.016***	-.013	-.000	.001	-.023	.005	.007
	(.005)	(.004)	(.009)	(.005)	(.005)	(.026)	(.003)	(.006)
Pre-Treat. Mean of DV-Low ELL	*0.115*	*0.103*	*.115*	*.085*	*.080*	*.043*	*.173*	*.200*
Pre-Treat. Mean of DV-High ELL	*0.096*	*0.097*	*.077*	*.054*	*.068*	*.040*	*.141*	*.160*
N	816189	927047	111017	124981	106947	10149	4724946	373417

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2011-2021 waves of the State Youth Risk Behavior Surveys (YRBS) and the Behavioral Risk Factor Surveillance System (BRSS) dataset from 2011 to 2021. Standard errors are clustered at the state level and are reported in parentheses. YRBS regressions in columns 1 through 4 include state and census region-by-wave fixed effects, gender, age, grade, and race. BRFSS regressions in columns 5 through 8 include controls for state, year, (seasonality) quarter, and census region-specific year fixed effects, gender, age, race, and educational attainment. State YRBS data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. BRFSS data are weighted by BRFSS-provided weights. Regressions control macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Table 10. Exploration of Effects of ELLs and Higher Penalty ELLs on Any and Dual Use of Tobacco Products, State YRBS, 2015-2021

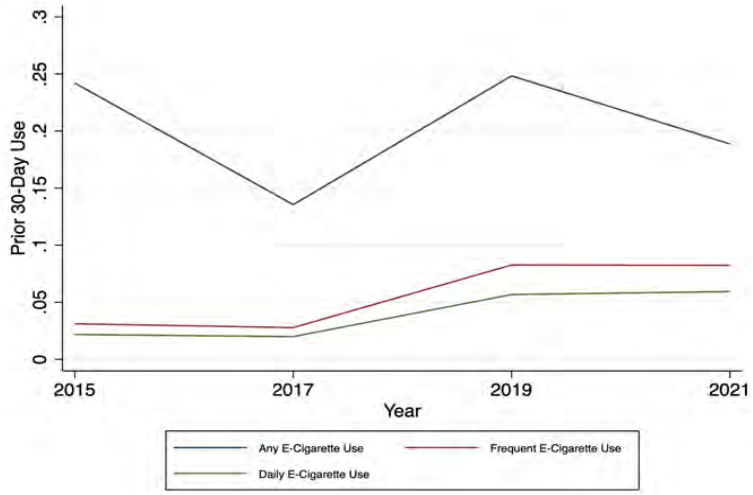
	(1)	(2)	(3)	(4)
	Any Tobacco Use	Dual ENDS and Combustible Use	Everyday ENDS Use and Any Combustible Use	Everyday ENDS Use and Everyday Combustible Use
			Panel I: Any ELL	
Any ELL	.012	.005	.002	.0003
	(.008)	(.006)	(.003)	(.001)
Pre-Treat. Mean of DV	*0.214*	*0.070*	*0.014*	*0.005*
			Panel II: High Penalty ELL vs Low Penalty ELL	
Low Penalty ELL	-.001	-.007	-.006	-.001
	(.012)	(.007)	(.003)	(.001)
High Penalty ELL	.016*	.009	.004	.001
	(.009)	(.007)	(.004)	(.001)
Pre-Treat. Mean of DV for Low ELL	*0.237*	*0.094*	*0.016*	*0.005*
Pre-Treat. Mean of DV for High ELL	*0.210*	*0.066*	*0.014*	*0.005*

***significant at 1% level **at 5% level *at 10% level

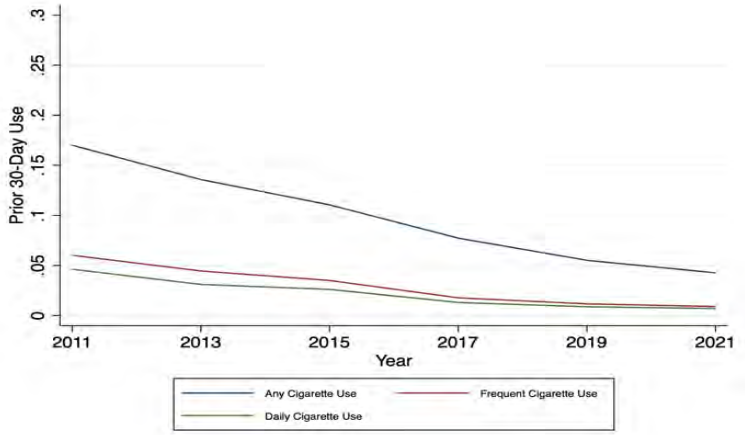
Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Appendix Figure 1. Average Trends in Tobacco Use Among Youths

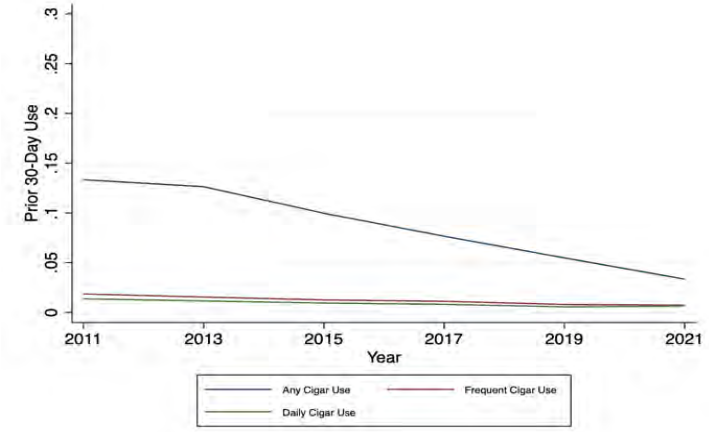
Panel (a): E-cigarette Use, 2015-2021



Panel (b): Cigarette Use, 2011-2021



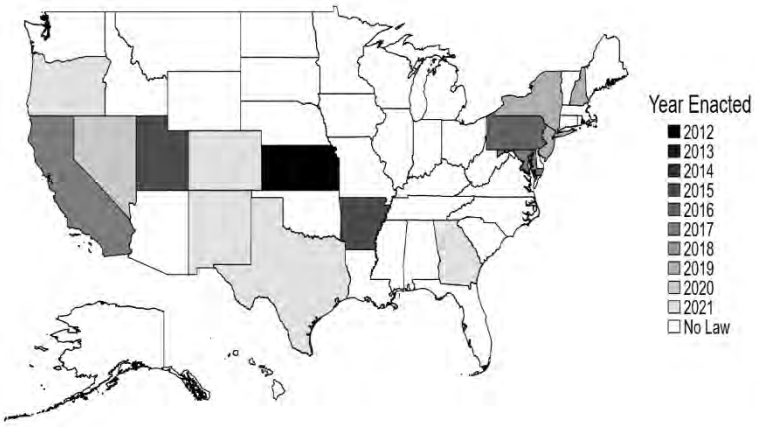
Panel (c): Cigar Use, 2011-2021



Notes: Weighted means are estimated from State Youth Risk Behavior Surveys during 2015-2021 waves in panel (a), and 2011-2021 waves in panels (b) and (c). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data.

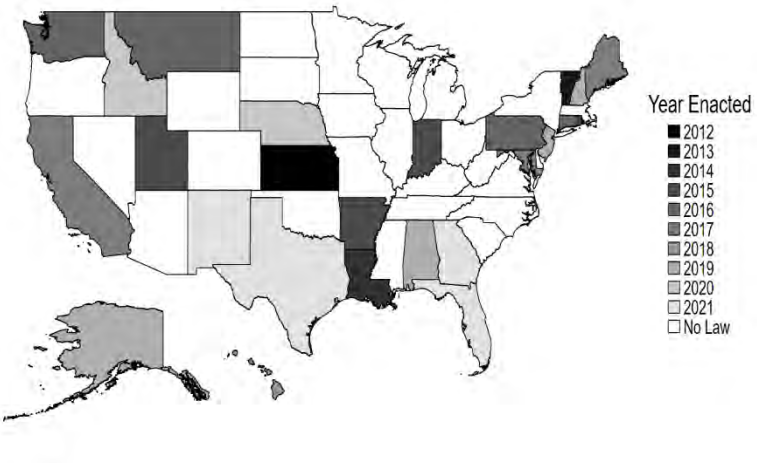
Appendix Figure 2. Geographic and Temporal Variation in Higher Penalties and Renewable Higher Fee ELLs

Panel (a): Higher Penalty ELL



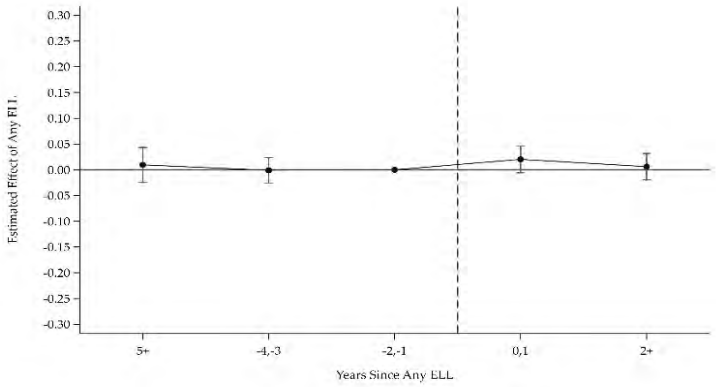
Panel (b): Renewable Higher Fee ELL

Panel (c): Criminal Penalty ELL

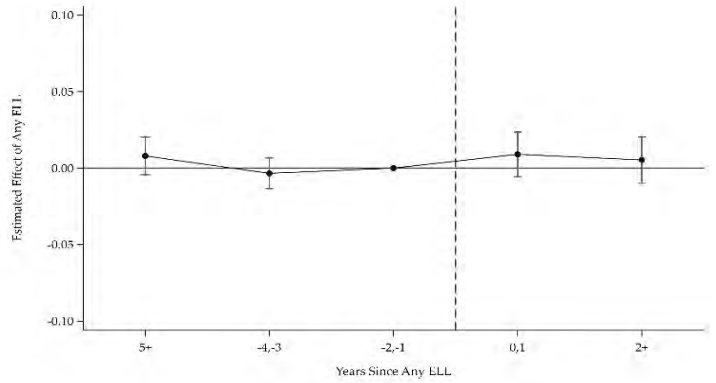


Appendix Figure 3. Sensitivity of Event-Study Analyses of ELLs and ENDS Use to Biennial Leads and Lags, Using TWFE Estimates, 2015-2021

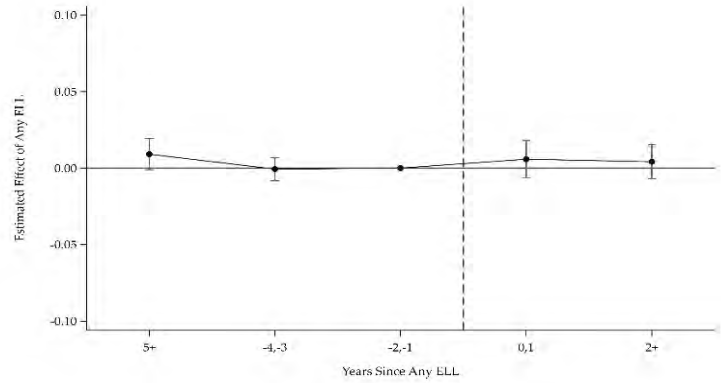
Panel (a): Any E-cigarette Use



Panel (b): Frequent E-cigarette Use

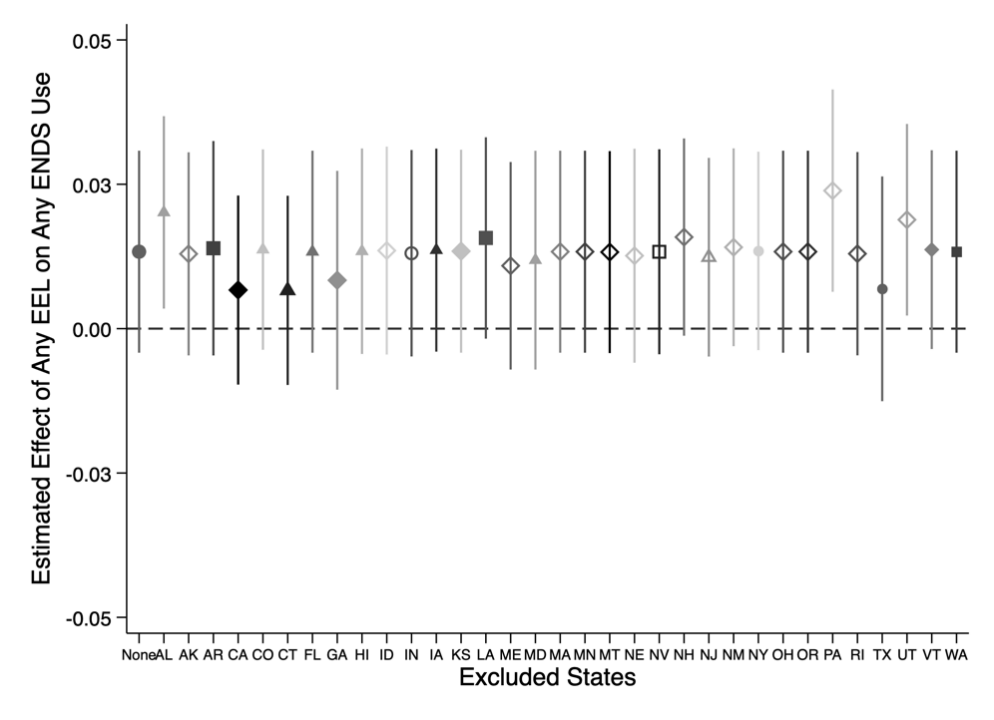


Panel (c): Daily E-cigarette Use



Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

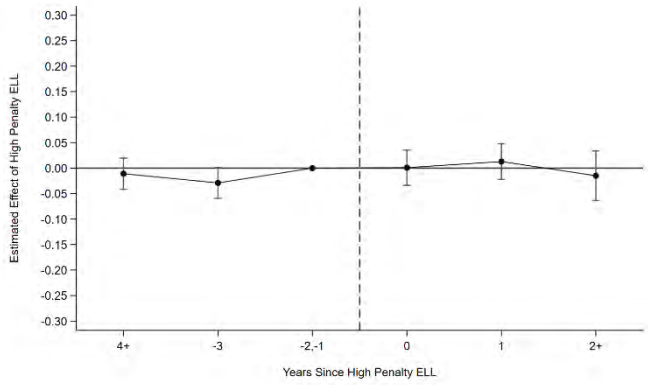
Appendix Figure 4. Leave-one-Treatment State-Out-at-a-Time Analysis, ELLs and Youth E-cigarette Use



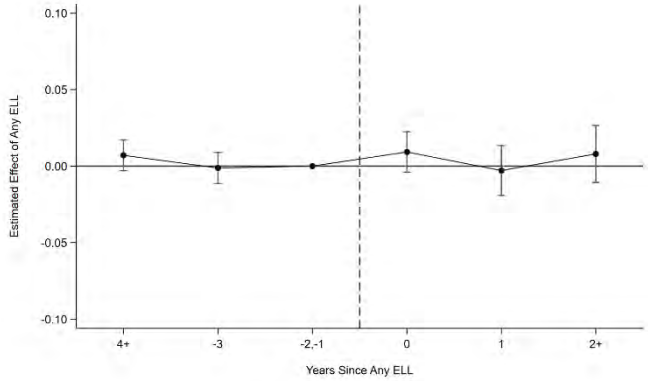
Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Appendix Figure 5A. Event-Study Analysis of Higher Penalty ELLs and Youth ENDS Use, Using TWFE Estimates

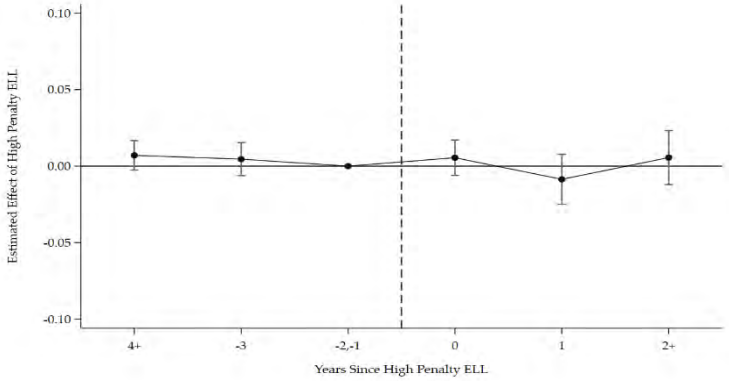
Panel (a): Any ENDS Use



Panel (b): Frequent ENDS Use

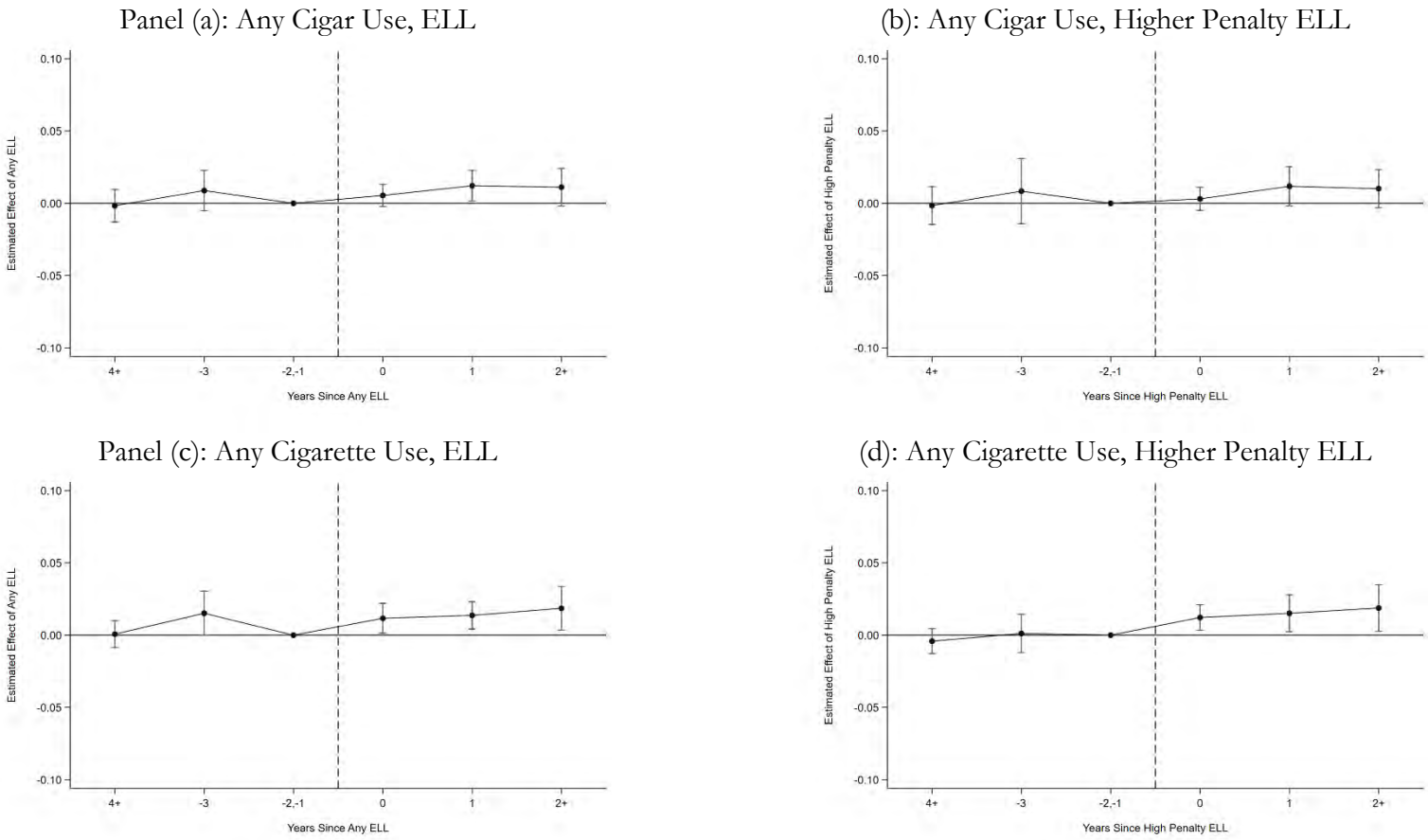


Panel (c): Daily ENDS Use



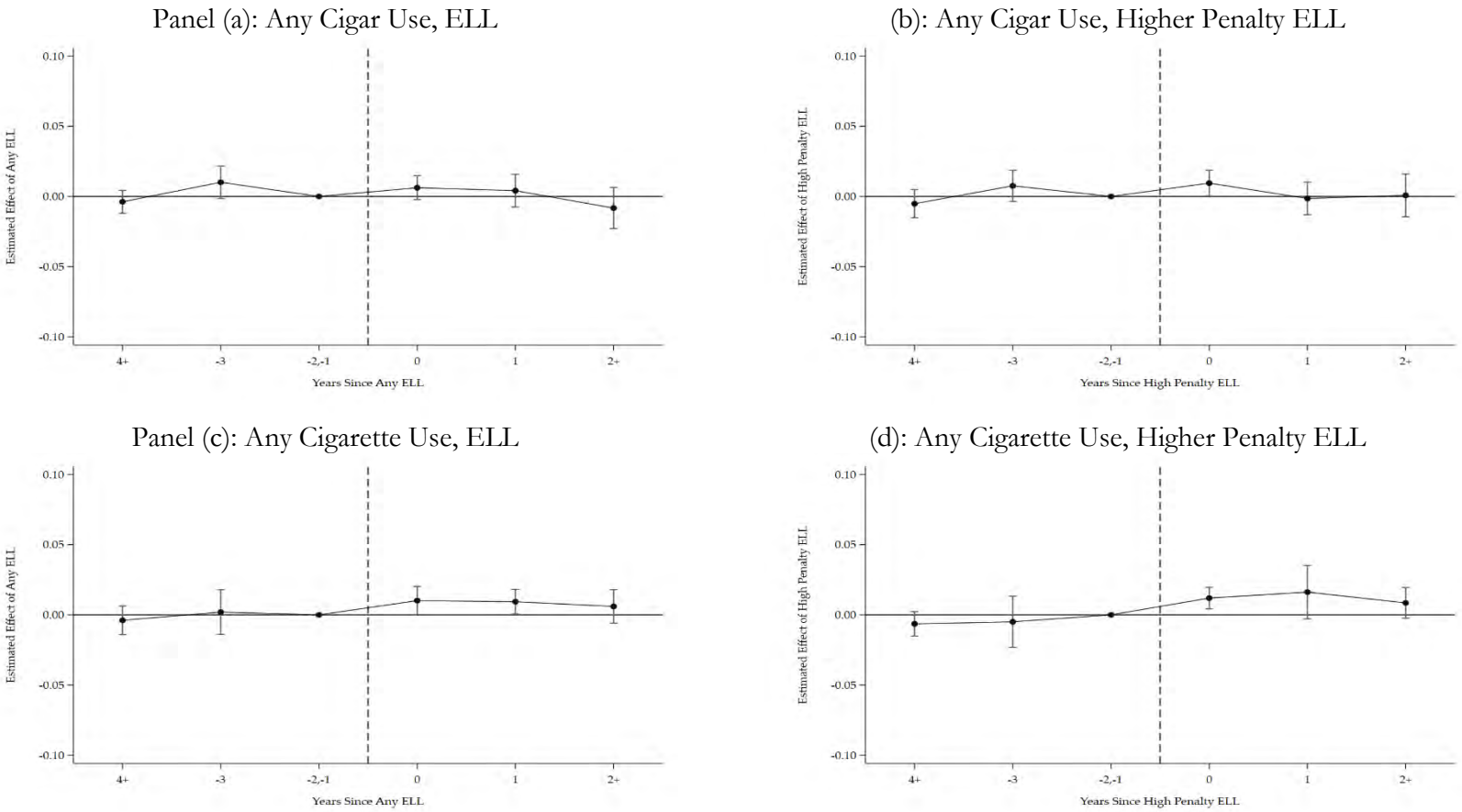
Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Vertical bars plot 95 percent confidence intervals. Vertical bars plot 95% confidence intervals that account for within-state clustering.

Appendix Figure 5B. Event-Study Analysis of ELLs and Prior-30 Day Cigarette and Cigar Use, Using TWFE Estimates, 2011-2021



Notes: Estimates are generated via weighted least squares using the 2011-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

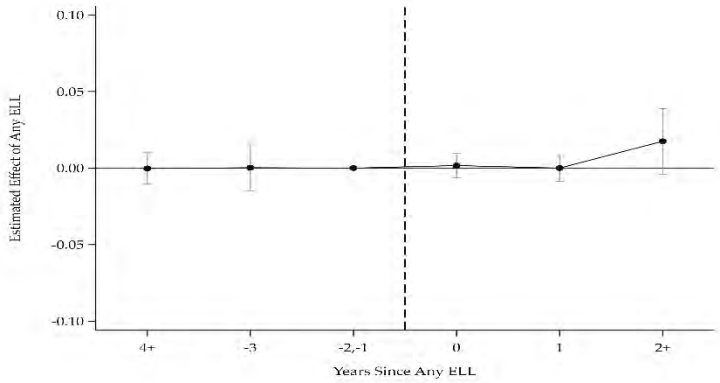
Appendix Figure 6. Event-Study Analysis of ELLs and Prior-30 Day Cigarette and Cigar Use, Using TWFE Estimates, 2015-2021



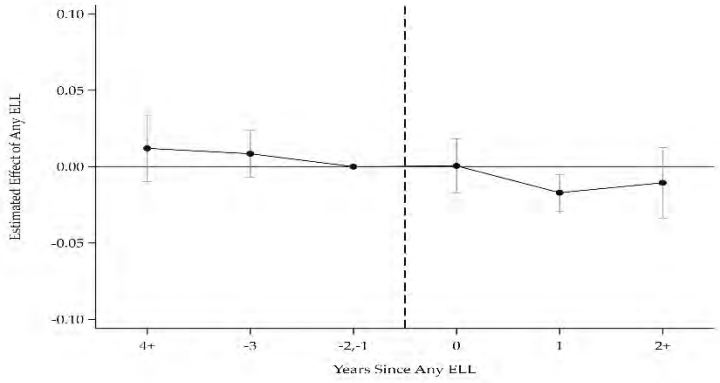
Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Vertical bars plot 95 percent confidence intervals. Vertical bars plot 95% confidence intervals that account for within-state clustering.

Appendix Figure 7. Event-Study Analysis of ELL and Combustible Tobacco Use Among Black Teenagers, Using Sun and Abraham Estimates

Panel (a): Any Cigarette Use



Panel (b): Any Cigar Use



Notes: Estimates are generated via Sun and Abraham event-study using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and wave fixed effects, demographics, macroeconomic controls, COVID-19 controls, tobacco policy controls, and other substances policy controls. Counterfactuals are never adopters of any ELL. Vertical bars plot 95 percent confidence intervals that account for within-state clustering.

Appendix Table 1A. Summary Statistics, State YRBS, 2015-2021 for ENDS, 2011-2021 for Combustible Tobacco Products

	Mean	Std. Dev.	N
Outcome Variables			
Any ENDS Use	.203	.402	622122
Frequent ENDS Use	.050	.217	622122
Daily ENDS Use	.035	.184	622122
Any Cigarette Use	.091	.288	927047
Frequent Cigarette Use	.028	.165	927047
Daily Cigarette Use	.021	.142	927047
Any Cigar Use	.085	.278	816189
Frequent Cigar Use	.012	.107	816189
Daily Cigar Use	.009	.093	816189
Individual Demographic Characteristics			
Female	.513	.500	927047
Age 12	.002	.047	927047
Age 13	.003	.059	927047
Age 14	.155	.362	927047
Age 15	.268	.443	927047
Age 16	.260	.439	927047
Age 17	.221	.415	927047
Age 18	.089	.285	927047
White	.551	.497	927047
Black	.135	.342	927047
Hispanic	.178	.382	927047
Other Race	.137	.344	927047
Grade 9	.284	.451	927047
Grade 10	.269	.443	927047
Grade 11	.244	.430	927047
Grade12	.203	.402	927047
Macroeconomic Controls			
Unemployment Rate	5.194	1.924	927047
Per capita Income	57246.322	8202.688	927047
Covid Controls			
Covid death rate	.0002	.0007	927047
State Tobacco Policies			
ENDS Licensure Law	.268	.442	927047
ELL lower penalty	.147	.354	927047
ELL higher penalty	.121	.325	927047
ELL lower fee	.252	.434	927047
Renewable ELL higher fee	.016	.124	927047
ELL Criminal penalty	.256	.436	927047
ELL civil/no penalty	.012	.109	927047
ENDS tax	.184	.544	927047
Minimum Legal Purchasing Age for ENDS	.757	.427	927047
ENDS clean indoor laws	.178	.382	927047

	Mean	Std. Dev.	N
ENDS Flavor Restrictions	.046	.207	927047
Tobacco-21 Law	.164	.370	927047
Cigarette tax	2.249	1.149	927047
Combustible Tobacco Licensure Law	.818	.386	927047
Cigarette clean indoor laws	.859	.347	927047
Menthol Cigarette Restrictions	0	0	927047
State Other Substance Policies			
Beer Tax	.301	.271	927047
Recreational Marijuana Law	.108	.310	927047
Medical Marijuana Law	.669	.469	927047

Notes: Outcome variables and demographic characteristics use data from the 2011-2021 waves of the State Youth Risk Behavior Surveys. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data.

Appendix Table 1B. Summary Statistics, BRFSS

	Mean	Std. Dev.	N
ENDS and Cigarette Use			
Any ENDS Use, Ages 18-20	.17	.375	38086
Daily ENDS Use, Ages 18-20	.063	.242	38086
Any Cigarette Use, Ages 18-20	.100	.299	106947
Any ENDS Use, Ages 21+	.039	.193	1548893
Daily ENDS Use, Ages 21+	.016	.124	1548891
Any Cigarette Use, Ages 21+	.164	.370	4724946
Demographic Characteristics			
Female	.569	.495	4892389
Age	55.101	17.407	4890266
Black	.08	.271	4893850
White	.767	.423	4893850
Hispanic	.07	.256	4893850
No High School	.076	.265	4893851
Some college	.274	.446	4893851
College	.367	.482	4893851

Notes: ENDS variables are from the 2016-2021 waves of the Behavioral Risk Factor Surveillance System (BRFSS). Combustible cigarette and demographic characteristics use data from 2011 to 2021 waves of the BRFSS. Data are weighted by BRFSS-provided survey weights.

Appendix Table 2. Marginal Effects of ELLs on Prior-Month Youth ENDS Use, Using Probit Regression Model, State YRBS, 2015-2021

	(1)	(2)
Panel I: Any ENDS Use		
ELL	.009	.015
	(.011)	(.010)
Pre-Treat. Mean of DV	*0.198*	*0. 198*
Panel II: Frequent ENDS Use		
ELL	.002	.009**
	(.006)	(.004)
Pre-Treat. Mean of DV	*0.040*	*0.040*
Panel III: Daily ENDS Use		
ELL	.0009	.006**
	(.004)	(.003)
Pre-Treat. Mean of DV	*0.028*	*0.028*
N	622,122	622,122
Controls:		
State and Wave FE?	Yes	Yes
Demographic Controls?	Yes	Yes
State and Census Region-by-wave FE?	No	Yes
Macroecon, COVID-19 & Spatial Controls?	No	Yes
Tobacco Policy Controls?	No	Yes
Other Substances Policy Controls?	No	No

***significant at 1% level **at 5% level *at 10% level

Notes: Average marginal effect estimates are generated via logistic regression using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions in column (1) control for state and wave fixed effects and regressions in column (2) control for state and census region-by-wave fixed effects. Demographic controls include gender, age, grade, and race dummies. Macroeconomic, COVID-19, and spatial controls include the state unemployment rate, state per capita income (in $2021), cumulative state COVID-19 death rate, and census region-specific wave fixed effects. Tobacco policy controls include tobacco 21 laws, cigarette taxes (in $2021), any tobacco licensure laws, indoor smoking restrictions, menthol cigarette restrictions, ENDS taxes (in $2021), minimum legal sales age laws for ENDS, indoor vaping restrictions, and ENDS flavor restrictions. Other substances policy controls include the state beer tax (in $2021), medical marijuana laws, and recreational marijuana laws.

Appendix Table 3A. Sun and Abraham Estimates of the Effect of ELLs on Black Teens' ENDS Use, State YRBS, 2015-2021

	(1) Any ENDS Use	(2) Frequent ENDS Use	(3) Daily ENDS Use
Panel I: Any ELL			
ELL	-0.0410*	-0.0181**	-0.0126**
	(0.0215)	(0.0079)	(0.0062)
Pre-Treat. Mean of Any ELL	*0.1308*	*0.0156*	*0.0111*
Panel II: High Penalty ELL			
ELL	-0.0320*	-0.0320*	-0.0117**
	(0.0174)	(0.0174)	(0.0055)
Pre-Treat. Mean of High Pen. ELL	*0.1271*	*0.0152*	*0.0109*
N	79731	79731	79731

***significant at 1% level **at 5% level *at 10% level

Notes: Sun and Abraham (2021) estimates are based on the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and wave fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Appendix Table 3B. Exploration of Alternative Definition for Criminal ELL and Youth ENDS Use, State YRBS, 2015-2021

	(1)	(2)	(3)
	Any ENDS Use	Frequent ENDS Use	Daily ENDS Use
Civil or No Penalty ELL	.015	.010*	.006
	(.01)	(.006)	(.005)
Criminal Penalty ELL	.007	-.005	-.005
	(.018)	(.007)	(.005)
Pre-Treat. Mean of DV - Civil	*0.208*	*0.046*	*0.032*
Pre-Treat. Mean of DV - Criminal	*0.194*	*0.038*	*0.027*
N	622122	622122	622122

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and a census region-by-wave fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls. For the alternative coding of criminal ELL, we categorize "Fine" and "Class A Infraction" as civil rather than criminal.

Appendix Table 4. Sensitivity of BRFSS ELL Estimates to Unweighted Regressions, 2016-2021

	(1)	(2)	(3)	(4)
	Aged 18-20	Aged 21+	Aged 18-20	Aged 21+
	Any ENDS Use		**Daily ENDS Use**	
Low Fee or Non-Renewable ELL	.046***	.002	.027***	.002
	(.01527)	(.001)	(.009)	(.0009)
Renewable High Fee ELL	-.014	.001	-.0007	-.0001
	(.010)	(.001)	(.008)	(.0008)
Pre-Treat. Mean of DV for Low Fee	0.164	0.055	.042	0.022
Pre-Treat. Mean of DV for High Fee	0.124	0.045	.036	0.018
N	38086	1548893	38086	1548891

***significant at 1% level **at 5% level *at 10% level

Notes: Unweighted estimates are generated via ordinary least squares using the 2016-2021 waves of the Behavioral Risk Factor Surveillance System (BRFSS). Standard errors are clustered at the state level and are reported in parentheses. Data are unweighted. Regressions control for state, year, (seasonality) quarter, and census region-specific year fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Appendix Table 5. Sensitivity of BRFSS ENDS Use Estimates to Renewable High Fee ELL, 2016-2021

	(1)	(2)	(3)	(4)
	Aged 18-20	Aged 21+	Aged 18-20	Aged 21+
	Any ENDS Use		Daily ENDS Use	
Low Fee or Non-Renewable ELL	.01632	.00112	-.001	.00149
	(.017)	(.00211)	(.009)	(.0013)
Renewable High Fee ELL	.028	-.007***	-.011	-.003*
	(.034)	(.002)	(.008)	(.002)
Pre-Treat. Mean of DV for Low Fee	0.151	0.052	0.051	0.021
Pre-Treat. Mean of DV for High Fee	0.120	0.045	0.036	0.018
N	38086	1548893	38086	1548891

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2016-2021 waves of the Behavioral Risk Factor Surveillance System (BRFSS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted by BRFSS-provided weights. Regressions control for state, year, (seasonality) quarter, and census region-specific year fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Appendix Table 6. Spillover Effects of ELLs on Combustible Tobacco for Renewable High Fee ELL, State YRBS and BRFSS, 2011-2021

	(1)	(2)	(3)	(4)
	Any Cigar Use Teens	Any Cigarette Use Teens	Any Cigarette Use 18-20	Any Cigarette Use 21+
	YRBS		**BRFSS**	
Low Fee or Non-Renewable ELL	.006	.012***	.002	-.0001
	(.005)	(.004)	(.006)	(.002)
Renewable High Fee ELL	.002	.014**	.001	.003
	(.006)	(.005)	(.008)	(.004)
Pre-Treat. Mean of DV for Low Fee	*0.109*	*0.102*	*.078*	*.165*
Pre-Treat. Mean of DV for High Fee	*.006*	*0.096*	*.065*	*.133*
N	816189	927047	106947	4724946

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2011-2021 waves of the State Youth Risk Behavior Surveys (YRBS) and the Behavioral Risk Factor Surveillance System (BRFSS) dataset from 2011 to 2021. Standard errors are clustered at the state level and are reported in parentheses. The YRBS regressions in columns 1 and 2 include state and census region-by-wave fixed effects, gender, age, grade, and race dummies. The BRFSS regressions in columns 3 and 4 include state, (seasonality) quarter, and census region-specific year fixed effects, gender, age, race, and educational attainment dummies. YRBS data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. BRFSS data are weighted by BRFSS-provided weights. Regressions control for macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Appendix Table 7. Exploring Effects of ELLs on Black Adult ENDS Use, BRFSS, 2016-2021

	(1)	(2)	(3)	(4)
	Aged 18-20 Black	Aged 21+ Black	Aged 18-20 Black	Aged 21+ Black
	Any ENDS Use		Daily ENDS Use	
	Panel I: Any ELL			
ELL	.004	-.003	.014	.002
	(.045)	(.007)	(.038)	(.002)
Pre-Treat. Mean of DV	.073	.037	.014	.009
	Panel II: High Penalty ELL vs Low Penalty ELL			
Low Penalty ELL	-.001	-.015**	-.01	.001
	(.042)	(.007)	(.031)	(.002)
High Penalty ELL	.006	.001	.021	.002
	(.05)	(.007)	(.045)	(.002)
Pre-Treat. Mean of DV for Low ELL	.085	.042	.014	.011
Pre-Treat. Mean of DV for High ELL	.069	.036	.013	.008
N	3469	118181	3469	118181

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2016-2021 waves of the Behavioral Risk Factor Surveillance System (BRFSS). Standard errors are clustered at the state level. Data are weighted by BRFSS-provided weights. Regressions control for state, year, (seasonality) quarter, and census region-specific year fixed effects, demographics, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

Appendix Table 8. Sensitivity of Dual and Any Tobacco Use Estimates to Use of Alternate ELL Definitions

	(1)	(2)	(3)	(4)
	Any Tobacco Use	Dual ENDS and Combustible Use	Everyday ENDS Use and Any Combustible Use	Everyday ENDS Use and Everyday Combustible Use
		Panel III: High Fee Renewable ELL vs Low Fee or Non-Renewable		
Low Fee or Non-Renewable ELL	.006	-.001	.002	-.0003
	(.011)	(.007)	(.005)	(.002)
Renewable High Fee ELL	.025*	.016**	.002	.001
	(.013)	(.007)	(.002)	(.001)
Pre-Treat. Mean of DV for Low Fee	*0.233*	*0.084*	*0.015*	*0.005*
Pre-Treat. Mean of DV for High Fee	*0.205*	*0.064*	*0.014*	*0.005*
		Panel IV: Criminal Penalty ELL vs Civil or No Penalty ELL		
Civil or No Penalty ELL	.0001	-.005	.002	.004
	(.038)	(.016)	(.008)	(.003)
Criminal Penalty ELL	.013	.005	.002	-.00001
	(.007)	(.006)	(.003)	(.00112)
Pre-Treat. Mean of DV – Civil	*0.205*	*0.058*	*0.012*	*0.005*
Pre-Treat. Mean of DV – Criminal	*0.217*	*0.074*	*0.015*	*0.004*
N	534483	534483	534483	534483

***significant at 1% level **at 5% level *at 10% level

Notes: Estimates are generated via weighted least squares using the 2015-2021 waves of the State Youth Risk Behavior Surveys (YRBS). Standard errors are clustered at the state level and are reported in parentheses. Data are weighted using individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Regressions control for state and census region-by-wave fixed effects, demographics,, macroeconomic conditions, COVID-19 controls, tobacco policy controls, and other substances policy controls.

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