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THE EFFECT OF ONLINE SALES BANS ON E-CIGARETTE USE

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ABSTRACT

Policymakers at the state and federal levels have argued that restricting online sales of e-cigarettes is a crucial policy tool to curb youth vaping. This study is the first to explore the effectiveness of statewide restrictions on online sales of electronic nicotine delivery systems (ENDS) on teen and young adult ENDS use. Using data from four national datasets (Monitoring the Future, State and Combined Youth Risk Behavior Surveillance System surveys, Population Assessment of Tobacco and Health, and Behavioral Risk Factor Surveillance System survey) and a generalized difference-in-differences approach, we find no evidence that such laws are effective at curbing youth ENDS use. With 95 percent confidence, we can rule out that online sales restrictions reduced prior-month ENDS use by more than 3.6 percent of the pre-treatment mean vaping rate. An exploration of mechanisms suggests that (1) while restrictions on online sales may have a small negative effect on online purchases, youths are able to substitute to other sources for ENDS products to compensate for reduced online access, and (2) online sources are a very rare source of e-cigarettes for youths. Finally, we also find no evidence that online sales restrictions reduce adult ENDS use.

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"Curbing internet sales is … one way for Congress to address prevalent use of e-cigarettes by young people."

- House Judiciary Committee Report No. 116-260 (2019)

"We must confront the growing youth vaping crisis. One key way to do that is by cutting off online sales to minors, one of the easiest ways for children to purchase these dangerous devices."

Senator Diane Feinstein (2020)

1. Introduction

The past two decades have witnessed a dramatic shift in the tobacco product landscape due to electronic cigarettes (e-cigarettes), or more broadly, electronic nicotine delivery systems (ENDS). Since their introduction to the U.S. market in 2007, e-cigarettes have surged in popularity—particularly among youth—surpassing conventional cigarettes in 2014 to become the most widely used tobacco product among adolescents (Dave et al., 2019). The rapid increase led the U.S. Surgeon General to declare youth vaping a national epidemic after e-cigarette use among high school students nearly doubled from 11.7% to 20.8% between 2017 and 2018, and use among middle school students rose from 3.3% to 4.9% in the same period (Cullen et al., 2019).

Electronic cigarettes have been marketed as a less harmful alternative to combustible cigarettes since their aerosols contain far fewer chemicals than cigarette smoke (Rom et al., 2015). The UK's Office for Health Improvement and Disparities estimated vaping to pose approximately 5% of the health risk of smoking (McNeill et al., 2022), although Allcott and Rafkin (2022) noted a wide range of uncertainty among experts. This presumed lower risk makes e-cigarettes a popular smoking cessation method.[1]

[1] A randomized controlled trial found that individual smokers who were not initially planning to quit smoking completely reduced their daily cigarette consumption by more than fifty percent when substituting with e-cigarettes (Caponnetto et al., 2013). Studies have also shown that despite a lower per-attempt success rate than, for example, quitting cold turkey, e-cigarettes may be more effective than other cessation products at helping smokers reduce their

Nonetheless, e-cigarettes still cause some level of harm due to the additives in them as well as extended heating (Critselis and Panagiotakos, 2024).[2] Given that even among smokers differences in death rates are difficult to detect before the age of 40, we are unlikely to know the full extent of health harms of e-cigarettes until they have been on the market in excess of 20 years (Jha et al., 2013). Additionally, e-cigarettes tend to attract younger generations, largely due to targeted advertisements featuring elements appealing to youth, such as flavors, fruit imagery, health references, and other positive sensations (Liu et al., 2023). Their appeal is further strengthened by the perceived social status elevation associated with their use, as well as the easy access afforded by inadequate oversight and age verification processes online (Williams, Derrick, and Ribisl, 2015).[3]

This poses a regulatory challenge: how can policymakers enable access to e-cigarettes as a harm reduction tool for adult smokers, while minimizing uptake among youth? A major focus of tobacco control efforts has been regulating supply channels through which youth obtain nicotine products. The internet has played an outsized role in facilitating underage access to both cigarettes and e-cigarettes, often bypassing age-verification laws (Williams, Derrick, and Phillips, 2017).[4] When they were introduced, e-cigarettes were heavily marketed and sold online, with more than 30-50% of their sales occurring through the internet. As of 2014, there were about 466 e-cigarette brands with their own websites and 7,764 unique flavors were identified online (Rom et al., 2015).

consumption (Hajek et al., 2019). Some evidence suggests lower dependency levels compared to other nicotine replacement therapies (Etter and Eissenberg, 2015) as well as lower levels of nicotine per puff than cigarettes (Schroeder and Hoffman, 2014).

[2] They are known to cause immediate increases in airway resistance and inflammation. Exposure to various components found in vape liquid (such as humectants, flavoring agents, and metals) can also significantly increase the secretion of pro-inflammatory cytokines in both the upper airways and lungs, heightening the risk of infection and pneumonia (Park, Crotty Alexander, and Christiani, 2022). Other adverse effects on health include increased blood pressure and decreased oxygen saturation (Critselis and Panagiotakos, 2024).

[3] Youths and young adults face unique risks as they are still undergoing development of their prefrontal cortex, the brain region responsible for rational decision-making, executive function, and higher-order cognitive abilities. Nicotine has been shown to impair this development, potentially causing adverse developmental consequences for individuals under age 24 (Lopez-Ojeda and Hurley, 2024).

[4] Online access to tobacco can also be an important channel for adult users. In a survey of adults, it was found that 71% had ever purchased tobacco or e-cigarettes online with major reasons cited being they are cheaper, it was more convenient, and saved them time (Jensen et al., 2022).

Fueled by the concern that online platforms can be a major access point for youth in procuring vaping products, there has been a concerted effort at the state and federal levels to adopt online sales restrictions with various levels of restrictiveness. Over the past fifteen years, 10 states have enacted regulations that restrict or prohibit the online sale and shipment of e-cigarettes. In 2009, the Family Smoking Prevention and Tobacco Control Act banned online sales of flavored cigarettes, but this did not extend to e-cigarettes. It was not until the passage of the Preventing Online Sales of E-Cigarettes to Children Act (POSECCA) in 2020—implemented in 2021—that federal policy directly restricted online e-cigarette sales by requiring adult signature upon delivery and prohibited the U.S. Postal Service (USPS) from shipping e-cigarette products – a shipping ban that has also been voluntarily honored by major private common carriers (i.e. UPS, Federal Express).

These policies aim to sever a critical supply route for underage users and reduce product availability overall. The regulatory push towards restricting such supply channels continues despite a lack of rigorous evidence base on their effectiveness. In its recently issued policy framework, for instance, the Association of State and Territorial Health Officials (ASTHO) recommended internet sales restrictions as part of a cornerstone set of policy interventions to limit ENDS availability for youth and to prevent youth use (Tobacco Control Network 2022). It is possible these regulations are ineffective altogether in their primary purpose of limiting youth access to purchasing e-cigarettes online. In fact, vendors may not even comply with the regulations and so youth may continue obtaining e-cigarettes online even in states where it should be illegal to do so (Bertrand, Diaz, Hair Schillo, 2023; Harati, Ellis, Satybaldiyeva, 2024). With respect to the national shipping ban, many online vendors switched to local and regional carriers that were not subject to the ban, and which, while raising shipping costs and times, nevertheless allowed online sales to continue.

Even under full compliance, the effectiveness of these policies depends on two key inputs: 1) the extent to which youth currently rely on online platforms to supply their e-cigarettes; and 2) the extent to which youth substitute to other sources for procuring e-cigarettes when faced with constraints on online purchases. At the height of e-cigarette use among youth, only about four percent of current youth vapers relied on online sources to procure ENDS products (based on 2017 National YRBS data), which potentially limits the population that would be impacted by internet sales restrictions. On the other hand, it is also possible that internet sales restrictions may affect a broader population of youth and effectively reduce overall e-cigarette use. Youth are regularly exposed to online e-cigarette ads,[5] and greater exposure is significantly associated with lower perceived risk of ENDS products and greater consumption (Pu and Zhang 2017). If constraining online sales is associated with complementary decreases in online ads and promotions for e-cigarettes, reduced exposure to such ads could be a pathway for online sales bans to have wider effects on the demand for ENDS. At the same time, even if ENDS use is effectively curtailed in response to the bans, broader health and welfare implications of these regulations further depend on the extent to which youth may be substituting towards combustible cigarettes.[6]

This study provides the first comprehensive evidence on how statewide online sales bans have impacted e-cigarette use and smoking behavior among adolescents and adults. We utilize data from five national surveys: Monitoring the Future (MTF), State and Combined Youth Risk Behavior Surveillance System surveys (YRBSS), longitudinal Population Assessment of Tobacco and Health (PATH), and Behavioral Risk Factor Surveillance System survey (BRFFS). We leverage the staggered

[5] For 2019, almost 16 percent of adolescents reported seeing ads or promotions for e-cigarettes "most of the time" or "always" when using the internet; an additional 28 percent reporting being exposed to such ads "sometimes" (National Youth Tobacco Survey).

[6] Such substitution effects for youth and young adults have been uncovered for other ENDS policies, including taxes (Abouk et al. 2023), minimum legal sales age (Dave et al. 2019), and restrictions on flavored ENDS products (Cotti et al. 2025; Saffer et al. 2025).

adoption of the bans, within a generalized difference-in-differences (DiD) approach, to estimate the effects of the restrictions on various margins of use. We find no evidence that restricting online sales is effective at curtailing youth e-cigarette use. Our null effects are precise enough to rule out declines in current vaping by more than 3.6 percent of the pre-treatment mean vaping rate. These null findings extend across all margins of use, including any dynamic transitions into ENDS initiation or cessation based on a longitudinal discrete time hazard analysis of youth in the PATH.

In exploring the channels underlying the ineffectiveness of the sales bans, we find four key results. First, youth did not often use the online channel for access before sales restrictions, consistent with prior survey work (CTFK, 2021). Second, while there is a significant "first-stage" decline in youth relying on online purchases as a supply source in response to the bans, these effects are small (less than a percentage point) given that very few youths were using online platforms for procuring e-cigarettes. Next, there is some indication of substitution in methods from online to in-person purchases and social channels that serve to mute any overall declines in use. Finally, we find no evidence that adults were affected by the policy either in e-cigarette or cigarette use despite potentially larger use rates compared to youth (NAQC, 2025).

A causal interpretation of our findings is supported by event study analyses and several other robustness checks. The results are also robust to an alternate stacked DiD estimator that mitigates any concerns related to dynamic and heterogenous treatment effects (Cengiz et al, 2019).

2. Background

Over the past fifteen years, states have increasingly enacted legislation to restrict or prohibit the online sale and shipment of cigarettes and e-cigarettes, motivated by concerns about youth access, tax evasion, and unregulated cross-state commerce. The earliest state-level restriction emerged in Utah, where a 2010 law (Utah Code § 76-10-105.1) required all tobacco transactions to occur in a face-to-face exchange, effectively prohibiting direct-to-consumer online sales. Arkansas

followed in 2015 with Act 1235 (§ 26-57-214), which required retailers to obtain a delivery permit and restricted shipment of tobacco products to consumers without one, again functioning as a de facto ban. Hawaii enacted similar restrictions effective January 2016 (HRS § 328J-18), mandating that all tobacco products be sold in face-to-face transactions and prohibiting remote sales to unverified buyers. Maine joined in 2017 with legislation (LD 1555-F) that allowed shipment of tobacco only to licensed retailers, cutting off direct online consumer purchases. South Dakota implemented a comparable prohibition in 2019 (SDCL § 10-50-99), banning the distribution of tobacco products to unlicensed consumers through the mail or internet. Vermont's 2019 statute (Title 7, § 1010) applied specifically to "tobacco substitutes," allowing only limited online sales and imposing retailer licensing requirements. New York in July 2020 under Public Health Law § 1399-LL, prohibited shipment of vapor and tobacco products to any unlicensed individual. Oregon enacted one of the most recent comprehensive bans, effective January 2022 (ORS § 180.441), explicitly prohibiting delivery of cigarettes and vapor products directly to consumers.

Other states have less restrictive policies. Ohio's statute (§ 2927.02) prohibits certain forms of distribution of tobacco and vapor products to minors but does not explicitly ban adult online purchases, making it relatively permissive. Massachusetts similarly allows online tobacco sales if age verification occurs at the point of delivery, reflecting a partial restriction rather than a full ban. These laws are like the federal expansion of the PACT (Prevent All Cigarette Trafficking) Act to include e-cigarettes in 2021 in that they don't completely prohibit online sales but do add a potential barrier for youth obtainment.

We leverage the variation in the adoption of these policies across states to provide the first empirical assessment of these restrictions, based on a causal research design, on both e-cigarette and cigarette consumption, for both youth and adults, across all salient margins of use. Our study contributes to a broader literature on substitution between cigarettes and e-cigarettes as e-cigarettes

are restricted or made more costly to obtain. This includes the effects of minimum purchase age of 18 laws (Friedman, 2015), minimum age of 21 purchase laws (Hansen et al, 2023), taxing e-cigarettes (Saffer et al, 2020; Abouk et al, 2023), licensure laws (Courtemanche et al, 2024), flavor bans (Cotti et al, 2025; Saffer et al, 2025), and indoor air laws (Cooper and Pesko, 2017).

3. Data

Our empirical analyses use data drawn from four national sources: the Monitoring the Future (MTF) survey, the Youth Risk Behavioral Surveillance System (YRBSS) survey, the Population Assessment of Tobacco and Health (PATH) survey, and the Behavioral Risk Factor Surveillance System (BRFSS). Each dataset has advantages and disadvantages, and each complements the others. We describe each data source, as well as our key measures, below.

3.1 Monitoring the Future (MTF)

We begin with our primary analyses of youth using data on 8th, 10th, and 12th graders from the MTF Main study over the period 2014-2023. The MTF Main study is a school-based repeated cross-sectional survey administered annually to students in classrooms via a web-based interface by the University of Michigan Survey Research Center.[7] The MTF survey is sponsored by the National Institute on Drug Abuse. These data are valuable for our study because they include information on middle and high school students' ENDS use and combustible tobacco use, as well as state identifiers, which allow the respondent's state of residence to be linked to the respondent's tobacco-related behaviors. Our analysis first examines the full sample of 8th through 12th graders before focusing on high school students (attending 10th or 12th grades) and then high school seniors (12th graders) to capture those with relatively higher rates of prior-month ENDS use.

[7] The University of Michigan notes that approximately 10 days before the survey is administered in schools, parents are notified. They have an opportunity to refuse their child's participation.

A key advantage of the MTF is that information on ENDS use is consistently available annually (rather than biennially) over an extended period spanning a decade. Respondents to the MTF are asked, "On how many days (if any) during the last 30 days have you vaped nicotine?" If the respondent reports vaping nicotine on at least one day in the prior month, the variable *Current ENDS Use* is set equal to 1; it is set equal to 0 otherwise. In the full sample, the share of respondents who report prior-month ENDS use is 13.7 percent. If we restrict the sample to high school students (i.e., those attending 10^{th} or 12^{th} grades), this percentage rises to 16.4 percent, and if we examine only high school seniors (i.e., those attending 12^{th} grade), this percentage is 18.1 percent.

We also measure *Frequent ENDS Use*, which captures more habitual use of ENDS. *Frequent ENDS Use* is set equal to 1 if the respondent reports nicotine vaping on at least 20 days in the last 30 days; it is set equal to 0 if the respondent reports fewer days of nicotine vaping (including abstaining entirely from vaping nicotine). We find that 4.0 percent of the full sample, 5.1 percent of high school students, and 6.1 percent of high school seniors reported frequent nicotine vaping.

In addition, we also measure combustible cigarette smoking among youths, which could be indirectly affected by a policy that changes the relative cost of accessing a related (substitute or complement) good. We generate measures of smoking using responses to the question, "How frequently have you smoked cigarettes during the past 30 days?" The response options are: "Not at all", "Less than one cigarette per day", "One to five cigarettes per day", "About one-half pack per day", "About one pack per day", "About one and one-half packs per day", and "Two packs or more per day." *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 a half pack or more in the past 30 days. In our full sample, 4.6 percent (0.7 percent) of respondents report current (heavier) cigarette smoking.

Panel (a) of Figure 1 shows trends in current and frequent nicotine vaping among the full MTF sample and among high school respondents. Prior-month and habitual youth ENDS use rose to a peak in 2019, reflecting the expansion of Juul in the U.S. e-cigarette market. Since that time, teen vaping has declined substantially, owing in part to a rise in the minimum legal purchasing age for ENDS products. In contrast, current (as well as heavier) smoking prevalence has declined steadily and precipitously over the sample period from 7.6 percent in 2014 to 1.8 percent in 2023 (Panel b of Figure 1).

3.2 Youth Risk Behavior Surveillance System (YRBSS)

To supplement the analyses of youth from the MTF, we use data from the YRBSS surveys. The State YRBSS surveys are collected by State Departments of Education and Health and Human Services and coordinated by the Centers for Disease Control and Prevention. The YRBSS is a biennial, school-based, repeated cross-sectional survey of 9th through 12th graders in the U.S. A strength of the data is that, 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, when using state-by-year data from the Surveillance, Epidemiology, and End Results (SEER) Program, the pooled sample of states can also be made nationally representative of high school-aged (ages 14-18) students.

In alternate models, given that the State YRBSS survey is unbalanced and in order to maximize identifying variation of our policy of interest through a larger representation of states, we augment the State YRBSS with data from the national YRBSS survey.[8] These data are collected by the CDC and, when weighted using CDC-provided sample weights, are designed to be representative of U.S. high school students nationally. We generate the Combined YRBSS survey

[8] Combining the YRBSS samples adds five more states to the analytic sample.

weights following Abouk et al. (2023), Cotti et al. (2025), Chuo et al. (2025), and Courtemanche et al. (2025). These weights are designed to make the resultant sample representative of the age-by-gender-by race/ethnicity population of 14-18-year-olds of each state and the nation as a whole.[9]

The YRBSS surveys contain information on prior-month nicotine vaping over the period 2015-2023. Specifically, respondents are asked, "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)." If a high school student reports vaping on at least one day in the prior month, the variable *Current ENDS Use* is set equal to 1; it is 0 otherwise. *Frequent ENDS Use* is set equal to 1 if the respondent reports ENDS use on at least 20 of the last 30 days and is 0 otherwise. Among State YRBSS respondents, 18.7 percent (5.3 percent) report current (frequent) ENDS use. In the Combined YRBSS sample, the rate of current (frequent) ENDS use is 19.8 percent (6.0 percent).

In addition to being state- and nationally-representative with appropriate weighting, the YRBSS offers a key advantage in including information on how youths typically purchase their e-cigarettes, albeit over a more limited span of the 2017-2023 waves. Respondents are asked, "During the past 30 days, how did you usually get your electronic vapor products?" We generate a categorical outcome variable named *Usual Sources* using five categories of responses to this question: (1) *Non-Use*, that is "not us[ing] any electronic vapor products during the past 30 days," (2) *Own Purchase at Store*, typically buying e-cigarettes him/herself "in a vape shop or tobacco shop," "in a convenience store, supermarket, discount store, or gas station," or "at a mall or shopping center kiosk or stand,"

[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 (Hansen et al., 2023; Rees et al., 2021; Sabia & Anderson, 2016).

(3) *Social Sources,* typically getting e-cigarettes "from a friend, family member, or someone else," (4) *Online Sources*, typically obtaining e-cigarettes "on the Internet, such as from a product website, vape store website, or other website like eBay, Amazon, Facebook Marketplace, or Craigslist," and (5) *Other Sources*, typically obtaining e-cigarettes by stealing them or in some other way.

Over the period 2017-2023, we find that in the State (Combined) YRBSS, 17.7 percent (18.6 percent) of respondents report being current ENDS users. 3.6 percent (4.3 percent) of the sample reports making their own retail-based purchases, 9.9 percent (10.1 percent) report relying on social sources, 0.5 percent (0.5 percent) report purchasing online, and 3.2 percent (3.4 percent) report using other sources. When expressed as a share of ENDS users rather than the entire sample, these numbers become 20.3 percent (23.1 percent) for retail, 55.9 percent (54.3 percent) for social, 2.8 percent (2.7 percent) for online, and 18.1 percent (18.3) for other sources. Therefore, social sources are most prevalent, while online purchases are relatively rare. This implies that large effects of online bans would have to come at least in part from spillovers to other sources.

Finally, we measure combustible cigarette smoking using responses to the following questionnaire item, "During the past 30 days, on how many days did you smoke cigarettes?" *Current (Frequent) Cigarette Smoking* is set equal to 1 if the respondent reports at least 1 (20) day(s) of prior month combustible cigarette use and 0 otherwise. We find that 6.1 percent (1.4 percent) of respondents in the State YRBSS report prior-month (frequent) cigarette smoking.

Figure 2 reports trends in prior-month ENDS use (panel a), online ENDS purchasing behavior (panel b), and cigarette smoking (panel c) among State YRBSS respondents. Mirroring the trends documented with the MTF, youth ENDS use peaked in 2019 and has declined subsequently. Reflecting a similar pattern, online ENDS purchasing decreased sharply between 2019 and 2021 (panel b), again reflecting a changing legal environment for youth purchases. Finally, over the 2015-

2023 period, prior-month cigarette smoking among youths has declined steadily from 10.1 percent in 2015 to 3.3 percent in 2023 (panel c).

3.3 Population Assessment of Tobacco and Health (PATH)

Finally, we augment our analyses of youth by incorporating data from the PATH . The PATH data collection effort, which began in 2013, is a joint research effort of the National Institutes of Health and the Food and Drug Administration. The PATH survey is a nationally representative longitudinal study of tobacco use with information on ENDS use and usual sources of ENDS products over the period 2013-2023. While not as large a dataset as the MTF and the YRBS, PATH data complement our analyses of these other datasets in at least three important ways. First, they include information on online purchases of ENDS products. Next, they allow us, via their longitudinal nature, to measure individual-specific transitions from e-cigarette using states — that is, nicotine vaping initiation (among baseline non-ENDS users) and cessation behavior (among baseline ENDS users) — in a discrete-time hazard framework. Finally, they make it feasible to use both state and individual fixed effects regression specifications, which allow us to more fully control for unmeasured heterogeneity that could lead to biased estimated treatment effects.

Our analyses utilize the PATH's youth survey waves, focusing on those aged 14-17 years. Respondents are asked: "In the past 30 days, on how many days did you use an electronic nicotine product?" *Current ENDS Use* and *Frequent ENDS Use* are coded analogously to the YRBSS as described above. Over the sample period under study (2013-2023), 7.3 percent (1.8 percent) of youths aged 14-17 reported current (frequent) ENDS use. Among those who were non-ENDS users in the first wave they were observed, 6.3 percent reported initiation into ENDS use at some point over which they were observed. Among baseline ENDS users, 35.8 percent reported cessation.

Finally, we measure combustible cigarette smoking among youth respondents using responses to the question, "In the past 30 days, on how many days did you smoke cigarettes?" The

mean rate of current cigarette smoking among youths over the sample period is 3.7 percent. We find that among baseline non-smokers, 2.5 percent report smoking initiation over the sample period. Among baseline smokers, 29.6 percent report smoking cessation.

Panel (a) of Figure 3 shows trends in current and frequent ENDS use among youth PATH respondents. We observe a similar pattern of youth ENDS use as with the MTF and YRBSS, with rates peaking in 2019. In contrast, cigarette smoking has steadily declined since 2013 (panel b).[10,11]

3.4 Adults: Behavioral Risk Factor Surveillance System Survey (BRFSS and PATH)

To study adults aged 18 and older, we use data from the 2016-2023 Behavioral Risk Factor Surveillance System (BRFSS) survey. The BRFSS is a nationally representative telephone survey that collects information on ENDS use among adults ages 18 and older for the period 2016-2023. Notably, during our study window, cellphones were incorporated into the telephone survey.

We measure *Current ENDS Use* using responses to the question, "Do you now use e-cigarettes or other electronic vaping products every day, some days, or not at all?" *Current ENDS Use* is set equal to 1 if the respondent reports using ENDS every day or some days; it is set equal to 0 otherwise. In most cases, we disaggregate the data into younger adults aged 18-30 years who are more likely to use ENDS and older adults over aged 30 who are less likely to do so. 13.7 percent of 18-30-year-olds and 4.2 percent of those over age 30 report prior month ENDS use in the BRFSS.

For the PATH, we use the adult survey of those aged 18-and-older and rely on the same questionnaire items that were asked of youths. Using the coding of outcomes described above, we

[10] Questions about whether youth obtained e-cigarettes online or in-person are more limited, asked of all youth ENDS users who "buy e-cigarettes themselves or give someone else money to buy them" beginning in wave 4 (years 2016-2018). These ENDS users are asked, "How do [you/they] usually buy your [ENDS] and e-liquid?" Responses include "in person," "from the internet", or "by telephone". For the full sample of youths (including non-ENDS users and those who do not buy e-cigarettes themselves or give someone else money to buy them), 2.7 percent of youths reported usually buying their ENDS products in person, 0.2 percent from the internet, and 0.04 percent by telephone.
[11] The means of ENDS use measures and demographic controls, by dataset, are shown in Appendix Table 1.

find that 16.4 percent of 18-30-year-olds and 4.8 percent of those over age 30 report prior-month ENDS use.

3.5 ENDS Online Sales Restrictions

We obtain data on statewide restrictions on the sales (or delivery) of ENDS products through our own searches of state legislative statutes. Table 1 and Figure 4 document the staggered rollout of the online ENDS sales restrictions. We find that 10 states adopted such statutes over the 2010-2023 period. In the notes to Table 1, we include the WestLaw sources used to document our listed effective dates.

4. Empirical Methods

We leverage the quasi-natural experiment provided by the staggered adoption of the online sales restrictions in these 10 states and adopt a generalized difference-in-differences (DiD) (also known as two-way fixed-effects) research design to derive plausibly causal estimates of the effects of these supply-side constraints on tobacco use behaviors. We modify our empirical set-up as needed for the separate datasets, and to address extensions to our main research question.

4.1 MTF and YRBSS

Our main analysis is focused on youth, and we begin with the repeated cross-sectional data drawn from the MTF Main study (and later the State and Combined YRBSS surveys, and corollary analyses of adults from the BRFSS survey). We estimate the following two-way fixed effects (TWFE) regression specification:

$$Y_{ist} = \lambda_0 + \lambda_1 OnlineRestrict_{st} + \mathrm{X_{ist}}\lambda_2 + Z_{st}\lambda_3 + \theta_s + \tau_t + \varepsilon_{ist} \quad (1)$$

where the dependent variable Y_{ist} measures current (or frequent) ENDS use among youth i residing in state s at time t (year-by-quarter in MTF and BRFSS; year-by-semester in YRBSS due to

more limited information on timing of survey). Our key treatment indicator is *Online Restrict*$_{st}$, an indicator for whether a statewide online sales restriction has been adopted. The vector θ_s is a time-invariant state fixed effect, and τ_t is a state-invariant time fixed effect. The latter fixed effects account for the national permanent ban on mailing ENDS products to consumers via USPS, which went into effect in April of 2021 as part of an amendment to the PACT act; other major U.S. parcel carriers (UPS, FedEx, DHL) have also agreed to honor these restrictions. In specification checks, we alternately model the national ban by redefining the treatment indicator, $OnlineRestrict_{st}$, to turn on for all states after the PACT amendment was adopted.

We control for a number of individual- and state-level variables. The vector X_{ist} includes individual demographic controls (age, sex, grade and race), while the vector Z_{st} incorporates time-varying state-level controls for the COVID-19 pandemic (cumulative COVID-19 death rate, University of Oxford COVID-19 Government Response Index, and percentage of fully vaccinated individuals) and macroeconomic conditions (unemployment rate, poverty rate, real per capita income, and the housing price index).[12] In our baseline specification, we also control for state-level ENDS taxes (Cotti et al. 2025), restrictions on the sales of flavored ENDS products (Saffer et al. 2024; Cotti et al. 2025), per-pack cigarette excise taxes (2023$) (Hansen et al. 2017), and ENDS and tobacco licensure laws (Courtemanche et al. 2024). In subsequent specifications, we add controls for ENDS age-restriction policies, including minimum legal sales age laws for ENDS (Friedman 2015; Abouk and Adams 2017) and Tobacco-21 laws (which apply to all tobacco products) (Hansen et al. 2023), as well as indoor vaping restrictions in restaurants, workplaces, and bars, and clean indoor air

[12] Unemployment rates are obtained from the Bureau of Labor Statistics, poverty rates from the University of Kentucky Poverty Research Center, real per capita personal income data from Federal Reserve Economic Data, and the Housing Price Index (HPI) from the Federal Housing Finance Agency. Cumulative COVID-19 deaths are from *The New York Times* COVID-19 repository (https://github.com/nytimes/covid-19-data), while the government-response index and share of fully vaccinated residents are from the Oxford Covid-19 Government Response Tracker (OxCGRT).

laws for smoking.[13] We also explore the robustness of estimates to the inclusion of controls for non-tobacco-substance-related policies, including beer taxes, regulations that affect access to marijuana (recreational marijuana laws, medical marijuana laws, marijuana decriminalization laws) and opioid-related drug policies (naloxone access laws and prescription drug monitoring programs).

Our key parameter of interest, λ_1, which capture the reduced-form impact of ENDS sales restrictions on consumption behavior, operating through any reinforcing and/or counteracting pathways; it is identified from within-state variation in the adoption of these restrictions over our sample period, as documented in Table 1 and Figure 4. The key identification assumptions underlying our research design are: (1) the absence of time-varying, state-specific unobservables correlated with treatment adoption and the outcome under study, (2) the absence of reverse causality whereby youth ENDS use drives the adoption of online sales restrictions, and (3) the absence of dynamic treatment effects that differ by timing of treatment adoption.

To explore the sensitivity of our estimate of λ_1 to unobservables, we estimate equation (1) using parsimonious and more saturated models (including many additional tobacco policy controls as well as policy controls affecting adjacent markets for alcohol, marijuana, and opioids). If the estimate of λ_1 is relatively stable across specifications, this would lend some support for counterfactuals and the parallel trends assumption. In addition, we also explore the sensitivity of λ_1 to forcing "closer geographic controls," by including census region-by-time fixed effects. This approach controls for any unmeasured regional shocks that commonly affect states within the same census region. We note, however, that forcing such proximate controls may not only reduce the

[13] ENDS taxes come from Cotti et al. (2025). Cigarette taxes, ENDS minimum legal sales age, and combustible tobacco smoking bans are obtained from the CDC STATE system (Centers for Disease Control and Prevention, 2024). ENDS flavor restrictions are obtained from Cotti et al. (2025). Tobacco-21 laws are obtained from Preventing Tobacco Addiction Foundation (https://tobacco21.org). State-level e-cigarette indoor vaping restrictions are obtained from Westlaw, guided by the Public Health Law Center (Michell Hamline School of Law), *U.S. E-cigarette Regulation: A 50-State Review* (2025).

amount of identifying variation but may also lead to more biased estimates if counterfactuals outside the treatment state's census region are the more appropriate controls (Neumark et al. 2014; Burkhauser et al. 2025).

Second, to further test for unobservable confounders and also reverse causality, we estimate event studies of the following form:

$$Y_{ist} = \lambda_0 + \sum_{k \neq -1} \pi_k D_{st}^k + X_{ist}\lambda_2 + Z_{st}\lambda_3 + \theta_s + \tau_t + \varepsilon_{ist} \quad (2)$$

where k indexes event time (that is, the number of years before and after a state adopts an online ENDS sales restriction), D_{st}^k is set equal to 1 if state s in year-by-quarter t is k years before or after adoption and is set equal to 0 otherwise, and π_j are event study coefficients on each of the leads ($k < 0$) and lags ($k \geq 0$). The reference period is one year prior to the adoption of a statewide online restriction ($k = -1$). If estimates of π_j for $k < 0$ in equation (2) are not statistically different from zero, this would lend support to the parallel trends assumption. It would also indicate that reverse causality, whereby rising ENDS use drives states to impose online ENDS sales restrictions, is unlikely to be an important source of bias.

Finally, in the presence of heterogeneous and dynamic treatment effects, TWFE estimates may be biased. This arises from "bad comparisons" in which earlier adopters serve as controls for later adopters. To explore whether our TWFE estimates are biased from such comparisons, we estimate stacked difference-in-differences models (Cengiz et al. 2019) in which we identify a treatment window from 5 years prior to treatment to 3 years after treatment, generate cohorts of treated jurisdictions by adoption timing, and restrict counterfactuals in each cohort to control states that had never or not yet implemented an online ENDS sales restriction. We then estimate the following modified version of equation (1):

$$Y_{icst} = \gamma_0 + \gamma_1 OnlineRestrict_{st} + X_{ist}\gamma_2 + Z_{st}\gamma_3 + \theta_{cs} + \tau_{ct} + \varepsilon_{icst} \qquad (3)$$

where c denotes the treatment cohort, with θ_{cs} representing cohort-specific state fixed effects, and τ_{ct} being cohort-specific period fixed effects. We also implement event-study analyses based on the stacked DiD approach, decomposing the treatment effect over time. If our stacked DiD estimates are similar in magnitude to our TWFE estimates, this would provide some validation that the TWFE estimates are not biased by heterogeneous and dynamic treatment effects.

After establishing the main reduced-form effects of ENDS sales restrictions on ENDS use, we turn to exploring first-stage mechanisms and estimate how these restrictions are proximally impacting where youth are obtaining their ENDS products. First, we consider the effects of these restrictions on a binary indicator for *Online ENDS Purchases*. Next, we directly model the various discrete choices with respect to how youths acquire their e-cigarette products, and estimate the following multinomial logit specification:

$$\Pr(Y_{ist} = j) = \frac{\exp(\lambda_{0j} + \lambda_{1j}\text{OnlineRestrict}_{st} + X_{ist}\lambda_{2j} + Z_{st}\gamma_{3j} + \theta_{sj} + \tau_{tj})}{1 + \sum_{j=1}^{J} \exp(\lambda_{0j} + \lambda_{1j} OnlineRestrict_{st} + X_{ist}\lambda_{2j} + Z_{st}\gamma_{3j} + \theta_{sj} + \tau_{tj})} \qquad (4)$$

where *j* indexes the usual source categories described above (e.g., own retail purchase in store, social sources, online sources and other sources).

4.2 PATH

In supplementary analyses, we leverage longitudinal information from the PATH to decompose overall ENDS participation effects into their initiation and cessation margins. To that end, we estimate discrete-time hazard models to obtain estimates of the effects of online ENDS sales restrictions on (1) initiation into ENDS use among initial non-users, (2) cessation of ENDS use

among baseline users, and (3) transitions into online ENDS purchases.[14] Specifically, we estimate a discrete-time hazard specification of the following form:

$$\Pr(S_{ist} = 1 \mid t-1 < T < t) = \delta_0 + \delta_1 OnlineRestrict_{st} + X_{ist}\delta_2 + Z_{st}\delta_3 + \eta_s + \psi_t + \mu_i + \varepsilon_{ist} \quad (5)$$

where S_{ist} indicates whether individual i experiences the event (initiation or cessation) between time $t-1$ and t, and μ_i are individual fixed effects. The approach described in equation (5) provides estimates of the effect of online ENDS sales restrictions on the conditional probability, δ_1, of transitioning across margins of ENDS use between periods $t-1$ and t. When studying initiation, the sample is restricted to non-ENDS using youth at baseline, and an indicator is defined for transitioning to ENDS use in period t, conditional on non-ENDS use in period $t-1$. Along the same lines, for cessation, the analysis sample is limited to youth ENDS users at baseline and an indicator is defined for transitioning to non-use in period t, conditional on being an ENDS user in period $t-1$. Similar models can be estimated where the outcome captures online ENDS purchasing behavior. Thus, the PATH data permits a more in-depth analysis of potential underlying behavioral dynamics in the impacts of online sales restrictions.

5. Results

Our main findings are reported in Tables 2 through 10 and Figure 5 through 7. Supplemental analyses and further robustness checks are presented in the Appendix. All regression models are weighted, and reported standard errors are clustered at the state level to account for arbitrarily correlated errors across individuals and over time within each state (Bertrand et al. 2004).

5.1 MTF Findings on Overall ENDS Use

[14] The number of individuals reporting online ENDS purchases at baseline is too small to permit analysis of transitions away from online purchasing.

We begin with estimates of the effect of online ENDS sales restrictions on youth ENDS use using data from the 2014-2023 MTF Main Study, reported in Table 2. Panel I reports findings for current ENDS use among all 8th-12th graders, while panel II focuses on high school students in 10th and 12th grades, and panel III examines high school seniors (12th graders), who have the highest prior-month vaping rate. We present estimates across five specifications that, progressing from column (1) to (5), capture increasing saturation with time-varying controls. In our most parsimonious specification (column 1), we find that after controlling for state fixed effects, year-by-quarter fixed effects, macroeconomic and COVID-19 controls, and baseline ENDS and tobacco policies, the adoption of a statewide online ENDS sales restriction is associated with a statistically insignificant and economically small 1.7 percentage-point increase in prior-month ENDS use among 8th-12th graders (panel I). The precision of our estimated treatment effect is such that we can rule out, with 95 percent confidence, that online ENDS sales restrictions reduce youth ENDS use by greater than 0.5 percentage points, or 3.6 percent relative to the pre-treatment mean of the dependent variable in treatment states. This null finding is, therefore, economically informative and suggests that this intervention has done little — either through a direct sales effect or through any indirect (health) signaling effect — to reduce overall youth ENDS use. When we include additional controls for ENDS age-based restrictions (column 2) and indoor vaping and smoking policies (column 3), the estimated treatment effect is largely unchanged, and we are still able to rule out, with 95 percent confidence, a similar 3.6 percent decline in current youth ENDS use. The addition of controls for beer taxes (column 4) and census region-by-period fixed effects (column 5) has little effect on the estimated intervention effect, its statistical significance, or the precision with which it is estimated.

Turning to older teenagers who are more likely to vape nicotine (panels II and III), the findings are comparable. Among high school students in grades 10-12 (panel II), we do not find that

the adoption of a statewide online sales restriction results in any meaningful decline in prior-month ENDS use; point estimates are statistically insignificant and positive (1.3 ~ 1.6 percentage points). Across specifications, we can rule out that this statewide intervention reduces ENDS use on the net among high school students by approximately 8 percent or more. The pattern of findings is quite similar when we restrict the sample to high school seniors; the treatment effects, while negative, are small (indicating a 0.2 to 0.5 percentage-point decline) and not statistically distinguishable from zero.

One concern with TWFE estimates is that they may be biased in the presence of heterogeneous and dynamic treatment effects. In Table 3, we present findings from the stacked DiD approach (equation 3) in which counterfactuals for each treatment state cohort are carefully selected to avoid the problematic comparisons and restricted to only the never and not-yet adopters. Across specifications (columns 1-5) and grades (panels I-III), the pattern of estimates from the stacked DiD estimator is quite similar to the TWFE estimates, suggesting that heterogeneous and dynamic treatment effects are a relatively unimportant source of bias in this case. Moreover, the precision of our estimated treatment effects is such that we can rule out, with 95 percent confidence, meaningful ENDS online sales restriction-induced declines in youth ENDS use.

To assess the credibility of the counterfactuals, we test for pre-treatment "parallel trends" and any indications of reverse causality by estimating event study analyses, as shown in Figure 5. Event study coefficients are estimated for both the TWFE and stacked DiD estimators, and across regression models that include parsimonious controls (column 1 of Tables 2 and 3), and a saturated set of time-varying controls (column 5 of Tables 2 and 3). These analyses underscore three points. First, coefficient estimates over the pre-treatment period do not point to any substantial or significant deviation in trends between the treated and control states and support the parallel trends assumption. This also suggests that reverse causality is an unimportant source of bias. Second, an examination of the post-treatment period also does not indicate any break in the trend from the pre-

treatment periods; hence, there is little evidence to suggest that the intervention resulted in shorter- or medium-term effects on e-cigarette use. With that said, online ENDS sales restrictions are relatively new, with the average number of post-treatment years during our data period being 3.5 years. Therefore, until more post-treatment data are available, we cannot rule out the possibility of longer-run effects. Third, as with the estimates reported in Tables 2 and 3, the event-study estimates are very similar for both the TWFE and stacked DiD estimators and across the parsimonious and fully-saturated specifications; the credibility of our counterfactual assumption is thus not sensitive to time varying shocks or dynamic heterogeneity.

Next, in Table 4, we explore the sensitivity of our estimated treatment effects to a number of specification checks. Column (1) presents baseline TWFE estimates from column (4) of Table 2. In column (2), we drop treated jurisdictions from our sample that only limit online sales via an age restriction (notably, Massachusetts and Ohio). We do so because there is some evidence that such weaker restrictions may be circumvented by vendors and consumers (Harati et al. 2024; Bertrand et al. 2025; Ma et al. 2024), potentially biasing our estimates toward zero. The omission of these jurisdictions from our analysis sample does not change the pattern of findings.

As noted above, in April 2021, amendments to the PACT Act extended the USPS ban on delivery of combustible cigarettes to e-cigarettes. In column (3), we explore an alternative definition of treatment in which all states are assumed to have adopted online sales restrictions post-April 2021. The resulting estimates are similar.

In columns (4) through (6), we extend our main specification (column 1) by adding policy controls for adjacent substance markets, including: in column (4), medical marijuana laws, recreational marijuana laws, and marijuana decriminalization, which have been found to be related to (adult) ENDS (Dave et al. 2025; Courtemanche et al. 2024) and cigarette smoking (Abouk et al. 2023; Dave et al. 2023; Courtemanche et al. 2024; Choi et al. 2019); in column (5), naloxone access

laws and prescription drug monitoring programs to account for other drug related policies; and in column (6), all of these policy controls jointly. Across these models, the estimated treatment effect remains statistically indistinguishable from zero.

Finally, in columns (7) and (8), we explore the sensitivity of estimates of λ_1 to more granular and stringent controls for spatial heterogeneity: (1) census division-by-time fixed effects, which force "close controls" (within census division treatment-control comparisons) in column (7), and (2) treated state-specific linear time trends to capture any unobserved differential trends across each of the treated states unfolding linearly in column (8). We continue to find no evidence that online ENDS sales restrictions significantly impact youth ENDS use, though we note that the coefficient in column (8) does become negative.

To this point, our analysis of ENDS use has focused exclusively on the extensive margin of ENDS use, that is, any ENDS use in the month prior to the survey. Table 5 explores whether the more intensive margin of ENDS use might be affected by online ENDS sales restrictions. The first two columns present findings from our *Frequent ENDS Use* measure, as described above. The last two columns present findings on *Frequent ENDS Use*, conditional on the respondent being a current ENDS user. The pattern of findings provides little support for the hypothesis that online ENDS sales restrictions impact more habitual ENDS users and their consumption behaviors; the results are robust for the overall MTF sample, as well as separately across high school students (10^{th} and 12^{th} grades) and high school seniors.

Finally, in Figure 6, we explore additional heterogeneity in the estimated treatment effect by demographic characteristics of the student, including, as measured in the public use survey, (1) race/ethnicity, (2) gender, and (3) whether the school the respondent attends is public or private. There is little indication here that the online sales bans have had any discernible effects on overall youth e-cigarette use.

5.2 Main YRBSS Findings on Overall Youth ENDS Use

We supplement our MTF analyses with corollary data on youth from the YRBSS surveys. Table 6A and Table 6B respectively provide estimates of the effects of online ENDS sales restrictions on youth ENDS use at the extensive and intensive margins; estimates based on data from the State YRBSS are reported in Panel I and those for the Combined State and National YRBSS are reported in Panel II. Consistent with our findings from the MTF study, regression results in Table 6A and 6B, supported by event-study estimates in Panel (a) of Figure 7, provide no evidence that online ENDS sales restrictions resulted in any significant declines ENDS use among U.S. high school students.

Together, the similar pattern of findings we observe in both the MTF and YRBSS adds a degree of validation for the key finding that the statewide policy under study has had little impact on overall youth ENDS use on either the extensive or intensive margins.

5.3 PATH: Dynamics in ENDS Use Effects

In Table 7, we capitalize on the longitudinal structure of the PATH to examine whether the null effects we find in the MTF and the YRBSS surveys are masking important underlying dynamics in the impact of online ENDS sales restrictions on specific margins of use. Notably, shifts in e-cigarette participation could reflect transitions into initiation among previous non-users and/or transitions into cessation among previous users; counteracting effects across these margins may present as an overall null effect on participation. In order to decompose these transitions, we estimate discrete-time hazard models and directly assess the impact of the ban on initiation into ENDS use among baseline non-users (panel I) and cessation of ENDS use among baseline ENDS users (panel II). Across all specifications, we find little evidence that these restrictions are affecting transition probabilities from non-use of ENDS to initiation or from current use of ENDS to cessation among youths. These results suggest that the earlier null effects on overall ENDS use are

not concealing important transition dynamics in this policy's impact or masking counteracting effects across the separate margins.

5.4 Mechanisms: Online Purchases and Alternative Sources

Together, our findings from the MTF, YRBSS, and PATH provide little support for the effectiveness of online ENDS sales restrictions. There are several explanations for this finding. One reason is that youth ENDS users typically do not obtain their ENDS products from online sources, even before the adoption of legal restrictions on such purchases. For instance, according to the State YRBSS, just 6.4 percent of all ENDS users who lived in states that later adopted online ENDS sales restrictions reported typically obtaining their e-cigarettes from an online source. Thus, there is little scope for online sales restrictions to be effective at curbing net youth ENDS use. Another explanation is that, even if online sales restrictions *are effective* at curbing youth online ENDS purchases, they may consequently induce youths to engage in compensatory behaviors and obtain their e-cigarettes from other sources.

In Table 8, we explore these proximate pathways, and estimate the effect of online ENDS sales restrictions on (1) the probability that a youth uses ENDS and typically obtains their ENDS products via online sources (panel I), and (2) their usual sources of ENDS products (panel II). We note that between 2017-2023, the period over which we have data on youths' use of online sources, just five states changed their online sales restriction policy.

The TWFE results in panel I provide strong evidence that online ENDS sales restrictions are associated with a 1.0 to 1.6 percentage-point decline in the probability that a youth uses ENDS products that are typically obtained from online sources.[15] This is a large effect (over 70 percent

[15] As a nuanced complement to the main finding of decreased online purchases, Appendix Table 2 reports no effect on youth initiation on ENDS use to online purchases in a discrete time hazard model, indicating the policy's impact is unlikely to work through the initiation margin. Estimating the cessation model (with individual fixed effects) proved empirically problematic given the small share of youth ENDS users who obtained their e-cigarettes online at baseline.

relative to the pre-treatment mean), suggesting that these laws do elicit a first-order response and are effective in curtailing online purchases.[16]

In panel II, we present marginal effects from the multinomial logistic regression that allows us to explore whether there are substitution effects of online ENDS sales restrictions on youths' other usual sources of e-cigarettes. As noted above, most ENDS users (76.2 percent) do not purchase their e-cigarettes directly from a store themselves or via online sources. They typically obtain their e-cigarettes via informal social sources. According to the 2017-2023 YRBSS survey, 57.6 percent of youth ENDS users obtain their ENDS products by borrowing vaping devices and e-liquid from friends or family, either via third-party purchase or bumming/borrowing vaping devices and e-liquid.

The pattern of findings we obtain highlights two points. First, online ENDS sales restrictions are proximally effective in their express intention of reducing online purchases of e-cigarettes among youth. We find a significant reduction 0.6 to 0.7 percentage point reduction in the probability that youth who use ENDS are obtaining them through online purchases. These magnitudes are large, representing a 40 to 50 percent reduction relative to the baseline mean prevalence of online ENDS purchases. This is not surprising since USPS and all other major carriers participate in the ban. However, the bans do not appear to stop all online purchases, as effect sizes are generally smaller than the pre-treatment mean. This may be due to illegal shipments by non-compliant vendors (Bertrand et al. 2025; Pearson et al. 2025).[17]

Second, there is some suggestive indication that the bans may partly induce substitution to social sources and in-person retail purchases. Marginal effects are positive for these source

[16] The estimated marginal effects using logistic regression are somewhat smaller in magnitude but provide a similar pattern of results (similar to the first row of estimates shown in panel II of Table 8).
[17] Many online vendors also shifted to local and regional shipping carriers, which are not subject to the PACT Act. Age verification is often required at time of delivery following the adoption of the PACT Amendment in April 2021, and the use of various local shipping agents has increased shipping times and costs.

categories, though imprecisely estimated. Given this imprecision and the limited sample, we view these findings as merely suggestive. Nonetheless, the directional findings point to two mechanisms which may have undermined the intended policy effect: 1) online sales ban did not fully crowd out all online purchases; and 2) teens appear to have shifted to social sources for e-cigarettes. The event study analyses in Panels (b)-(d) of Figure 7 confirm that online ENDS sales restrictions significantly reduce online purchases and induce some discernible substitution toward other sources.

5.5 Spillovers to Combustible Cigarette Smoking

Policies that restrict access to e-cigarettes could potentially influence youth combustible cigarette smoking. There is, for example, evidence that ENDS and combustible cigarettes are substitutes among youths (Abouk et al. 2023; Cotti et al. 2025; Courtemanche et al. 2025). Given that the online sales bans have not had any discernible or substantial effect on overall e-cigarette use, it is unlikely for these bans to generate downstream substitution or other spillover effects. One possibility, however, is that by affecting youths' sources of obtaining e-cigarettes, there may be indirect effects on cigarette use to the extent that these usual sources overlap across tobacco products. In Table 9, we directly explore whether online ENDS sales restrictions impact youth and young adult combustible cigarette smoking. Evidence from MTF and the YRBSS in Table 9, as well as in Appendix Table 3 for the PATH, provide little support for the hypothesis that cigarette smoking is impacted by statewide restrictions on online e-cigarette sales.

5.6 Adults

We close with a discussion of the effects of online ENDS sales restrictions on adults, with particular attention on young adults aged 18-30 who have relatively higher rates of ENDS use and who have been found to be affected by restrictions on ENDS access (Dave et al. 2023; Cotti et al, 2025; Courtemanche et al. 2025). In Table 10, we utilize data from the BRFSS between 2016-2023

and find no evidence that online sales restrictions reduce ENDS use among either young (ages 18-30) or older adults (ages > 30).[18] An evaluation of the initiation and cessation margins for young adults (Appendix Table 4) as well as for adults overall (Appendix Table 5) provides no support for any significant effects of online sales restrictions on initiation, cessation, or the transition into online purchases.

6. Conclusion

Banning the sales of e-cigarettes purchased online has been advocated as an important strategy to curb youth vaping. The Association of State and Territorial Health Officials (ASTHO), comprised of chief health officials across the U.S., recommended internet sales restrictions as part of a set of policy interventions to address the issue of youth e-cigarette use. Over the past decade, ten states have adopted fairly comprehensive restrictions on online sales and delivery of e-cigarette products, and these actions at the state level culminated with the 2021 national USPS shipping ban, which also has been voluntarily honored by major private common carriers. At the heart of these recommendations and policy actions is the recognition that age-verification for internet-based tobacco retailers is easily circumvented and enforcement of underage internet sales has proven challenging. Since youth can and do acquire e-cigarette products from internet vendors, the rationale for these bans presumes that restrictions on online sales would effectively reduce e-cigarette use among youth.

To date, however, there is a very limited causal evidence base to inform this policy rationale. This study is the first to directly estimate the effect of online sales restrictions on e-cigarettes on nicotine vaping. Across a multitude of national datasets, we find that the statewide restrictions on online ENDS use did not have their intended effect of reducing youth vaping. Estimates obtained

[18] Appendix Figure 1 and 2 presents event study estimates supporting a null effect of online sales restrictions of ENDS on adult ENDS use.

from the MTF are the most precise, suggesting that among middle and high school students, we can, with 95 percent confidence, rule out online sales ban-induced declines in prior-month ENDS use of larger than 3.6 percent of the pre-treatment vaping rate. A causal interpretation of this null result is supported by a variety of specification checks, including event-study analyses. Moreover, supplementary analyses confirm that the null findings are not masking any meaningful effects of these policies on specific sub-populations or consumption margins. We also find no evidence of downstream effects on cigarette use. In contrast to industry concerns that online sales restrictions may make it difficult for some adults to purchase ENDS products as part of a harm-reduction approach, we also do not find any evidence of significant effects among adults.

There are at least three reasons for the overall null finding. First, the policy appears to target a purchase channel that is extremely rare. Estimates from the National YRBSS show that under three percent of youth ENDS users rely on the internet as their usual ENDS source, leaving limited scope for online sales restrictions to impact overall use. This would only not be the case if banning online sales leads to spillover effects on other sources, for instance by reducing youth exposure to online vaping advertisements. Second, we find that online sales bans do curb online purchases of ENDS products but do not eliminate them completely. That is, due to non-compliant shipments and online vendors switching to non-common local and regional carriers, youth access to online sales of e-cigarettes is not completely absent. Third, we find some evidence of substitution to social channels and in-store purchases to compensate for the reduction in online purchases.

These findings are of clear importance to policymakers. Supply-side restrictions that prevent youth access to ENDS products can and do play an integral role in addressing high rates of e-cigarette use among adolescents, as evidenced by the effectiveness of minimum legal sales age restrictions, Tobacco 21, and certain comprehensive restrictions on flavored e-cigarettes (Dave et al. 2019; Hansen et al. 2023; Cotti et al. 2025; Safer et al. 2025). The literature on such policies,

however, also underscores that policy effectiveness is a function of the importance of the margins being affected, potential circumvention channels, and possible substitution effects. In the case of online sales restrictions, all of these considerations turn out to be salient and serve to jointly limit the impact of the statewide bans.

We note that these statewide bans that preceded the PACT Act were generally more comprehensive and binding in terms of online shipments. The federal ban, on the other hand, applies only to USPS and has been voluntarily adopted by the major common carriers; many online vendors continue to ship ENDS products through local and regional couriers while remaining compliant of the PACT Act. As such, the national ban is also unlikely to have its intended effects on overall youth tobacco use. One qualification to these conclusions is that our estimates represent average treatment effects among the treated states in the short- and medium terms, over an average observable post-policy window of about four years. If effects take longer to unfold or interact more strongly with Tobacco 21 and other age-based restrictions over time, then future research with more extended data will be necessary to detect them.

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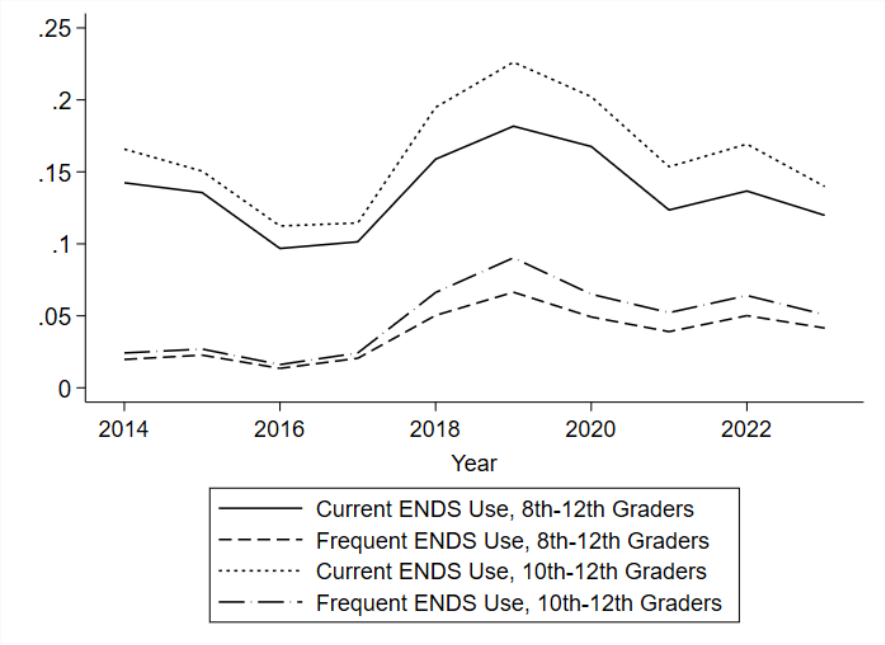
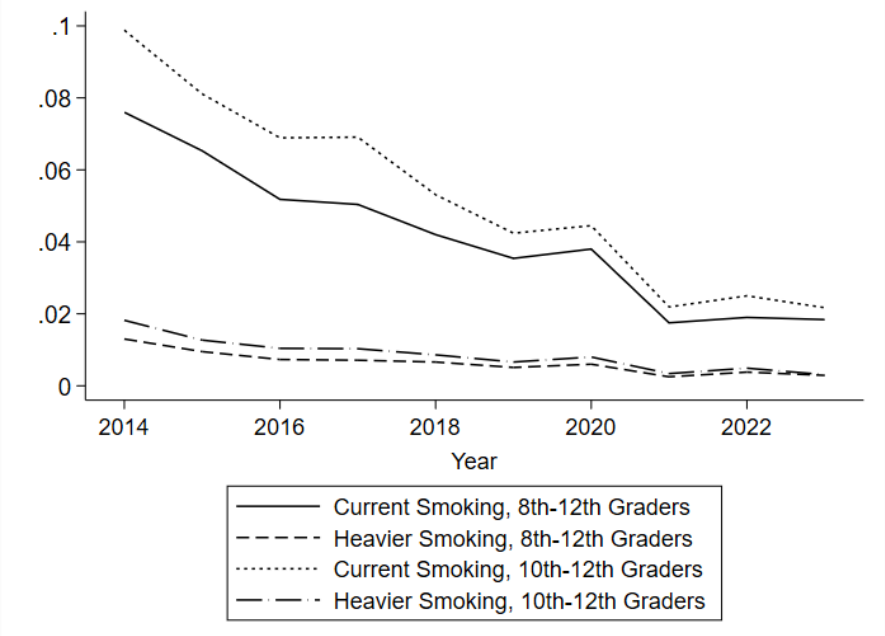
Figure 1. Trends in Current and Frequent ENDS Use among Youth in MTF

Panel (a): ENDS Use



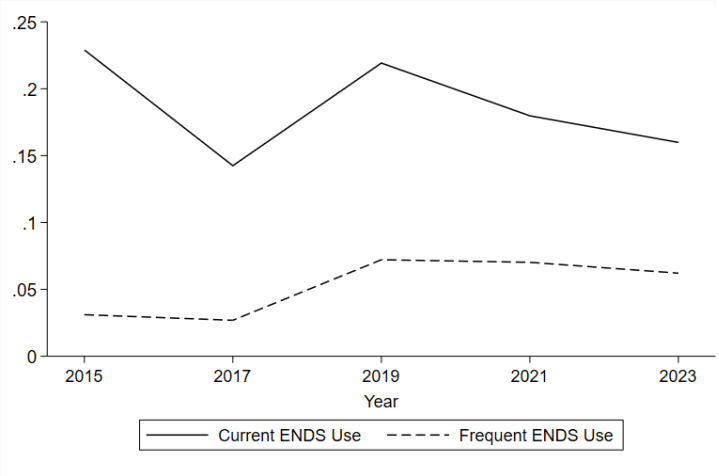
Panel (b): Cigarette Smoking



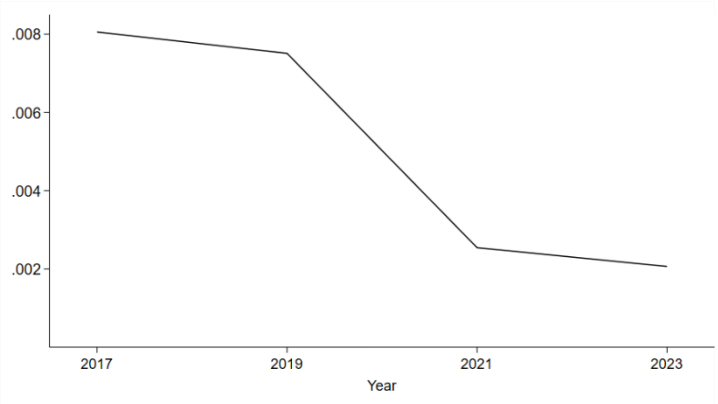
Source: Author's calculation from the Monitoring The Future (MTF) spanning period 2014 through 2023.

Figure 2. Trends in ENDS Use, Online ENDS Purchases, and Smoking among Youth, State YRBSS

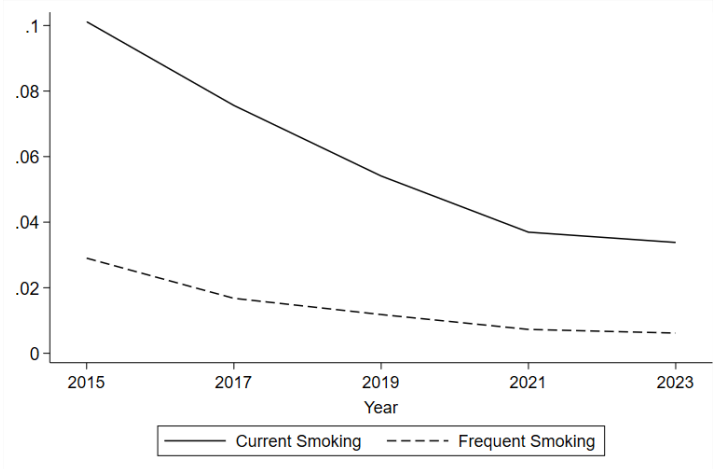
Panel (a): ENDS Use (2015-2023)



Panel (b): Online ENDS Purchases (Available 2017-2023)



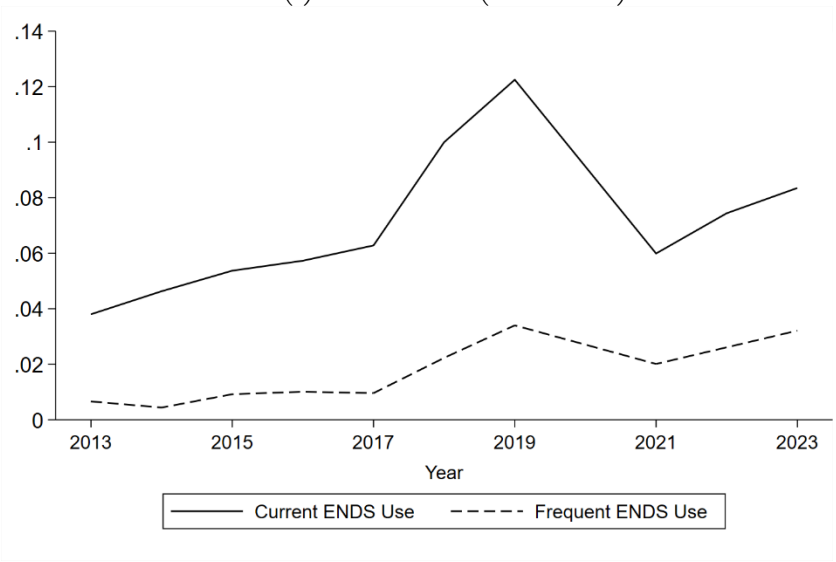
Panel (c): Cigarette Smoking (2015-2023)



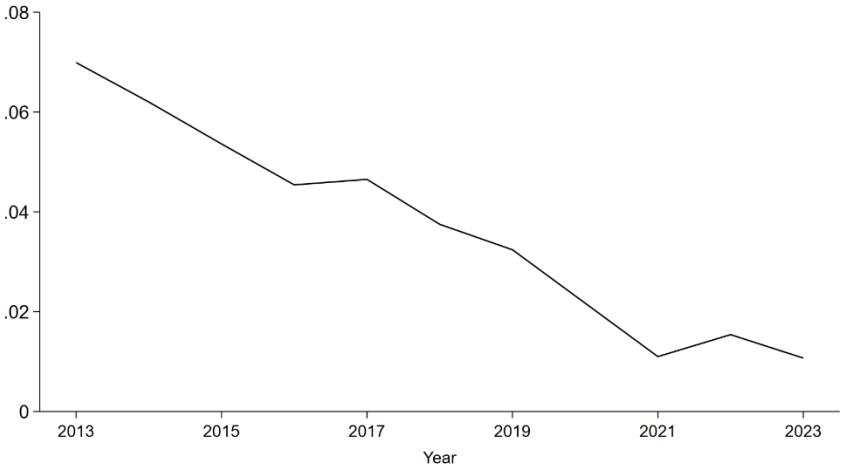
Source: Author's calculation from State YRBSS.

Figure 3. Trends in ENDS Use and Cigarette Smoking among Youth in PATH

Panel (a): ENDS Use (2013-2023)

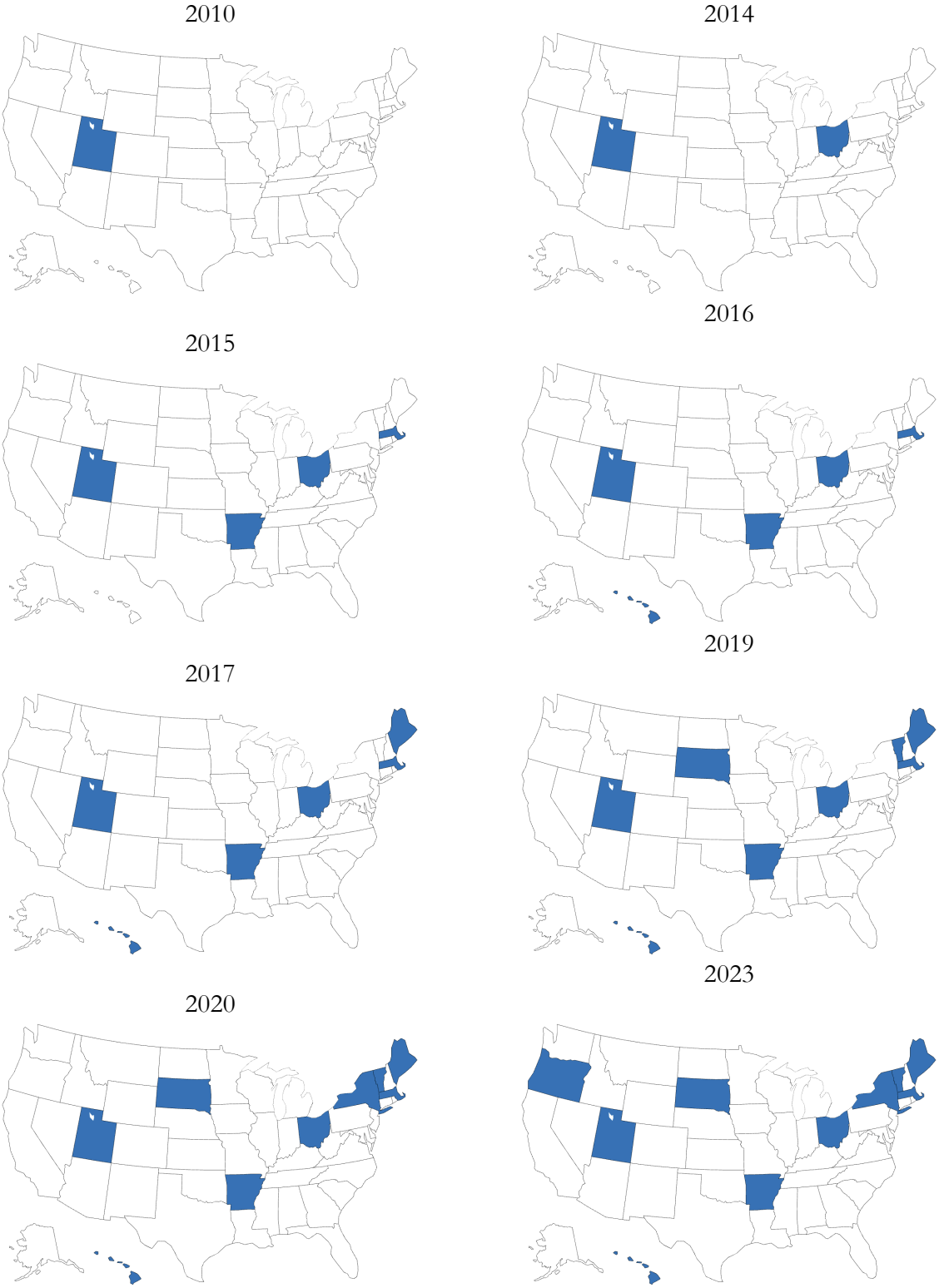


Panel (b): Current Cigarette Smoking (2013-2023)



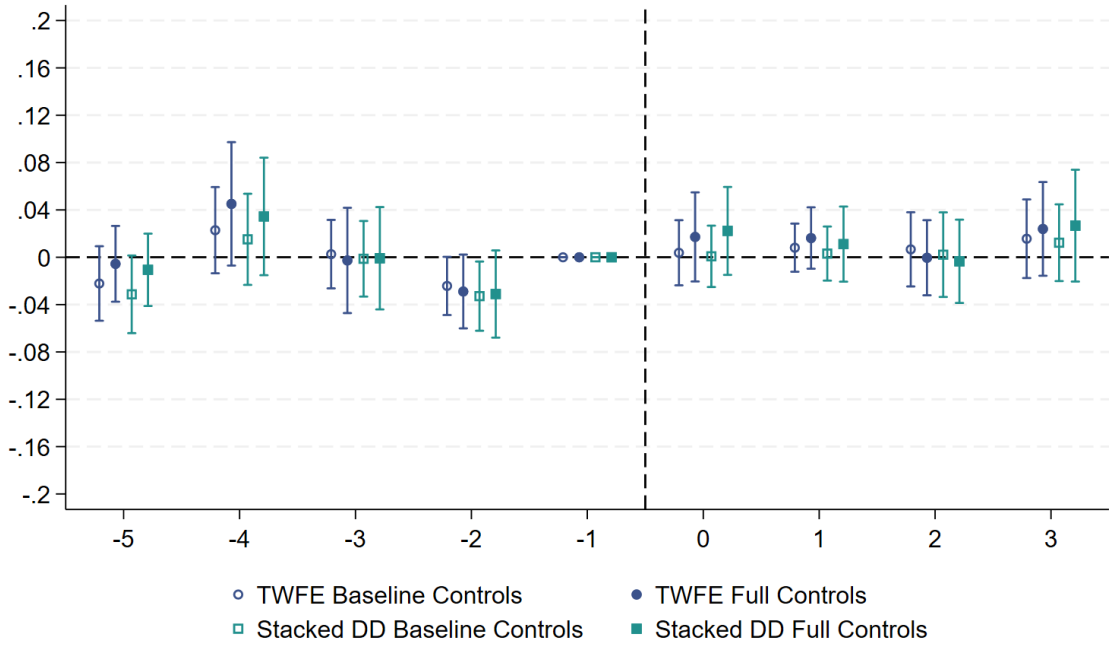
Source: Author's calculation from PATH.

Figure 4. Temporal and Spatial Variation in Online ENDS Sales Restrictions



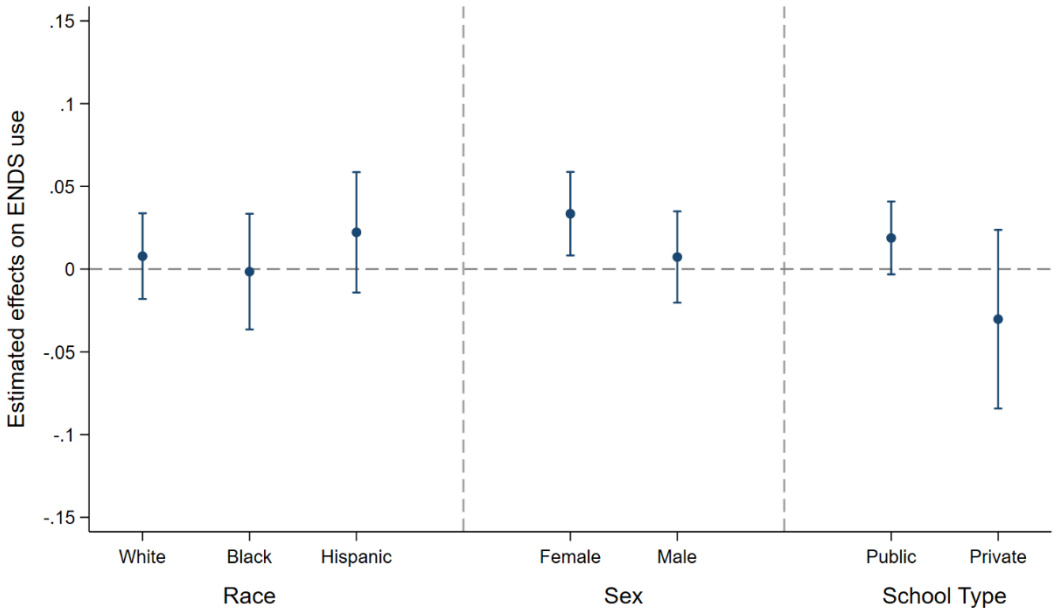
Source: Collected by the authors from state legislative statutes.

Figure 5. Event Study Analysis of ENDS Online Sales Restriction and Youth Current ENDS Use, MTF



Notes: Event-study regressions are estimated using the Monitoring The Future (MTF) data collected over the period 2014-2023. Baseline controls include state fixed effects, year-by-quarter fixed effects, demographic characteristics (sex, race, age, and grade), state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, the percentage of fully vaccinated individuals, unemployment rate, poverty rate, per capita income, an index for housing prices, ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. Full controls additionally include minimum legal sales age (MLSA) laws, tobacco 21 laws, indoor vaping restrictions, indoor smoking restrictions, beer taxes (in $2023), and Census region-by-time fixed effects. Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around estimated effect of online ENDS sales restrictions.

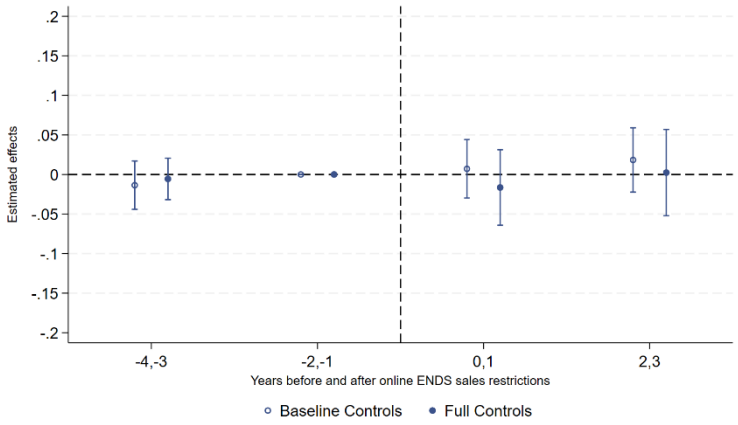
Figure 6. Heterogeneity in Effects of ENDS Online Sales Restrictions on Youth ENDS Use, MTF



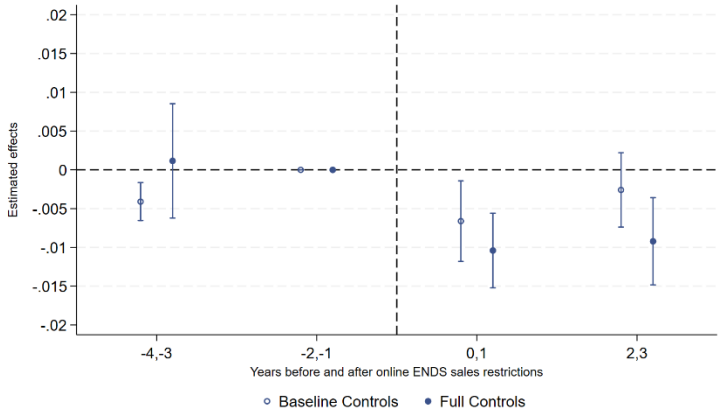
Notes: Estimates are generated via weighted least squares using the Monitoring The Future (MTF) data collected over the period 2014-2023. All regressions include state fixed effects, year-by-quarter fixed effects, demographic characteristics (sex, race, age, and grade), state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, the percentage of fully vaccinated individuals, unemployment rate, poverty rate, per capita income, an index for housing prices, ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, ENDS licensure laws, minimum legal sales age (MLSA) laws, tobacco 21 laws, indoor vaping restrictions, indoor smoking restrictions, and beer taxes (in $2023). Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around estimated effect of online ENDS sales restrictions.

Figure 7. Event-Study Analysis of ENDS Online Sales Restrictions and Youth Current ENDS Use, State YRBSS (2017-2023)

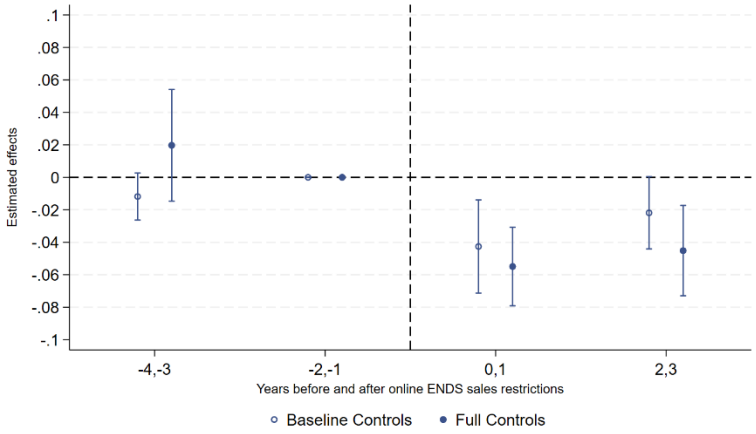
Panel (a): Current ENDS Use



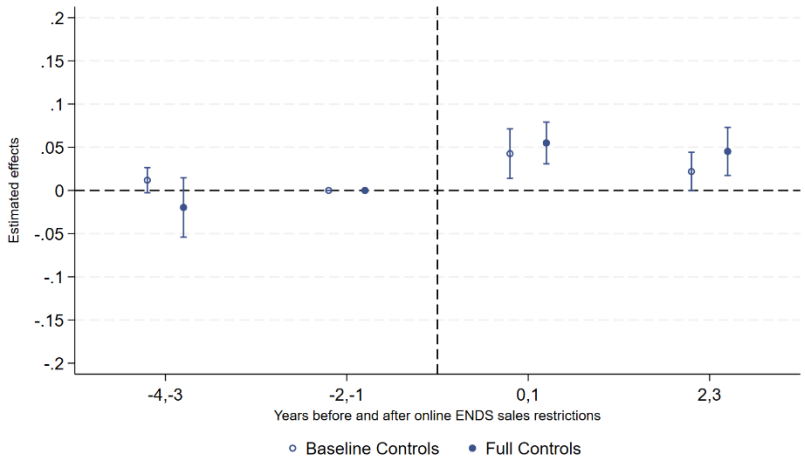
Panel (b): Use of ENDS Usually Obtained from Online Source



Panel (c): Usually Obtain ENDS from Online Source | Current ENDS Use



Panel (d): Usually Obtain ENDS from Source Other than Online | Current ENDS Use



Notes: Event-study regressions are estimated using the State and National Youth Risk Behavior Surveillance System (YRBSS) data collected over the period 2017-2023. Baseline controls include state fixed effects, year-by-semester fixed effects, demographic characteristics (sex, race, age, and grade), state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, the percentage of fully vaccinated individuals, unemployment rate, poverty rate, per capita income, an index for housing prices, ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. Full controls additionally include minimum legal sales age (MLSA) laws, tobacco 21 laws, indoor vaping restrictions, indoor smoking restrictions, beer taxes (in $2023), and Census region-by-time fixed effects. Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around the estimated effect of online ENDS sales restrictions.

Table 1. Statewide Online ENDS Sales Restrictions

State	Effective Date
Arkansas	July 22, 2015
Hawaii	January 1, 2016
Maine	November 1, 2017
Massachusetts	September 25, 2015
New York	July 1, 2020
Ohio	August 2, 2014
Oregon	January 1, 2022
South Dakota	July 1, 2019
Utah	May 11, 2010
Vermont	July 1, 2019

Notes: Effective dates were collected by the authors from state legislative statutes. Arkansas requires a permit for the delivery of tobacco products, including vaping products, explicitly defining an ENDS retailer as "over the counter … to consumers." (A.C.A. §§ 26-57-203, 26-57-214) Hawaii requires tobacco products, including ENDS, to be sold face-to-face (HRS §§ 328J-18, 328J-1). In Maine, tobacco products, including ENDS, can only be shipped to tobacco distributors and tobacco retailers (22 M.R.S.A. §§ 1555-F, 1551). Massachusetts allows internet sales of ENDS if the buyer's age is confirmed (940 CMR 21.04). New York prohibits shipping to any person who is not a licensed wholesaler, warehouse, or U.S. government agent (McKinney's Public Health Law § 1399-ll). Ohio prohibits the distribution of tobacco and vapor products over the Internet without age verification (R.C. § 2927.02). Oregon prohibits online delivery of cigarettes and ENDS (O.R.S. § 180.441). South Dakota bans distributing tobacco products, including ENDS, to consumers (SDCL §§ 10-50-99, 34-46-20). Utah requires face-to-face exchange for tobacco or ENDS sales to consumers (U.C.A. §§ 76-10-105.1, 59-14-803, 59-14-509). Vermont specifies that tobacco substitutes, including ENDS, can only be shipped to wholesale or retail dealers (7 V.S.A. §§ 1010, 1001).

Table 2. TWFE Estimates of Effects of ENDS Online Sales Restrictions on Youth Current ENDS Use, MTF

	(1)	(2)	(3)	(4)	(5)
			Panel I. All Grades		
Online ENDS Sales Restriction	0.0168	0.0194	0.0169	0.0169	0.0190
	(0.0109)	(0.0117)	(0.0112)	(0.0111)	(0.0123)
Pre-Treat. Mean of DV	0.1295	0.1295	0.1295	0.1295	0.1295
N	198221	198221	198221	198221	198221
			Panel II. 10th and 12th Grades		
Online ENDS Sales Restriction	0.0146	0.0163	0.0147	0.0147	0.0129
	(0.0136)	(0.0139)	(0.0137)	(0.0137)	(0.0181)
Pre-Treat. Mean of DV	0.1528	0.1528	0.1528	0.1528	0.1528
N	138628	138628	138628	138628	138628
			Panel III. 12th Grade		
Online ENDS Sales Restriction	-0.0058	-0.0053	-0.0053	-0.0050	-0.0022
	(0.0161)	(0.0158)	(0.0157)	(0.0154)	(0.0157)
Pre-Treat. Mean of DV	0.1606	0.1606	0.1606	0.1606	0.1606
N	72980	72980	72980	72980	72980
Control Variables:					
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes
Census Region-by-Year-by-Quarter FE?	No	No	No	No	Yes

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

Notes: Estimates are generated via weighted least squares using the Monitoring The Future (MTF) data collected over the period 2014-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Table 3. Stacked DD Estimates of Effect of ENDS Online Sales Restrictions on Youth Current ENDS Use, MTF

	(1)	(2)	(3)	(4)	(5)
			Panel I. All Grades		
Online ENDS Sales Restriction	0.0136	0.0185	0.0167	0.0168	0.0182
	(0.0129)	(0.0153)	(0.0150)	(0.0150)	(0.0167)
Pre-Treat. Mean of DV	0.1318	0.1318	0.1318	0.1318	0.1318
N	1001725	1001725	1001725	1001725	1001725
			Panel II. 10th and 12th Grades		
Online ENDS Sales Restriction	0.0107	0.0131	0.0125	0.0130	0.0088
	(0.0154)	(0.0166)	(0.0169)	(0.0169)	(0.0239)
Pre-Treat. Mean of DV	0.1597	0.1597	0.1597	0.1597	0.1597
N	705244	705244	705244	705244	705244
			Panel III. 12th Grade		
Online ENDS Sales Restriction	-0.0237	-0.0224	-0.0223	-0.0212	0.0044
	(0.0254)	(0.0259)	(0.0258)	(0.0251)	(0.0187)
Pre-Treat. Mean of DV	0.1652	0.1652	0.1652	0.1652	0.1652
N	381857	381857	381857	381857	381857
Control Variables:					
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes
Census Region-by-Year-by-Quarter FE?	No	No	No	No	Yes

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

Notes: Estimates are generated via weighted least squares using the Monitoring The Future (MTF) data collected over the period 2014-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Table 4. Robustness of Estimates in Table 2 to Additional Controls and Alternate Definitions of Treatment, MTF

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline (Table 2, column 4)	Excluding States with Weaker Policies	Federal Law Included as Treatment	Additional Controls for MJ Policies	Controls for Drug Policies	Columns (4) and (5)	Column (6) + Census Division-by-Time FE	Column (6) + Treated State-Specific Linear Time Trends
Online ENDS Sales Restriction	0.0169	0.0220	0.0037	0.0096	0.0170	0.0094	0.0189	-0.0082
	(0.0111)	(0.0152)	(0.0084)	(0.0122)	(0.0116)	(0.0131)	(0.0133)	(0.0192)
Pre-Treat. Mean of DV	0.1295	0.1302	0.1407	0.1295	0.1295	0.1295	0.1295	0.1295
N	198221	185284	198221	198221	198221	198221	198221	198221
Control Variables:								
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Beer Tax?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Marijuana Related Policies?	No	No	No	Yes	No	Yes	Yes	Yes
Drug Policies?	No	No	No	No	Yes	Yes	Yes	Yes
Division-by-Year-by-Quarter FE?	No	No	No	No	No	No	Yes	No
Treated State-Specific Linear Time Trends?	No	No	No	No	No	No	No	Yes
Definition of Treated Group:								
States with Weaker Policies Excluded? (with only age restrictions)	No	Yes	No	No	No	No	No	No
All States Treated Post April 2021?	No	No	Yes	No	No	No	No	No

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

Notes: Estimates are generated via weighted least squares using the Monitoring The Future (MTF) data collected over the period 2014-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Table 5. Exploration of Effect of ENDS Online Sales Restrictions on Intensive Margin of Youth ENDS Use, MTF

	(1)	(2)	(3)	(4)
	Full Sample		Current Users	
		Panel I. All Grades		
Online ENDS Sales Restriction	0.0009	0.0057	-0.0077	-0.0002
	(0.0049)	(0.0055)	(0.0146)	(0.0187)
Pre-Treat. Mean of DV	0.0285	0.0285	0.2198	0.2198
N	198221	198221	27976	27976
		Panel II. 10th and 12th Grades		
Online ENDS Sales Restriction	-0.0008	0.0061	-0.0105	-0.0024
	(0.0065)	(0.0081)	(0.0171)	(0.0232)
Pre-Treat. Mean of DV	0.0346	0.0346	0.2265	0.2265
N	138628	138628	23220	23220
		Panel III. 12th Grade		
Online ENDS Sales Restriction	-0.0076	-0.0036	-0.0029	-0.0151
	(0.0085)	(0.0082)	(0.0312)	(0.0305)
Pre-Treat. Mean of DV	0.0353	0.0353	0.2197	0.2197
N	72980	72980	13568	13568
Control Variables:				
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	Yes	Yes	Yes	Yes
Beer Tax?	Yes	Yes	Yes	Yes
Census Region-by-Year-by-Quarter FE?	No	Yes	No	Yes

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

Notes: Estimates are generated via weighted least squares using the Monitoring The Future (MTF) data collected over the period 2014-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Table 6A. TWFE Estimates of Effects of Online ENDS Sales Restrictions on Youth Current ENDS Use, YRBSS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Panel I: State YRBSS			
Online ENDS Sales Restriction	0.0095	-0.0056	-0.0068	-0.0048	-0.0048	-0.0034	-0.0026
	(0.0201)	(0.0205)	(0.0200)	(0.0203)	(0.0203)	(0.0191)	(0.0205)
Pre-Treat. Mean of DV	0.1938	0.1938	0.1938	0.1938	0.1938	0.1975	0.1938
N	735109	735109	735109	735109	732209	735109	735109
				Panel II: Combined YRBSS			
Online ENDS Sales Restriction	0.0302	0.0246	0.0203	0.0158	-0.0156	0.0214	0.0247
	(0.0308)	(0.0291)	(0.0264)	(0.0263)	(0.0170)	(0.0221)	(0.0230)
Pre-Treat. Mean of DV	0.2086	0.2086	0.2086	0.2086	0.2047	0.2067	0.2086
N	807753	807753	807753	807753	802480	807753	807753
Control Variables:							
State and Year-by-Semester FE?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes	Yes	Yes
Census Region-by-Year-Semester FE?	No	No	No	No	No	No	Yes
Definition of Treated Group:							
States with Weaker Policies Excluded? (with only age restrictions)	No	No	No	No	Yes	No	No
All States Treated Post April 2021?	No	No	No	No	No	Yes	No

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

Notes: Estimates are generated via weighted least squares using the State and National Youth Risk Behavior Surveillance System (YRBSS) collected over the period 2015-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and Tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Table 6B. TWFE Estimates of Effects of Online ENDS Sales Restrictions on Youth Frequent ENDS Use, YRBSS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Panel I: State YRBSS			
Online ENDS Sales Restriction	0.0001	0.0010	0.0047	0.0063	0.0063	-0.0098	0.0055
	(0.0076)	(0.0087)	(0.0094)	(0.0102)	(0.0102)	(0.0099)	(0.0097)
Pre-Treat. Mean of DV	0.0405	0.0405	0.0405	0.0405	0.0405	0.0447	0.0405
N	735109	735109	735109	735109	732209	735109	735109
				Panel II: Combined YRBSS			
Online ENDS Sales Restriction	0.0124	0.0185	0.0171	0.0163	0.0044	-0.0161	0.0203
	(0.0216)	(0.0205)	(0.0184)	(0.0182)	(0.0092)	(0.0291)	(0.0173)
Pre-Treat. Mean of DV	0.0395	0.0395	0.0395	0.0395	0.0413	0.0459	0.0395
N	807753	807753	807753	807753	802480	807753	807753
Control Variables:							
State and Year-by-Semester FE?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes	Yes	Yes
Census Region-by-Year-Semester FE?	No	No	No	No	No	No	Yes
Definition of Treated Group:							
States with Weaker Policies Excluded? (with only age restrictions)	No	No	No	No	Yes	No	No
All States Treated Post April 2021?	No	No	No	No	No	Yes	No

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

Notes: Estimates are generated via weighted least squares using the State and National Youth Risk Behavior Surveillance System (YRBSS) collected over the period 2015-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and Tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Table 7. Discrete-Time Hazard Estimates of the Effects of ENDS Online Sales Restrictions on Initiation and Cessation of Youth ENDS Use, PATH

	(1)	(2)	(3)	(4)	(5)
			Panel I. Initiation (Non-User to Current User)		
Online ENDS Sales Restriction	0.0217	0.0202	0.0194	0.0191	0.0144
	(0.0157)	(0.0150)	(0.0152)	(0.0152)	(0.0153)
Pre-Treat. Mean of DV 1	0.0532	0.0532	0.0532	0.0532	0.0532
Pre-Treat. Mean of DV 2	0.0547	0.0547	0.0547	0.0547	0.0547
N	61921	61921	61921	61921	61921
			Panel II. Cessation (Current User to Non-User)		
Online ENDS Sales Restriction	-0.0586	-0.0095	-0.0090	-0.0079	0.0137
	(0.2531)	(0.2303)	(0.2333)	(0.2324)	(0.2413)
Pre-Treat. Mean of DV 1	0.3140	0.3140	0.3140	0.3140	0.3140
Pre-Treat. Mean of DV 2	0.3818	0.3818	0.3818	0.3818	0.3818
N	2210	2210	2210	2210	2210
Control Variables:					
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects and Age	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes
Census Region-by-Year-by-Quarter FE?	No	No	No	No	Yes

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

Notes: Estimates are generated via discrete time hazard model using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Table 8. Estimates of Effect of Online ENDS Sales Restrictions on Usual Sources of ENDS, YRBSS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	State YRBSS					Combined YRBSS	
	Panel I: Usually Purchase ENDS Online, OLS						
Online ENDS Sales Restriction	-0.0102***	-0.0109***	-0.0120***	-0.0129***	-0.0155***	-0.0064*	-0.0064**
	(0.0025)	(0.0030)	(0.0032)	(0.0031)	(0.0024)	(0.0035)	(0.0032)
Pre-Treat. Mean of DV	0.0142	0.0142	0.0142	0.0142	0.0142	0.0121	0.0121
	Panel II: Usual Sources of ENDS, Multinomial Logistic Regression						
Online Sources	-0.0042***	-0.0042***	-0.0047***	-0.0056***	-0.0074***	-0.0020	-0.0020
	(0.0012)	(0.0012)	(0.0014)	(0.0015)	(0.0016)	(0.0021)	(0.0019)
Pre-Treat. Mean of DV	0.0142	0.0142	0.0142	0.0142	0.0142	0.0121	0.0121
Own Purchase at Store	-0.0087	0.0079	0.0037	0.0067	0.0012	0.0233*	0.0233*
	(0.0063)	(0.0086)	(0.0083)	(0.0093)	(0.0078)	(0.0133)	(0.0137)
Pre-Treat. Mean of DV	0.0448	0.0448	0.0448	0.0448	0.0448	0.0613	0.0613
Social Sources	0.0432**	0.0234	0.0010	0.0023	0.0058	-0.0051	0.0123
	(0.0191)	(0.0204)	(0.0144)	(0.0160)	(0.0117)	(0.0132)	(0.0151)
Pre-Treat. Mean of DV	0.1287	0.1287	0.1287	0.1287	0.1287	0.1119	0.1119
Other Sources	-0.0011	-0.0016	-0.0053	-0.0103	-0.0144***	-0.0095	-0.0177***
	(0.0051)	(0.0080)	(0.0075)	(0.0068)	(0.0050)	(0.0061)	(0.0053)
Pre-Treat. Mean of DV	0.0285	0.0285	0.0285	0.0285	0.0285	0.0269	0.0269
N	442763	442763	442763	442763	442763	491410	491410
Control Variables:							
State and Year-by-Semester FE?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes	Yes	Yes
Census Region-by-Year-Semester FE?	No	No	No	No	Yes	No	Yes

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

Notes: Estimates are generated using the State (columns 1-5) and Combined (columns 6-7) Youth Risk Behavior Surveillance System (YRBSS) collected over the period 2017-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and Tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Table 9. TWFE Estimates of Effects of Online ENDS Sales Restrictions on Youth Cigarette Smoking, MTF and Combined YRBSS

	(1)	(2)	(3)	(4)
	MTF		**Combined YRBSS**	
	Panel I. Current Cigarette Smoking			
Online ENDS Sales Restriction	-0.0035	-0.0044	-0.0031	-0.0033
	(0.0038)	(0.0040)	(0.0065)	(0.0078)
Pre-Treat. Mean of DV	0.0566	0.0566	0.0674	0.0674
N	334599	334599	851179	851179
	Panel II. Heavier (MTF) and Frequent (YRBSS) Cigarette Smoking			
Online ENDS Sales Restriction	-0.0032	-0.0036	-0.0018	-0.0018
	(0.0029)	(0.0027)	(0.0048)	(0.0048)
Pre-Treat. Mean of DV	0.0093	0.0093	0.0202	0.0202
N	334599	334599	851179	851179
Control Variables:				
State and Year-by-Semester FE?	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	Yes	Yes	Yes	Yes
Beer Tax?	Yes	Yes	Yes	Yes
Census Region-by-Year-Semester FE?	No	Yes	No	Yes

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

Notes: Estimates are generated via weighted least squares using the Monitoring The Future (MTF) data collected over the period 2014-2023 and the State and National Youth Risk Behavior Surveillance System (YRBSS) collected over the period 2015-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and Tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

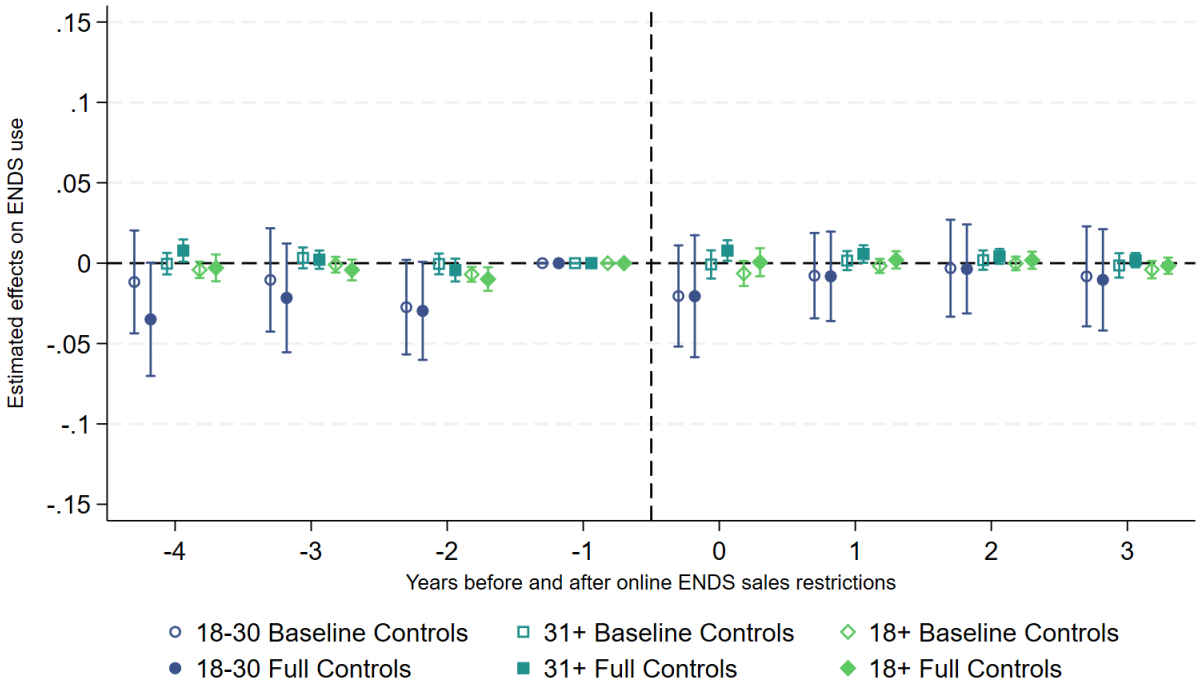
Table 10. Estimates of Effects of Online ENDS Sales Restrictions on Adult Current ENDS Use, BRFSS

	(1)	(2)	(3)	(4)	(5)	(6)
			Panel I: Young Adults Aged 18-30			
Online ENDS Sales Restriction	0.0042	0.0077	0.0071	0.0069	0.0129	-0.0028
	(0.0069)	(0.0064)	(0.0070)	(0.0069)	(0.0086)	(0.0085)
Pre-Treat. Mean of DV	0.0915	0.0915	0.0915	0.0915	0.0915	0.1090
N	289231	289231	289231	289231	273428	289231
			Panel II: Older Adults Over Age 30			
Online ENDS Sales Restriction	0.0010	0.0017	0.0022	0.0018	-0.0031	-0.0007
	(0.0028)	(0.0029)	(0.0033)	(0.0034)	(0.0031)	(0.0017)
Pre-Treat. Mean of DV	0.0293	0.0293	0.0293	0.0293	0.0293	0.0380
N	2089716	2089716	2089716	2089716	1979954	2089716
Control Variables:						
State and Year-by-Semester FE?	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Characteristics?	Yes	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes	Yes
Definition of Treated Group:						
States with Weaker Policies Excluded? (with only age restrictions)	No	No	No	No	Yes	No
All States Treated Post April 2021?	No	No	No	No	No	Yes

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

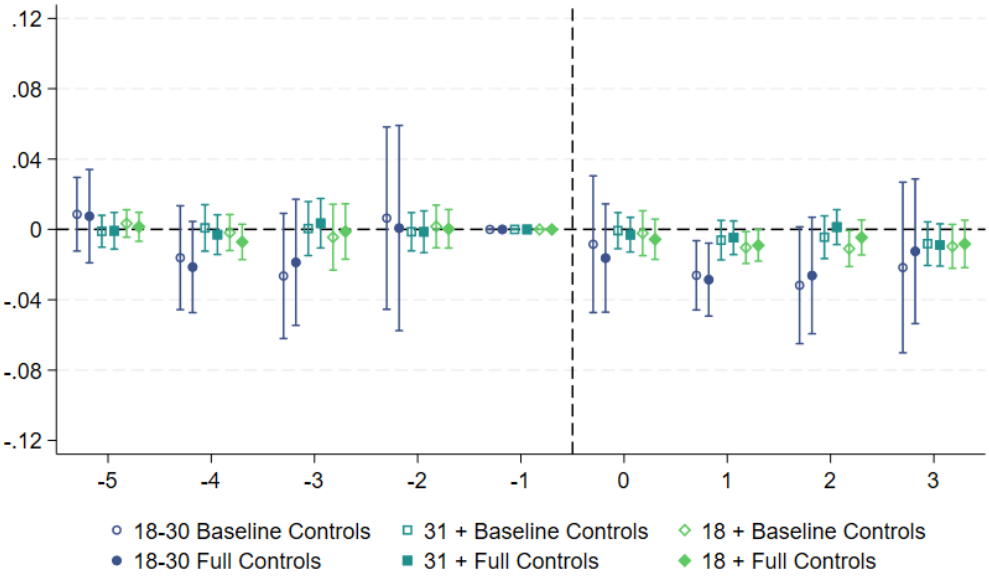
Notes: Estimates are generated via weighted least squares using the Behavioral Risk Factor Surveillance System (BRFSS) data collected over the period 2016-2023. Demographic characteristics include sex, race, age, and grade. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and Tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Appendix Figure 1. Event-Study Analysis of ENDS Online Sales Restrictions and Adult ENDS Use, BRFSS



Notes: Event-study regressions are estimated using the Behavioral Risk Factor Surveillance System (BRFSS) data collected over the period 2016-2023. Baseline controls include state fixed effects, year-by-semester fixed effects, demographic characteristics (sex, race, age, and grade), state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, the percentage of fully vaccinated individuals, unemployment rate, poverty rate, per capita income, an index for housing prices, ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. Full controls additionally include minimum legal sales age (MLSA) laws, tobacco 21 laws, indoor vaping restrictions, indoor smoking restrictions, beer taxes (in $2023), and Census region-by-time fixed effects. Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around the estimated effect of online ENDS sales restrictions.

Appendix Figure 2. Event-Study Analysis of ENDS Online Sales Restriction and Current ENDS Use among Adults, PATH



Notes: Event-study regressions are estimated using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. Baseline controls include state fixed effects, year-by-quarter fixed effects, individual fixed effects, age, state-by-year cumulative COVID-19 deaths rates, an index of overall government response to the pandemic, the percentage of fully vaccinated individuals, unemployment rate, poverty rate, per capita income, an index for housing prices, cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. Full controls additionally include minimum legal sales age (MLSA) laws, tobacco 21 laws, indoor vaping restrictions, indoor smoking restrictions, beer taxes (in $2023), and Census region-by-time fixed effects. Regressions are weighted, and standard errors are clustered at the state level. Vertical lines are 95% confidence intervals around estimated effect of online ENDS sales restrictions.

Appendix Table 1. Summary Statistics for Youth Datasets

Variables	Mean			
	MTF	**State YRBSS**	**Combined YRBSS**	**PATH-Youth**
Demographic characteristics				
Female	0.491	0.495	0.488	0.486
White, non-Hispanic	0.491	0.505	0.546	0.503
Black, non-Hispanic	0.134	0.144	0.141	0.127
Hispanic	0.265	0.246	0.240	0.235
Other	0.110	0.106	0.072	0.134
Age 10-14	0.293	N/A	N/A	N/A
12-14	N/A	0.142	0.200	N/A
14	N/A	N/A	N/A	0.246
15	0.168	0.255	0.201	0.249
16	0.185	0.253	0.199	0.251
17	0.158	0.235	0.199	0.253
18+	0.197	0.115	0.201	NA
Grade 8	0.307	N/A	N/A	N/A
9	N/A	0.271	0.301	N/A
10	0.352	0.256	0.206	N/A
11	N/A	0.240	0.203	N/A
12	0.341	0.233	0.290	N/A
ENDS Use and Cigarette Smoking				
Current ENDS Use	0.137	0.187	0.198	0.073
Frequent ENDS Use	0.040	0.053	0.060	0.018
Current Cigarette Smoking	0.046	0.061	0.065	0.037
Heavier Cigarette Smoking	0.007	N/A	N/A	N/A
Frequent Cigarette Smoking	N/A	0.014	0.016	N/A
Sources of ENDS				
Online Purchases	N/A	0.005	0.005	0.002
Own Purchase at Store (In Person)	N/A	0.036	0.043	0.027
Social Sources	N/A	0.099	0.101	N/A
Other Sources	N/A	0.032	0.034	N/A
Purchase By Telephone	N/A	N/A	N/A	0.0004
Observations	198221	735109	807753	65651

Notes: The number of observations for cigarette smoking questions is 334,599 in MTF, 776,429 in State YRBSS, and 851,179 in Combined YRBSS. ENDS source questions are available from wave 4 onward in PATH (N = 39,288), and in YRBSS survey years 2017-2023 (N = 442,763 for State YRBSS and N=491,410 for Combined YRBSS).

Appendix Table 2. Effects of ENDS Online Sales Restrictions on Youth Initiation of ENDS Online Purchase, PATH

	(1)	(2)	(3)	(4)	(5)
Online ENDS Sales Restriction	0.0005	0.0000	0.0002	0.0004	-0.0008
	(0.0028)	(0.0027)	(0.0027)	(0.0027)	(0.0024)
Pre-Treat. Mean of DV	0.0029	0.0029	0.0029	0.0029	0.0029
N	40973	40973	40973	40973	40973
Control Variables:					
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects and Age	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes
Census Region-by-Year-by-Quarter FE?	No	No	No	No	Yes

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

Notes: Estimates are generated via discrete time hazard model using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2016-2023. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Appendix Table 3. Effects of ENDS Online Sales Restrictions on Dynamics in Initiation and Cessation of Cigarette Smoking among Youth, PATH

	(1)	(2)	(3)	(4)	(5)
			Panel I. Initiation		
Online ENDS Sales Restriction	0.0117	0.0103	0.0100	0.0102	0.0083
	(0.0071)	(0.0067)	(0.0069)	(0.0069)	(0.0050)
Pre-Treat. Mean of DV	0.0186	0.0186	0.0186	0.0186	0.0186
N	63197	63197	63197	63197	63197
			Panel II. Cessation		
Online ENDS Sales Restriction	0.1027	0.0603	0.0719	0.0747	0.0955
	(0.1079)	(0.1292)	(0.1361)	(0.1370)	(0.2174)
Pre-Treat. Mean of DV	0.4143	0.4143	0.4143	0.4143	0.4143
N	1663	1663	1663	1663	1663
Control Variables:					
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects and Age	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes
Census Region-by-Year-by-Quarter FE?	No	No	No	No	Yes

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

Notes: Estimates are generated via discrete time hazard model using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Appendix Table 4. Effects of ENDS Online Sales Restrictions on Dynamics in Initiation and Cessation of ENDS Use among Young Adults Aged 18-30, PATH

	(1)	(2)	(3)	(4)	(5)
			Panel I. Initiation (Non-User to Current User)		
Online ENDS Sales Restriction	-0.0080	-0.0074	-0.0080	-0.0086	-0.0107
	(0.0105)	(0.0108)	(0.0112)	(0.0115)	(0.0112)
Pre-Treat. Mean of DV	0.0868	0.0868	0.0868	0.0868	0.0868
N	74203	74203	74203	74203	74203
			Panel II. Cessation (Current User to Non-User)		
Online ENDS Sales Restriction	-0.0484	-0.0490	-0.0555	-0.0576	-0.0678
	(0.0626)	(0.0639)	(0.0615)	(0.0618)	(0.0642)
Pre-Treat. Mean of DV	0.4839	0.4839	0.4839	0.4839	0.4839
N	12517	12517	12517	12517	12517
			Panel III. Transition into Online ENDS Purchase		
Online ENDS Sales Restriction	0.0038	0.0042	0.0042	0.0040	0.0021
	(0.0040)	(0.0042)	(0.0043)	(0.0042)	(0.0040)
Pre-Treat. Mean of DV	0.0099	0.0099	0.0099	0.0099	0.0099
N	61613	61613	61613	61613	61613
Control Variables:					
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects and Age	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes
Census Region-by-Year-by-Quarter FE?	No	No	No	No	Yes

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

Notes: Estimates are generated via discrete time hazard model using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.

Appendix Table 5. Effects of Online ENDS Sales Restrictions on Initiation and Cessation of ENDS Use among All Adults (18 and over), PATH

	(1)	(2)	(3)	(4)	(5)
			Panel I. Initiation (Non-User to Current User)		
Online ENDS Sales Restriction	0.0025	0.0033	0.0035	0.0035	0.0028
	(0.0025)	(0.0027)	(0.0027)	(0.0027)	(0.0032)
Pre-Treat. Mean of DV	0.0299	0.0299	0.0299	0.0299	0.0299
N	166808	166808	166808	166808	166808
			Panel II. Cessation (Current User to Non-User)		
Online ENDS Sales Restriction	0.0234	0.0281	0.0187	0.0187	0.0131
	(0.0296)	(0.0336)	(0.0335)	(0.0343)	(0.0379)
Pre-Treat. Mean of DV	0.4807	0.4807	0.4807	0.4807	0.4807
N	19390	19390	19390	19390	19390
			Panel III. Initiation of Online ENDS Purchase		
Online ENDS Sales Restriction	-0.0006	-0.0005	-0.0003	-0.0002	-0.0000
	(0.0012)	(0.0013)	(0.0014)	(0.0014)	(0.0014)
Pre-Treat. Mean of DV	0.0033	0.0033	0.0033	0.0033	0.0033
N	123957	123957	123957	123957	123957
Control Variables:					
State and Year-by-Quarter FE?	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects and Age	Yes	Yes	Yes	Yes	Yes
COVID-19 and Macro Controls?	Yes	Yes	Yes	Yes	Yes
Baseline ENDS and Tobacco Policies?	Yes	Yes	Yes	Yes	Yes
ENDS Age Restriction Policies?	No	Yes	Yes	Yes	Yes
Indoor Vape and Smoke Policies?	No	No	Yes	Yes	Yes
Beer Tax?	No	No	No	Yes	Yes
Census Region-by-Year-by-Quarter FE?	No	No	No	No	Yes

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

Notes: Estimates are generated via discrete time hazard model using the Population Assessment of Tobacco and Health (PATH) data collected over the period 2013-2023. COVID-19 controls include state-by-year cumulative COVID-19 death rates, an index of overall government response to the pandemic, and the percentage of fully vaccinated individuals. Macroeconomic controls include the unemployment rate, poverty rate, per capita income, and an index for housing prices. Baseline ENDS and tobacco controls include ENDS and cigarette taxes (in $2023), flavored ENDS restrictions, tobacco licensure laws, and ENDS licensure laws. ENDS age restriction policies include minimum legal sales age (MLSA) laws and tobacco 21 laws. Standard errors are clustered at the state level and reported in parentheses.