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SCHOOL VAPING BANS AND YOUTH E-CIGARETTE USE

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ABSTRACT

With the goal of curbing electronic nicotine delivery systems (ENDS) use among youths, 40 states and the District of Columbia have adopted restrictions on nicotine vaping at elementary and secondary (K-12) schools. This study is the first to estimate the effect of K-12 school vaping restrictions (SVRs) on ENDS use among youth. Using data from several nationally representative data sources and a generalized difference-in-differences approach, we find little evidence that school indoor vaping restrictions reduce youth ENDS use. With 95% confidence, we can rule out SVR-induced youth vaping declines of more than 3.5%. Descriptive evidence suggests that students may respond to SVRs by substituting to smaller vaping devices and vaping in school locations that are less easily detectable by school employees (e.g., bathrooms and locker rooms). In contrast, we find that comprehensive vaping restrictions covering school campuses, workplaces, restaurants, and drinking establishments are associated with a 1.5-2.6 percentage-point reduction in teen nicotine vaping. This result is concentrated on the initiation margin of use and is consistent with the hypothesis that broader place-based restrictions increase the costs of youth ENDS use.

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1. Introduction

> "A comprehensive tobacco-free campus policy prohibits any tobacco use, including e-cigarettes, on school property by anyone at any time."
>
> - U.S. Surgeon General (2016)

> "Whether sitting in class, playing games outside or waiting at the school bus stop, we must protect young people from deadly second-hand smoke and toxic e-cigarette emissions."
>
> - World Health Organization (2023)

Electronic nicotine delivery systems (ENDS) are devices in which a liquid, typically containing nicotine, flavorings, and other compounds such as propylene glycol and glycerin, is heated using a metal coil to produce an aerosol that is inhaled (Sharma et al., 2025). The rapid rise in prior-month nicotine vaping among teenagers in the 2010s — from 1.1 percent of U.S. high school students in 2011 to 27.5 percent in 2019 (Wang et al., 2019) — prompted the U.S. Surgeon General's Office to sound the alarm of an "epidemic" of teenage ENDS use (U.S. Surgeon General, 2018). Public health advocates expressed concern that without effective policy action, the tobacco-related public health successes of prior decades, which included substantial reductions in teen cigarette smoking and nicotine addiction, could be reversed (Glantz et al., 2022; Arora et al., 2025).

With the goal of curbing youth nicotine vaping, a flurry of anti-vaping policies was adopted at the local, state, and federal levels during the 2010s and 2020s. Many were designed to restrict access to ENDS products by increasing the price of e-cigarettes (e.g., ENDS taxes) or restricting sales of ENDS (e.g., restrictions on sales of flavored ENDS, minimum legal sales ages, online sales bans, retail licensure laws). Prior studies suggest that many (though not all) of these policies were successful at their intended objective: curbing teen vaping (Friedman 2015; Hansen et al., 2023; Abouk et al., 2023; Courtemanche et al., 2024; Chuo et al., 2025; Cotti et al., 2025a,b; Courtemanche et al., 2025; Dave et al., 2025b; Saffer et al., 2025), contributing to a sharp decline in youth nicotine vaping between 2019 and 2024 (Jamal, 2024). However, very little is known about the effect of an important youth-focused anti-vaping intervention that is designed to (1) limit *where* teenagers can vape, (2) curb "social vaping" among friends, (3) reduce adverse health effects of exposure to secondhand e-cigarette aerosol, and (4) equivalate cigarettes and e-cigarettes with respect to clean indoor air laws. This study is the first to explore the effects of elementary and secondary (K-12) school vaping restrictions (SVRs) on youth vaping.

During the period 2010-2024, 40 states and the District of Columbia adopted a statewide school indoor vaping restriction (SVR) on elementary and secondary (K-12) campuses. A subset of these jurisdictions (27 states) extended their SVRs to include the entire K-12 campus, which could span the campuses' outdoor grounds, parking lots, and athletic fields. With 54 percent of high school students reporting that they had seen e-cigarette use inside the school building and an additional 18 percent having seen such use outside on school grounds, SVRs are targeted to address an important modality of how and where youths consume e-cigarettes.[1] They enjoy the support of the U.S. Surgeon General as well as the World Health Organization and follow decades of state and federal clean indoor air laws that banned smoking on school campuses (U.S. Surgeon General, 2016; World Health Organization, 2023). Though well-intentioned and presently forming the cornerstone of policy recommendations to prevent youth initiation into e-cigarette use (Tobacco Control Network 2022), there is very little rigorous evidence to date on the effectiveness of SVRs. It remains unclear whether and to what extent such place-based restrictions on use impose a prohibitive cost on youth or if they are readily circumvented through compensatory behaviors.

SVRs may reduce youth ENDS use in several ways. First, because teenagers spend approximately 800 to 900 hours per year, or about one-third of their waking hours, attending school (Hansen et al., 2024), restricting vaping on K-12 campuses may have important negative effects on ENDS use. Relatedly, because teen nicotine vaping may often arise because of peer socialization activities, targeting schools for bans may be a particularly effective way to curb youth nicotine vaping. Second, SVRs may reduce ENDS use among teenagers' older schoolmates and teachers, as well as K-12 staff members. Such peer effects, which may include positive role modeling effects, may reduce ENDS use. Third, enforcement of these regulations may lead to greater monitoring of teen vaping behavior, including confiscation of visible vaping devices. SVRs may also send an information signal to students that e-cigarettes are hazardous to their health, curbing use through a health knowledge channel. Finally, SVRs could change social norms with respect to ENDS use, stigmatizing the behavior and resulting in less of it.

However, there may be unintended effects of SVRs that undermine advocates' objectives. If enforcement of these laws is weak due to inadequate resources, insufficient training, or avoidance by teachers who themselves vape, the effects of SVRs may be muted. Effects may also be muted because purchasing ENDS products among many high school-aged students was illegal in many

[1] Among middle-school students, 51 percent reported witnessing e-cigarette use in school buildings or on school grounds. These figures are based on data from the 2019 National Youth Tobacco Survey (NYTS).

states prior to December 2019 and federally since that time. Additionally, SVRs that are not accompanied by a supportive school environment, including cessation support for students already using e-cigarettes, risk displacing rather than reducing use, with teens simply moving their vaping outside (for indoor-only bans) or off of school property (for campus-wide bans). Moreover, SVRs could induce teens to choose vaping locations within schools that allow for more privacy for their (now) illicit activities, such as bathrooms or locker rooms.[2]

The effect of SVRs on overall youth nicotine vaping may also be muted if teens respond to new vaping restrictions by choosing vaping devices that are more easily concealable from school staff and teachers. For instance, SVRs may prompt teens to switch to disposable or partially disposable vapes that produce less vapor or are disguised as everyday objects or toys, replacing the bulkier, harder-to-conceal models (e.g., tank-based models) they previously used. Indeed, youths have increasingly favored disposable e-cigarettes over pod-based systems, with usage rates currently reaching approximately 60 percent among current vapers (Birdsey, 2023). Youths may also substitute more easily concealable vaping devices, such as those shaped like small USB sticks produced by Juul.

Finally, to the extent that traditional combustible cigarettes and e-cigarettes are substitutes for some teenagers (DeCicca et al., 2022; Abouk et al., 2023; Courtemanche et al., 2025), SVRs may induce some teens to smoke, which could result in poorer net tobacco-related health both for users and those exposed to secondhand tobacco smoke (National Academies of Sciences, Engineering and Medicine 2018; Levy et al., 2018).

To explore the effect of statewide SVRs on youth nicotine vaping, we draw data from multiple nationally representative sources (State and National Youth Risk Behavior Survey, Monitoring the Future, Population Assessment of Tobacco and Health) and use a generalized difference-in-differences approach. In the main, our findings provide little support for the hypothesis that SVRs are effective at curbing youth ENDS use. We find little evidence that indoor SVRs or campus-wide SVRs have economically important or statistically significant effects on youth ENDS use. The precision with which our null findings are estimated is informative. We can, with 95 percent confidence, rule out indoor SVR-induced declines in youth ENDS use of more than 3.5 percent and campus-wide SVR-induced declines in youth ENDS use of more than 5.0 percent. We also find no evidence that the more extensive margin of youth vaping is impacted by SVR adoption.

[2] Place-based substitution in tobacco use has, in fact, been detected in smoking responses to the adoption of clean indoor air laws (Adams and Cotti, 2008; Adda and Cornaglia, 2010; Carpenter et al., 2011).

Auxiliary analyses using repeated cross-sectional data from Monitoring the Future (MTF) and individual-level longitudinal data from the Population Assessment of Tobacco and Health (PATH) yield similar null findings on the effect of campus-wide SVRs on youth vaping. This null finding persists when we estimate discrete-time hazard models that separately estimate the effects of SVR adoption on the initiation and cessation margins of use. Pseudo-placebo tests on young adults also show no impacts where we expect little effect.

What can explain our null findings? First, we find some evidence that in response to SVRs, students substitute away from larger vaping devices ("tanks") and toward smaller vaping devices (e.g., disposable vapes) that are more easily concealable and less easily detectable by school authorities. To the extent that disposable e-cigarettes tend to deliver higher and more consistent nicotine concentrations on average,[3] compared to many standard tank systems, such SVR-induced substitution may end up exposing youths who continue to vape to higher levels of nicotine and a higher risk of nicotine dependence.

Second, we find evidence of place-based substitution within-schools, where ENDS users are more likely to be seen by fellow students vaping in bathrooms or locker rooms rather than in hallways, cafeterias, or outdoors. This may be because locations such as bathrooms are more private and may help teen vapers to avoid detection. Additionally, teens may substitute to vaping off school property.

Finally, while SVRs alone do not appear to be effective, we do find that comprehensive school-inclusive vaping restrictions — that is, campus-wide SVRs that are also accompanied by indoor vaping bans at workplaces, restaurants or drinking establishments — have a negative impact on youth vaping. Difference-in-difference-in-differences (DDD) estimates from the PATH show that comprehensive vaping restrictions are associated with a 1.0-2.6 percentage-point reduction in youth relative to young adult prior-month nicotine vaping. Importantly, workplace and restaurant vaping restrictions by themselves have no effect on youth vaping, so the interactive effect of SVRs and workplace/restaurant restrictions is consistent with the hypothesis that broad place-based restrictions reduce available options for teen ENDS use. Finally, analysis of longitudinal data shows that changes in the trajectory of youth vaping caused by comprehensive vaping restrictions may persist into young adulthood, and no evidence that such statutes induce substitution toward more unhealthy combustible cigarettes.

[3] The average nicotine strength of disposable vapes has increased substantially, almost tripling over 2017-2022, and has exceeded that of prefilled pod-type devices since 2020 (Diaz et al. 2025; Wang et al. 2023).

2. Background

2.1 ENDS and Tobacco-Related Public Health

The introduction of electronic nicotine delivery system (ENDS) products to the U.S. tobacco market from China in 2006-2007 brought with it the potential for both tobacco-related health benefits and challenges. On the one hand, if in response to increased access to ENDS, traditional cigarette smokers substitute, in whole or in part, to ENDS, there are likely to be important tobacco-related public health benefits because e-cigarettes contain lower levels and numbers of toxicants than traditional cigarettes (National Academies of Sciences, Engineering and Medicine 2018; McNeill et al., 2018). Cigarette smoking is the leading cause of preventable death among U.S. adults, responsible for nearly 500,000 deaths per year as well as increased risk of a myriad of cancers, heart disease, severe respiratory ailments, and stroke (U.S. Surgeon General, 2014). On the other hand, ENDS use is not harmless; nicotine vaping carries an elevated risk of respiratory and cardiovascular disease (Xie et al., 2020; Wold et al., 2022), including for those exposed to secondhand e-cigarette aerosol (Cui et al., 2024). Moreover, many tobacco control advocates worry that the availability of ENDS products, particularly flavored ENDS, may lure teenagers onto a long-term path of nicotine addiction and eventually smoking (Helgertz and Kingsbury, 2023). Thus, some policy strategists argue for a nuanced strategy of (1) providing access to ENDS as a "reduced risk product" for adult cigarette smokers (or likely cigarette smokers), but (2) not providing ENDS access to teens who would have otherwise abstained from all tobacco products or for whom cigarettes and e-cigarettes are complements.

2.2. Potential Harm of ENDS Use

Concern over high rates of ENDS use among teens is particularly acute for several reasons. First, because ENDS products are relatively new, their long-term health impacts remain unknown. Early exposure to ENDS byproducts — such as nicotine and aerosolized substances, including fine particulate matter (PM2.5) and heavy metals — may lead to cumulative health risks that are not yet fully understood (Grana et al., 2014, Qasim et al., 2017). Second, youths' prefrontal cortexes, which serve memory, executive functioning, attention, and emotion regulation are not fully developed (Goriounova and Mansvelder 2012). This diminished brain functioning may impede rational decision-making as well as lead teens to hyperbolically discount the future health costs of current ENDS use (Van den Bos et al., 2015).

Additionally, nicotine is a neurotoxin that disrupts maturation of their dopamine and serotonin systems. This disruption can lead to cognitive impairment, emotional disorders, and a heightened vulnerability to addiction among youths (Yuan et al., 2015). Moreover, studies have linked youth nicotine consumption with cognitive decline (Dai et al., 2022) including difficulties with concentration and task focus, as well as increased impulsive behavior in adulthood (England et al., 2017). Finally, tobacco control advocates claim that sellers may be targeting teens for nicotine addiction via the marketing of ENDS products (U.S. Surgeon General, 2016; Helgertz and Kingsbury, 2023) as well as the availability of "child-friendly" flavors (e.g., fruit, candy, or cocktail flavors) (Birdsey, 2023), each of which could, in theory, lure teenagers down a path of nicotine addiction (Cotti et al., 2025a).

2.3 Regulatory Environment for ENDS and Youth

As discussed above, in response to rising ENDS use rates between 2011 and 2019, local, state, and federal lawmakers undertook several legislative strategies to curb nicotine vaping, particularly among teenagers. Such interventions have included minimum legal sales age laws (Friedman et al., 2019; Friedman and Wu 2020; Hansen et al., 2023), restrictions on the sales of flavored ENDS products (Cotti et al., 2025a; Saffer et al., 2025), online sales delivery bans (Aksu et al., 2025), e-cigarette licensure laws (Courtemanche et al., 2024), and e-cigarette taxation (Allcott and Rafkin, 2022; Cotti et al., 2022; Abouk et al., 2023; Chuo et al., 2025; Courtemanche et al., 2025; Dave et al. 2025a; Dave et al., forthcoming).

In the main, these studies have found that e-cigarette taxation, minimum legal sales age laws, and restrictions on the sale of flavored e-cigarettes are more effective anti-vaping strategies than licensure laws or online sales delivery bans. However, there is also evidence that policies reducing vaping can have unintended consequences, with some measures encouraging substitution toward cigarette smoking. Studies find that higher ENDS taxes, flavor bans, and tobacco-21 laws can lead some users to switch to combustible products (Dave et al., 2019; Friedman and Pesko, 2022; Abouk et al., 2023; Pesko et al., 2023; Cotti et al., 2025a). In contrast, indoor vaping bans are typically implemented in places where smoking is already prohibited and thus may not carry the same unintended consequences.

2.4 Secondhand Cigarette Smoke and Secondhand E-Cigarette Aerosol Exposure

Exposure to secondhand smoke (SHS) from combustible cigarettes is a major public health hazard with well-documented adverse health effects. Globally, SHS is responsible for an estimated 1.22 million premature deaths annually (Stanaway et al., 2018). Burning cigarettes release smoke that contains carcinogens and toxicants, which are involuntarily inhaled by bystanders, leading to cellular injury and subsequent disease. Such exposure contributes to the development of cancer, cardiovascular disease, and a range of other conditions, including type 2 diabetes, asthma, chronic obstructive pulmonary disease, and lower respiratory infections (Öberg et al., 2011; Flor et al., 2024). Estimates suggest that for every 31 adult smokers observed over a 24-year period, one additional death can be attributed to SHS exposure. A substantial proportion of this excess mortality and the associated health burden fall disproportionately on children, who are more vulnerable to disease (Yousuf et al., 2020). Furthermore, smoke from combustible cigarettes constitutes a persistent source of environmental contamination and contributes to third-hand smoke exposure. Following indoor smoking, numerous smoke-derived chemicals deposit onto surfaces, undergo subsequent chemical transformations, and pose significant health risks to individuals who come into contact with them (Jacob III et al., 2017).

Secondhand exposure to vaping aerosol is regarded as less harmful than exposure to secondhand combustible tobacco smoke (Fernández et al., 2015). This distinction arises because vape emissions contain fewer toxicants than those produced through the combustion of tobacco. Although e-cigarettes release nicotine, the concentrations are approximately tenfold lower than those emitted by combustible cigarettes. This difference is of public health relevance; for instance, cotinine concentrations, a biomarker of nicotine exposure, were observed to be six times higher among adolescents residing in households with exposure to secondhand smoke (SHS) compared with those exposed to secondhand aerosol (Czogala et al., 2014). Comparable patterns have also been reported among younger children (Tattan-Birch et al., 2024).

Nonetheless, growing evidence suggests that emissions from electronic nicotine delivery systems (ENDS) are not harmless to bystanders (U.S. Surgeon General, 2016). These include exposure to nicotine and fine particulate matter ($PM_{2.5}$), which can harm vulnerable groups such as children and pregnant women. Biomarker studies confirm nicotine absorption in non-users (Czogala et al., 2014; Tattan-Birch et al., 2024). Although ENDS aerosols contain lower toxicant levels than cigarette smoke, concentrations can still exceed WHO air quality guidelines in enclosed spaces (Fernández et al., 2016). Such exposures have been associated with respiratory symptoms, impaired lung function, and increased cardiovascular risk, highlighting potential health consequences for non-smokers, particularly among sensitive populations.

Thus, secondhand exposure to e-cigarette aerosol is not harmless, particularly in poorly ventilated environments (Cui et al., 2024). For example, youth with asthma who are exposed to ENDS aerosols are more likely to experience asthma attacks (Bayly et al., 2019). In addition, exposure to secondhand nicotine vape has been linked to increased risks of bronchitis symptoms and shortness of breath among young adults (Islam et al., 2022). This is especially worrying given that school bathrooms, typically small, enclosed spaces, are a common location for youth vaping (Ramamurthi et al., 2019).

2.5. Clean Indoor Air Laws for Smoking

Starting in the 1970s, states and localities began adopting clean indoor air laws, which ban smoking in public and private buildings. The primary objective of these laws is to protect non-smokers from involuntary exposure to harmful pollutants emitted by combustible tobacco products, and secondarily at lowering overall smoking rates (Eriksen and Cerak, 2008). These policies differ in scope, ranging from partial restrictions (e.g., in workplaces) to comprehensive bans encompassing schools, workplaces, bars, and restaurants.

Evans et al. (1999) exploit the staggered rollout of workplace smoking bans across states and over time and, using data from the 1991 and 1993 National Health Interview Surveys (NHIS) and supplements to the Current Population Survey (CPS) and a two-way fixed effects approach, find that adoption of these laws is associated with a 5-6 percentage point reduction in smoking prevalence. On the other hand, Adda and Cornaglia (2010) study the effect of comprehensive smoke free laws that extend to workplaces, bars, and restaurants. Using a BRFSS sample spanning the period 1984-2006 and using a difference-in-differences design that leverages variation in the share of the state population covered by "100% smoke-free laws." They find no evidence of a significant reduction in smoking prevalence attributable to these bans. Instead, their results point to an unintended displacement of smoking from public to private homes. Moreover, using biological markers that capture exposure to secondhand tobacco smoke among non-smokers (cotinine levels), Adda and Cornaglia (2010) find that comprehensive smoking bans increased cotinine levels among children under age 12 residing with smokers.

Carton et al. (2016) revisit Adda and Cornaglia (2010) and use data from the BRFSS over a longer window, 1996-2010. Using a two-way fixed effects approach, they find that comprehensive indoor smoking bans reduce smoking prevalence by 2 to 3 percentage points (or about 11 to 15 percent reduction relative to the mean), with the largest impact observed among young adults and low-income individuals, with the largest effects in jurisdictions where smoking bans extend to bars.

McGeary et al. (2020) employ a difference-in-differences approach using data on 86 million U.S. births from 1990-2012 to examine the impact of comprehensive smoking bans on birth outcomes. They find that clean indoor air laws increase birth weight by approximately 13–18 grams, and the probability of low-birth weight by 0.2 percentage points. Moreover, using data from the 1998-2013 National Health Interview Survey, they find that clean indoor air laws reduce the probability of in-home smoking, suggesting *positive spillover effects* of public smoking restrictions.

Adams and Cotti (2008) study narrower indoor smoking restrictions and, using data from the U.S. Fatality Analysis Reporting System (FARS), find that the adoption of restaurant/bar smoking bans led smokers to cross-state borders to avoid the new law, increasing alcohol-related traffic fatalities by 13 percent.

While most of the existing literature on the effects of clean indoor air laws focuses primarily on adults, two studies of which we are aware study the impact of school smoking bans on youth combustible cigarette use. Exploiting the staggered implementation of school-wide smoking prohibitions across German states, Pfeifer et al. (2020) find that birth cohorts attending school during the reform experienced significant reductions in both smoking prevalence (extensive margin) and intensity, with cigarette consumption declining by approximately 19–25 percent.

In contrast, evaluations of Tobacco-Free School Laws in the United States provide limited evidence of effectiveness in curbing youth smoking. Using a difference-in-differences approach and data from the 1991–2011 YRBSS, Bhatt and Hinrichs (2017) analyze the staggered adoption of school-based smoking bans across states. Their results indicate small, statistically insignificant increases in smoking, suggesting that the reforms were largely ineffective. These null effects may be explained by weak enforcement of the bans during the study period.

2.6 School Vaping Restrictions

The U.S. federal government imposed restrictions on smoking in educational settings as part of the Pro-Children Act of 1994, which prohibits indoor smoking in facilities that serve children, including in elementary and secondary schools.[4] However, because this 1994 law predates the

[4] In the 1980s, the regulatory environment around smoking in schools was still developing, with most measures aimed primarily at restricting student smoking. However, total campus-wide bans were relatively rare, and it remained common

emergence of e-cigarettes, the policy does not explicitly address ENDS or other vaping products; that is, the statute has not been amended to reflect changes in tobacco product technology.

Beginning in 2010, states began implementing K-12 school vaping bans to restrict the use of ENDS products in K-12 buildings and on school grounds. Most often, these laws expand the legal definition of "smoking" to include vaping devices, provide clear definitions of what constitutes an ENDS device, specify the prohibition of nicotine vaping indoors and on campus, and establish penalties for violations.

As of December 2024, 40 states and the District of Columbia (D.C.) had adopted statutes that prohibited ENDS use in elementary and secondary school buildings and 27 states restricted nicotine vaping campus-wide, including outdoors (e.g., parking lots, sports fields, campus green spaces) on K-12 school campuses. In the main, these latter statutes apply to anyone on a campus, including students, school personnel, and visitors.[5]

Violations of school vaping restrictions could result in small monetary fines, with some states imposing harsher penalties. For instance, students who are found to violate school vaping restrictions in Florida may be required to complete an anti-vaping program or community service.[6] In Nebraska, a minor's violation of a school vaping restriction is classified as a misdemeanor,[7] with penalties applied directly to students. In practice, however, vaping restrictions are generally enforced by school staff, who are responsible for monitoring and identifying students using e-cigarettes on school grounds. Tanz et al. (2023) surveyed high school personnel in North Carolina and found that, to enforce campus-wide nicotine vaping bans, staff typically patrolled hallways and bathrooms. When a student was caught vaping on school property, the incident was referred to the principal's office, where an administrator would usually confiscate the device, notify the parents, and assign either in-school or out-of-school suspension.

Enforcing anti-vaping policies presents significant challenges due to the rise of "stealth vaping" (Yingst et al., 2019). Unlike combustible cigarettes, which had a standardized and recognizable appearance, ENDS are often designed to resemble everyday objects such as USB sticks, pens, and key fobs, making them difficult for teachers to detect. Compared to earlier, bulkier

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for faculty and staff to smoke inside school buildings. Source: https://www.cdc.gov/Mmwr/preview/mmwrhtml/00001371.htm

[5] The majority of the 27 states that have adopted a campus-wide school vaping restriction ban nicotine vaping at all times, including after classes are dismissed, nights, and weekend (e.g. Montana, Utah). Others, however, limit vaping during school hours or school-sponsored events (e.g., Missouri, Texas).

[6] https://www.flsenate.gov/laws/statutes/2018/877.112

[7] https://nebraskalegislature.gov/laws/statutes.php?statute=28-1418

vape devices, newer models are compact, easier to conceal, and produce less visible vapor. When combined with techniques like deep inhalation and exhaling into clothing, these features enable students to vape discreetly within school settings (Ramamurthi et al., 2019). School staff noted that the discreet appearance and the discreet vapor that those products produce (Schillo et al., 2020, Jongenelis and Robinson, 2023) make enforcement challenging.

Studies on the effect of K–12 school vaping restrictions have generally appeared in the public health literature, often relying on cross-school variation in vaping policies for identification (Kostuch et al., 2024). One exception is Milicic et al. (2018), who evaluate the impact of school-level e-cigarette prohibitions on student vaping behavior using data from 69 secondary schools in Ontario, Canada between 2013 and 2016. While the authors do not include school fixed effects in their regression (which would have allowed for a difference-in-differences analysis), Milicic et al. (2018) find that schools adopting bans on e-cigarette use at schools experienced a 32 percent reduction in the odds of past-30-day e-cigarette use.

2.7 Non-School Indoor Vaping Restrictions

Much of the empirical research on place-based vaping restrictions has focused on the effects of indoor vaping bans in restaurants, bars, and workplaces on adult tobacco use. Using a two-way fixed effects (TWFE) approach, Yang et al. (2022) find that indoor vaping bans in workplaces, restaurants, and bars had little impact on adult e-cigarette use. Using a similar approach, while also accounting for county-level policy variation, Cheng et al. (2023) also find that indoor vaping restrictions had little impact on adult ENDS use.

Friedman et al. (2021) use data from the National Health Interview Survey (NHIS) covering the 2014–2018 period and find that, while clean indoor air laws reduced both cigarette and ENDS use, adding vaping restrictions to existing statutes did not further reduce vaping and may have weakened the benefits of smoking bans. Consistent with Friedman et al. (2021), Nguyen and Bornstein (2021) find that the adoption of public and workplace vaping bans across Canadian provinces had no effect on adult ENDS use. Together, these studies suggest that restaurant and workplace-focused vaping restrictions have limited impact on adult vaping behavior.[8]

[8] There is some evidence of unintended effects of indoor vaping bans on smoking behavior among pregnant women. Cooper and Pesko (2017) find that comprehensive indoor vaping bans increased prenatal smoking rates in affected U.S. counties.

Two studies examine the effect of state policies that prohibit indoor vaping at workplaces, restaurants, and bars on youth electronic nicotine delivery systems (ENDS) use. Vuolo et al. (2024) found that adolescents (ages 13–18) living in states with such bans saw 18 percent lower odds of initiating nicotine vaping. Similarly, using two waves of Youth Risk Behavior Surveillance System (YRBSS) data, Choi et al. (2022) find that clean indoor air laws (which ban indoor smoking in workplaces, restaurants, and bars), when extended to include ENDS use, were associated with a 23 percentage-point reduction in the likelihood that youth had ever used ENDS.

2.8 Contributions

This study makes several novel contributions. We are the first to estimate the effect of SVRs on youth ENDS use, with careful attention to heterogeneity in state SVRs (e.g., school indoor vaping restrictions, campus-wide SVRs, and campus-wide SVRs coupled with other place-based indoor vaping restrictions). Second, we are the first to apply dynamic difference-in-differences estimators, including those that allow for heterogeneous and dynamic treatment effects, to test for the parallel trends assumption underlying our estimates as well as to explore how treatment effects evolve over time. Finally, this study is the first to empirically explore mechanisms through which SVRs impact youth ENDS use, including substitution across vaping locations as well as substitution across vaping devices that vary in their degree of concealability and likelihood of detection by school staff.

3. Data

3.1 Youth Risk Behavior Surveillance System Survey

Our principal analysis uses data from the State Youth Risk Behavior Surveillance System (YRBSS) survey. The State YRBSS surveys are biennial in nature and cover students attending 9th through 12th grades (high school) in the United States. These surveys are collected by State Departments of Education and Health and Human Services and coordinated by the Centers for Disease Control and Prevention (CDC). When weighted by CDC-provided sample weights, each state survey is designed to be representative of each state's population of high school students. In addition, applying sample weights generated from the state-by-year population data from the Surveillance, Epidemiology, and End Results (SEER) Program, the pooled sample of states can be made nationally representative of high school-aged students aged 14-18 years.

In addition, because the State YRBSS survey is an unbalanced panel of states and years and we wish to maximize identifying variation for our policy variable of interest (SVR), we further experiment by augmenting the State YRBSS with data from the national YRBSS survey, which includes state-years that are not available in the state YRBSS survey. For the combined YRBSS, we construct sample weights designed to make the joint sample representative of 14-18-year-olds at the state and national levels following Abouk et al. (2023), Cotti et al. (2025b), and Courtemanche et al. (2025).[9]

The State YRBSS surveys introduced questions related to youth nicotine vaping in 2015, allowing us to utilize the 2015-2023 period to study the effect of SVRs on youth nicotine vaping. To measure youth ENDS use, we use responses to the following YRBSS questionnaire item:

> "During the past 30 days, on how many days did you use an electronic vapor product?" [Examples: electronic vapor product includes e-cigarettes, vapes, vape pens, e-cigars, e-hookahs, hookah pens, and mods (such as Juul, SMOK, Suorin, Vuse, and blu)]

Current ENDS Use is set equal to 1 if the respondent reports vaping nicotine on at least one of the prior 30 days; it is set equal to 0 otherwise. In addition, we also measure more habitual or addictive e-cigarette consumption. *Frequent ENDS Use* is set equal to 1 if the respondent reports vaping nicotine on at least 20 of the prior 30 days; it is set equal to zero otherwise. In our State YRBSS (Combined YRBSS) sample, 18.7 percent (19.8 percent) of youths report current ENDS use in the past 30 days and 5.3 percent (6.0 percent) report frequent ENDS use. Panel (a) in Appendix Figure 1 documents trends in youth ENDS use. Prior-month and habitual youth ENDS use rose to a peak in 2019, reflecting the rapid expansion of Juul in the U.S. e-cigarette market. Since 2019, youth ENDS use has rapidly declined.

[9] Adjusted population weights for the Combined YRBSS are generated from the Surveillance Epidemiology and End Results Program (http://seer.cancer.gov/popdata/). We calculate the state-by-year share of the youth population that falls in each age-by-gender-by-race/ethnicity bin i, s_{ist} (age 12-14, age 15, age 16, age 17, age 18, male, female, non-Hispanic White, non-Hispanic Black, Hispanic, and other race/ethnicity). We then calculate each respondent's sample weight as $[s_{ist}/n_{ist}]$*StatePop14_18$_{st}$, where n_{ist} is the number of YRBSS sampled individuals in age-by-gender-by-race-ethnicity bin i in state s at year t and StatePop14_18$_{st}$ is the SEER estimated population of 14-to-18-year-olds in state s at year t. In this construction, we are following the recent literature that applies similar SEER-constructed weights in analyses of the combined YRBSS data (Sabia and Anderson, 2016; Anderson et al., 2021; Hansen et al., 2023).

In addition to ENDS use, which is our primary outcome of interest, we also measure combustible cigarette smoking among youths, as it could be affected via general equilibrium effects. Respondents to the YRBSS are asked:

"During the past 30 days, on how many days did you smoke cigarettes?"

Current Cigarette Smoking is set equal to one if the respondent reports prior-month cigarette smoking on at least one day in the prior 30 days and 0 otherwise. *Frequent Cigarette Smoking* is set equal to 1 if the respondent reports smoking on at least 20 of the prior 30 days and is set equal to zero otherwise. We find that 6.1 percent of youths in the State YRBSS report cigarette smoking in the prior 30 days and 1.4 percent report frequent smoking. Panel (b) in Appendix Figure 1 shows that prior-month cigarette smoking among youth has decreased from 10.1 percent in 2015 to 3.3 percent in 2023.

3.2 Monitoring the Future

We next turn to the Monitoring the Future (MTF) Main study. The MTF is a school-based nationally representative survey of middle and high school students attending 8th, 10th, and 12th grades. Funded via the National Institute on Drug Abuse and administered by the University of Michigan Survey Research Center, the survey began in 1975 and is designed to provide information on health and health behaviors of youth, with particular attention to substance use. Approximately 1-2 weeks prior to the survey's administration, students are informed of the dates of the survey and parents are given an opportunity to decline their child's participation if they wish. We make use of the restricted-use MTF data, which include state-identifiers, necessary for merging in information on state online ENDS sales restrictions, macroeconomic and COVID-19 controls, and other relevant ENDS and combustible tobacco policies.

Questions on nicotine vaping were added to the MTF Main study in 2014; therefore, our MTF analysis sample covers the 2014-2023 waves. Respondents to the MTF are asked:

"On how many days (if any) during the last 30 days have you vaped nicotine?"

If a youth reports having vaped nicotine on at least one of the prior 30 days, *Current ENDS Use* is set equal to 1; it is set to 0 otherwise. Among the full sample of 8th-12th grade respondents, 13.7 percent reported prior-month nicotine vaping. For high school students attending grades 10 and 12, 16.3 percent reported prior-month nicotine vaping and for 12th graders this number was 18.1 percent. In addition, we also measure the more intensive margin of ENDS use with the outcome variable *Frequent ENDS Use*, which is set equal to 1 if respondents report ENDS use on at least 20 of the prior 30 days; it is set equal to 0 otherwise. This outcome is designed to capture more habitual ENDS use, perhaps reflecting a higher degree of nicotine addiction. We find that 4.0 percent of MTF respondents reported frequent ENDS use in the prior month. Panel (a) in Appendix Figure 1 shows trends in current and frequent youth ENDS use in the MTF. Consistent with the YRBSS, we find that youth ENDS use peaked in 2019 and has declined since.

In addition, an important advantage of the MTF is that beginning in the year 2019, respondents are asked whether they vaped on school property[10]:

"During the last 30 days have you vaped nicotine on school grounds during school hours?"

School Property ENDS Use is set equal to 1 if the respondent reports having vaped nicotine on school property in the last 30 days; it is set equal to 0 otherwise. We find that 3.0 percent of all respondents report using ENDS products on school property; among current ENDS users, this number is 25.7 percent.

Finally, we generate measures of smoking using responses to the following MTF questionnaire item:

"How frequently have you smoked cigarettes during the past 30 days?"

Current Cigarette Smoking is set equal to 1 if the respondent reports prior-month cigarette smoking on at least one day in the past 30 days; it is set equal to 0 otherwise. *Heavier Cigarette Smoking* is set equal to 1 if the respondent reports smoking "about half-pack per day" or more in the past 30 days.[11]

3.3 Population Assessment of Tobacco and Health

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[10] In 2019-2021, the survey asks whether respondents used Juul on school property, and in 2021 and later, whether they vaped on school property. We combine these responses into a single variable to capture variation in the adoption of comprehensive vaping restrictions.

[11] Note that the MTF data do not include information on the frequency of smoking, which precludes us from defining a corollary "frequent cigarette smoking" measure, as with the YRBSS, capturing cigarette use on at least 20 of the prior 30 days.

To augment our analyses of repeated cross-sectional data on youths, we turn to a nationally representative individual-level panel dataset, the Population Assessment of Tobacco and Health (PATH). The PATH is a longitudinal survey that began in 2013 and was a joint effort of the National Institutes of Health (NIH) and the Food and Drug Administration (FDA), the latter of which has regulatory authority over tobacco products, including ENDS. We make use of waves 1 through 7 of the PATH data, which includes both original and "replenishment" samples of youths. Our focus is on high-school aged students aged 14-17, though below we describe how we also extend the analysis to adults aged 20-34 who were either (1) affected by K-12 school vaping restrictions as teenagers (to study longer-run effects), or (2) born in birth cohorts such that they were not directly exposed to SVRs, and could serve as a pseudo-falsification test. We note, however, that some young adults could be affected by K-12 school vaping restrictions because they were employed as K-12 teachers or staff members, or were the older siblings, parents, or other householders of affected teens. In auxiliary analysis below, we evaluate this possibility.

The longitudinal PATH data have included questions on nicotine vaping since the inception of the survey in 2013 through our latest wave surveyed in 2023. Thus, our analyses with the PATH span the full 2013-2023 period. While our samples are smaller than the above-mentioned surveys (N^{PATH} = 65,415 versus $N^{State\ YRBSS}$ = 735,109 and N^{MTF} = 198,221), the PATH data offer valuable advantages. First, because the survey follows the same individuals over time, we can (1) control for individual fixed effects to more fully capture unmeasured heterogeneity (i.e., because each person is her/his own control, and (2) estimate discrete-time hazard models that allow for separately estimating the effects of SVRs on dynamic transitions into vaping initiation (among baseline non-ENDS users) and into vaping cessation (among baseline ENDS users). Second, the PATH includes information on potential mechanisms that may further contextualize the effect of SVRs on youth ENDS use, including (1) the type of vaping devices youths use, some of which are more easily concealed than others (e.g., smaller disposable vapes versus larger pre-filled "tanks"); and (2) the locations in schools where students have been observed vaping by classmates (e.g., bathrooms, locker rooms, hallways, classrooms).

With respect to our main outcome, *Current ENDS Use*, respondents are asked:

"In the past 30 days, on how many days did you use an electronic nicotine product?"

If a youth reports ENDS use on "some" or "all" of the last 30 days, *Current ENDS Use* is set equal to 1; it is set equal to 0 otherwise. Our measure of more habitual use, *Frequent ENDS Use*, is set equal to one if the respondent reports nicotine vaping on at least 20 of the last 30 days; it is set equal to zero otherwise. In the PATH, 7.3 (1.8) percent of 14-17-year-olds report current (frequent) ENDS use. Panel (a) in Appendix Figure 3 shows trends in nicotine vaping in the PATH with a pattern generally similar to that observed in the YRBSS and MTF.

With respect to mechanisms, the PATH survey includes information on the type of electronic nicotine delivery system (ENDS) used, which may shed light on whether certain devices are more difficult for school staff and teachers to detect. Specifically, in the survey waves 2 through 7, current ENDS users are asked[12]:

> "[Do you use an] electronic nicotine product…device with a tank that you refill with liquids?"

Refillable Tank is set equal to 1 if the respondent reports use of a vaping device with a refillable tank; it is set equal to 0 otherwise. We find that 2.6 percent of all teens and 36.1 percent of current vapers report currently using a refillable tank. Among ever vapers, 13.1 percent have used a refillable tank. In the wave 6 and 7 surveys, teenage respondents to the PATH who are ever ENDS users are also asked:

> "[Do you use an] electronic nicotine product…[that is] a disposable device?"

Disposable Vape Device is set equal to 1 if the respondent reports prior-month ENDS use with a disposable device; it is set equal to 0 otherwise. We find that 3.5 percent of teens and 40.7 percent of current vapers report using a disposable vape device. Among ever vapers, 43.1 percent report having used a disposable device.

In waves 6 and 7, respondents are asked about school-locations where they observed nicotine vaping in school:

[12] In waves 6 and 7, this question is asked of respondents who have ever used ENDS, but we code the variable as 0 for non-current users to maintain consistency across waves.

> "In the past 30 days, did you see anyone using e-cigarettes or other electronic nicotine products in or around schools: (a) No, (b) Inside a school bathroom or locker room (c) Inside a classroom, (d) Some other area of the school, such as the hallway or cafeteria, (e) Outside of the school, such as in the parking lot, sidewalk, or other school grounds, (f) Somewhere else at school not listed here."

Bathroom or Locker Room Vaping is set equal to 1 if the respondent reported seeing ENDS use inside a school bathroom or locker room in the past 30 days; it is set equal to 0 otherwise. *Other School Vaping* is set equal to 1 if teens report seeing individuals vaping in any of these school locations (and not bathrooms or locker rooms); it is set equal to 0 otherwise. We find that 44.0 percent of 14-17-year-olds report seeing ENDS use in a school bathroom or locker room while 8.7 percent report seeing ENDS use in another location on school property.

Another mechanism through which SVRs could affect youth ENDS use is through impacting health perceptions. Respondents are asked the following questions:

> "How harmful do you think e-cigarettes or other electronic nicotine products are to health? (a) Not at all harmful, (b) Slightly harmful, (c) Somewhat harmful, (d) Very harmful, (e) Extremely harmful."

Very Harmful is set equal to 1 if the respondent reported very harmful or extremely harmful; it is set equal to 0 otherwise. We find that 78.7 percent of teens believe that e-cigarettes are very harmful or extremely harmful. In addition, the PATH allows us to measure relative health risks of e-cigarettes and combustible cigarettes:

> "Do you think using e-cigarettes or other electronic nicotine products is less harmful, about the same, or more harmful than smoking cigarettes?"

Relatively Harmful is set equal to 1 if the respondent reported about the same or more harmful; it is set equal to 0 otherwise. We find that 70.8 percent of teens believe that e-cigarettes are about the same or more harmful than combustible cigarettes.

Finally, we measure combustible cigarette smoking using responses to this survey item:

"In the past 30 days, on how many days did you smoke cigarettes?"

Current Cigarette Smoking is set equal to 1 if the respondent reports prior-month cigarette smoking on at least one day in the past 30 days; it is set equal to 0 otherwise. *Frequent Cigarette Smoking* is set equal to 1 if the respondent reports smoking on at least 20 of the prior 30 days and is set equal to zero otherwise. We find that 3.7 percent and 1.0 percent of 14-17-year-olds are current and frequent cigarette smokers, respectively.

3.4 Adults: PATH, Behavioral Risk Factor Surveillance System (BRFSS) Survey, Current Population Survey-Tobacco Use Supplements (CPS-TUS)

Finally, we examine the effects of SVRs on young adults aged 20-34: (1) to hold our research design up to a pseudo-placebo test, as K-12 school vaping restrictions should have a much smaller effect on adults who were not exposed to SVRs as youths (perhaps on K-12 school employees), and (2) to explore the effects of SVRs on ENDS use among adults who were exposed to this policy as youths.

In the PATH, we focus on young adults aged 20-34 and then focus specifically on 20-34-year-olds who were not previously exposed to SVRs as youths, as well as those who were previously exposed (to test for longer-run effects on ENDS use trajectories).

We complement this analysis with two additional nationally representative surveys that include information on adults' past-month ENDS use: (1) the 2016–2023 Behavioral Risk Factor Surveillance System (BRFSS), a nationally representative telephone survey conducted by the Centers for Disease Control and Prevention that collects information on the health and health behaviors of adults aged 18 and older, and (2) the 2014-2023 Current Population Survey-Tobacco Use Supplements (CPS-TUS), a nationally representative survey that includes information on adults' use of tobacco products, including ENDS. We use the latter dataset because there is occupational information that enables us to identify individuals employed in the educational sector, including those working in settings covered by the legislation (i.e., K–12 schools). That is, we are able to explore whether SVRs are binding for adults who work in schools.

For PATH, we use the adult survey and rely on the same questionnaire items that were asked of youths. Using the same coding of outcomes described above for PATH, we find that 14.4 percent of 20-34-year-olds report prior-month ENDS use, including 22.4 percent of those who were previously exposed to an SVR as youths and 23.3 percent of those who were never exposed to these laws.[13]

In the BRFSS, 12.0 percent of all 20-34-year-olds report being current ENDS users, whereas the corresponding figure for workers in education instruction and library occupations, which in the CPS-TUS includes K–12 employees and staff members pooled with others such as primary school employees, is considerably lower, with only 2.0 percent reporting current ENDS use.[14]

3.5 School Vaping Restrictions

Our key independent variable, *SVR*, measures whether a state has adopted a K-12 school indoor vaping restriction. These laws were compiled from various sources, including the Public Health Law Center (2024) and our own review of state statutes. Between 2010 and 2023, 40 states and D.C. adopted laws that restricted the use of ENDS products indoors at elementary and secondary schools. In addition, we also measure a subset of SVRs that extend school indoor vaping bans to include the entire school campus (e.g., bans on vaping in the school parking lot, green spaces, athletic fields) (*Campus-Wide SVRs*). We find that 26 states and D.C. adopted a campus-wide SVR between 2010 and 2023. Finally, we measure comprehensive, school-inclusive vaping restrictions.[15] A total of 15 states adopted comprehensive place-based vaping restrictions; that is, the regulatory regime included campus-wide bans on nicotine vaping at K-12 buildings and outdoor grounds as well as indoors at workplaces and restaurants/drinking establishments.[16] The effective dates for these regulations are shown in Table 1, and Figure 1 visually shows the staggered adoption of these policies.

4. Empirical Approach

[13] Note that for those who previously appeared in the PATH-youth survey, we are able to measure the respondent's state of residence when they were teens. We experiment with restricting the sample to those who report a current state of residence as adults and have their state of residence as teenagers. The pattern of findings is qualitatively similar to when we assume the respondent's state of residence does not change over time.
[14] We construct a measure in both the BRFSS and CPS-TUS datasets that identifies respondents who reported using e-cigarettes either every day or on some days.
[15] Each of these states also enacted a school indoor vaping restriction.
[16] A total of 27 states and D.C. adopted indoor vaping bans at restaurants, bars, and workplaces (see Appendix Table 2) We note that every state that had an indoor vaping restriction at restaurants, bars, and workplaces also banned vaping indoors at K-12 schools. Thus, the interactive effects of school indoor vaping restrictions and other place-based indoor vaping bans cannot be distinguished from other place-based indoor vaping bans.

We capitalize on the staggered adoption of school vaping bans and variation in their scope, across states, and implement a generalized difference-in-differences (DD) research design to estimate plausibly causal effects of these place-based restrictions on e-cigarette use behaviors. As needed, we adapt our empirical set-up across the separate data structures and to explore extensions to our main research question.

4.1 Estimation with Repeated Cross-Sectional Data (YRBSS, MTF)

Using repeated cross-sectional data on youths from the 2015-2023 State YRBSS and 2014-2023 MTF (and, later, on adults from the 2016-2023 BRFSS and 2014-2023 CPS-TUS), we begin by estimating the following two-way fixed effects logistic regression models:

$$\Pr(Y_{\text{ist}} = 1) = \frac{\exp(\beta_0 + \beta_1 \text{SVR}_{st} + \boldsymbol{X_{ist}\beta_2} + \theta_s + \tau_t + \varepsilon_{ist})}{1 + \exp(\beta_0 + \beta_1 \text{SVR}_{st} + \boldsymbol{X_{ist}\beta_2} + \theta_s + \tau_t + \varepsilon_{ist})} \tag{1}$$

where Y_{ist} measures prior-month nicotine vaping for youth (or adult) i residing in state s at year-quarter t (in MTF and year-semester in YRBSS). The key right-hand side variable, SVR_{st}, is an indicator capturing whether any school vaping restriction was in effect in that state-year-quarter. The vector $\boldsymbol{X_{ist}}$ includes individual-level demographic traits (sex, age, grade and race/ethnicity for youths; sex, age, education, and race/ethnicity for adults) as well as a wide set of state-level time-varying controls for macroeconomic conditions (natural log of unemployment and poverty rate)[17], the COVID-19 pandemic (cumulative COVID-19 case rates, COVID-19 government stringency index)[18], ENDS policies (ENDS taxes per mL of e-liquid, ENDS minimum legal sales age of 18 years, ENDS licensure law, ENDS online sales restriction, and restrictions on sales of flavored ENDS), combustible tobacco policies (Tobacco-21 laws, menthol cigarette flavor bans, excise tax per pack of cigarettes in 2023 dollars; combustible tobacco licensure law, clean indoor air laws for

[17] Unemployment rates are obtained from the Bureau of Labor Statistics, and poverty rates from the University of Kentucky Poverty Research Center.
[18] Cumulative COVID-19 cases are from *The New York Times* COVID-19 repository (https://github.com/nytimes/covid-19-data), while the government-response index is from the Oxford Covid-19 Government Response Tracker (OxCGRT).

combustible cigarette smoking, and bans on the delivery of cigarettes purchased online)[19], and alcohol and marijuana policies (beer tax in $2023, recreational marijuana law, medical marijuana law, and marijuana decriminalization law).[20] In the vector $\boldsymbol{X_{ist}}$, we also control for whether a state has adopted a workplace or restaurant/drinking establishment indoor vaping ban. Finally, θ_s includes time-invariant state fixed effects and τ_t captures state-invariant year-quarter (or year-semester) fixed effects. Regressions are weighted using survey weights and standard errors are clustered at the state level to account for correlated errors (ε_{ist}) across individuals within the same state and over time (Bertrand et al., 2004). In all tables, we report marginal effects.

In alternate specifications, we explore the effect of additional, progressively more inclusive, types of school vaping restrictions, including campus-wide school indoor vaping restrictions (CWSVR_{st}):

$$\Pr(Y_{\text{ist}} = 1) = \frac{\exp(\gamma_0 + \gamma_1 \text{CWSVR}_{st} + \boldsymbol{X_{ist}\gamma_2} + \theta_s + \tau_t + \varepsilon_{ist})}{1 + \exp(\gamma_0 + \gamma_1 \text{CWSVR}_{st} + \boldsymbol{X_{ist}\gamma_2} + \theta_s + \tau_t + \varepsilon_{ist})} \qquad (2)$$

where the vector $\boldsymbol{X_{ist}}$ now includes an additional indicator for an "indoor only" SVR.

Finally, we estimate the effect of comprehensive school-inclusive vaping restrictions (CompSVR_{st}):

$$\Pr(Y_{\text{ist}} = 1) = \frac{\exp(\delta_0 + \delta_1 \text{CompSVR}_{st} + \boldsymbol{X_{ist}\delta_2} + \theta_s + \tau_t + \varepsilon_{ist})}{1 + \exp(\delta_0 + \delta_1 \text{CompSVR}_{st} + \boldsymbol{X_{ist}\delta_2} + \theta_s + \tau_t + \varepsilon_{ist})} \qquad (3)$$

where CompSVR_{st} is an indicator for whether a state has both a campus-wide school vaping restriction *and* a law banning vaping at restaurants, bars, and/or workplaces. In the vector $\boldsymbol{X_{ist}}$, we now also control for (1) campus-wide SVRs without restaurant/drinking establishment/workplace indoor bans, (2) indoor vaping bans at restaurants/drinking establishments/workplaces without

[19] ENDS taxes come from Cotti et al. (2025b). ENDS minimum legal sales age, ENDS licensure laws, combustible cigarette taxes, combustible tobacco licensure laws, and combustible tobacco smoking bans are obtained from the CDC STATE system (Centers for Disease Control and Prevention, 2024). ENDS online sales restrictions are from WestLaw sources following Aksu et al. (2025). Tobacco-21 laws are obtained from Preventing Tobacco Addiction Foundation (https://tobacco21.org). ENDS flavor, menthol flavor restrictions, and online tobacco product sales restrictions are obtained from the Public Health Law Center (2021).
[20] Marijuana laws are from Anderson et al. (2021). Beer taxes are obtained from National Institutes of Health Alcohol Policy Information System (https://alcoholpolicy.niaaa.nih.gov/apis-policy-topics/beer/30/about-this-policy) and Urban-Brookings Tax Policy Center (https://taxpolicycenter.org/statistics/state-alcohol-excise-tax-rates).

campus-wide SVRs, and (3) indoor-only school vaping restrictions, with and without indoor vaping restrictions at restaurants/drinking establishments/workplaces.

Identification of our main treatment effects (β_1, γ_1, and δ_1) from equations (1)-(3) comes from within-state variation in SVRs, as described in Table 1 and Appendix Table 1. In order for our specifications to generate unbiased estimates of our treatment effects, there must be (1) no state-specific, time-varying unobservables associated with both our key treatments of interest and with the outcomes under study, (2) no reverse causality whereby changes in youth nicotine vaping drive the adoption of school vaping restrictions, and (3) no heterogeneous and dynamic treatment effects.

We undertake several strategies to descriptively test these assumptions. First, with respect to state-specific time-varying unobservables, we explore the robustness of our estimates to the inclusion of controls for observable tobacco policy policies as well as additional controls for census region-by-year fixed effects. These controls force treatment states to have geographically proximate controls ("close controls"), which may be more similar to treated states, and also control for unmeasured census region-specific time shocks. In addition, we also experiment with controls for state-specific linear time trends to capture any unmeasured state-level unobservables that may be unfolding linearly. While these additional controls may reduce bias from unobserved heterogeneity, geographically proximate controls and the inclusion of state-specific time trends can exacerbate bias, particularly in the presence of heterogeneous and dynamic treatment effects (Meer and West, 2016; Burkhauser et al., 2025). Thus, we view these robustness checks as descriptive rather than dispositive.

Next, to descriptively test for reverse causality, as well as the common trends assumption, we conduct an event-study analysis whereby we decompose the estimated treatment effect over time:

$$\Pr(Y_{\text{ist}} = 1) = \frac{\exp(\beta_0 + \sum_{k\neq-1} \pi_k D_{st}^k + \boldsymbol{X_{ist}\beta_2} + \theta_s + \tau_t + \varepsilon_{ist})}{1 + \exp(\beta_0 + \sum_{k\neq-1} \pi_k D_{st}^k + \boldsymbol{X_{ist}\beta_2} + \theta_s + \tau_t + \varepsilon_{ist})} \tag{4}$$

where k denotes event time (years relative to a state's adoption of an SVR). D_{st}^k is set equal to 1 if state s in year-by-semester t is k years before or after adoption and is set equal to 0 otherwise, and π_k are event study coefficients on each of the leads ($k < 0$) and lags ($k \geq 0$). The reference period is 1-2 years prior to the adoption of an SVR in the YRBSS (because it is a biennial survey), and 1 year prior in the MTF. The parameters π_k denote the coefficients on the decomposed treatment effect.

If estimates of π_k for $k < 0$ in equation (3) are not statistically different from zero, this would tend to support the parallel trends assumption as well as suggest that reverse causality is not an important source of bias.

Finally, in the presence of heterogeneous and dynamic effects of SVRs, estimates of our treatment effects may be biased (Goodman-Bacon, 2021). To mitigate this possibility, we implement a stacked difference-in-differences design (Cengiz et al., 2019; Wing et al., 2024), which constructs cohort-specific comparisons and excludes inappropriate control observations. We define each cohort (treatment states and set of counterfactual states) based on the year-semester an SVR was adopted and build a cohort-specific event study window of 6 years preceding through 5 years following adoption (in the YRBSS).[21] To improve statistical power while maintaining comparability across cohorts, we follow Dube et al. (2025) and invoke an effect stabilization assumption, under which treatment effects may be dynamic in the short run but stabilize after five years, allowing additional observations from earlier-treated cohorts (more than five years after adoption) to serve as counterfactuals. We then stack our cohorts and estimate an event-study regression similar to equation (4) where we also include cohort-by-state and cohort-by-time fixed effects. If the stacked DD estimates of our treatment effects are similar in magnitude to the TWFE estimates, that consistency reduces concern that the TWFE estimator is biased by heterogeneous or dynamic treatment effects.

4.2 Estimation with Individual-Level Panel Data (PATH)

Turning to longitudinal data from the PATH, we begin by estimating an individual fixed effects model of the following form via ordinary least squares (OLS):

$$Y_{ist} = \lambda_0 + \lambda_1 \mathrm{SVR}_{st} + \boldsymbol{X_{ist}\lambda_2} + \theta_s + \tau_t + \mu_i + \varepsilon_{ist} \tag{5}$$

where μ_i are individual fixed effects. We use OLS regression in the PATH rather than logistic regression in this case because of the wide set of fixed effects we employ.

[21] In the YRBSS, we define the event study window as 6 years prior to 5 years after the introduction of school vaping restrictions. In the MTF and PATH, the window is 6 years prior to 4 years after the introduction of these restrictions.

In addition, we more fully exploit the longitudinal design of the PATH by estimating discrete-time hazard models to separately identify the effect of SVRs on vaping initiation and cessation decisions. Specifically, we estimate a discrete-time hazard model of the following form:

$$\Pr(E_{ist} = 1 \mid t-1 < T < t) = \eta_0 + \eta_1 \mathrm{SVR}_{st} + \boldsymbol{X_{ist}\eta_2} + \theta_s + \tau_t + \mu_i + \varepsilon_{ist} \qquad (6)$$

where E_{ist} indicates whether individual i experiences the event (defined as vaping initiation or cessation) between time $t-1$ and t. When studying vaping initiation, the sample is restricted to non-ENDS users at baseline, and E_{ist} is set equal to one when the youth transitions to using ENDS in period t, conditional on not using ENDS in period $t-1$; E_{ist} is set to zero otherwise. Analogously, when studying cessation behavior, the analysis sample is limited to ENDS users at baseline and E_{ist} is set equal to one if the youth cease vaping in period t conditional on being an ENDS user in period $t-1$.

5. Results

Figures 2-7 and Tables 2-13 show our main estimates. Supplemental analyses are included in the appendix. As noted above, all regressions are weighted, and standard errors are corrected for clustering at the state level (Bertrand et al., 2004).

5.1 School Indoor Vaping Restrictions and Campus-Wide School Vaping Restrictions

5.1.1 YRBSS Findings

Table 2 presents TWFE estimates of the effect of school indoor vaping restrictions on youth ENDS use using data from the 2015-2023 State YRBSS. Panel I shows estimates of the effect of any school indoor vaping restriction on current (a) and frequent (b) ENDS use among youths. Controlling for state fixed effects, year-by-semester fixed effects, and macroeconomic and COVID-19 controls, we find that the adoption of a statewide SVR is associated with a statistically insignificant 0.9 percentage-point *increase* in current ENDS use (panel Ia, column 1). The addition of controls for restaurant, drinking establishment, or workplace indoor vaping restrictions (column 2) leaves the estimate largely unchanged. Similarly, the addition of ENDS policies (ENDS taxes, ENDS MLSA laws, ENDS licensure laws, ENDS flavor restrictions, ENDS online sales restrictions) in column (3), combustible tobacco policies (cigarette taxes, indoor air laws, tobacco-21 laws, tobacco licensure laws, menthol flavor restrictions, and combustible tobacco online sales restrictions) in column (4), and substance use policies (beer taxes, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws) in column (5) has little impact on the estimated treatment effect. In our preferred specification (panel Ia, column 5), we can, with 95 percent confidence, rule out SVR-induced declines in teenage vaping of more than 3.5 percent.[22]

Turning to frequent ENDS use in panel Ib, we find little evidence that school-based indoor vaping restrictions affect the more intensive margin of youth ENDS use. The estimated treatment effects are largely positive, around 0.5 to 0.7 percentage points, and statistically indistinguishable from zero at conventional levels.

One reason for the null finding on indoor SVRs could be that teenage nicotine vapers respond to the policy by moving outside (perhaps even on school grounds). In panel II of Table 2, we turn to campus-wide SVRs, which expand the set of prohibited locations where teenagers and school staff can vape to include the school parking lot, athletic fields, green areas, and any other school property. In theory, expanding place-based restrictions will impose a higher cost on vapers (e.g., travel costs, exposure to inclement weather or cold temperatures, smaller peer group with whom to socialize while vaping), which could reduce its prevalence or intensity. However, our findings in panel II provide little support for the hypothesis that campus-wide SVRs reduce teen nicotine vaping. Across columns (1)-(5) in panel IIa, we find no evidence that campus-wide restrictions reduce current ENDS use among youths. In our preferred (fully saturated) specification in column (5), we find that campus-wide SVRs are associated with a statistically insignificant 0.58 percentage-point increase in ENDS use among youths. The precision of this estimate is such that we can rule out, with 95 percent confidence, campus-wide SVR-induced reductions of more than 5.0 percent.[23] In panel IIb, we examine the more intensive margin of ENDS use and, likewise, we find no evidence that campus-wide vaping bans reduce frequent ENDS use.

Figure 2 shows event-studies for any SVRs and campus-wide SVRs using specifications with parsimonious controls that include other vaping restrictions (column 2 of Table 2). Panel (a) shows event study coefficients using TWFE estimates while panel (b) uses stacked DD estimates. The

[22]Along the same lines, we can rule out SVR-induced increases in vaping of greater than 16.1 percent, though there is little theoretical reason to expect SVRs to result in a net increase in vaping.

[23] In the State YRBSS, 14 states identify the treatment effect on campus-wide bans, while 8 states identify the treatment effect on indoor-only SVRs. However, after controlling for indoor vaping restrictions at restaurants, bars, or workplaces, these treatment effects are identified off of 8 and 1 states, respectively. While we do not report the coefficient on indoor-only school vaping laws, our estimated treatment effects are never negative in sign and always statistically insignificant.

pattern of findings is generally consistent with the parallel trends assumption and suggests that in the post-treatment period, SVRs do little to curb youth ENDS use.

In Table 3, we explore the sensitivity of our estimates to controls for spatial heterogeneity. Column (1) reproduces column (5) in Table 2 while column (2) add census region-by-semester to the baseline specification in column (1), and column (3) augments the specification in column (1) with state-specific linear time trends. The pattern of findings continues to suggest a null effect of SVRs on youth ENDS use.

Appendix Table 3 shows estimates of the effect of SVRs on youth ENDS use in the National and State (Combined) YRBSS sample. While the treatment effects are less precisely estimated and somewhat more negative, the pattern of null findings is similar to that observed in the State YRBSS sample.

In Figure 3, we explore whether our null findings are masking important heterogeneity in the estimated treatment effects by gender, race/ethnicity, or age. Our findings provide little support for the hypothesis that SVRs are effective at reducing vaping among males, females, non-Hispanic Whites, non-Hispanic Blacks, Hispanics/Others, or younger and older teenagers.

5.1.2 PATH and MTF Findings

We next turn to longitudinal analyses of the PATH data to explore the effects of SVRs on nicotine vaping among high school-aged youth aged 14-17. Columns (1)-(3) of Table 4A report TWFE estimates similar to Table 2 with the exception that the specification includes both state and individual fixed effects. Consistent with the findings in Section 5.11, we find no evidence that the adoption of a SVR, whether indoor only (panel I) or campus-wide SVRs (panel II), reduces ENDS use among teenagers. Event study analyses, shown in panel (a) of Figure 4, support counterfactual validity and show no evidence of differential pre-adoption trends. They also provide little evidence of a causal impact of SVRs, though we do note that in the PATH, the negative coefficients get slightly larger in absolute magnitude over the longer-run, especially for campus-wide SVRs; this suggests some scope for more comprehensive and binding placed-based restrictions to have a deterrent effect in comparison to more limited bans, a point which we explore in greater detail below.

In columns (4)-(6) of Table 4A, we estimate the effect of SVR adoption on young adults aged 20-34 who were never previously exposed to SVRs as teenagers and thus constitute a relatively "clean" control group.[24] However, we recognize that the control group is imperfect given that some of these youths may have younger siblings in schools (and be indirectly affected via sibling spillovers) or be employed as K-12 school employees, which we test below. Across columns (4)-(6), we find no evidence that SVRs affect young adult vaping behavior. This pattern is also observed for all adults aged 20-34 surveyed in the BRFSS (see column 1 of Appendix Table 4). Moreover, we also find no evidence that SVRs lead to a statistically significant change in vaping behavior among employees in educational settings, such as teachers and librarians, though the marginal effect is negative and the effect size is substantial relative to the low pre-treatment vaping mean, which is generally less than 3 percent (see column 2 of Appendix Table 4).[25]

In Table 4B, we show triple-differences estimates of the effect of SVR adoption on youth relative to young adult nicotine vaping. Each of our specifications also includes state-by-year-quarter fixed effects to control any unmeasured state-level common shocks that impact young adult vapers. The pattern of DDD findings is consistent with DD and suggest little support for the hypothesis that SVRs were an effective policy to curb youth vaping behavior.[26]

In Table 5, we more explicitly exploit the longitudinal structure of the PATH to explore how SVRs impact dynamic transitions across salient margins of ENDS use. Specifically, we estimate discrete-time hazard models of initiation into ENDS use among baseline non-users (columns 1 and 2) and cessation among baseline users (columns 3 and 4).[27] We find no evidence that SVRs lead to any significant or meaningful effects on either initiation or cessation of ENDS use among youths. With respect to more comprehensive campus-wide vaping bans (Panel II), there is some suggestive evidence from the point estimates that these restrictions may deter youth initiation, on the order of about 1.0 to 1.1 percentage points, though these estimates are imprecise.

Next, we turn to the MTF data on 8th through 12th graders to widen the sample of adolescents and also examine middle school students' response to SVRs. The pattern of findings in

[24] When we have information on the state of residence while a teenager from the youth PATH survey, we use this information to determine whether the respondent was previously exposed to treatment. When such information is not available, we use information on the respondent's current state of residence.
[25] Restricting the sample to young adults working in occupations within the K-12 educational sector substantially limits the sample size and more definitive interpretations.
[26] In panels I and II of Appendix Table 5, we show DD and DDD estimates of the effect of SVRs on frequent ENDS use among youths in the PATH, mimicking our analyses in the YRBSS on the more intensive margin of use. The pattern of results continues to point to a null impact of SVRs.
[27] For adolescents, the initiation margin is more relevant, and school vaping restrictions have been expressly recommended as a policy tool to discourage new initiates (Tobacco Control Network 2022). While the cessation margin is less salient for this age group and largely reflects transitions out of experimentation or casual use, we present these estimates for comparison.

Table 6 and panel (b) of Figure 4 is consistent with the null findings we report from the YRBSS and PATH data.[28]

5.2 Mechanisms to Explain the Null Effect of SVRs

Why are SVRs ineffective at curbing net youth ENDs use? Table 7 provides some descriptive empirical evidence on this question using data from MTF and PATH. One answer may be that SVRs induce changes in the locations where students choose to vape (panel I). In columns (1) and (2) of panel I, we explore whether SVRs reduce vaping on school property. Somewhat surprisingly, we find *no evidence that SVRs reduce net vaping on school property* following the introduction of SVRs. Our findings in the next four columns suggest why. We do find that the adoption of an SVR is associated with a significant reduction in the probability that a youth observes vaping in school in more easily observed areas such as hallways, classrooms, or lunch areas (panel I, columns 3 and 4), but with an increase in the probability that a youth observes vaping in less easily monitored spaces, including school bathrooms or locker rooms (panel I, columns 5 and 6). Specifically, in our most parsimonious specifications, we find that SVR adoption is associated with a 7.9 percentage-point reduction in the probability of vaping in hallways, classrooms, lunch areas, or on outside school grounds, but a commensurate 8.5 percentage-point increase in the probability of vaping in bathrooms or locker rooms. Thus, students may be responding to SVRs by shifting their e-cigarette use to locations where monitoring and detection are less likely rather than reducing their overall consumption.

Second, with respect to vaping devices, e-cigarettes may differ in size, form, and detectability by school officials. Certain vape models — especially newer, pod-based, or disposable devices — are designed to be compact and produce minimal vapor, making them substantially more discreet and difficult to detect relative to older vape models, which include refillable "tanks" (see Appendix Figure 4 for examples of the range and evolution of e-cigarettes over time, showing a shift from bulkier, non-replaceable models to smaller, more concealable designs). If students respond to SVRs by changing the devices they use, we might expect a substitution away from larger, reusable models

[28] In Appendix Table 6, we use the PATH adult sample who were exposed to any school vaping restrictions in their youth to examine the long-term effects of the restrictions. Point estimates are suggestive of a longer-term decline in ENDS use, on the order of 1.4 to 2.1 percentage points. A persistent decline in young adulthood is consistent with the suggestive protective effect on youth initiation into first-time ENDS use, based on the discrete time hazard analyses (Table 5). We caveat these interpretations by noting, however, that both of these sets of estimates are imprecise and not statistically significant.

toward smaller and easily concealable devices. To examine this hypothesis, we turn to the PATH and estimate the relationship between school-based vaping restrictions and the types of e-cigarettes students report using.[29]

Our findings in panel II of Table 7 show that SVR adoption is associated with a 1.0 to 1.2 percentage point reduction in the probability that a youth used a refillable tank-based vaping device (columns 1 and 2) and a 1.8 to 3.9 percentage point increase in the probability that a youth used a disposable e-cigarette (columns 3 and 4). This pattern of behavior is consistent with the hypothesis that youths respond to SVRs by substituting to smaller, less visible, more easily concealable vape devices to avoid detection.

Overall, these findings suggest that rather than reducing net youth ENDS use, SVRs may primarily induce behavioral adjustments that allow students to continue vaping while evading detection. The evidence points to strategic behavioral adaptation — through both the substitution of devices and relocation of vaping activities — as a potential mechanism limiting the effectiveness of school-based vaping policies.

Finally, in Appendix Table 7, we explore how changes in perceptions of health risks associated with e-cigarette use (both absolutely and relative to combustible cigarettes) may have changed in response to SVRs. Our findings provide some support for the hypothesis that SVRs may have increased the share of teens who believed that e-cigarettes were very or extremely harmful (columns 1 and 2), as well as the share who believed that e-cigarettes are about the same or more harmful than combustible cigarettes (columns 3 and 4), though these effects are not statistically significant at conventional levels.

5.3 Effects of Comprehensive K-12 School-Inclusive and Other Place-Based Indoor Vaping Restrictions

Comprehensive vaping restrictions — that is, campus-wide K-12 school vaping restrictions that are accompanied by workplace, restaurant or drinking establishment indoor vaping restrictions — may be more effective than indoor or campus-wide SVRs since they restrict more places where students can vape and may send an even stronger health signal to teens about the dangers of nicotine vaping. In Table 8, we find little evidence that comprehensive place-based restrictions significantly affect current ENDS use among youths (columns 1-3), but there is evidence that such

[29] Again, we emphasize that the analysis reported in panel II of Table 7 should be regarded as descriptive given that we do not observe vaping device measurement consistently over the PATH sample period (as noted in Section 3).

laws reduce frequent ENDS use among youth by about 1-2 percentage-points, suggesting that the more intensive margin of ENDS use is impacted by these laws.[30,]

Importantly, we find no evidence that indoor vaping restrictions at workplaces, restaurants, or drinking establishments that are not accompanied by campus-wide school vaping restrictions impacts youth ENDS use. This pattern of findings suggests that (1) the *interaction of these policies* is important for affecting youth vaping behavior, and (2) expanding the set of places where youths cannot vape may sufficiently raise the cost of vaping to deter those on the margin of ENDS use from engaging in such behavior. It may also be that a more comprehensive set of anti-vaping laws signals to students that there are important health risks of vaping, which we will explore below.

Event study analyses of comprehensive school-inclusive vaping restrictions in Figure 5 are consistent with the parallel trends assumption and suggest that these policies reduce youth ENDS use, especially on the more intensive margin of use. Our exploration of demographic heterogeneity in Figure 6 points to a broad reduction in frequent ENDS use across demographic groups, including males and females, and among non-Hispanic Whites and others, though the protective effects are more pronounced among older (ages 16+) compared to younger teens.

Turning to the PATH data in Table 9A, we find comprehensive school-inclusive, place-based vaping restrictions are associated with a 1.6 to 1.7 percentage-point reduction in youth ENDS use (columns 1-3) but with no change in vaping among young adults aged 20-34 who were not previously treated by a comprehensive statute (columns 4-6). There is no evidence that other place-based vaping restrictions significantly impacted youth vaping behavior, and unlike the State YRBSS, there is less evidence that frequent ENDS use among youths is impacted.

Table 9B presents our preferred triple-differences (DDD) estimates in which we estimate the effect of comprehensive vaping restrictions on youth versus (untreated) young adult nicotine vaping. In leveraging never-treated young adults as an additional within-state counterfactual, these models can now include state-by-time fixed effects to control for any unmeasured state-specific temporal shocks that commonly affected youth and young adult vaping. Across specifications (columns 1-3), we find that the adoption of school-inclusive comprehensive vaping restrictions is associated with a 2.4 to 2.6 percentage-point reduction in the probability of youth vaping. When we estimate discrete-time hazard models from the PATH (Appendix Table 9), we find that much of the effect we

[30] In Appendix Table 8, we use the combined YRBSS sample and find that comprehensive SVRs are associated with a statistically significant 2-3 percentage point reduction in both current (panel I) and frequent (panel II) ENDS use. Adding controls for spatial heterogeneity does not materially affect these patterns.

observe comes from the initiation margin as the adoption of comprehensive school-inclusive school vaping restrictions is associated with an approximately two percentage-point reduction in the probability that a non-ENDS user at baseline initiates vaping.[31]

Figure 7 shows event-study analyses of comprehensive school-inclusive vaping restrictions and youth vaping, using both the MTF and PATH data and for the TWFE (panel a) as well as stacked DD estimates (panel b). The pattern of findings points to larger impacts of these statutes in the years following adoption (especially three or more years following adoption), consistent with the hypothesis that being bound by such statutes over a longer window of time (during one's high school years) may negatively impact ENDS participation.

5.4 Comprehensive Vaping Restrictions and Youth Vaping Across Affected Locations

While we do not have information on youth ENDS use in workplaces, restaurants, drinking establishments or other places outside of school, in Table 10, we endeavor to explore populations for whom we might find evidence of stronger effects of comprehensive, school-inclusive laws. Specifically, we endeavor to examine whether the effects of comprehensive laws vary with potential exposure to the locations those laws cover. For instance, we use information on employment of teenagers (aged 15 and older) in the MTF to examine whether vaping behavior falls more among those who are more likely to have workplaces to go to on a regular basis. Similarly, we also turn to the Behavioral Risk Factor Surveillance System (BRFSS) data to measure whether a teenager aged 18-19 is more likely to be eating out at restaurants frequently by measuring how often they consumed French fries in the last month. Because these measures are endogenous and could capture other hard-to-measure characteristics of youths, we view this exercise as descriptive in nature.[32] But we would expect that if comprehensive school-inclusive vaping restrictions were effective at curbing youth vaping, then the effects of these laws should be stronger among teens who report working during the school year and who frequently eat out given the broader coverage of these laws.

[31] Evidence from the MTF is somewhat weaker (Appendix Table 10 and panel (a) of Figure 7), though the estimated effects are generally negative and become larger in the years following adoption, consistent with the hypothesis that being bound by such statutes over a longer window of time (during one's high school years) may negatively impact ENDS participation.

[32] In results available upon request, we estimate the effect of comprehensive school-inclusive vaping restrictions on (1) teen employment, and (2) teens' frequently going out to restaurants (proxied by frequent French fry consumption). We can, with 95% confidence, reject the hypothesis that these laws significantly impacted either outcome.

First, in columns (1)-(2) of Table 10, we use the MTF data to document that for the analysis sample under study, comprehensive, school-based vaping restrictions are associated with an approximately 2 percentage-point reduction in nicotine vaping among teenagers ages 15 and older. Next, we explore whether ENDS use effects are larger among teenagers who report working during the school year. Our findings in columns (3)-(4) show that these negative effects are concentrated among employed youths, consistent with the hypothesis that comprehensive laws have bite at workplaces as well as schools. Moreover, in columns (5)-(6), we explore the effect of comprehensive vaping restrictions on youth vaping on school property, by employment status of the youth, and again find evidence that the largest reductions in vaping on school property occurs among working teens, who are also impacted by workplace restrictions.[33]

Finally, in columns (7)-(8), we explore whether comprehensive school-inclusive vaping restrictions have larger effects on vaping among teens who we proxy as going out to restaurants frequently (around 2.5 or more times per week) by measuring French fry consumption. Consistent with our hypothesized mechanism, we find that comprehensive vaping restrictions reduce ENDS use more among teens who are likely to dine out more often.[34] Taken together, the results in Table 10 provide suggestive evidence that comprehensive vaping restrictions have larger effects on vaping among youths who are more likely to be present at locations covered by the restrictions.[35]

5.5 Unintended Spillovers to Combustible Cigarette Smoking

Policies that limit use of e-cigarettes might also affect youths' combustible cigarette use. Prior work suggests ENDS and cigarettes are substitutes for youths (Abouk et al., 2023; Cotti et al., 2025a; Courtemanche et al., 2025). Because one perceived advantage of ENDS is indoor usability, school vaping restrictions could reduce their relative appeal. While we note that all states in the U.S. banned combustible cigarette smoking in schools and in most restaurants, bars, and workplaces at the time that SVRs and comprehensive school-inclusive vaping restrictions were adopted, such laws

[33] In Appendix Table 11, we observe a reduction in the use of refillable tank-type devices after the adoption of comprehensive restrictions, but no impact on the use of disposable e-cigarettes. Taken together, these findings point to a decrease in overall use of vaping devices, consistent with our main result that comprehensive restrictions reduce overall ENDS use. We do not find evidence that comprehensive restrictions affect assessments of the health risks of e-cigarette use.

[34] Using thresholds other than 10 for the number of days per month of French fry consumption, we find a qualitatively similar pattern of results.

[35] Appendix Table 12 presents the effects of indoor school vaping restrictions on the same set of outcomes as Table 10. We find no evidence that restrictions limited to schools, without extending to a broader set of places, generate similar differential effects by work status or frequent eating out.

could nonetheless affect the relative costs of using these products. In Table 11, we explore whether school vaping restrictions affect youth smoking. Across YRBSS, MTF, and PATH we find little evidence that indoor SVRs, campus-wide SVRs, or comprehensive school-inclusive vaping restrictions affected the probability of youth cigarette smoking.

5.6 Longer-Run Effects Comprehensive SVRs

Finally, we close in Table 12 with an evaluation of the longer-run effects of school-inclusive restrictive vaping policies on young adult ENDS use among those who were previously exposed to such policies. We use the PATH data for this exercise and, in columns (3)-(4), restrict our analysis to adults who report both their state of residence as a youth (from the PATH-youth file) and as a young adult (from the PATH adult file) to ensure that we are correctly matching the policy the adult was exposed to as a youth. In columns (1) and (2), we use a full adult sample of similarly aged adults (aged 20-30) and assume that their state of residence as an adult was identical as their state of residence as an adult. We define treatment as exposure to comprehensive school-inclusive vaping bans during their youth and control for birth cohort fixed effects (as well as contemporaneous vaping policies).

Panel I presents estimates for current ENDS use during young adulthood. We find that comprehensive vaping restrictions are associated with an approximately 1.3 to 3.7 percentage point reduction in vaping. Given potential measurement error in assigning childhood state of residence in the full sample, which would likely attenuate the estimated impact, when we restrict to the limited sample for whom we can observe the residence during both youth and young adulthood the treatment effects are invariably larger in magnitude and more precisely estimated (3.4 to 3.7 percentage point reduction). This finding suggests that the contemporaneous reductions in ENDS use associated with comprehensive vaping restrictions persist into young adulthood. The persistence of vaping abstinence is further consistent with the deterrent effects of these policies on youth initiation (Appendix Table 9). With respect to cigarette smoking (panel II), the long-run effects are uniformly negative, but never statistically distinguishable from zero at conventional levels.[36]

6. Conclusions

[36] Appendix Table 13 reports results for frequent ENDS use. We find that comprehensive restrictions also have persistent negative effects on frequent ENDS use.

Tobacco control advocates have urged the adoption of SVRs as an important policy tool to curb youth vaping. However, to date, there is very little evidence on whether banning nicotine vaping at schools is an effective anti-vaping strategy. This study is among the first to study whether these policies are effective in reducing youth e-cigarette use. Exploiting the staggered adoption of such legislation spanning the period 2013-2023, we estimate their impact using multiple national data sources using a generalized difference-in-differences approach.

Across datasets, we find no evidence that school-based ENDS bans significantly reduced youth e-cigarette use on either the extensive or intensive margins. In our main analysis using YRBS data and our preferred specification, we can rule out, with 95 percent confidence, declines in current ENDS use larger than 3.5-5 percent of the pre-treatment mean. When we explore potential mechanisms, we find suggestive evidence that points to evasion of these laws among teenagers. Specifically, SVRs displaced vaping activity away from easily detectable school locations (such as hallways, classrooms, and the cafeteria) to less easily monitored locations such as bathrooms and locker rooms. In addition, SVRs may have encouraged teenagers to use smaller, replaceable vaping devices that are easier to conceal than earlier, bulkier tank-based systems. To the extent that disposable ENDS devices have been presently found to deliver stronger concentrations of nicotine on average (Wang et al. 2023; Diaz et al. 2025), such substitution across device types may expose youth to higher levels of nicotine and heighten their risk of nicotine dependence.[37]

The presence of strong compensatory responses implies that place-based restrictions would need to be more comprehensive and binding in scope in order to limit displacement effects and impose a sufficiently high cost on vapers. When we examine comprehensive, school-inclusive vaping restrictions that, in addition to schools, also include other workplaces, bars, or restaurants, we find robust evidence across the YRBSS and PATH data sources that these laws were more effective in reducing ENDS use among youths. This result may indicate that stricter vaping restrictions, which further limit the places where youth can vape, could lead to a reduction in use. We find no evidence of substitution effects toward cigarette smoking.

Taken together, our results indicate that school-based policies aimed at prohibiting vaping may be undermined by behavioral adaptation among students. However, we also find that expansions in place-based restrictions may have important deterrent effects on youth nicotine

[37] As youth become more nicotine dependent, this also magnifies challenges for effective policy guidance since the increase in the addictive stock among current youth vapers has been found to make them less responsive to standard policy interventions such as e-cigarette taxes (Dave et al. 2025b).

vaping, including among new initiates, that extend into young adulthood. We conclude that understanding how youth adapt to regulations and policies is critical for designing more effective interventions to reduce youth vaping.

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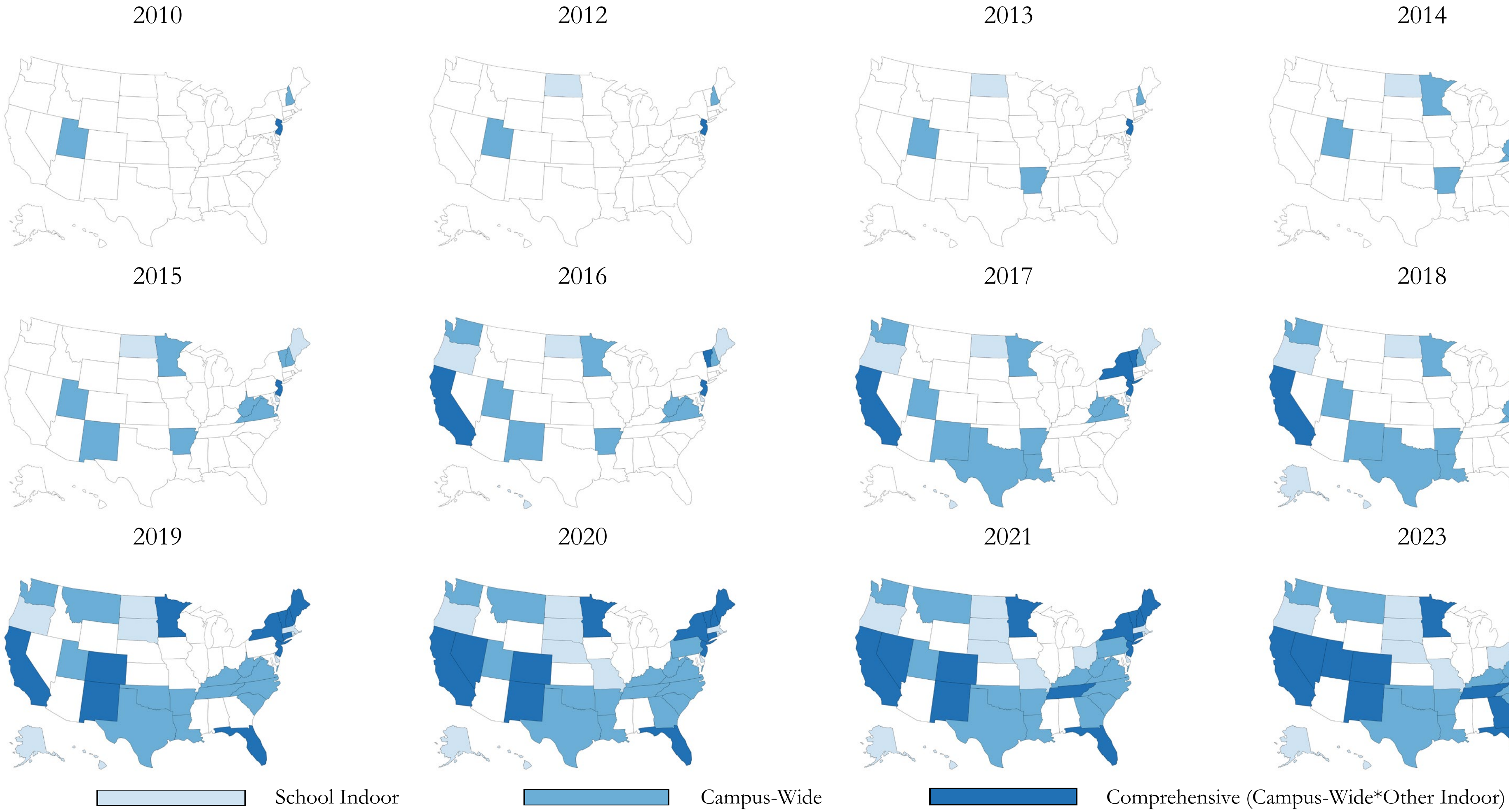
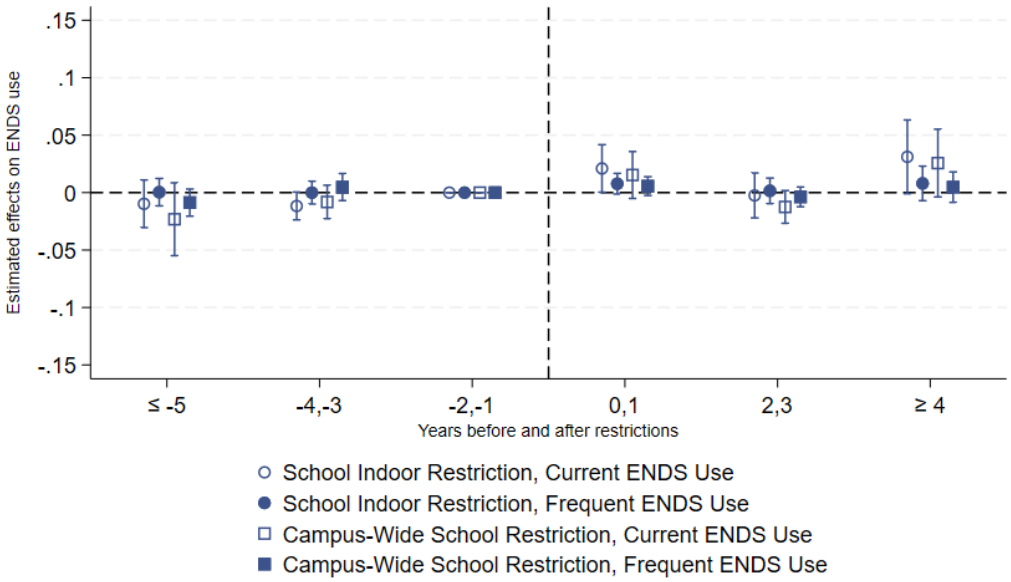
Figure 1. Staggered Adoption of K-12 School Vaping Restrictions



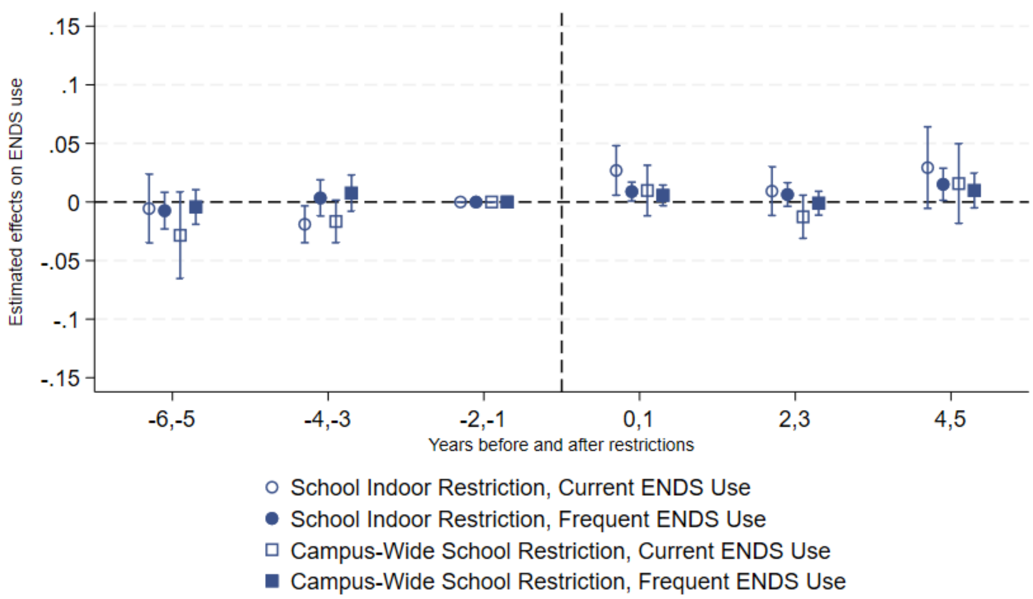
Notes: The different shades represent K-12 school indoor vaping restrictions, campus-wide restrictions, and comprehensive school-inclusive place-based restrictions (at restaurants, workplaces, or drinking establishments) in order of darkness. Collected by the authors from state legislative statutes.

Figure 2. Event Study Analysis of School Indoor and Campus-Wide Vaping Restrictions and Youth ENDS Use, Using TWFE and Stacked DD Estimates, State YRBSS

Panel (a): TWFE Estimates

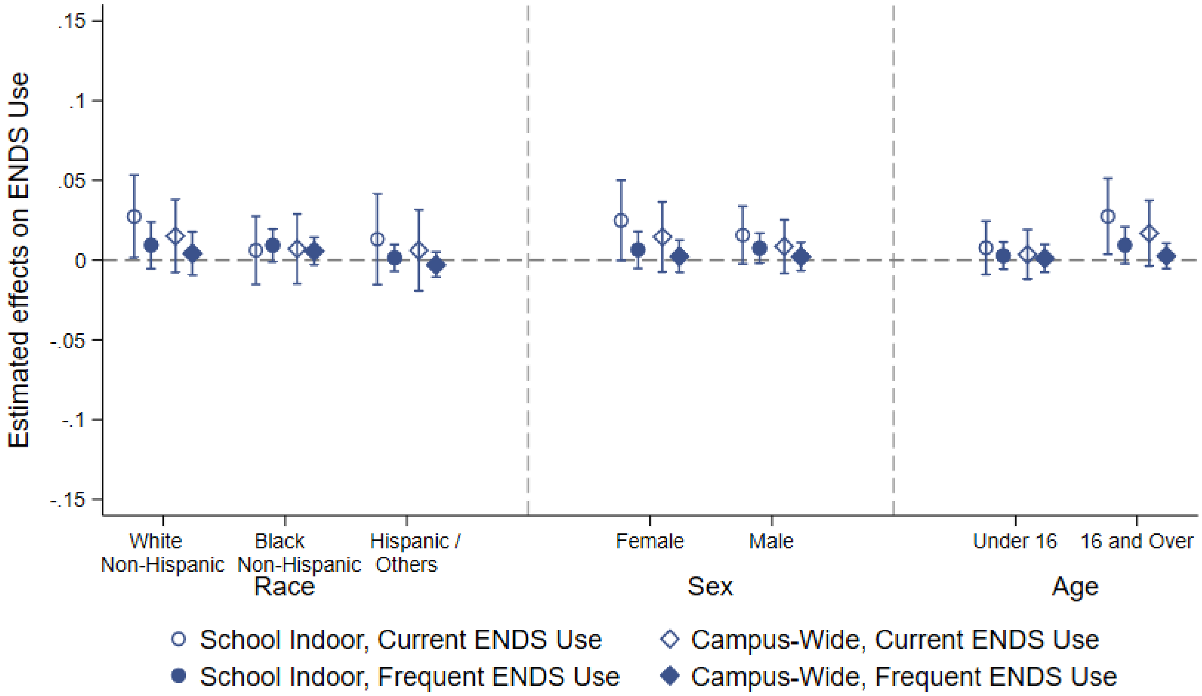


Panel (b): Stacked DD Estimates



Notes: Event-study regressions are estimated using the State Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. TWFE models include state fixed effects and year-by-semester fixed effects, and stacked DD models include cohort-by-state fixed effects and cohort-by-year-by-semester fixed effects. All models include demographic controls, macroeconomic controls, COVID-19 controls, and other vaping restrictions. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around the estimated effect.

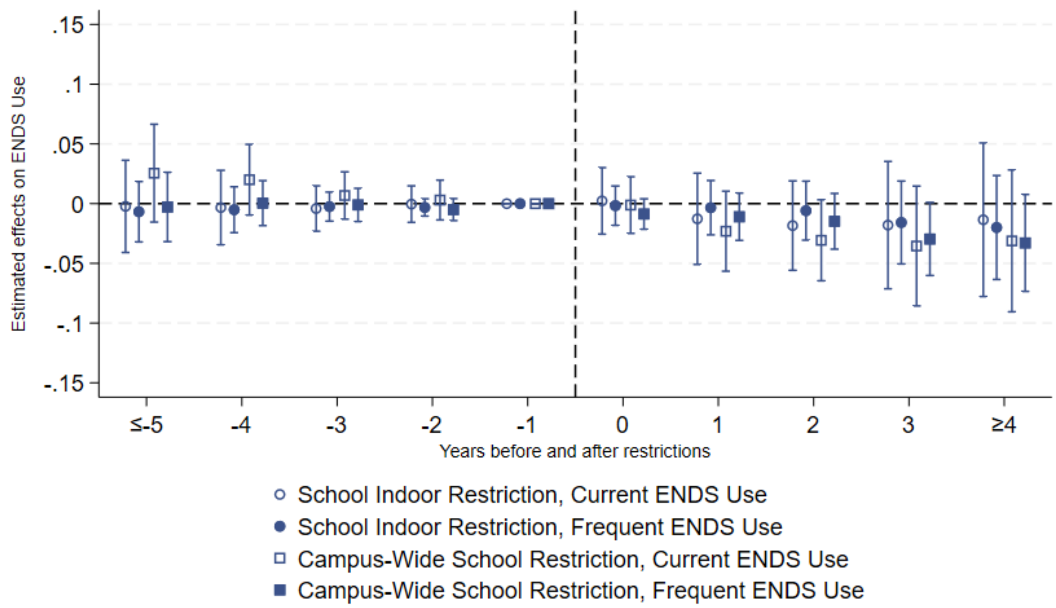
Figure 3. Heterogeneity in Effects of School Indoor and Campus-Wide Vaping Restrictions on Youth ENDS Use, State YRBSS



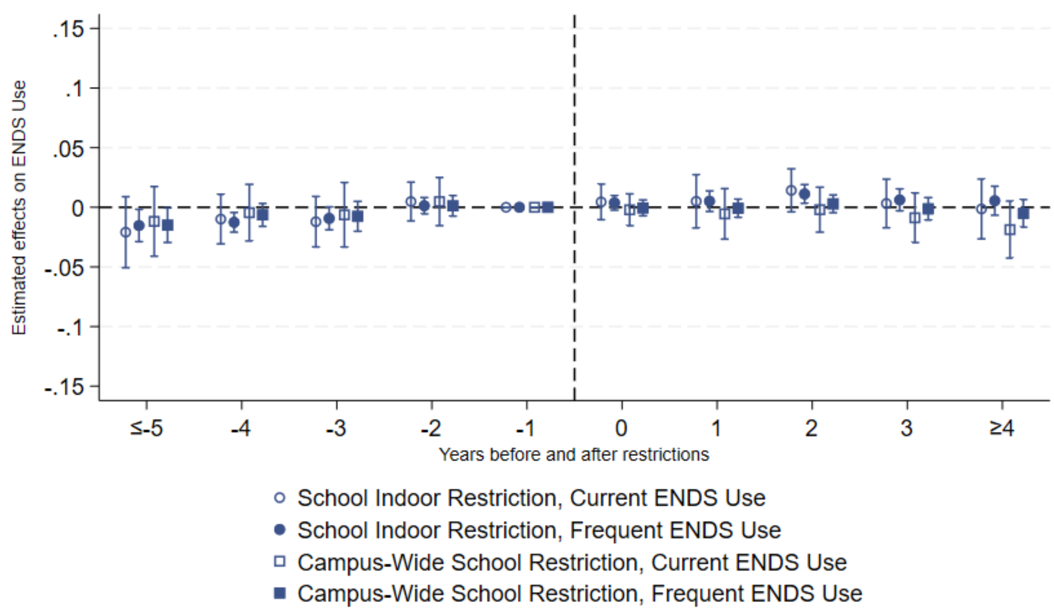
Notes: Average marginal effect estimates, using weighted logistic regression, are generated from individual-level State Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. All models include state fixed effects, year-by-semester fixed effects, demographic controls, macroeconomic controls, COVID-19 controls, controls for ENDS and combustible policies, and controls for substance policies. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level, and vertical lines are 95% confidence intervals around the estimated effect.

Figure 4. Event Study Analysis of School Indoor and Campus-Wide Vaping Restrictions and Youth ENDS Use, PATH and MTF

Panel (a): PATH



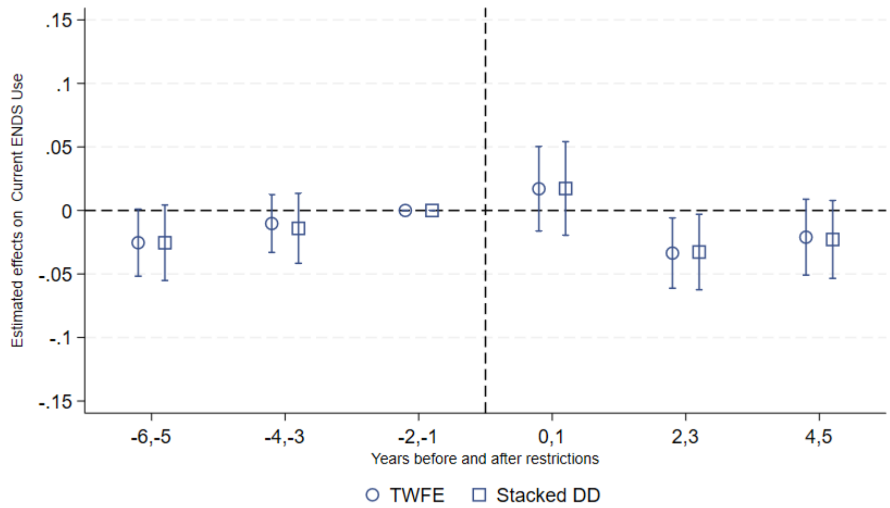
Panel (b): MTF



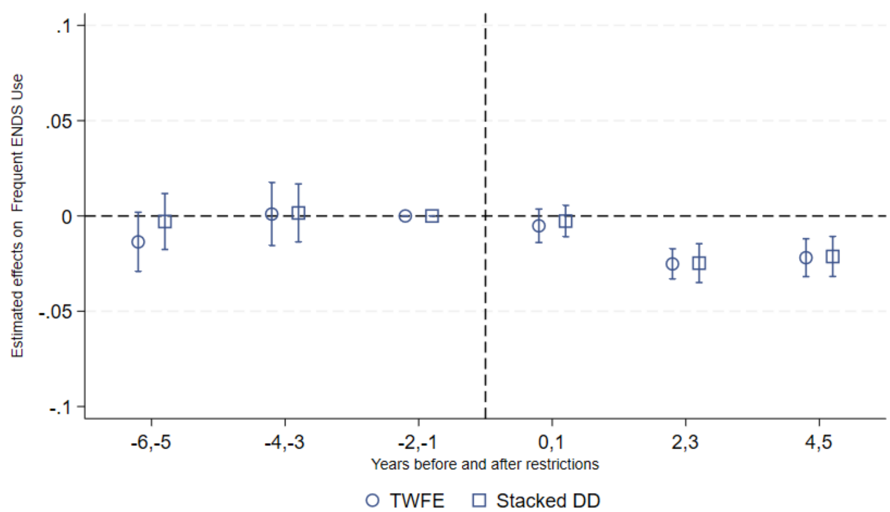
Notes: Event-study regressions are estimated using the Population Assessment of Tobacco and Health (PATH, 2013-2023) and the Monitoring the Future (MTF, 2014-2023) data. All models include state fixed effects, year-by-quarter fixed effects, macroeconomic controls, COVID-19 controls, and other vaping restrictions. MTF models include demographic controls (sex, grade, age, race), and PATH models include age and individual fixed effects. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around the estimated effect.

Figure 5. Event Study Analysis of Comprehensive School Inclusive Place-Based Vaping Restrictions and Youth ENDS Use, State YRBSS

Panel (a): Current ENDS Use

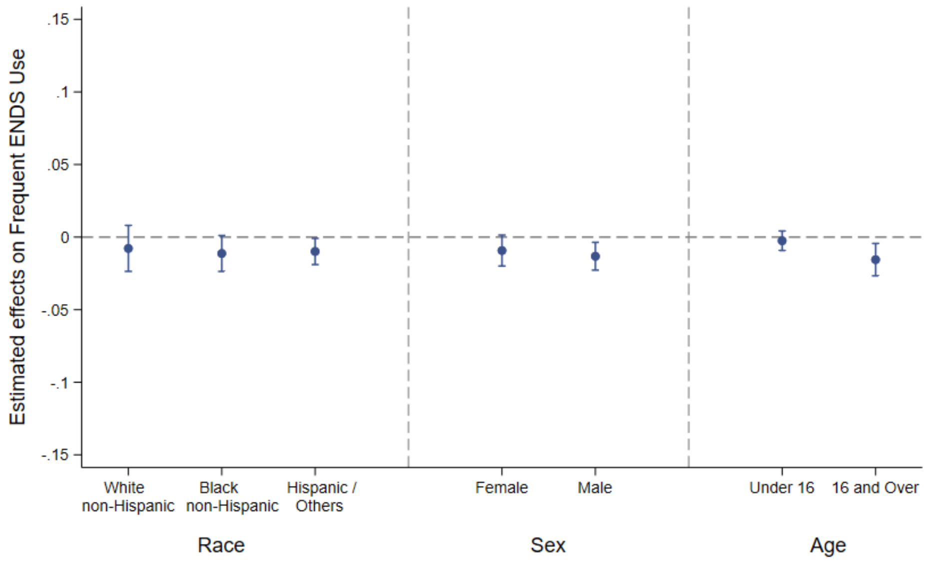


Panel (b): Frequent ENDS Use



Notes: Event-study regressions are estimated using the State Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. TWFE models include state fixed effects and year-by-semester fixed effects, and stacked DD models include cohort-by-state fixed effects and cohort-by-year-by-semester fixed effects. All models include demographic controls, macroeconomic controls, COVID-19 controls, and other indoor vaping restrictions. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around the estimated effect.

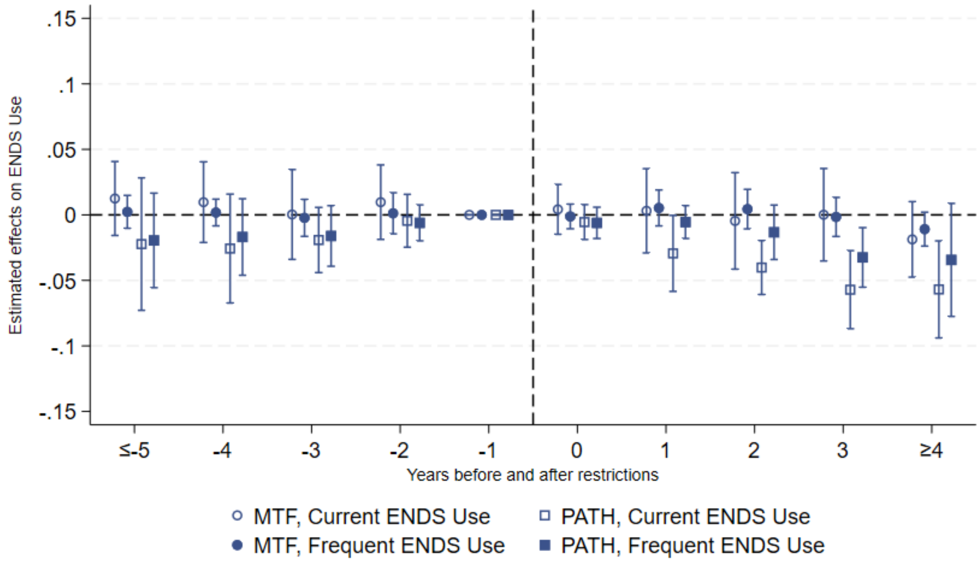
Figure 6. Heterogeneity in Effects of Comprehensive School Inclusive Place-Based Vaping Restrictions and Frequent Youth ENDS Use, State YRBSS



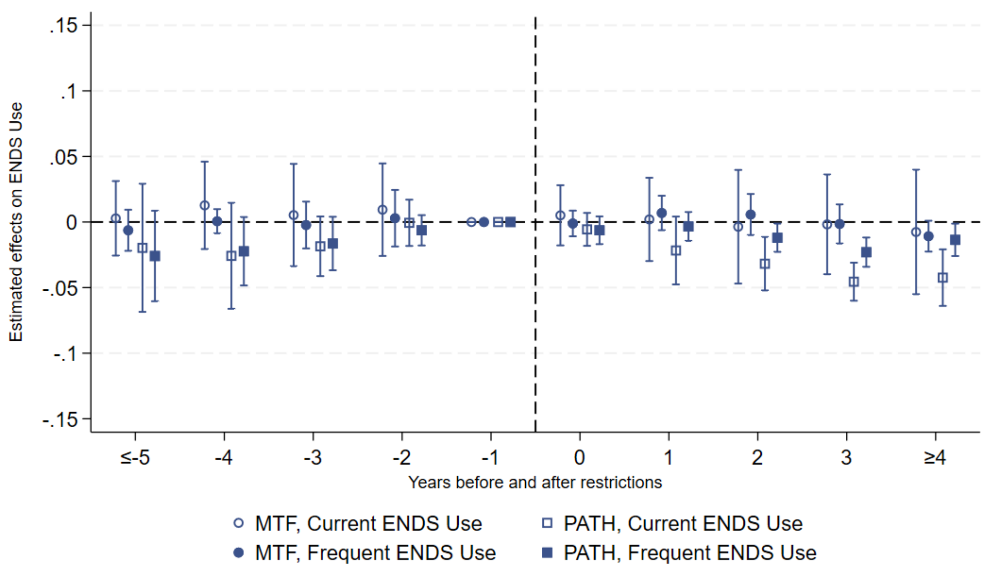
Notes: Average marginal effect estimates, using weighted logistic regression, are generated from individual-level State Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. All models include state fixed effects, year-by-semester fixed effects, demographic controls, macroeconomic controls, COVID-19 controls, controls for ENDS and combustible policies, and controls for substance policies. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level, and vertical lines are 95% confidence intervals around the estimated effect

Figure 7. Event Study Analysis of Comprehensive School Inclusive Place-Based Vaping Restrictions and Youth ENDS Use, MTF and PATH

Panel (a): TWFE Estimates



Panel (b): Stacked DD Estimates



Notes: Event-study regressions are estimated using the Population Assessment of Tobacco and Health (PATH, 2013-2023) and the Monitoring the Future (MTF, 2014-2023) data. TWFE models include state fixed effects and year-by-quarter fixed effects, and stacked DD models include cohort-by-state fixed effects and cohort-by-year-by-quarter fixed effects. All models include macroeconomic controls, COVID-19 controls, and other indoor vaping restrictions. MTF models include demographic controls (sex, grade, age, race), and PATH models include age and individual fixed effects. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around the estimated effect.

Table 1. Statewide K-12 School Vaping Restrictions

	K-12 Indoor Vaping Restriction	Campus Wide K-12 Vaping Restriction	Comprehensive School Inclusive Place-Based Workplace/ Restaurant/Drinking Vaping Restriction
Alaska	October 1, 2018		
Arkansas	August 16, 2013	August 16, 2013	
California	June 9, 2016	June 9, 2016	June 9, 2016
Colorado	July 1, 2019	July 1, 2019	July 1, 2019
Connecticut	October 1, 2019	October 1, 2019	October 1, 2019
Delaware	October 5, 2015		
District Of Columbia	February 18, 2017		
Florida	July 1, 2019	July 1, 2019	July 1, 2019
Georgia	July 22, 2020	July 22, 2020	July 1, 2023
Hawaii	January 1, 2016		
Illinois	January 1, 2024		
Kentucky	June 27, 2019	June 27, 2019	
Louisiana	June 22, 2017	June 22, 2017	
Maine	October 15, 2015	September 19, 2019	September 19, 2019
Maryland	July 1, 2024		
Massachusetts	December 31, 2018		
Minnesota	July 1, 2014	July 1, 2014	July 1, 2019
Missouri	August 28, 2020		
Montana	May 7, 2019	May 7, 2019	
Nebraska	November 14, 2020		
Nevada	January 1, 2020	January 1, 2020	January 1, 2020
New Hampshire	July 31, 2010	July 31, 2010	July 1, 2019
New Jersey	July 10, 2010	July 10, 2010	July 10, 2010
New Mexico	December 15, 2015	December 15, 2015	June 14, 2019
New York	July 25, 2017	July 25, 2017	November 22, 2017
North Carolina	February 21, 2019	February 21, 2019	
North Dakota	December 6, 2012		
Ohio	September 30, 2021		
Oklahoma	July 1, 2019	July 1, 2019	
Oregon	January 1, 2016		
Pennsylvania	January 26, 2020	January 26, 2020	
Rhode Island	July 1, 2018		
South Carolina	August 1, 2019	August 1, 2019	
South Dakota	July 1, 2019		
Tennessee	April 17, 2019	April 17, 2019	July 1, 2021
Texas	April 15, 2017	April 15, 2017	
Utah	May 11, 2010	May 11, 2010	May 3, 2023
Vermont	July 1, 2014	July 1, 2014	July 1, 2016
Virginia	July 1, 2014	July 1, 2014	
Washington	June 28, 2016	June 28, 2016	
West Virginia	June 6, 2014	June 6, 2014	

Source: Collected by the authors from state legislative statutes.

Table 2. Logistic Regression Estimates of the Effect of School Vaping Restrictions on Youth ENDS Use, State YRBSS, 2015-2023

	(1)	(2)	(3)	(4)	(5)
	Panel I: School Indoor Vaping Restriction				
	(a) Current ENDS Use				
School Indoor Vaping Restriction	0.0091	0.0129	0.0133	0.0081	0.0123
	(0.0091)	(0.0102)	(0.0084)	(0.0086)	(0.0097)
Pre-Treat Mean DV	0.1947	0.1947	0.1947	0.1947	0.1947
N	735109	735109	735109	735109	735109
	(b) Frequent ENDS Use				
School Indoor Vaping Restriction	-0.0006	0.0047	0.0054	0.0055	0.0074
	(0.0042)	(0.0046)	(0.0042)	(0.0044)	(0.0047)
Pre-Treat Mean DV	0.0410	0.0410	0.0410	0.0410	0.0410
N	735109	735109	735109	735109	735109
	Panel II: Campus-Wide School Vaping Restriction				
	(a) Current ENDS Use				
Campus-Wide School Vaping Restriction	0.0036	0.0062	0.0085	0.0024	0.0058
	(0.0089)	(0.0089)	(0.0070)	(0.0072)	(0.0081)
Pre-Treat Mean DV	0.2036	0.2036	0.2036	0.2036	0.2036
N	735109	735109	735109	735109	735109
	(b) Frequent ENDS Use				
Campus-Wide School Vaping Restriction	-0.0047	0.0005	0.0021	0.0013	0.0024
	(0.0041)	(0.0039)	(0.0033)	(0.0036)	(0.0039)
Pre-Treat Mean DV	0.0387	0.0387	0.0387	0.0387	0.0387
N	735109	735109	735109	735109	735109
Controls:					
State and Year-by-Semester FE?	Yes	Yes	Yes	Yes	Yes
Demographics?	Yes	Yes	Yes	Yes	Yes
Macroeconomic and COVID?	Yes	Yes	Yes	Yes	Yes
Other Place-Based ENDS Restrictions?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
Combustible Tobacco Policies?	No	No	No	Yes	Yes
Substance Policies?	No	No	No	No	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Average marginal effect estimates, using weighted logistic regression, are generated from individual-level State Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. Sample weights are generated using the individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level.

Table 3. Sensitivity of Estimates in Table 2 to Additional Controls for Spatial Heterogeneity

	(1)	(2)	(3)
		Panel I: School Indoor Vaping Restriction	
		(a) Current ENDS Use	
School Indoor Vaping Restriction	0.0123	0.0152	0.0210
	(0.0097)	(0.0098)	(0.0135)
Pre-Treat Mean DV	0.1947	0.1947	0.1947
N	735109	735109	735109
		(b) Frequent ENDS Use	
School Indoor Vaping Restriction	0.0074	0.0073	-0.0009
	(0.0047)	(0.0055)	(0.0072)
Pre-Treat Mean DV	0.0410	0.0410	0.0410
N	735109	735109	735109
		Panel II: Campus-Wide School Vaping Restriction	
		(a) Current ENDS Use	
Campus-Wide School Vaping Restriction	0.0058	-0.0004	0.0095
	(0.0081)	(0.0088)	(0.0126)
Pre-Treat Mean DV	0.2036	0.2036	0.2036
N	735109	735109	735109
		(b) Frequent ENDS Use	
Campus-Wide School Vaping Restriction	0.0024	-0.0023	-0.0028
	(0.0039)	(0.0046)	(0.0076)
Pre-Treat Mean DV	0.0387	0.0387	0.0387
N	735109	735109	735109
Additional Controls:			
Census Region-by-Year-Semester FE?	No	Yes	No
State-Specific Linear Time Trends?	No	No	Yes

** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

Notes: Average marginal effect estimates, using weighted logistic regression, are generated from individual-level State Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. Sample weights are generated using the individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. All models include state fixed effects, year-by-semester fixed effects, demographic controls, macroeconomic controls, COVID-19 controls, controls for ENDS and combustible policies, and controls for substance policies. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level.

Table 4A. TWFE Estimates of the Effects of School Vaping Restrictions on Youth and Adult ENDS Use, PATH

	(1)	(2)	(3)	(4)	(5)	(6)
Analysis Sample →		Youths Aged 14-17			Young Adults Aged 20-34 Never Previously Treated by a SVR (Placebo Check)[a]	
			Panel I. School Indoor Vaping Restriction			
School Indoor Vaping Restriction	-0.0067	-0.0027	-0.0028	-0.0001	-0.0015	-0.0056
	(0.0083)	(0.0156)	(0.0155)	(0.0072)	(0.0074)	(0.0080)
Pre-Treat. Mean of DV	0.0699	0.0699	0.0699	0.1384	0.1384	0.1384
N	65415	65415	65415	82553	82553	82553
			Panel II. Campus-Wide School Vaping Restriction			
Campus-Wide School Vaping Restriction	-0.0107	-0.0083	-0.0065	-0.0008	-0.0019	-0.0064
	(0.0089)	(0.0136)	(0.0143)	(0.0072)	(0.0067)	(0.0075)
Pre-Treat. Mean of DV	0.0704	0.0704	0.0704	0.1386	0.1386	0.1386
N	65415	65415	65415	82950	82950	82950
Control Variables:						
State, Year-by-Quarter, Individual FE + Baseline Controls?	Yes	Yes	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	Yes	No	Yes	Yes
ENDS, Combustible Tobacco, & Substance Use Policies?	No	No	Yes	No	No	Yes

*$p<.1$, **$p<.5$, ***$p<.01$

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Baseline controls include state and year-by-quarter fixed effects, age, individual fixed effects, macroeconomic controls, and COVID-19 controls. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarettes taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level and reported in parentheses.

[a] Prior treatment exposure is determined using respondents' state of residence while a teenager (PATH Youth) when available; otherwise, we proxy prior exposure using respondents' current state of residence.

Table 4B. Difference-in-Difference-in-Differences (DDD) Estimates of the Effect of School Vaping Restrictions on ENDS Use Among Youths (Aged 14-17) vs Young Adults Aged 20-34 Never Previously Treated by a SVR, PATH

	(1)	(2)	(3)
	Panel I: School Indoor Vaping Restriction		
School Indoor Vaping Restriction * Youth Aged 14-17	-0.0093 (0.0110)	-0.0017 (0.0164)	-0.0011 (0.0169)
Pre-Treat. Mean of DV	0.0699	0.0699	0.0699
N	147968	147968	147968
	Panel II: Campus-Wide School Vaping Restriction		
Campus-Wide School Vaping Restriction * Youth Aged 14-17	-0.0156 (0.0114)	-0.0113 (0.0148)	-0.0082 (0.0159)
Pre-Treat. Mean of DV	0.0704	0.0704	0.0704
N	148365	148365	148365
Control Variables:			
State-by-Year-by-Quarter FE & Baseline Controls?	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	Yes
ENDS, Combustible Tobacco, Substance Use Policies?	No	No	Yes

*$p<.1$, **$p<.5$, ***$p<.01$

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Baseline controls include year-by-quarter fixed effects, age, individual fixed effects, macroeconomic controls, and COVID-19 controls. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarettes taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level and reported in parentheses.

Table 5. Discrete-Time Hazard Estimates of the Effects of School Vaping Restrictions on Initiation and Cessation of Youth ENDS Use, PATH

	(1)	(2)	(3)	(4)
	Initiation (Among Non-ENDS Users at Baseline)		Cessation (Among ENDS Users at Baseline)	
	Panel I. School Indoor Vaping Restriction			
School Indoor Vaping Restriction	-0.0030	-0.0058	-0.0427	-0.0614
	(0.0159)	(0.0155)	(0.1403)	(0.1407)
Pre-Treat. Mean of DV	0.0656	0.0656	0.5550	0.5550
N	61921	61921	2210	2210
	Panel II. Campus-Wide School Vaping Restriction			
Campus-Wide School Vaping Restriction	-0.0107	-0.0113	-0.0028	-0.0397
	(0.0137)	(0.0139)	(0.1182)	(0.1202)
Pre-Treat. Mean of DV	0.0636	0.0636	0.5663	0.5663
N	61921	61921	2210	2210
Control Variables:				
State, Year-by-Quarter FE, Individual FE, Age?	Yes	Yes	Yes	Yes
Macro, COVID, Other Place-Based ENDS Restrictions?	Yes	Yes	Yes	Yes
ENDS Policies?	No	Yes	No	Yes
Combustible Tobacco Policies?	No	Yes	No	Yes
Substance Use Policies?	No	Yes	No	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level.

Table 6. Estimates of the Effect of School Vaping Restrictions on Youth ENDS Use, MTF

	(1)	(2)	(3)	(4)	(5)
	Panel I: School Indoor Vaping Restriction				
School Indoor Vaping Restriction	0.0058	0.0087	0.0096	0.0115	0.0124
	(0.0070)	(0.0083)	(0.0077)	(0.0077)	(0.0111)
Pre-Treat. Mean of DV	0.1374	0.1374	0.1374	0.1374	0.1374
N	198221	198221	198221	198221	198221
	Panel II: Campus-Wide School Vaping Restriction				
Campus-Wide School Vaping Restriction	-0.0031	-0.0021	-0.0005	0.0052	0.0101
	(0.0081)	(0.0079)	(0.0069)	(0.0068)	(0.0115)
Pre-Treat. Mean of DV	0.1373	0.1373	0.1373	0.1373	0.1373
N	198221	198221	198221	198221	198221
Control Variables:					
State FE, Year-by-Quarter FE, Demog, Macro, COVID?	Yes	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restrictions?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
Combustible Tobacco Policies?	No	No	No	Yes	Yes
Substance Use Policies?	No	No	No	No	Yes
School FE?	No	No	No	No	Yes

**p*<.1, ***p*<.5, ****p*<.01

Notes: Estimates are generated via weighted logistic regression using the Monitoring The Future (MTF) data collected over the period 2014-2023. Demographic characteristics include sex, race, age, and grade. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarettes taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level and reported in parentheses.

Table 7. Exploration of Mechanisms to Explain Null Effect of School Indoor Vaping Restriction on Youth ENDS Use, PATH & MTF

	Panel I: Substitution Across School Vaping Locations						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	E-Cigarette Use on School Property[a]		Observed Vaping in More Easily Observable School Locations[b] (e.g., Hallways, Classrooms, on Campus)		Observed Vaping in School Bathrooms or Locker Rooms[b]		E-Cigarette Use Exclusively off School Property[a]
School Indoor Vaping Restriction	0.003	0.004	-0.079**	-0.206***	0.085	0.318***	0.003
	(0.005)	(0.006)	(0.038)	(0.031)	(0.063)	(0.072)	(0.012)
Pre-Treat. Mean of DV	0.030	0.030	0.093	0.093	0.399	0.399	0.080
N	83825	83825	4931	4931	4931	4931	83825
Controls?							
Baseline Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	No	Yes	No	Yes	Yes

	Panel II: Substitution Across Vaping Devices			
	(1)	(2)	(3)	(4)
	Refillable Tank[c]		Disposable E-Cigarettes[c]	
School Indoor Vaping Restriction	-0.012*	-0.010	0.018	0.039**
	(0.006)	(0.010)	(0.020)	(0.019)
Pre-Treat. Mean of DV	0.034	0.034	0.016	0.091
N	56597	56597	21911	8983
Controls?				
Baseline Controls?	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	Yes	Yes

** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

Notes: Estimates are generated using the Monitoring the Future data (e-cigarette use on school property, 2019-2023) and the Population Assessment of Tobacco and Health data (refillable tank use 2014-2023; disposable e-cigarette use in the past 30 days, 2018-2023; disposable e-cigarette use among ever users and observed vaping at specific locations in school, 2021-2023). All models include baseline demographic controls (sex, grade, age, race in MTF; age and individual fixed effects in PATH) and macroeconomic controls (unemployment rate, poverty rate). In the models for vape types in the past 30 days and health risks beliefs, baseline controls additionally include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. Standard errors are in parentheses and clustered at the state level.

[a] Data come from the MTF (2019-2023).

[b] Data come from the PATH (2021-2023).

[c] Data come from the PATH: refillable tank use (2014-2023); disposable e-cigarette use among past 30 day users (column 3; 2018-2023); and disposable e-cigarettes use among ever users (column 4; 2021-2023).

Table 8. Logistic Regression Estimates of the Effect of Comprehensive School-Inclusive and Other Place-Based Indoor Vaping Restrictions on Youth ENDS Use, State YRBSS, 2015-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Current ENDS Use			**Frequent ENDS Use**		
Campus-Wide School Vaping Restriction * Workplace/Dining/Drinking Vaping Ban	-0.0008 (0.0109)	0.0027 (0.0119)	-0.0048 (0.0123)	-0.0119*** (0.0038)	-0.0112*** (0.0039)	-0.0088** (0.0043)
Campus-Wide School Vaping Restriction Only		0.0080 (0.0100)	0.0056 (0.0094)		0.0007 (0.0043)	0.0021 (0.0042)
Workplace/Dining/Drinking Establishment Indoor Vaping Restriction Only		0.0196 (0.0161)	-0.0018 (0.0173)		-0.0009 (0.0043)	-0.0037 (0.0072)
Pre-Treat Mean DV	0.1929	0.1929	0.1929	0.0386	0.0386	0.0386
N	735109	735109	735109	735109	735109	735109
Controls:						
State FE, Year-by-Semester FE, Demog, Macro, COVID?	Yes	Yes	Yes	Yes	Yes	Yes
K-12 School Indoor Vaping Restriction Only? [a]	No	Yes	Yes	No	Yes	Yes
ENDS, Combustible Tobacco, and Substance Use Policies?	No	No	Yes	No	No	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Average marginal effect estimates, using weighted logistic regression, are generated from individual-level State Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. Sample weights are generated using the individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level.
[a] All states that have a dining/workplace vaping restriction have a K-12 school vaping restriction in place during our sample period. Thus, we cannot distinguish between the effect of dining/workplace indoor vaping restrictions and the interactive effect of K-12 school indoor vaping restrictions and dining/workplace indoor vaping restrictions.

Table 9A. TWFE Estimates of the Effects of Comprehensive School-Inclusive and Other Place-Based Indoor Vaping Restrictions on Youth Current ENDS Use, PATH

	(1)	(2)	(3)	(4)	(5)	(6)
Analysis Sample →	Youth Aged 14-17			Young Adults Aged 20-34 Never Previously Treated by a SVR (Placebo Check)[a]		
Campus-Wide School Vaping Restriction * Workplace/Dining/Drinking Vaping Ban	-0.0160** (0.0075)	-0.0165** (0.0069)	-0.0156 (0.0101)	-0.0003 (0.0070)	-0.0001 (0.0088)	-0.0040 (0.0143)
Campus-Wide School Vaping Restriction Only		-0.0050 (0.0158)	-0.0049 (0.0157)		-0.0003 (0.0078)	-0.0048 (0.0084)
Workplace/Dining/Drinking Establishment Indoor Vaping Restriction Only		0.0059 (0.0245)	-0.0007 (0.0250)		0.0042 (0.0085)	0.0076 (0.0099)
Pre-Treat. Mean of DV	0.0716	0.0716	0.0716	0.1405	0.1405	0.1405
N	65415	65415	65415	86318	86318	86318
Control Variables:						
Controls:						
State FE, Year-by-Semester FE, Demog, Macro, COVID?	Yes	Yes	Yes	Yes	Yes	Yes
K-12 School Indoor Vaping Restriction Only? [a]	No	Yes	Yes	No	Yes	Yes
ENDS, Combustible Tobacco, & Substance Use Policies?	No	No	Yes	No	No	Yes

**p*<.1, ***p*<.5, ****p*<.01

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Baseline controls include state and year-by-quarter fixed effects, age, individual fixed effects, macroeconomic controls, and COVID-19 controls. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarettes taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level and reported in parentheses.

[a] Prior treatment exposure is determined using respondents' state of residence while a teenager (PATH Youth) when available; otherwise, we proxy prior exposure using respondents' current state of residence.

Table 9B. Difference-in-Difference-in-Differences (DDD) Estimates of Comprehensive School-Inclusive Place-Based Vaping Restriction on ENDS Use Among Youths (Aged 14-17) vs Young Adults (Aged 20-34) Never Previously Treated by a SVR, PATH

	(1)	(2)	(3)
Comprehensive School-Inclusive Vaping Restriction * Youth Aged 14-17	-0.0260***	-0.0261***	-0.0240*
	(0.0096)	(0.0095)	(0.0137)
Campus-Wide School Vaping Restriction Only * Youth Aged 14-17		-0.0056	-0.0048
		(0.0168)	(0.0174)
Workplace/Dining/Drinking Establishment Indoor Vaping Restriction Only * Youth Aged 14-17		0.0111	0.0030
		(0.0254)	(0.0252)
Pre-Treat. Mean of DV	0.0716	0.0716	0.0716
N	151733	151733	151733
Control Variables:			
State-by-Year-by-Quarter FE & Baseline Controls?	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	Yes
ENDS, Combustible Tobacco, Substance Use Policies?	No	No	Yes

**p<.1, **p<.5, ***p<.01*

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Baseline controls include year-by-quarter fixed effects, age, individual fixed effects, macroeconomic controls, and COVID-19 controls. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarettes taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level and reported in parentheses.

Table 10. Exploring Populations for Whom Comprehensive (School and Workplace/Restaurant/Drinking) Vaping Restrictions Most Reduce ENDS Use among Teenagers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ENDS Use		ENDS Use Among Working	ENDS Use Among Non-Working	ENDS Use at School among Working	ENDS Use at School among Non-Working	ENDS Use among Teens Likely Eating Out Frequently[a]	ENDS Use among Teens Likely Not Eating Out as Much[a]
Comprehensive School Vaping Restriction	-0.0205* (0.0110)	-0.0186 (0.0141)	-0.0354** (0.0178)	-0.0002 (0.0173)	-0.0153** (0.0076)	0.0139 (0.0134)	-0.0508* (0.0284)	0.0006 (0.0178)
Pre-Treat. Mean of DV	0.1291	0.1291	0.1759	0.0940	0.0600	0.0275	0.1788	0.1058
N	54738	54738	21838	31825	23320	32901	4349	7797
Controls:								
Baseline Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dataset:	MTF	MTF	MTF	MTF	MTF	MTF	BRFSS	BRFSS

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates are generated via weighted logistic regression using the Monitoring The Future (MTF) data collected over the period 2019-2023 and Behavioral Risk Factor Surveillance System (BRFSS) data collected over the period 2017–2022. Baseline controls include age and individual fixed effects, macroeconomic controls, and COVID-19 controls. Macroeconomic controls include unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. Standard errors are in parentheses and clustered at the state level.

[a] Eating out frequently is proxied using the reported frequency of eating French fries in the past month from the BRFSS. Respondents who report eating French fries 10 or more times in the past month are classified as eating out frequently; all others are classified as not eating out frequently.

Table 11. Exploration of Spillover Effects of School Vaping Restrictions on Cigarette Smoking, State YRBSS, PATH and MTF

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome →	Current Smoking	Frequent Smoking	Current Smoking	Frequent Smoking	Current Smoking	Heavier Smoking[a]
Dataset →	YRBSS		PATH		MTF	
	Panel I: School Indoor Vaping Restriction					
School Indoor Vaping Restriction	0.0035	0.0006	-0.0056	-0.0008	0.0010	-0.0003
	(0.0042)	(0.0015)	(0.0099)	(0.0039)	(0.0029)	(0.0011)
Pre-Treat Mean DV	0.0755	0.0195	0.0468	0.0127	0.0556	0.0086
N	776429	776429	65556	65496	334599	334599
	Panel II: Campus-Wide School Vaping Restriction					
Campus-Wide School Vaping Restriction	0.0000	-0.0005	-0.0060	-0.0025	0.0003	0.0003
	(0.0033)	(0.0011)	(0.0093)	(0.0035)	(0.0030)	(0.0011)
Pre-Treat Mean DV	0.0818	0.0216	0.0476	0.0126	0.0588	0.0088
N	776429	776429	65556	65496	334599	334599
	Panel III: Comprehensive School-Inclusive Vaping Restriction					
Comprehensive K-12 Campus Inclusive Place-Based Vaping Restriction	0.0036	-0.0006	-0.0081	-0.0074*	0.0049	0.0014
	(0.0040)	(0.0016)	(0.0057)	(0.0038)	(0.0078)	(0.0032)
Pre-Treat Mean DV	0.0656	0.0161	0.0370	0.0091	0.0506	0.0073
N	776429	776429	65556	65496	334599	334599

** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

Notes: Estimates are generated from individual-level State Youth Risk Behavior Survey (YRBS, 2015-2023), the Population Assessment of Tobacco and Health (PATH, 2013-2023), and the Monitoring the Future (MTF, 2014-2023) data. All models include demographic controls, macroeconomic controls, COVID-19 controls, controls for ENDS and combustible policies, and controls for substance policies. YRBSS and MTF models include demographic controls (sex, grade, age, race), and PATH models include age and individual fixed effects. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level.

[a] In MTF, cigarette use intensity is measured by the amount smoked in the past month (not days smoked). We define "Heavier Smoking" as smoking half a pack per day or more in the past month.

Table 12. Longer-Term Effects of Comprehensive School-Inclusive Vaping Restrictions on ENDS Use and Combustible Cigarette Smoking Among Young Adults Previously Treated by a Comprehensive School-Inclusive Vaping Restriction, PATH

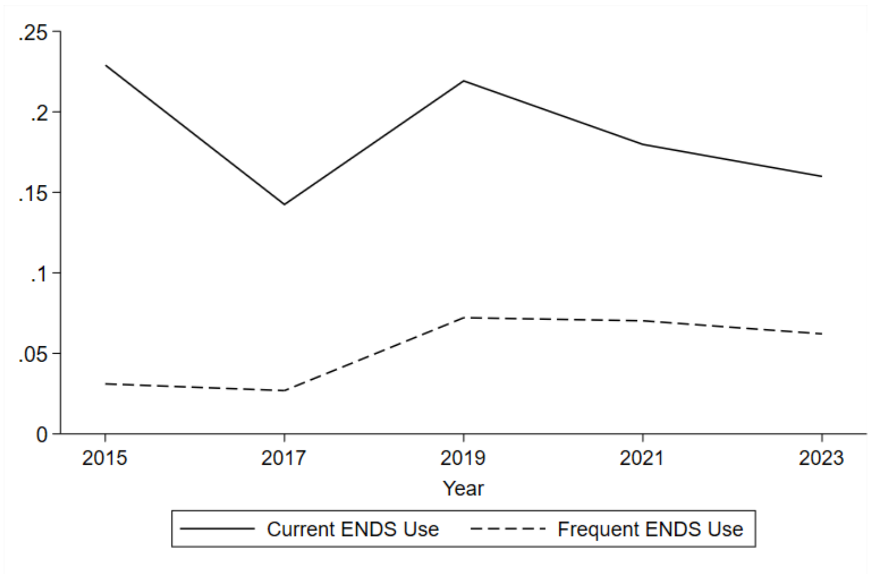
	(1)	(2)	(3)	(4)
Analysis Sample →	Full Sample		Adults Observed in PATH as Youth	
	Panel I: Current ENDS Use			
Comprehensive School-Inclusive Vaping Restriction	-0.0135 (0.0297)	-0.0130 (0.0299)	-0.0368** (0.0182)	-0.0340* (0.0187)
Pre-Treat. Mean of DV	0.1437	0.1437	0.2406	0.2406
N	89840	89840	11210	11210
	Panel II: Current Cigarette Smoking			
Comprehensive School-Inclusive Vaping Restriction	-0.0131 (0.0218)	-0.0095 (0.0221)	-0.0233 (0.0163)	-0.0227 (0.0166)
Pre-Treat. Mean of DV	0.2467	0.2467	0.1265	0.1265
N	90166	90166	11212	11212
Control Variables:				
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes
Youth State and Grade Cohort FE?	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes
Current Place-Based Vaping Restriction?	Yes	Yes	Yes	Yes
Macroeconomic and COVID?	Yes	Yes	Yes	Yes
ENDS Policies?	No	Yes	No	Yes
Combustible Tobacco Policies?	No	Yes	No	Yes
Substance Policies?	No	Yes	No	Yes

** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

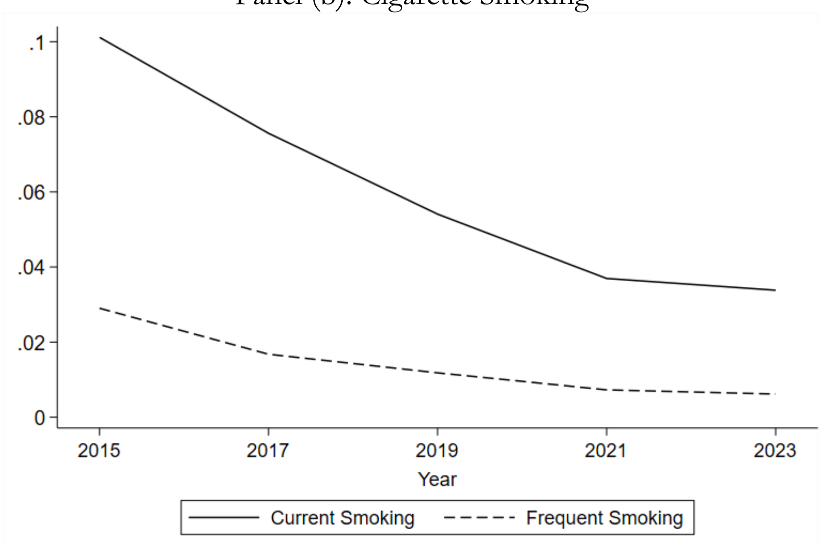
Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Demographic controls include sex, age, race, and education. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the level of state of residence as youths.

Appendix Figure 1. Trends in ENDS Use and Combustible Cigarette Smoking among Youths, State YRBSS

Panel (a): ENDS Use



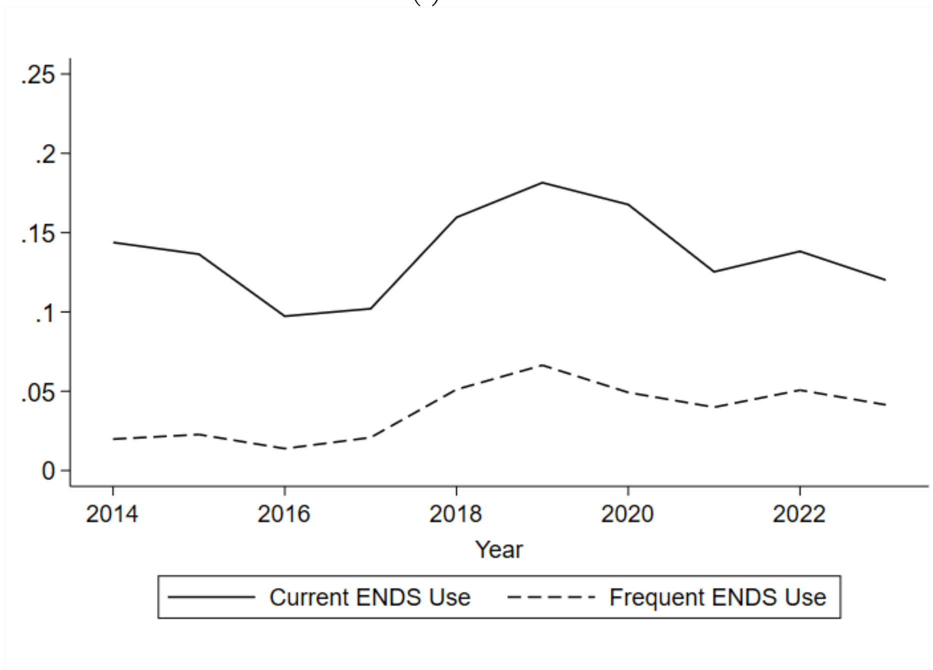
Panel (b): Cigarette Smoking



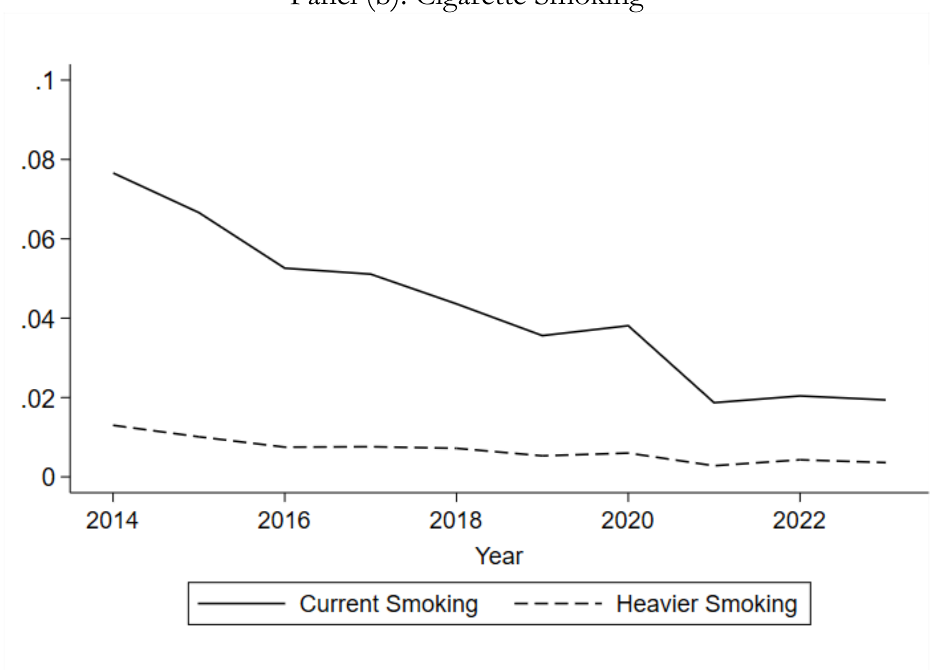
Source: Author's calculation from State YRBSS, 2015-2023.

Appendix Figure 2. Trends in ENDS Use and Combustible Cigarette Smoking Among Youths, MTF

Panel (a): ENDS Use



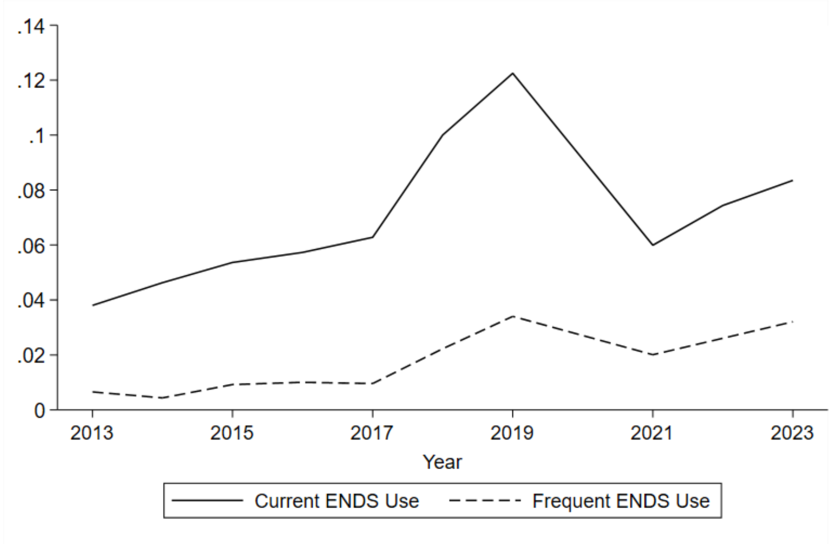
Panel (b): Cigarette Smoking



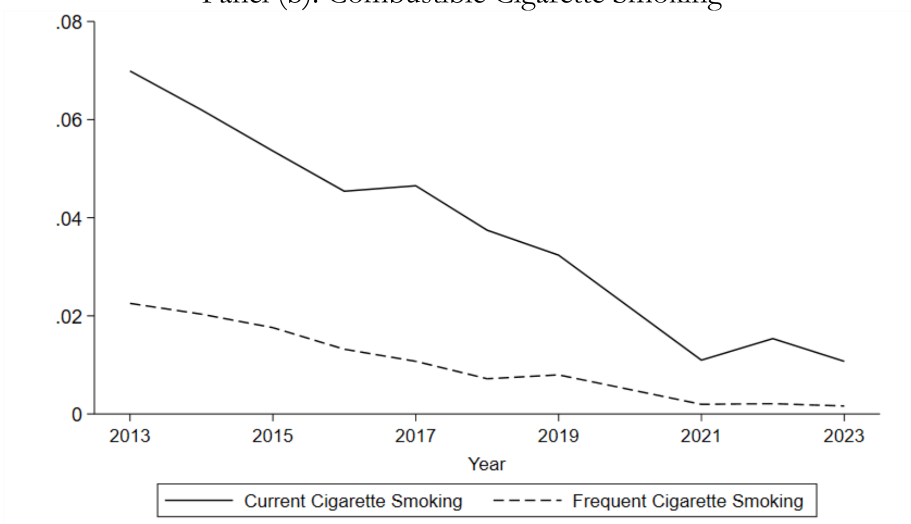
Source: Author's calculation from the Monitoring The Future (MTF), 2014-2023.

Appendix Figure 3. Trends in ENDS Use and Cigarette Smoking among Youths, PATH

Panel (a): ENDS Use



Panel (b): Combustible Cigarette Smoking



Source: Author's calculation from PATH, 2013-2023.

Appendix Figure 4. Types of Vaping Devices

Generated with ChatGPT 5.1 (OpenAI) using the prompt: “Illustrate vape evolution (vape pen → box mod → pod → disposable) in accurate relative scale, labeled, with generic non-branded designs.”

Appendix Table 1. Summary Statistics for Main Datasets

Datasets →	State YRBSS	PATH-Youths	MTF	PATH-Adults 20-34
Demographic characteristics				
Female	0.495	0.486	0.491	0.495
White, non-Hispanic	0.505	0.504	0.488	0.553
Black, non-Hispanic	0.144	0.127	0.118	0.130
Hispanic	0.246	0.235	0.195	0.206
Other	0.106	0.134	0.199	0.111
Age				26.883
10-14	N/A	N/A	0.293	N/A
12-14	0.142	N/A	N/A	N/A
14	N/A	0.246	N/A	N/A
15	0.255	0.249	0.168	N/A
16	0.253	0.251	0.185	N/A
17	0.235	0.253	0.158	N/A
18+	0.115	NA	0.197	N/A
Grade 8	N/A	N/A	0.307	N/A
9	0.271	N/A	N/A	N/A
10	0.256	N/A	0.352	N/A
11	0.240	N/A	N/A	N/A
12	0.233	N/A	0.341	N/A
ENDS Use and Cigarette Smoking				
Current ENDS Use	0.187	0.073	0.137	0.144
Frequent ENDS Use	0.053	0.018	0.040	0.011
Current Cigarette Smoking	0.061	0.037	0.046	N/A
Heavier Cigarette Smoking	N/A	N/A	0.007	N/A
Frequent Cigarette Smoking	0.014	0.010	N/A	N/A
Observations	735109	65415	198221	91727

Notes: The number of observations for cigarette smoking questions is 334,599 in MTF, 65,556 in PATH (Youth), 776,429 in State YRBSS, and 851,179 in Combined YRBSS.

Appendix Table 2. Effective Dates for Workplace, Restaurant, or Drinking Establishment Indoor Vaping Restrictions

State	Effective Date
Alaska	October 1, 2018
California	June 9, 2016
Colorado	July 1, 2019
Connecticut	October 1, 2019
Delaware	October 5, 2015
District Of Columbia	February 18, 2017
Florida	July 1, 2019
Georgia	July 1, 2023
Hawaii	January 1, 2016
Illinois	January 1, 2024
Maine	October 15, 2015
Maryland	July 1, 2024
Massachusetts	December 31, 2018
Minnesota	July 1, 2019
Nebraska	November 14, 2020
Nevada	January 1, 2020
New Hampshire	July 1, 2019
New Jersey	July 10, 2010
New Mexico	June 14, 2019
New York	November 22, 2017
North Dakota	December 6, 2012
Ohio	September 30, 2021
Oregon	January 1, 2016
Rhode Island	July 1, 2018
South Dakota	July 1, 2019
Tennessee	July 1, 2021
Utah	May 3, 2023
Vermont	July 1, 2016

Source: Collected by the authors from state legislative statutes.

Appendix Table 3. Sensitivity of Estimates in Table 2 to Use of Combined YRBSS Survey

	(1)	(2)	(3)	(4)	(5)
	Panel I: School Indoor Vaping Restriction				
	(a) Current ENDS Use				
School Indoor Vaping Restriction	-0.0039	0.0052	-0.0031	-0.0049	-0.0075
	(0.0122)	(0.0128)	(0.0134)	(0.0139)	(0.0142)
Pre-Treat Mean DV	0.2168	0.2168	0.2168	0.2168	0.2168
N	807753	807753	807753	807753	807753
	(b) Frequent ENDS Use				
School Indoor Vaping Restriction	0.0051	0.0054	0.0024	0.0020	0.0026
	(0.0066)	(0.0060)	(0.0070)	(0.0070)	(0.0070)
Pre-Treat Mean DV	0.0438	0.0438	0.0438	0.0438	0.0438
N	807753	807753	807753	807753	807753
	Panel II: Campus-Wide School Vaping Restriction				
	(a) Current ENDS Use				
Campus-Wide School Vaping Restriction	-0.0142	-0.0099	-0.0129	-0.0124	-0.0197
	(0.0133)	(0.0134)	(0.0129)	(0.0147)	(0.0155)
Pre-Treat Mean DV	0.2208	0.2208	0.2208	0.2208	0.2208
N	807753	807753	807753	807753	807753
	(b) Frequent ENDS Use				
Campus-Wide School Vaping Restriction	-0.0087	-0.0088	-0.0111	-0.0104	-0.0125
	(0.0073)	(0.0084)	(0.0087)	(0.0085)	(0.0082)
Pre-Treat Mean DV	-0.5546	-0.6150	-0.6809	-0.6557	-0.6888
N	0.0413	0.0413	0.0413	0.0413	0.0413
Controls:					
State and Year-by-Semester FE?	Yes	Yes	Yes	Yes	Yes
Demographics?	Yes	Yes	Yes	Yes	Yes
Macroeconomic and COVID?	Yes	Yes	Yes	Yes	Yes
Other Place-Based ENDS Restrictions?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
Combustible Tobacco Policies?	No	No	No	Yes	Yes
Substance Policies?	No	No	No	No	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Average marginal effect estimates, using weighted logistic regression, are generated from individual-level State and National (Combined) Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. Sample weights are generated using the individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level.

Appendix Table 4. Estimates of the Effect of School-Based Vaping Restrictions on Adult ENDS Use, BRFSS and CPS-TUS

	(1)	(2)
Sample →	Adults Aged 20-34	K-12 Teachers/ Staff Aged 20-34
	Panel I. School Indoor Vaping Restriction	
School Indoor Vaping Restriction	0.0025	-0.0146
	(0.0037)	(0.0113)
Pre-Treat. Mean of DV	0.0897	0.0283
N	361377	3526
	Panel II. Campus-Wide School Vaping Restriction	
Campus-Wide School Vaping Restriction	0.0015	-0.0066
	(0.0033)	(0.0114)
Pre-Treat. Mean of DV	0.0813	0.0168
N	253758	3526
Dataset?	BRFSS	CPS-TUS

** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

Notes: Column 1 reports average marginal effect estimates generated using weighted logistic regression from individual-level Behavioral Risk Factor Surveillance System (BRFSS) data collected over the period 2016–2023. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID-related controls include the state-by-year cumulative COVID-19 case rate and an index measuring the overall government response to the pandemic. ENDS policies include ENDS taxes (in 2023 dollars), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online ENDS sales. Combustible tobacco policies include cigarette taxes (in 2023 dollars), Tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in 2023 dollars), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level. The regression includes population weights. Column 2 reports average marginal effect estimates generated using data from the Tobacco Use Supplement to the Current Population Survey (CPS-TUS) collected over the period 2014–2023. Estimation is restricted to adults currently working in education, instruction, and library occupations (e.g., teachers and librarians).

Appendix Table 5. Effects of SVRs on Frequent ENDS Use among Youths, PATH

	(1)	(2)	(3)	(4)	(5)	(6)
Estimator →	DD	DD	DD	DDD	DDD	DDD
Analysis Sample →		Youth Aged 14-17			Youths Aged 14-17 vs "Untreated" Young Adults Aged 20-34	
			Panel I: School Indoor Vaping Restriction			
School Indoor Vaping Restriction	0.0012	-0.0002	-0.0012	0.0049	0.0027	0.0017
	(0.0051)	(0.0087)	(0.0081)	(0.0050)	(0.0077)	(0.0073)
Pre-Treat. Mean of DV	0.0138	0.0138	0.0138	0.0138	0.0138	0.0138
N	65275	65275	65275	143035	143035	143035
			Panel II: Campus-Wide School Vaping Restriction			
Campus-Wide School Vaping Restriction	-0.0041	-0.0065	-0.0062	0.0001	-0.0030	-0.0022
	(0.0050)	(0.0072)	(0.0071)	(0.0052)	(0.0071)	(0.0071)
Pre-Treat. Mean of DV	0.0136	0.0136	0.0136	0.0136	0.0136	0.0136
N	65275	65275	65275	143392	143392	143392
			Panel III: Comprehensive School Vaping Restrictions			
Campus-Wide School Vaping Restriction * Workplace/Dining/Drinking Vaping Ban	-0.0050 (0.0046)	-0.0041 (0.0043)	-0.0044 (0.0061)	0.0002 (0.0048)	0.0018 (0.0045)	0.0042 (0.0066)
Campus-Wide School Vaping Restriction Only		-0.0021 (0.0086)	-0.0032 (0.0080)		0.0009 (0.0078)	0.0001 (0.0076)
Workplace/Dining/Drinking Establishment Indoor Vaping Restriction Only		0.0206 (0.0127)	0.0176 (0.0125)		0.0210 (0.0146)	0.0172 (0.0146)
Pre-Treat. Mean of DV	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156
N	65275	65275	65275	148794	148794	146468
Control Variables:						
State-by-Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes	Yes
Age and Individual FE?	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic and COVID?	Yes	Yes	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	Yes	No	Yes	Yes
ENDS, Combustible Tobacco, and Substance Use Policies?	No	No	Yes	No	No	Yes

**p<.1, **p<.5, ***p<.01*

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarettes taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level and reported in parentheses.

Appendix Table 6. Longer-Term Effects of School Vaping Restrictions on Previously Treated Young Adults Among Those with Information on State of Residence as Teenager, PATH

	(1)	(2)	(3)	(4)
	Current ENDS Use		Frequent ENDS Use	
	Panel I. School Indoor Vaping Restrictions			
School Indoor Vaping Restriction	-0.0195	-0.0208	-0.0063	-0.0065
	(0.0152)	(0.0153)	(0.0063)	(0.0061)
Pre-Treat. Mean of DV	0.2406	0.2406	0.0251	0.0251
N	11210	11210	10254	10254
	Panel II. Campus-Wide School Vaping Restrictions			
Campus-Wide School Vaping Restriction	-0.0144	-0.0160	-0.0075	-0.0077
	(0.0159)	(0.0160)	(0.0065)	(0.0064)
Pre-Treat. Mean of DV	0.2406	0.2406	0.0251	0.0251
N	11210	11210	10254	10254
Control Variables:				
Current State FE and Year-by-Quarter FE?	Yes	Yes	Yes	Yes
Teen State FE and Grade Cohort FE?	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes
Current Place-Based Vaping Restriction?	Yes	Yes	Yes	Yes
Macroeconomic and COVID?	Yes	Yes	Yes	Yes
ENDS Policies?	No	Yes	No	Yes
Combustible Tobacco Policies?	No	Yes	No	Yes
Substance Use Policies?	No	Yes	No	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Demographic controls include sex, age, race, and education. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the level of state of residence as youths.

Appendix Table 7. Effect of School Vaping Restrictions on Assessment of Perceived Health Risks of E-Cigarette Use, PATH and MTF

	(1)	(2)	(3)	(4)
	Agreed that E-Cigarette Use is Very Harmful to One's Health		Agreed that E-Cigarette Use Just as or More Harmful than Combustible Cigarettes	
School Indoor Vaping Restriction	0.0364	0.0413	0.0181	0.0109
	(0.0476)	(0.0558)	(0.0153)	(0.0151)
Pre-Treat. Mean of DV	0.7296	0.7296	0.6293	0.6293
N	21877	21877	63344	63344
Controls?				
Baseline Controls?	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	No	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates are generated using the Population Assessment of Tobacco and Health data (e-cigarette absolute health risk beliefs, 2018-2023; relative health risk beliefs, 2013-2023). All models include baseline demographic controls (sex, grade, age, race in MTF; age and individual fixed effects in PATH) and macroeconomic controls (unemployment rate, poverty rate). In the models for vape types in the past 30 days and health risks beliefs, baseline controls additionally include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. Standard errors are in parentheses and clustered at the state level

Appendix Table 8. Estimates of the Effect of Comprehensive K-12 School-Inclusive and Other Place-Based Indoor Vaping Restrictions on Youth ENDS Use, Combined YRBSS

	(1)	(2)	(3)	(4)	(5)
		Panel I: Current ENDS Use			
Campus-Wide School Vaping Restriction * Workplace/Dining/Drinking Vaping Ban	-0.0322***	-0.0291**	-0.0244*	-0.0203	-0.0262*
	(0.0091)	(0.0116)	(0.0125)	(0.0162)	(0.0147)
Campus-Wide School Vaping Restriction Only		0.0012	-0.0057	-0.0087	-0.0160
		(0.0142)	(0.0140)	(0.0152)	(0.0156)
Workplace/Dining/Drinking Establishment Indoor Vaping Restriction Only		0.0237*	0.0092	0.0091	0.0122
		(0.0143)	(0.0135)	(0.0147)	(0.0135)
Pre-Treat Mean DV	0.2088	0.2088	0.2088	0.2088	0.2088
N	807753	807753	807753	807753	807753
		Panel II: Frequent ENDS Use			
Campus-Wide School Vaping Restriction * Workplace/Dining/Drinking Vaping Ban	-0.0162***	-0.0123**	-0.0099**	-0.0103*	-0.0130***
	(0.0048)	(0.0052)	(0.0049)	(0.0055)	(0.0046)
Campus-Wide School Vaping Restriction Only		-0.0003	-0.0021	-0.0033	-0.0061
		(0.0069)	(0.0076)	(0.0077)	(0.0073)
Workplace/Dining/Drinking Establishment Indoor Vaping Restriction Only		0.0493***	0.0438***	0.0427***	0.0461***
		(0.0144)	(0.0147)	(0.0138)	(0.0146)
Pre-Treat Mean DV	0.0449	0.0449	0.0449	0.0449	0.0449
N	807753	807753	807753	807753	807753
Controls:					
State and Year-by-Semester FE?	Yes	Yes	Yes	Yes	Yes
Demographics, Macro, and COVID Controls?	Yes	Yes	Yes	Yes	Yes
K-12 School Indoor Vaping Restriction Only?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
Combustible Tobacco Policies?	No	No	No	Yes	Yes
Substance Use Policies?	No	No	No	No	Yes

** p < 0.1, ** p < 0.05, *** p < 0.01*

Notes: Average marginal effect estimates, using weighted logistic regression, are generated from individual-level State and National (Combined) Youth Risk Behavior Survey (YRBS) collected over the period 2015-2023. Sample weights are generated using the individual State YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level.

[a]All states that have a dining/workplace vaping restriction have a K-12 school vaping restriction in place during our sample period. Thus, we cannot distinguish between the effect of dining/workplace indoor vaping restrictions and the interactive effect of K-12 school indoor vaping restrictions and dining/workplace indoor vaping restrictions.

Appendix Table 9. Discrete-Time Hazard Estimates of the Effects of Comprehensive School Vaping Restrictions on Initiation and Cessation of Youth ENDS Use, PATH

	(1)	(2)	(3)	(4)
	Initiation		**Cessation**	
Comprehensive K-12 Campus Inclusive Place-Based Vaping Restriction	-0.0203**	-0.0208	-0.0954	-0.1462
	(0.0077)	(0.0144)	(0.1283)	(0.1416)
Pre-Treat. Mean of DV	0.0656	0.0656	0.4453	0.4453
N	61921	61921	2210	2210
Control Variables:				
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes
Age and Individual FE?	Yes	Yes	Yes	Yes
Macroeconomic and COVID?	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	Yes	Yes	Yes	Yes
ENDS Policies?	No	Yes	No	Yes
Combustible Tobacco Policies?	No	Yes	No	Yes
Substance Policies?	No	Yes	No	Yes

** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the state level.

Appendix Table 10. Effects of Comprehensive K-12 School-Inclusive and Other Place-Based Indoor Vaping Restrictions on Youth Current ENDS Use, MTF

	(1)	(2)	(3)
Campus-Wide School Vaping Restriction * Workplace/Dining/Drinking Vaping Ban	-0.0100 (0.0127)	-0.0056 (0.0135)	0.0058 (0.0104)
Campus-Wide School Vaping Restriction Only		0.0045 (0.0085)	0.0096 (0.0080)
Workplace/Dining/Drinking Establishment Indoor Vaping Restriction Only		0.0257*** (0.0075)	0.0157* (0.0091)
Pre-Treat. Mean of DV	0.1285	0.1285	0.1285
N	198221	198221	198221
Control Variables:			
State FE, Year-by-Quarter FE, Demog, Macro, COVID?	Yes	Yes	Yes
School Indoor Only Vaping Restriction?	No	Yes	Yes
ENDS, Combustible Tobacco, and Substance Use Policies?	No	No	Yes

**p<.1, **p<.05, ***p<.01*

Notes: Estimates are generated via weighted logistic regression using the Monitoring The Future (MTF) data collected over the period 2014-2023. Demographic characteristics include sex, race, age, and grade. Macroeconomic controls include the unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarettes taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023), recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are clustered at the state level and reported in parentheses.

Appendix Table 11. Effects of Comprehensive School Vaping Restrictions on Types of Vaping Devices and Assessment of Health Risks of E-cigarette Use

	Panel I: Vaping Devices			
	Refillable "Tank"		Disposable E-Cigarettes	
Comprehensive School Vaping Restriction	-0.0087 (0.0076)	-0.0121* (0.0068)	-0.0034 (0.0274)	0.0041 (0.0300)
Pre-Treat. Mean of DV	0.0340	0.0340	0.0122	0.0122
N	56597	56597	21911	21911
	Panel II: Assessment of Health Risks of E-Cigarette Use			
	Agreed that E-Cigarette Use is Very Harmful to One's Health		Agreed that E-Cigarette Use Just as or More Harmful than Combustible Cigarettes	
Comprehensive School Vaping Restriction	-0.0264 (0.0510)	-0.0110 (0.0583)	-0.0017 (0.0132)	0.0019 (0.0138)
Pre-Treat. Mean of DV	0.7747	0.7747	0.6504	0.6504
N	21877	21877	63344	63344
Controls:				
Baseline Controls?	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	No	Yes

** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

Notes: Estimates are generated using the Population Assessment of Tobacco and Health data (refillable tank use 2014-2023; disposable e-cigarette use in the past 30 days and e-cigarette absolute health risk beliefs, 2018-2023; relative health risk beliefs, 2013-2023). Baseline controls include age and individual fixed effects, macroeconomic controls, and COVID-19 controls. Macroeconomic controls include unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. Standard errors are in parentheses and clustered at the state level.

Appendix Table 12. Heterogeneity in School Indoor Vaping Restriction Effects on Youth ENDS Use by Employed and Eating Out Populations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ENDS Use		ENDS Use Among Working	ENDS Use Among Non-Working	ENDS Use at School among Working	ENDS Use at School among Non-Working	ENDS Use among Teens Likely Eating Out Frequently[a]	ENDS Use among Teens Likely Not Eating Out as Much[a]
School Indoor Vaping Restriction	-0.0032	0.0053	-0.0002	0.0076	0.0010	0.0026	0.0173	0.0132
	(0.0158)	(0.0199)	(0.0312)	(0.0178)	(0.0097)	(0.0090)	(0.0189)	(0.0408)
Pre-Treat. Mean of DV	0.1464	0.1464	0.2016	0.1026	0.0675	0.0325	0.1177	0.1482
N	54738	54738	21838	31825	23320	32901	7797	4349
Controls:								
Baseline Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other Place-Based Vaping Restriction?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dataset:	MTF	MTF	MTF	MTF	MTF	MTF	BRFSS	BRFSS

** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

Notes: Estimates are generated via weighted logistic regression using the Monitoring The Future (MTF) data collected over the period 2019-2023 and Behavioral Risk Factor Surveillance System (BRFSS) data collected over the period 2017–2022. Baseline controls include age and individual fixed effects, macroeconomic controls, and COVID-19 controls. Macroeconomic controls include unemployment rate and poverty rate. COVID-19 controls include state-by-year cumulative COVID-19 cases rates and an index of overall government response to the pandemic. Standard errors are in parentheses and clustered at the state level.

[a] Eating out frequently is proxied using the reported frequency of eating French fries in the past month from the BRFSS. Respondents who report eating French fries 10 or more times in the past month are classified as eating out frequently; all others are classified as not eating out frequently.

Appendix Table 13. Longer-Term Effects of Comprehensive School-Inclusive Vaping Restrictions on Frequent ENDS Use, PATH

	(1)	(2)	(3)	(4)
Analysis Sample →	Full Sample		Adults Observed in PATH as Youth	
	Panel I: Frequent ENDS Use			
Comprehensive School-Inclusive Vaping Restriction	0.0011 (0.0037)	0.0010 (0.0038)	-0.0060* (0.0032)	-0.0060* (0.0034)
Pre-Treat. Mean of DV	0.0111	0.0111	0.0251	0.0251
N	84459	84459	10254	10254
	Panel II: Frequent Cigarette Smoking			
Comprehensive School-Inclusive Vaping Restriction	-0.0042 (0.0052)	-0.0047 (0.0051)	0.0004 (0.0090)	-0.0004 (0.0091)
Pre-Treat. Mean of DV	0.0221	0.0221	0.0079	0.0079
N	74099	74099	10862	10862
Control Variables:				
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes
Youth State and Grade Cohort FE?	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes
Current Place-Based Vaping Restriction?	Yes	Yes	Yes	Yes
Macroeconomic and COVID?	Yes	Yes	Yes	Yes
ENDS Policies?	No	Yes	No	Yes
Combustible Tobacco Policies?	No	Yes	No	Yes
Substance Policies?	No	Yes	No	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates are generated via weighted least squares using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Demographic controls include sex, age, race, and education. Macroeconomic controls include the unemployment rate and poverty rate. COVID controls include state-by-year cumulative COVID-19 cases rate and an index for overall government response to the pandemic. ENDS policies include ENDS taxes (in $2023), minimum legal sales age (MLSA) laws, flavored ENDS restrictions, ENDS licensure laws, and restrictions on online sales of ENDS products. Combustible tobacco policies include cigarette taxes (in $2023), tobacco 21 laws, tobacco licensure laws, and clean indoor air laws. Substance policies include beer taxes (in $2023, recreational marijuana laws, medical marijuana laws, and marijuana decriminalization laws. Standard errors are in parentheses and clustered at the level of state of residence as youths.