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Are E-Cigarette Taxes Losing their Bite?*

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Abstract. The rise in nicotine vaping among U.S. teenagers in the late 2010s prompted tobacco control advocates to press for higher electronic nicotine delivery system (ENDS) taxes to curb their use. This study is the first to explore how the effectiveness of e-cigarette taxation as an anti-vaping policy tool has evolved over time. Using data from several nationally representative data sources and a generalized difference-in-differences approach, we find that since 2020, the effectiveness of a one dollar increase in ENDS taxes in curbing youth nicotine vaping has declined by over 50 percent. This finding is consistent with the marginal youth vaper becoming more tax inelastic over time. Descriptive evidence shows that the composition of youth ENDS users appears to have shifted toward those with a higher addictive stock and a greater taste for risk, which could make youths less tax responsive. For adults, where nicotine vaping rates are stable or slightly rising and compositional shifts are somewhat less pronounced, we find much less evidence that ENDS tax effectiveness has changed over time.

JEL Codes: I18; I20
Keywords: e-cigarettes taxes; vaping; electronic nicotine delivery systems (ENDS)

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1. Introduction

The U.S. Surgeon General deemed the rise of electronic cigarette (e-cigarette) use among teenagers in the late 2010s to be an "epidemic" (U.S. Surgeon General 2018). In 2011, just 1.5 percent of U.S. high school students reported prior-month use of electronic nicotine delivery systems (ENDS) products (Centers for Disease Control and Prevention 2013). By 2019, this number had reached 27.5 percent, with an astounding 46.9 percent of youth reporting that they had used ENDS in their lifetime (Centers for Disease Control and Prevention 2020).

One of the most popular policy tools to reduce nicotine vaping is e-cigarette taxation (Centers for Disease Control and Prevention 2024a). As of November 2025, 33 states, the District of Columbia, and a few large local jurisdictions have adopted e-cigarette taxes.[1] There is substantial variation in ENDS taxes across states and over time (Cotti et al. 2024). The highest ENDS tax states (e.g., California, District of Columbia, Minnesota, Vermont) report e-cigarette tax rates of over $2 or $3 per mL of e-liquid (2023$) while the lowest ENDS tax states (e.g., Georgia, Kansas, Kentucky, North Carolina, Virginia) report tax rates of less than $0.10 per mL (see Figure 1 and Appendix Table 1).[2] There is robust empirical evidence that e-cigarette taxes had their intended effect: reducing youth nicotine vaping (Abouk et al. 2023; Dave et al. 2024; 2025; Chuo et al. 2025; Courtemanche et al. 2025).

Indeed, anti-vaping policies such as e-cigarette taxation (Abouk et al. 2023), restrictions on the sales of flavored ENDS products (Cotti et al. 2025; Saffer et al. 2025), and higher minimum legal purchasing ages (Hansen et al. 2023; Friedman 2015) — along with rising anti-vaping sentiment (MacMonegle et al. 2025), and the onset of the COVID-19 pandemic (Wang et al. 2019; Gaiha et al. 2020) — had a substantial impact on the vaping "epidemic" among youths. Between 2019 and 2021, the prior-month youth vaping rate among U.S. high school students fell from 27.5 percent to 11.3 percent, by 2024, just 7.8 percent reported prior month ENDS use (CDC 2024). This rapid decline in vaping has caused tobacco control advocates to claim an important public health victory and argue for continued restrictions on youth access to e-cigarettes (CDC 2024; CTFK 2024; FDA 2024). But will increases in ENDS taxes continue to be an effective policy strategy to curb youth nicotine vaping?

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[1] These jurisdictions include Montgomery County, Maryland, Chicago, Illinois, and Cook County, Illinois.
[2] Figure 1 and Appendix Table 1 show ENDS tax rates for "closed system" ENDS products, which include e-cigarettes with pre-filled/refillable cartridges such as JUUL. This was the most popular e-cigarette product used by youths during their rise to popularity in the 2010s. Appendix Table 2 shows the corresponding values for "open system" products, which include refillable, tank-based, and more customizable ENDS devices.

The decline in the prevalence of youth vaping, and potentially important changes in the composition of youth vapers, raise important challenges for the effectiveness of future e-cigarette taxation. Continued increases in ENDS taxes could have a diminishing impact on youth nicotine vaping if the marginal youth nicotine vaper has changed over time such that current vapers have a higher marginal utility of vaping. A teenager who vaped nicotine in the early 2020s did so in the face of a wider set of policies that restrict access to ENDS and a greater degree of anti-vaping sentiment relative to a teenager who vaped nicotine in the mid-late 2010s. Thus, such a youth is likely to have a higher marginal utility of e-cigarette consumption and be less sensitive to changes in taxes. Relatedly, events such as the E-cigarette or Vaping Use-Associated Lung Injury (EVALI) crisis in 2019 and the COVID-19 pandemic in early 2020[3] — along with a myriad of policy interventions designed to curb nicotine vaping (e.g., raising of minimum legal purchasing ages, restrictions on the sales of flavored ENDS products) that have proliferated since 2019 — may have changed youths' beliefs about the health risks associated with nicotine vaping and reduced e-cigarette demand (Jin et al. 2024; Dave et al. 2020; Gaiha et al. 2020) for more responsive users (at more elastic margins), leaving nicotine vapers who are, on average, less risk averse and less responsive to tax increases.

Relatedly, trends in the average nicotine content of e-cigarette products sold in the U.S. market have been steadily rising over the past decade (Romberg et al. 2019; Wang et al. 2023; Ali et al. 2023). In recent years, this increase in nicotine concentration has been particularly pronounced among ENDS products, such as disposables, that enjoy greater popularity among youth (Wang et al. 2023). In light of these shifts in the ENDS market, the average youth vaper today would be more likely to be exposed to higher levels of nicotine, develop nicotine dependence, and consequently find it relatively more difficult to reduce their consumption in response to higher taxes.

In addition, the means through which teens obtain their e-cigarettes may have changed over time, which could have impacted the effect of ENDS taxes on their use. The imposition of minimum legal purchasing ages for e-cigarettes may have pushed teens away from direct in-person purchase options and toward informal social sources of e-cigarettes (Hansen, McNichols, and Sabia 2023). This means that teenagers' use of social markets, illicit markets, or other informal methods of exchanges have become increasingly common. Informal exchanges for tobacco products are often quite complex (Ribisl 2003; Friend et al. 2001). Those who lend their vaping devices to others (or

[3] In a national survey of youth and young adults conducted during the pandemic, the vast majority of underage youth who had reported cutting down on their e-cigarette use cited parental supervision at home, difficulty getting e-cigarettes, and wanting to protect their lungs as driving factors (Gaiha et al. 2020).

are willing to purchase e-cigarettes for others) may be compensated in non-monetary ways (e.g., lenders becoming future borrowers via "social credit" or borrowers providing other non-cash favors to lenders). In that case, ENDS tax pass-through may not be full, which could insulate youths from the impact of taxation (Hansen et al. 2013; Carpenter and Cook 2008; Katzman, Markowitz, and McGeary 2007). With some youth vapers shifting from retail outlets to online purchases over the pandemic, this could further undermine the effectiveness of higher ENDS taxation considering the relatively high degree of tax non-compliance among online vendors (Gaiha et al. 2020; Mejorado et al. 2025).

The impact of ENDS taxes on youth (or adult) use may further change to the extent that the market for ENDS products has become more competitive over time (Diaz et al. 2025). While JUUL dominated the market for e-cigarettes in the late 2010s (Huang et al. 2019), by the 2020s, the market for e-cigarettes was dominated by many firms, including Vuse, JUUL Labs Inc., Altria Group Inc., British American Tobacco, NJOY, and many other firms (Custom Market Insights, 2025). This increase in market competition is likely to generate less tax passthrough to consumer prices, leading to smaller impacts of ENDS taxes on youth use.

On the other hand, several factors could also counteract these channels to stabilize or even enhance the effectiveness of ENDS taxes. While the presence of a borrowing market can help youth evade higher tobacco taxes, and reduce their effectiveness, the social market itself may contract as the supply of "lenders" – the pool of e-cigarette users who are able or willing to lend ENDS products to peers – increasingly shrinks as monetary costs continue to rise (Katzman, McGeary and Markowitz 2007). For instance, evidence in the context of cigarette taxes suggests that higher taxation further tends to restrain third-party purchases, an important component of the secondary market for underage youth (Hansen et al. 2013). Subsequently, if these alternate informal supply channels for ENDS products diminish over time in response to higher taxes (and other restrictions), ENDS taxes may elicit a stronger response from the marginal youth vaper who now has fewer substitution sources. Moreover, if there are multiplicative effects such that the presence of one complementary tobacco restriction raises the efficacy of others, then it is possible that the higher non-monetary costs of ENDS products – resulting from the proliferation of purchase restrictions (e.g. Tobacco 21 laws, online sales bans, restrictions on flavored ENDS products) may reinforce the channels underlying the effectiveness of cost-based polices (e.g. ENDS taxes).

This study is the first to explore how the effectiveness of e-cigarette taxation in curbing youth nicotine vaping has changed over time and provide evidence on why such changes may have

occurred. We also compare the effects on youths to younger and older adults. Using data across several national data sources (Youth Risk Behavior Surveillance System, Monitoring The Future, Population Assessment of Tobacco and Health, Behavioral Risk Factor Surveillance System, and Current Population Survey-Tobacco Use Supplements) and a generalized difference-in-differences approach, our findings provide robust evidence that the effectiveness of ENDS taxes in reducing youth nicotine vaping has been diminishing over time. Using data from the State YRBSS spanning the period 2015-2019, we find that a one dollar increase in the ENDS tax (in 2023$) is associated with a 5.7 percentage-point (27.8 percent) decline in youth ENDS use. However, over the period 2015-2023 the estimated marginal effect of a one-dollar tax increase falls by 57.9 percent to 2.4 percentage points (11.7 percent). The decline in ENDS tax impact over time is statistically distinguishable from zero at conventional levels. Estimates from the Monitoring the Future (MTF) and the Population Assessment of Tobacco and Health (PATH) follow a very similar pattern and corroborate this diminishing tax responsiveness over more recent periods. In longitudinal discrete time hazard analyses, we further confirm that the decrease in the tax response extends to both the initiation and cessation margins.

Descriptive analyses suggest that our findings can be attributed, in part, to the changing composition of ENDS users over time. Principal component analysis (PCA) shows that teenagers with higher addictive stock and less risk aversion were less responsive to ENDS taxes than their less addicted and more risk averse counterparts; as the composition of ENDS users shifted toward more addicted and risk tolerant youths in the 2020s, the effectiveness of ENDS taxation as an anti-vaping tool progressively weakened. We also find some support for the hypothesis that shifts away from own in-store purchases of e-cigarettes and toward informal social sources, especially among older teenagers (ages 18), may have helped to insulate youths from the effect of e-cigarette taxes. We find less evidence that changing market competition can explain our findings.

Finally, we explore changes over time in the ENDS tax-induced substitution response in relation to combustible cigarettes. The extent of this substitution into cigarettes vis-à-vis the own-tax response on ENDS use, in conjunction with the relative risk of the two tobacco products, is a critical input in the welfare impact of higher ENDS taxation (Dave et al. 2024). Thus, understanding how these responses have shifted over time, both absolutely and relative to each other, is integral for continued policy guidance on raising ENDS taxes. We find that, countering the declining own-tax response on ENDS use, the spillover effects of ENDS taxes to combustible cigarettes have remained stable or even somewhat strengthened. That is, over more recent periods, while higher

ENDS taxes have been less likely to deter vaping for the average user, those users who do respond on the margin by curbing ENDS consumption – being less risk averse and having built up a higher nicotine addictive stock – are more likely to substitute into cigarette use.

In contrast to youths, ENDS tax effects for adults, especially for those aged 30 and older, do not appear to have substantially changed over time. Using data from the Behavioral Risk Factor Surveillance System (BRFSS), the PATH, and the Current Population Survey-Tobacco Use Supplements, we find ENDS tax effects that are small, relatively stable, and sometimes close to zero (especially for older adults) consistent with (1) higher incomes muting the tax responsiveness of adults relative to youths, and (2) the hypothesis that the marginal adult nicotine vaper has not substantially changed over time.

2. Background

2.1 ENDS and Combustible Cigarettes

The introduction of ENDS products into the U.S. tobacco market carried both public health promise as well as potential costs. Increased access to ENDS may serve as an important harm reduction goal for some adult smokers by inducing smoking cessation through substitution to e-cigarettes (Zhuang et al., 2016; Warner et al., 2023). While there is evidence that nicotine vaping causes respiratory and heart health harm (National Academies of Sciences, 2018; U.S. Department of Health and Human Services, 2016), the harm caused by combustible tobacco products appears worse (National Academies of Sciences, Engineering and Medicine 2018; McNeill et al. 2018), with cigarette smoking responsible for the deaths of 480,000 persons per year as well as an increased risk of stroke, heart disease, respiratory disease, and a myriad of cancers (Centers for Disease Control and Prevention 2024). Despite gains to adult smokers who substitute to electronic cigarettes (e-cigarettes), tobacco control advocates worry that increased access to ENDS among youths may "onboard" teenagers on a path to nicotine addiction (Etter 2018; Friedman et al. 2019; Khouja et al. 2020).

Public health concerns about the prevalence of teenage vaping has prompted a number of policy strategies to curb youth ENDS use, including the imposition of minimum legal purchasing ages on ENDS and other tobacco products (Friedman 2015; Hansen et al. 2023; Pesko 2023), restrictions on the sales of flavored ENDS products (Cotti et al. 2025; Saffer et al. 2025), restrictions on the sale of ENDS products purchased online (Harati et al. 2024; Bertrand et al. 2025; Aksu et al.

2025), restrictions on nicotine vaping on school campuses, (Dave et al. 2025), and one of the most effective strategies to date, e-cigarette taxation.

2.2 ENDS Taxes and ENDS Use

ENDS taxes may negatively affect ENDS use through several channels. First, and most directly, increases in ENDS taxes will increase ENDS prices, which will reduce the quantity of e-cigarettes demanded by consumers. The extent to which ENDS taxes are passed on to consumers (pass-through) depends on the relative elasticity of supply and demand for ENDS, market structure (in the ENDS market and broader tobacco markets), and the tax level. There is evidence to suggest that the U.S. e-cigarette market is relatively competitive. Using NielsenIQ Retail Scanner data, Cotti et al (2022) find that 90 percent of ENDS taxes are passed on to consumer retail prices. Thus, price effects are likely to be an important channel through which ENDS taxes affect ENDS use.

In addition to price effects, ENDS taxes could also serve as an informational signal from policymakers to consumers about the health risk of nicotine vaping. For instance, Abouk et al. (2023) found that increases in ENDS taxes are associated with an increase in the share of middle and high school students who perceive regular ENDS use as greatly risky to one's health. In theory, it is also possible that ENDS taxes could change consumers' relative risk perceptions of e-cigarettes as compared to other related products, such as traditional combustible cigarettes.

Finally, ENDS taxes might impose a social stigma on nicotine vaping ("sin tax") that could deter consumption. With respect to cigarettes, there is evidence that higher state cigarette taxes are positively associated with state anti-smoking sentiment (DeCicca et al. 2007).

A growing literature in health economics has documented that ENDS taxation is an effective way to reduce youth (Abouk et al. 2023) and young adult (Pesko et al. 2020; Dave et al. 2024,2025) ENDS use. First, with respect to youths, using data from the Youth Risk Behavior Survey (YRBS) and Monitoring the Future (MTF), Abouk et al. (2023) find that a one dollar increase in ENDS taxes is associated with a 2-7 percentage-point decline in prior-month youth nicotine vaping. This pattern of findings is shown in other YRBS-based studies as well (Dave et al. 2024, 2025; Courtemanche et al. 2025). Chuo et al. (2025) show that the effect of ENDS taxes on ENDS use is stronger for heterosexual teens than for LGBQ teens.

With respect to adults, there is evidence that ENDS taxes are more effective at reducing young adult vaping relative to vaping among older adults. Specifically, Dave et al. (2024; 2025) find that ENDS taxation reduces nicotine vaping more among those under age 30 relative to those aged

30 and older. Along the same lines, Pesko, Courtemanche & Maclean (2020) use data from the Behavioral Risk Factor Surveillance System (BRFSS) and the National Health Interview Survey (NHIS) and find that e-cigarette tax adoption is associated with a 0.5 percentage point decline in ENDS usage among adult males aged 21 and older. Additionally, using Nielsen Retailer Panel data, Allcott and Rafkin (2022) and Cotti et al. (2022) find that ENDS taxes reduce ENDS sales.

In contrast, among those aged 31 and older, there is less evidence that ENDS taxes reduce ENDS use. There may be several reasons for this. First, prior month ENDS usage rates for those aged 31 and older are very low (3.5 percent in 2018 and 4.9 percent in 2023), leaving relatively little scope for ENDS taxes to curb use substantially. Second, average household income among those aged 31 and older is higher than average household income for those aged 18-30, which may lead to a smaller tax elasticity among the former demographic group. Third, the reasons for ENDS use among older adults may be quite different than for younger users. If ENDS use is more likely to be a tool of smoking cessation (or reducing the frequency and intensity of cigarette smoking) than for utility from consumption among older individuals, such persons may be less responsive to changes in ENDS taxes. Relatedly, it could be that the cessation margin of nicotine vaping, which is more likely to be impacted among adults than among youths, may be less impacted than the initiation margin. Together, the above studies find that ENDS taxation (largely) had its intended public health effect: reducing teen and young adult ENDS use, but limited effects on adults over age 30.

2.3 Spillover Effects of ENDS Taxes

Given the relative health risks of e-cigarettes and combustible cigarettes, understanding whether these goods are economic complements or substitutes is critical for assessing the full tobacco-related health effects of ENDS taxes. Several studies provide evidence that ENDS and combustible tobacco cigarettes are substitutes. Abouk et al. (2023) find that a one dollar increase in ENDS taxes is associated with a 0.5-1.5 percentage-point (10-20 percent) increase in prior-month cigarette smoking among U.S. teenagers. Courtemanche et al. (2025) find a similar pattern of results in the combined state and national YRBSS.[4]

The pattern of findings for young adults is similar. Using data from the Current Population Survey–Tobacco Use Supplements, Friedman and Pesko (2022) find that a one dollar increase in ENDS taxes reduces ENDS use among young adults ages 18-25 by 2-3 percentage points, but is also

[4] Evidence for a substitution effect appears weaker in the state YRBSS alone (Dave et al. 2025).

associated with a 3-4 percentage-point increase in past-month cigarette smoking, consistent with the hypothesis that ENDS and combustible cigarettes are economic substitutes.[5]

While much of the focus of the ENDS tax literature has been on the tobacco market, a growing literature has started to explore spillover effects of ENDS taxation on related health outcomes. Dave et al. (2024) study the impact of ENDS taxes on youth and young adult alcohol consumption, with particular attention to behaviors that may capture drinking-related externalities. Using data from the State YRBSS and the Fatality Analysis Reporting System (FARS), the authors find that a one dollar increase in the ENDS tax is associated with a 1-2 percentage-point (8-11 percent) decline in youth binge drinking and a 5-10 percent reduction in alcohol-related traffic fatalities involving 16-20-year-olds.

Building on their alcohol work, Dave et al. (2025) study spillover effects of ENDS taxes on youth substance use, with particular attention to marijuana given that it, like nicotine, can be vaped. Using data from the state YRBSS, they find that a one dollar increase in the ENDS tax is associated with a 1.1 to 1.4 percentage-point (6 to 8 percent) decline in youth marijuana use.

Two very recent working papers explore the effects of ENDS taxes on obesity and mental health. Courtemanche et al. (2025) use data from the combined state and national YRBS and BRFSS and find that a one-dollar (2023$) increase in the ENDS tax is associated with a 0.8-1.0 percentage-point (7.0-8.7 percent) decline in the probability that a female youth is obese. Cotti et al. (2025b) find no evidence that ENDS taxes have a statistically significant or economically meaningful impact on youth depressive symptoms or suicidality.

2.4 Related Literature on Effectiveness of Cigarette Taxation

Our study is most related to prior work in the economics of tobacco literature that explored the changing effectiveness of traditional cigarette taxation as a tobacco control policy to curb cigarette smoking. Using data from the 1991-2005 state and national YRBSS, Carpenter and Cook (2008) found that a one dollar increase in the per pack cigarette tax (2005$) is associated with a 2-3 percentage-point decline in youth smoking participation. This corresponds to an implied tax elasticity of approximately -0.11. Hansen, Rees, and Sabia (2017) expand this work by including

[5] Analyses of sales data nationwide also provide support for the hypothesis that ENDS and traditional cigarettes are economic substitutes (Allcott and Rafkin 2022; Cotti et al. 2022; Pesko and Warman 2022). ENDS taxes is not the only policy instrument to provide evidence to suggest that ENDS and combustible cigarettes are substitutes. This has been found in studies of minimum legal sales ages for e-cigarettes (Friedman 2015) as well as restrictions on the sales of flavored ENDS products (Cotti et al. 2024; Saffer et al. 2024).

additional YRBS survey waves from 2007, 2009, 2011, and 2013. These survey waves were collected over a period when U.S. high school students' smoking participation rates fell from 20.0 percent in 2007 to 15.7 percent in 2013 (Centers for Disease Control and Prevention 2024). This was also a period over which there were frequent and large increases in cigarette taxes, providing a new and rich source of identifying variation.

Hansen, Rees, and Sabia (2017) find that as additional survey years are added to their analysis sample, the estimated effect of a one dollar increase in cigarette taxes on youth smoking participation declined. This result suggests that youths became much less responsive to cigarette taxes in the post-2005 period. Moreover, they find little evidence of a negative relationship between cigarette taxes and youth smoking over the period 2007–2013. The authors conclude that the marginal smoker may have changed over time such that s/he was more likely to be a "hardcore user" with a more inelastic demand for cigarettes.

The pattern of findings on adults is more mixed. Using data from the Behavioral Risk Factor Surveillance Survey over the period 2000-2005, DeCicca and McLeod (2008) find consistent evidence that older adults' smoking participation is negatively impacted by state cigarette tax increases, particularly for less educated and lower income households. The authors argue that their findings stand in contrast to prior evidence that the cessation margin of smoking is largely unaffected by cigarette taxes. On the other hand, Callison and Kaestner (2014) study the impact of large increases in state cigarette taxes over the 1995-2007, arguably giving the policy its best opportunity to curb adult smoking. Using data from the Current Population Survey-Tobacco Use Supplements and a synthetic matched difference-in-differences approach, they find that the association between cigarette taxes and adult smoking is "negative, small, and not usually statistically significant."

However, data from more recent years suggests that cigarette taxes may still impact smoking, at least among some older adults. Maclean et al. (2016) use data from the Health and Retirement Study through 2008 and find that a one dollar increase in the per pack state cigarette tax is associated with a reduction in the number of cigarettes smoked per day among older adult smokers by 3-5 percent. Finally, Pesko et al. (2020) use data from the 2011-2018 Behavioral Risk Factor Surveillance System and National Health Interview Survey and find that cigarette tax increases reduce adult cigarette smoking.[6]

[6] They also find that cigarette tax increases are associated with an increase in adult e-cigarette use, consistent with the hypothesis that these goods are economic substitutes.

3. Data

For our empirical analyses, we draw data from several nationally representative datasets, each with corresponding strengths (and weaknesses) that complement the others. We discuss each below in the context of measuring ENDS use for both youths and adults.

3.1 Measuring ENDS Use Across National Datasets

First, we draw data on youths from the State, National, and Combined Youth Risk Behavior Surveillance System (YRBSS) surveys. The YRBSS are biennial (odd-numbered years only) pencil-and-paper school-based surveys coordinated by the Centers for Disease Control and Prevention (CDC). These surveys are designed to measure health and health behaviors of U.S. high school students attending grades 9 through 12.[7]

The National YRBS is administered by the CDC and, when weighted, is designed to be representative of all U.S. high school students nationwide. The State YRBS is administered by State Departments of Health and Human Services and Education and coordinated by the CDC. When weighted, the State YRBSS is designed to be representative of each state's population of high school students; the addition of population data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program is used to make the State YRBS representative of the U.S. population of high school-aged students (aged 14-18).[8]

Finally, given that the National and State YRBS surveys are not balanced panels of state-years, we pool these two surveys to generate the Combined State and National YRBS Survey to maximize identifying variation from changes in ENDS taxes. While the State and National YRBSS CDC-provided person-specific weights are not designed to be combined (and we do not do so), we generate sample weights designed to make each state's sample representative of the gender-age-race/ethnicity composition of the state's 14-18-year-olds in each year; we also use the SEER to make the pooled sample of states representative of the national population of high school-aged

[7] https://www.cdc.gov/yrbs/index.html

[8] The person-specific sample weights we generate make the sample representative of all 14-to-18-year-olds in the U.S. Our person-specific sample weights are calculated as the product of the normalized State YRBSS person weight (renormalized to sum to one in each state-year) and the state-by-year-by race/ethnicity-by gender population data on 14-to-18-year-olds available from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER). We use the detailed full population data that the National Cancer Institute provides alongside cancer-related information in SEER to construct our weights. The population data are based on Census data. Thus, our weights are based on the full population, not a subset of cancer patients.

students aged 14-18 years.[9] This approach has been undertaken in a number of studies, including in the e-cigarette literature to which we contribute (Abouk et al. 2023, Courtemanche et al. 2025; Cotti et al. 2025).

Respondents to each of the YRBSS surveys were asked about their prior-month ENDS use over the period 2015-2023:

> "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, ehookahs, hookah pens, and mods (such as JuuL, SMOK, Suorin, Vuse, and blu)]*

The outcome variable *ENDS Participation* is set equal to 1 if the respondent reports prior month ENDS use on at least one of the last 30 days and is set equal to 0 otherwise. *Frequent ENDS Use* is set equal to 1 if the respondent reports ENDS use on at least 20 of the prior 30 days and 0 otherwise. Figure 2 documents trends in ENDS use in the YRBSS samples over the 2015-2023 period. We find that current ENDS use declined between 2015 and 2017, peaked in 2019, and then fell sharply in the post-2020 period. Frequent ENDS use followed a similar pattern, with relatively low levels through 2017, a marked increase in 2019, and then a modest decline and stabilization through 2023. This pattern suggests that in the post-2020 period, a larger share of teenage ENDS users were more habitual users, a point to which we shall later return.

Next, we turn to high school students (those attending grades 10 and 12) from Monitoring the Future (MTF). The MTF study has been conducted each year since 1975 by the University of Michigan Survey Research Center and has been supported by the National Institute on Drug Abuse, a part of the National Institutes of Health. Students complete self-administered, machine-readable questionnaires in their usual classrooms, with University of Michigan personnel on hand. When weighted, our sample of 10th and 12th graders can be made nationally representative. Our MTF sample focuses on the period 2014-2023, when we have information on youth ENDS use. Respondents to the MTF are asked:

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

[9] Following a number of studies of the effects of health policy shocks on risky health behaviors (Abouk et al., 2023b; Anderson et al., 2020; Cotti et al., 2025; Hansen et al., 2017), we use the combined YRBSS to maximize identifying variation. We overcome concerns raised by the CDC by not combining sample weights from each survey and instead constructing sample weights that appropriately weight age-by-gender-by-race/ethnicity-specific populations at the state and national levels.

ENDS Participation is set equal to 1 if the respondent reports using ENDS on more than one day in the past month, and 0 otherwise. Panel (a) of Figure 3 documents trends in ENDS use in the MTF sample, where we find a peak in ENDS use in 2019, followed by a sharp decline thereafter.

For our final youth-based analysis, we draw data from the youth survey of the Population Assessment of Tobacco and Health (PATH). PATH was launched in 2011 and is a collaborative effort between the National Institutes of Health and the Food and Drug Administration. The PATH survey is not school-based, and is primarily conducted through in-person, computer-assisted interviews (CAPI/ACASI). During the COVID-19 pandemic, data collection shifted to telephone interviews, with later waves incorporating a mix of telephone and ACASI modes (FDA 2024). As is the case with the YRBSS and MTF, this survey is useful for our purposes because it includes detailed information on tobacco use, including ENDS, and is longitudinal in nature, which allows for analyses of the initiation and cessation margins of ENDS use in a discrete-time hazard framework that includes individual fixed effects. Moreover, the PATH also includes an adult module (18 and older), allowing us to compare ENDS tax effects within the same dataset.

With respect to nicotine vaping, we focus on high school youths aged 14-17 years; when we turn to adults, we examine both younger adults aged 18-30. Over the 2013-2023 period (waves 1 through 7), youth and adult respondents to the PATH are asked:

"In the past 30 days, on how many days did you use e-cigarettes?"

ENDS Participation is set equal to 1 if the respondent reports nicotine vaping on at least one day and is set equal to 0 otherwise. Panel (b) of Figure 3 describes trends from the PATH in youth ENDS use.

With respect to adult-based datasets, we draw data from the PATH (as described above) and the BRFSS, a telephone survey of U.S. adults (aged 18 years and older) coordinated by the Centers for Disease Control and Prevention. This survey is the adult analogue of the YRBSS and contains detailed questions on health outcomes, health behaviors, and health care utilization. When weighted, the survey is designed to be representative of U.S. adults. Our analysis focuses on younger adults aged 18-30, for whom many prior studies have found evidence of a significant ENDS tax effect (Pesko et al. 2022; Courtemanche et al. 2025; Dave et al. 2024,2025), and adults over age 30, for whom there is less evidence of ENDS tax bite. The BRFSS includes information

on prior-month adult ENDS use in each year over the periods 2016-2018 and 2020-2023. In these survey waves, respondents to the BRFSS are asked:

> "Would you say you have never used e-cigarettes or other electronic vaping products in your entire life or now use them every day, use them some days, or used them in the past but do not currently use them at all?"

ENDS Participation is set equal to 1 if the respondent reported using ENDS on some days or every day.

In Appendix Figure 1, we show trends in ENDS use among younger adults (panel a) and older adults (panel b) from the PATH while in Appendix Figure 2, we show trends in ENDS use for the same age groups in the BRFSS. The pattern of findings shows that, in contrast to youths, the prevalence of young adult (aged 18-30) ENDS use remains stable or slightly rises over time, including in the post-2020 period. For those over age 30, ENDS participation appears to stay stable over time.

Finally, in auxiliary analysis, we draw data on adults aged 18 and older from the Current Population Survey-Tobacco Use Supplement (CPS-TUS). The Tobacco Use Supplement is sponsored by the National Cancer Institute and has been administered by the U.S. Census Bureau every 3-4 years since the 1992-1993 initial wave. When weighted, the survey is designed to be representative of all U.S. adults. Respondents to the CPS-TUS are asked about their prior-month ENDS use in three survey waves: 2014–2015, 2018–2019, and 2022–2023. Specifically, respondents are asked:

> "Do you use e-cigarettes now, on some days, every day, or not at all?

ENDS Participation is set equal to 1 if the respondent reported using ENDS now, on some days, or every day. For the sample period, 7.2 percent of 18-30-year-olds and 1.8 percent of those over age 30 report ENDS participation.

3.2 ENDS Taxes

Our key treatment variable measures the closed system (pre-filled cartridge) ENDS tax rate per mL of e-liquid (in 2023 dollars). To generate a harmonized per mL of e-liquid equivalent tax

(from excise, ad valorem, and hybrid ENDS taxes)[10], we follow Cotti et al. (2023, 2024), who use Nielsen Scanner data to collect average state-by-year ENDS wholesale prices and assume a 35 percent retailer markup. For the three sub-state jurisdictions with ENDS taxes, we incorporate city and county taxes into our state-level tax variable by generating a population-weighted prevailing ENDS tax following earlier studies (e.g., Abouk et al. 2023; Dave et al. 2025).

As noted above, Appendix Table 1 provides information on state-by-year prevailing ENDS taxes per mL of e-liquid (in 2023$). Our main analyses focus on the harmonized tax rate for closed-system e-cigarettes, such as disposables and pre-filled pod and cartridge devices, since these are generally more popular among youth vapers. In alternate specifications, we also test the "open system" tax rate, which applies to refillable and customizable devices, as our main treatment variable; while less popular among youth overall, these devices tend to be more preferred among the regular and frequent youth vapers. Both series of tax rates are highly correlated (correlation ~ 0.9), and our findings and conclusions are not materially altered across either treatment measure.

4. Empirical Models

We begin by pooling data spanning the period 2013-2019[11] and estimate a two-way fixed effects (TWFE) difference-in-differences regression of the following form via ordinary least squares:

$$Y_{ist} = \beta_0 + \beta_1 ENDSTax_{st} + \mathbf{X}'_{ist}\boldsymbol{\beta_2} + \mathbf{Z}'_{st}\boldsymbol{\beta_3} + \theta_s + \tau_t \ (+ \pi_i) + \varepsilon_{ist} \quad (1)$$

where *i* indexes the respondent, *s* the respondent's state of residence, and *t* indexes time (year and semester in YRBSS, year and quarter in MTF, PATH, BRFSS, CPS-TUS). The outcome variable Y_{ist} measures ENDS participation and $ENDSTax_{st}$ measures the prevailing state-by-year ENDS tax equivalent (per mL of e-liquid) in 2023 dollars, following Cotti et al. (2024). The vector $\mathbf{X}_{ist}$ includes individual demographic characteristics (age, gender, race/ethnicity, grade in school for youths;

[10] States vary in how they structure ENDS taxes. Some employ ad valorem taxes (e.g., California, Colorado, Illinois, Indiana, Maine, Maryland, Massachusetts, Minnesota, Nevada, New Mexico, New York, Oregon, Pennsylvania, Utah, Vermont, District of Columbia, and Wyoming), while others use specific per-milliliter (mL) volume-based taxes (e.g., Delaware, Kansas, Louisiana, North Carolina, Ohio, Virginia, West Virginia, Wisconsin). Several states adopt hybrid systems, taxing open systems on an ad valorem basis and closed systems per mL or per cartridge (e.g., Connecticut, Georgia, Kentucky, New Hampshire, New Jersey, New Mexico, and Washington). (See Cotti et al. 2024)

[11] For the YRBSS surveys, our data span the period 2015-2023; for the MTF, our data span 2014-2023, for the PATH out data span 2013-2023, for the BRFSS, our data span 2016-2023, and for the CPS-TUS our data span 2014-2023.

educational attainment and marital status for adults),[12] and the vector $\mathbf{Z}_{st}$ includes time-varying state-specific measures comprising (1) state macroeconomic conditions (unemployment rate, poverty rate), (2) state COVID-19 shocks (cumulative COVID-19 death rate and the Oxford University government stringency index), (3) other ENDS policies (restrictions on sales of flavored ENDS, ENDS minimum legal sales age of 18, Tobacco-21 laws, indoor vaping restrictions, ENDS licensure laws), (4) cigarette taxes (excise tax per pack in 2023 dollars), indoor smoking restrictions, and (5) alcohol and marijuana policies (beer tax in 2023 dollars, medical and recreational marijuana laws).[13] Finally, θs is a time-invariant state effect, τ_t is a state-invariant time effect, and ε_{ist} is the individual disturbance term. Additionally, in the PATH, our individual-level longitudinal dataset, we can also add controls for individual fixed effects, π_i. All regressions are weighted by a person-specific survey weight and standard errors are clustered at the state level (Bertrand et al. 2004). Our key parameter of interest, β_1, measures the effect of a one dollar increase in ENDS taxes (in 2023$) on ENDS participation.

To explore how the effect of ENDS taxes has evolved over time, we next re-estimate equation (1) on analysis samples that add subsequent survey waves through 2023. If the absolute magnitude of the estimate of β_1 declines (increases) with the addition of newer survey waves, this would be suggestive of a declining (increasing) effectiveness of the ENDS tax in reducing ENDS use in more recent years. Moreover, we formally test whether the effect of ENDS tax increases on ENDS use was significantly different prior to versus after 2020 by estimating equation (1) for the full sample available (e.g., in YRBSS, 2015-2019) and interacting a post-2020 dummy with the ENDS tax (and each the right-hand side variables, including state fixed effects). We also estimate seemingly unrelated regressions to more flexibly test cross-model restrictions, specifically whether the estimated treatment effect over the 2015-2019 period is significantly different from the estimated treatment effect in 2015-2023.

The comparison of the tax response over the earlier period, through 2019, relative to its extension to more recent periods (through 2023, based on data availability) is motivated by several

[12] In the PATH data, grade in school and educational attainment are excluded due to high rates of missing information, and marital status is not collected.

[13] Unemployment figures are from the U.S. Bureau of Labor Statistics. COVID-19 cases and deaths are taken from the New York Times database, and policy stringency is measured using the Oxford COVID-19 Government Response Tracker. State Tobacco 21 information is provided by the Preventing Tobacco Addiction Foundation. Data on cigarette taxes, the minimum legal sales age for ENDS, and clean indoor air policies are sourced from the CDC's STATE System. E-cigarette licensure data follow Courtemanche et al. (2024); flavor-ban variables are from Cotti et al. (2025a); and e-cigarette tax measures are from Cotti et al. (2023). Beer tax data are drawn from the Alcohol Policy Information System. Marijuana policy data are compiled by Anderson and Rees (2023) and Wen et al. (2021).

key considerations. First, 2019 marked the peak in youth e-cigarette use with more than one out of four high school students (27.5 percent) reporting current participation, and following the U.S Surgeon General declaring youth vaping an epidemic in just the previous year; since then, youth e-cigarette use has fallen markedly, to the point where in 2024 less than one out of 10 high schoolers (7.8 percent) reported using the product. Second, the period since 2019 witnessed several shocks in the ENDS market on the policy front (Tobacco 21; online sales restrictions; ENDS flavor bans) as well as with respect to accessibility and health information (COVID-19; EVALI), which likely played a role in curbing ENDS use among youth and potentially shifting the composition of remaining ENDS users or new initiates. Third, much of extant (albeit limited) direct evidence on youths' responsiveness to ENDS taxes is based on pre-pandemic data (Abouk et al. 2023; Diaz et al. 2023; Pesko and Warman 2022), presenting a clear point of comparison for assessing how this responsiveness has changed as we widen the lens to the more recent post-pandemic periods.

We examine the robustness of our estimates of β_1 to several specification checks, including more parsimonious versus saturated model specifications, use of the alternate tax rate based on open system ENDS products, and the use of logistic regression as compared to OLS. In addition, we explore heterogeneity in ENDS tax effects by demographic characteristics (age, race/ethnicity).

To test for dynamics in ENDS tax effects, as well as to test the common trends assumption, we follow Schmidheiny and Siegloch (2023) and Matsuzawa et al. (2025) by estimating the following continuous-treatment event study regression:

$$Y_{ist} = \Phi_0 + \sum_{j=\underline{J};\, j\neq -1}^{\bar{J}} \beta_j D_{st}^{j} + \mathbf{X}_{ist}'\boldsymbol{\varphi_1} + \mathbf{Z}_{st}'\boldsymbol{\varphi_2} + \alpha_s + \theta_t + \varepsilon_{ist}, \quad (2)$$

where D_{st}^{j} is the difference in real ENDS taxes between survey wave (year) *t* and *t-1*. The reference period in our event study analyses is the wave preceding the ENDS tax change. For our full sample period *-J* is equal to 5 or more years preceding ENDS tax changes, and *J* is equal to 4 or more years or more following ENDS tax changes.[14] If $\beta_j = 0$ for $j < 0$, such evidence would tend to support the common trends assumption. Moreover, the absence of pre-treatment trends would provide validation that reverse causality is not an important source of bias.

[14] This is true for our analyses spanning 2013-2021 and 2013-2023. However, for our analyses that end in 2019 (or early 2020), our event studies span from 3 years prior to treatment to 2 or more years following treatment.

An important concern with the TWFE approach described above is that in the presence of heterogeneous and dynamic treatment effects, using earlier adopters of ENDS tax hikes as controls for later adopters may create (potentially downward) bias in the estimated treatment effects. To guard against this possibility, we estimate stacked difference-in-differences (DiD) regressions where we (1) restrict the set of counterfactuals to not-yet or never adopters during the period from 6 years prior to treatment to 5 years following treatment, and (2) focus on prominent increases in the ENDS tax of at least $0.20 per year (in nominal dollars), and estimate a regression model of the following form:[15]

$$Y_{icst} = \delta_0 + \delta_1 PromENDSTax_{cst} + \boldsymbol{X}'_{icst}\,\boldsymbol{\delta_2} + \boldsymbol{Z}'_{icst}\,\delta_3 + \alpha_{cs} + \theta_{ct} + \varepsilon_{icst}, \quad (3)$$

where $PromENDSTax_{cmst}$ is an indicator for whether a state has implemented a prominent ENDS tax increase of $0.20 or higher, *c* denotes each treatment cohort with its selected counterfactuals, α_{cs} is a cohort-specific state effect, and θ_{ct} is a cohort-specific year effect. Moreover, as with our TWFE model, we also explore whether stacked difference-in-differences estimates differ in the pre- versus post-2020 periods.[16]

Finally, leveraging the longitudinal structure of the PATH data, we also explore whether the effects of ENDS taxes on the initiation and cessation margins changed in the earlier versus post-2020 periods. Specifically, we estimate a discrete-time hazard model of the following form:

$$\Pr(E_{ist=1} \mid t\text{-}1<T<t) = \delta_0 + \delta_1 ENDSTax_{st} + \mathbf{X}'_{ist}\boldsymbol{\varphi_1} + \mathbf{Z}'_{st}\boldsymbol{\varphi_2} + \eta_s + \psi_t + \mu_i + \varepsilon_{ist} \quad (4)$$

where E indicates whether individual i experiences the event (initiation or cessation) between periods *t-1* and *t*. The estimated parameter of interest, δ_1,identifies the effect of ENDS taxes on the conditional probability of transitioning across margins of ENDS use between periods *t-1* and *t*,. For initiation, we restrict the sample to non-ENDS using youth at baseline, and E_{ist} is set equal to 1 when

[15] Note that at the time of the writing of this paper, there is no peer-reviewed alternative "continuous treatment" difference-in-differences estimator that accounts for heterogeneous and dynamic treatment effects with publicly available code for implementation. The new working paper by Callaway et al. (2024) offers some hope that such an estimator may be forthcoming.

[16] In the appendix, we explore the robustness of our stacked DiD estimates to an alternate treatment intensity of a prominent tax rate increase of $0.10 or higher. The findings are qualitatively similar and uncover highly similar patterns in the evolution of the tax response.

the respondent transitions to being an ENDS user in period t, conditional on non-ENDS use in period *t-1*; it is set equal to 0 otherwise. For cessation, the analysis sample is limited to youth ENDS users at baseline; E_{ist} is set equal to 1 when the respondent transitions to being a non-ENDS user in period t, conditional on being an ENDS user in period *t-1*; it is set equal to 0 otherwise.[17] Again, our focus is on how estimates of δ_1 change as we extend the analysis sample from 2013-2019 to 2013-2023.

5. Results

Our main findings appear in Tables 1-8 and Figures 4-9. Supplemental analyses are found in the appendix. All regressions are weighted and standard errors are corrected for clustering at the state level.

5.1 YRBSS Findings

Table 1 shows TWFE estimates of the effects of ENDS taxes on ENDS participation using our three YRBSS surveys across the three sample periods under study: 2015-2019 (column 1), 2015-2021 (column 2), and 2015-2023 (column 3). Panel I provides estimates using our baseline set of controls, including state and period fixed effects, demographic characteristics, macroeconomic conditions, COVID-related health, and ENDS/tobacco policies for which there is evidence of potentially important effects: restrictions on sales of flavored ENDS (Cotti et al. 2025; Saffer et al. 2025), ENDS minimum legal purchasing ages (Friedman 2015; Hansen et al. 2023; Pesko 2023), tobacco-21 laws (Hansen et al. 2023), cigarette taxes (Pesko, Courtemanche & Maclean 2020), and ENDS licensure laws (Courtemanche et al 2024).

Using these baseline controls (panel I) and the State YRBSS data over the period 2015-2019, we find that a one dollar per mL of e-liquid increase in the ENDS tax (in 2023$) is associated with a significant and substantial 5.7 percentage point decline in ENDS participation. This is equivalent to a 27.9 percent decline relative to the 2015-2019 youth vaping mean (semi-elasticity). The addition of the 2021 data to the analysis sample (column 2) reduces the marginal effect of a one-dollar tax increase (in 2023$) to 3.0 percentage points (15.0 percent) and the addition of the 2023 wave (column 3) further reduces the marginal effect to 2.4 percentage points (12.6 percent). A comparison of column (1) and column (3) shows that the estimated tax response fell by 57.4 percent

[17] In both cases, individuals leave the sample once they transition.

over time; the tax semi-elasticity (the percent change in ENDS use following a one dollar increase in ENDS taxes) fell by 54.8 percent.[18]

We conduct two empirical tests of whether the estimated tax effects have significantly changed over time. First, we use the pooled 2015-2023 sample and interact a dummy that turns on for the post-2019 period with each of the right-hand side variables (including state fixed effects). The p-value in column (4) comes from a test of the interaction of a post-2019 dummy with the ENDS tax. Thus, we find that the estimated ENDS tax effect in the pre-2020 period is significantly different (at the 5 percent significance level) than in the post-2019 period, with a p-value = 0.04. Second, we estimate the models for the 2015-2019 period (column 1) and the 2015-2023 period (column 3) jointly within a seemingly unrelated regression (SUR) framework, and implement a cross-equation test for whether the coefficients across these periods are significantly different from one another; this approach yields a p-value of 0.09 (as reported in column 5) Together, this pattern of findings suggests that the impact of ENDS taxes on youth ENDS use has declined over time.

When we turn to the Combined YRBSS survey, which maximizes identifying variation, the pattern of results using baseline controls (panel I) is similar to the State YRBSS. We estimate the marginal effect of a one-dollar increase in ENDS taxes on youth ENDS participation of -0.042 in the 2015-2019 period (panel I, row 2, column 1), which declines to -0.019 over the extended 2015-2023 period (panel 1, row 2, column 3). This implies a 54.7 percent reduction in the absolute magnitude of the tax response, and a 50.2 percent reduction in the estimated semi-elasticity. We can reject the hypothesis that the estimated marginal effects are the same in the pre-2020 and post-2019 period with strong precision (p-value = 0.006), and at a we can reject the hypothesis that the estimated tax effect in column (1) is significantly different from the estimated effect in column (3) at a marginal level of significance (p = 0.102).

Turning to the baseline models estimated with the national YRBSS (panel I, row 3), we find a similar pattern with the effectiveness of ENDS taxation declining substantially over time. The estimated marginal effect falls by 72.1 percent from -0.061 (column 1) to -0.017 (column 3), and the semi-elasticity falls by 68.3 percent (from 26.8 percent to 8.49 percent). While the estimated test of difference in coefficients in the pre-2020 and post-2019 periods is not statistically significant at

[18] In Appendix Table 3, we derive very similar findings from models that utilize the alternate harmonized tax rate based on open system ENDS devices (Panel 1) and models estimated via logistic regression (Panel II).

conventional levels (p-value = 0.212), the estimated marginal effects for the 2015-2019 and 2015-2023 periods are statistically different at the 5 percent level (p-value = 0.016 in column 5).[19]

In panel II of Table 1, we add additional controls to our baseline specification, including more tobacco/ENDS policies such as ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces and indoor smoking restrictions, and alcohol and marijuana policies like beer taxes ($2023), and medical and recreational marijuana laws. The pattern of findings across all three datasets mirrors those derived from the baseline specifications, suggesting that our choice of controls is relatively unimportant in identifying the tax effects and their shift over time.

Column I of Figure 4 shows event-study coefficients for our three sample periods for the State (panel a), Combined (panel b), and National (panel c) YRBSS surveys.[20] The event study analyses highlight three points. First, across all YRBSS samples, we generally find evidence consistent with the parallel trends assumption; lead effects are close to zero and statistically insignificant. Second, any response from the ENDS taxes materializes only following their adoption over the post-policy periods. Third, a consistent pattern emerges over this post-treatment window, such that the estimated effect of ENDS taxes on youth ENDS participation is largest in the period following enactment (0-1 years following treatment) and dissipates somewhat over time. Moreover, following the patterns evident in the average point estimates discussed above (from Table 1)the estimated effect of ENDS taxes is larger in the period 2015-2019 than in the 2015-2023 (or 2015-2021) periods. These dynamics are consistent with the impact of ENDS taxes on youth ENDS participation diminishing over time.[21]

In Column II of Figure 4 we explore whether these estimates are potentially biased due to dynamic treatment heterogeneity. As noted above, we focus on prominent increases in ENDS taxes that exist over all three sample periods and estimate event studies using the stacked DiD estimator. Specifically, we focus on ENDS tax increases of $0.20 or higher per mL of e-liquid. The pattern of

[19] In Appendix Table 4, we present estimates of the effect of ENDS taxes on frequent ENDS use among youths, defined as use of ENDS products on at least 20 of the last 30 days. In this specification, *Frequent ENDS Use* is set equal to 0 for both non-users and light users (those using ENDS products on 1-19 days in the last month). As for current vaping, we find that ENDS taxation on this more intensive margin of ENDS use also exhibits a weakening effect among youths over time.

[20] Note that for the 2015-2019 period, we are only able to present coefficients for the periods 3-4 years prior to treatment to 2-3 years after treatment, while for the extended periods (2015-2021 and 2015-2023) we show event-study coefficients for the full period from 5 or more years prior to 4 or more years after.

[21] Column I of Appendix Figure 3 shows event studies using TWFE estimates for Frequent ENDS Use and obtains a similar pattern of findings to Column I of Figure 4.

findings generated with the stacked DiD approach is consistent with our TWFE-based event studies.[22]

5.2 MTF Findings

In Table 2, we explore the effect of ENDS taxes on ENDS participation among 10th and 12th graders (high school students) using the 2014-2023 MTF. Our findings are, in the main, quite similar to what we observed in the three YRBSS-based estimates described above. During 2014 through the pre-COVID (March 2020) period, we find that a one dollar increase in ENDS taxes is associated with a 2.9 percentage-point (17.2 percent) decline in youth ENDS participation. The addition of data from 2021 (column 2) and 2023 (column 3) reduces the effect of ENDS taxation. In fact, extending the sample with these additional waves of data, in both baseline and extended specifications, the impact of a one-dollar increase in ENDS taxes on youth ENDS participation falls to -0.006 to -0.008 and becomes statistically indistinguishable from zero at conventional levels. While less precisely estimated (due to smaller sample sizes), we do detect some evidence that the estimated ENDS tax effect in the 2014-2019 period is significantly different than the estimated effect from 2014-2023.[23,24]

Panel (a) of Figure 5 shows the event study analysis using TWFE estimates and is consistent with the pattern of findings shown in Figure 4 and provides strong evidence that the effectiveness of ENDS taxes as an anti-vaping strategy among youth is diminishing over time.

5.3 PATH-Youth Findings

Table 3 examines the impact of ENDS taxes on ENDS participation among 14-17-year-olds in the PATH youth survey. We present results using both individual fixed effects alone (rows 1 and 3) as well as individual and state fixed effects (rows 2 and 4). The former allows teen movers across states with different ENDS tax rates to identify treatment effects, while the latter are identified only via stayers within states across multiple waves. The pattern of results is the same.

[22] Column II of Appendix Figure 3 shows event studies for *Frequent ENDS Use* and finds a similar pattern of results. Appendix Figure 4 focuses on prominent increases in ENDS taxes of $0.1 per mL and finds similar results on both *Current & Frequent* ENDS participation.
[23] In Appendix Table 5 we explore the effect of ENDS taxation on *Frequent ENDS Use* in the MTF. The pattern of findings is similar to that observed in our analyses of the YRBSS surveys.
[24] An examination of 8th graders surveyed in the MTF in Appendix Table 6 shows a similar pattern of results.

We find the largest (in absolute magnitude) effect of ENDS taxes on ENDS participation in the 2015-2019 period, with estimated marginal effects of -0.027 to -0.035. The addition of data from waves through 2021 (column 2) and 2023 (column 3) reduces the (absolute) magnitude of the estimated treatment effect. In the full sample period, we find that a one dollar increase in the ENDS tax is associated with a 1.4 to 1.7 percentage point decline in youth ENDS use, with estimated effects statistically significant at the 10 percent level or less. Thus, we find that the effectiveness of ENDS taxation as an anti-vaping strategy for youths declined by approximately 50 percent over time. Estimated semi-elasticities fell comparably. Event-study analysis in panel (b) of Figure 5 supports the parallel trends assumption and, as with the corollary analyses for the YRBSS and the MTF samples, corroborates the pattern of declining magnitudes of post-treatment effects over time. We note, however, that especially with the addition of both individual and state fixed effects, the differences in the estimated semi-elasticities are imprecise and not statistically distinguishable from zero at conventional levels.[25]

In Table 4, we more fully exploit the individual-level panel nature of the PATH data to estimate discrete-time hazard models that inform tax responses with respect to dynamic transitions into salient margins of use. Notably, we separately study the initiation margin – which is particularly relevant for youth given that the peak e-cigarette initiation risk occurs between ages 14 through 17 – as well as the cessation margin. These models include both individual and state fixed effects and our full set of observable controls. The pattern of findings suggests that the declining effectiveness of ENDS taxes as a youth anti-vaping tool is evident when we specifically examine the initiation margin of use. Most (95.4 percent) 14-17-year-olds were non-vapers at baseline. We find that among baseline non-ENDS users, a one dollar increase in ENDS taxes is associated with a 3.6 percentage-point decline in the probability of initiating e-cigarette use in a subsequent wave. The addition of data through 2023 reduces the absolute magnitude of the initiation effect by approximately 50 percent to 1.8 percentage points. Moreover, while much less precisely estimated, the estimated effect of ENDS taxes on ENDS cessation (among baseline ENDS users) also appears to be diminishing over time.[26]

5.4 Heterogeneity Across Demographic Characteristics

[25] Appendix Table 7 shows PATH-based estimates of the effect of ENDS taxes on *Frequent ENDS Use* among youths. The pattern of findings is similar to that observed for the YRBSS and MTF.
[26] Discrete-time hazard models of initiation and cessation of frequent ENDS use are shown in Appendix Table 8.

Figure 6 explores heterogeneity in youth ENDS participation effects over time by demographic characteristics of youths, including race/ethnicity, gender, and age. In the main, the findings suggest that ENDS taxes reduce ENDS participation across races/ethnicities, though the effects on Black/Hispanics is generally smaller and, in some cases (PATH), null.[27] There are effects for both females and males as well as older and younger teenagers.[28]

Across datasets, and across all demographic groups, there is consistent evidence that the effect of ENDS taxes on youth vaping participation has abated in more recent periods. That is, ENDS tax increases are most effective in the 2015-2019 period than when additional years of data are included in the analysis period.

5.5. An Exploration of Mechanisms

One important channel through which the effectiveness of ENDS taxation has declined over time is the changing composition of youth ENDS users. Figure 7 illustrates that, among current ENDS users, those who vape on at least 20 of the prior 30 days (frequent and perhaps heavier vapers) has risen steadily across all datasets over the years. Moreover, over time the share of youth nicotine vapers who also report prior-30 day marijuana use has also risen over time, though alcohol use has remained relatively stable. Together, these findings suggest that while overall ENDS participation has fallen, those youths who vape nicotine are increasingly those who have become more nicotine dependent; in light of trends indicating an increase in the average nicotine concentration among ENDS products sold (Wang et al. 2023), current youth vapers would be predicted to have built up a greater addictive stock. Moreover, the sample of current youth vapers also appears to have shifted towards those who are less risk averse (with respect to other risky behaviors) over time.

If those with a higher addictive stock and are less risk averse are less likely to be responsive to e-cigarette taxes, their rising share among vapers could explain why the effectiveness of e-cigarette taxes as an anti-vaping tool has declined over time. To explore this, we conduct a principal component analysis (PCA) to extract a latent index of risk/addictive stock among ENDS users, using the three measures described above (e.g., frequent ENDS use, marijuana use, and alcohol use). Our PCA captures an underlying latent index for risk/addictive stock (Bai and Ng 2002). The first

[27] ENDS use among blacks and Hispanics are relatively lower as well, which may explain the smaller average tax responses overall.
[28] Using an age cutoff around age 18 produces a similar pattern of findings as when examining those aged 15 and younger versus 16-18 (see Appendix Figure 5).

principal component — which consistently explains more than 60 percent of the total variation in risky behaviors — serves as our summary index of underlying risk. We then categorize youth ENDS users into lower-risk (below-median PCA score) and higher-risk (above-median) samples and separately pool these samples with non-ENDS users to estimate the differential effect of ENDS taxes on ENDS use across these higher-risk and lower-risk users. We focus on the pre-2020 samples prior to large compositional shifts in youth ENDS users.

In Table 5, we provide estimates of the effects of ENDS taxes on lower (panel I) and higher (panel II) risk ENDS users. Across datasets, we find strong evidence that the effect of ENDS taxes on ENDS use is smaller (in absolute magnitude) for higher risk ENDS users. This is consistent with the hypothesis that ENDS users who are more addicted to nicotine and more risk-tolerant are less responsive to ENDS taxes. Consequently, as shown in Figure 7, as remaining ENDS users become more likely to be addicted to nicotine and more likely to engage in risky behaviors (with respect to marijuana), one would predict that ENDS tax effects would decline over time. We interpret these analyses as exploratory and descriptive given that the characteristics associated with the latent risk index may be a function of ENDS taxes, raising issues related to endogenous stratification.

Finally, in Appendix Table 9, we restrict our samples of the Combined YRBSS to higher-risk ENDS users and non-users over the 2015-2019, 2015-2021, and 2015-2023 periods and estimate the effect of ENDS taxes on ENDS use in this selected sample. Our findings show that for this relatively more homogeneous sample of higher-risk users, the effect of ENDS taxes on ENDS use remains modest and relatively stable over time. This result is again consistent with the hypothesis that compositional shifts (based on addictive stock and risk aversion) may, in part, explain the declining effectiveness of ENDS taxation among youth vapers.

Next, we examine whether the effectiveness of ENDS taxes may also depend on youths' sources of obtaining e-cigarettes, building on recent work by Cotti et al. (2025c). Cotti et al. (2025c) find evidence that having alternative sources of e-cigarettes other than direct purchases from a store (e.g., borrowing vaping devices from friends, having third parties who are willing to purchase e-cigarettes) may insulate youths from the impact of e-cigarette taxation. Our results from the Combined YRBSS in Table 6A show that this pattern of results holds for 18-year-olds when re-estimating their findings; ENDS use among these older teens is not responsive to taxation when they are able to rely on other sources for procuring their ENDS products.[29] ENDS users under the

[29] These analyses begin in 2017 because data on usual sources of e-cigarettes in the YRBSS are only available beginning in that year. We stop our analysis in 2021 to have enough waves of data for the analysis.

age of 18 have far lower rates of in-store purchases than 18-year-olds (14.0 percent versus 46.9 percent) due to the imposition of minimum legal purchasing ages.

In Figure 8, we document trends in the rate at which youth ENDS users obtain e-cigarettes from a direct in-store own purchase versus obtain their e-cigarettes from other sources. In the Combined YRBSS survey, our findings show that among those aged 18 (or 19) years, the share of ENDS users who purchase e-cigarettes from a store is declining and the share obtaining their e-cigarettes in some other way (e.g., third-party purchase, borrowing or bumming, internet purchases) has increased. This pattern of findings is consistent with the hypothesis that increased reliance on alternative sources for e-cigarettes among 18-year-olds may be one reason for the declining effectiveness of ENDS taxes among 18-year-olds relative to younger users (see Table 6B). In contrast, for those under the age of 18, the prevalence of in-store e-cigarette purchases versus obtaining e-cigarettes in some other way does not substantially change over the sample period.

5.6 Spillovers Effects to Combustible Cigarettes Over Time

In Table 7, we explore the effect of ENDS taxation on combustible cigarette use given growing evidence that e-cigarettes and cigarettes are substitutes for youths (Abouk et al. 2023). We use data from both the combined YRBSS and the MTF, the datasets where the strongest evidence for substitution effects have been found. The pattern of evidence across datasets suggests some evidence that ENDS and cigarettes remain substitutes, and that, while the magnitude of the substitution effect is sensitive to model specification, the effect (especially in the combined YRBSS) remains relatively stable over time. This is consistent with the shifting composition of remaining ENDS users towards those who are more risk-tolerant and have accumulated a higher level of nicotine addictive stock. While these users are less responsive to e-cigarette taxes and costs on average, those that do respond, on the margin, to higher taxes appear to be more likely to switch into cigarettes given their higher level of nicotine addiction (i.e. they are more likely to have used ENDS products more frequently and intensely).[30]

[30] In Appendix Table 10, we provide estimates of the effect of ENDS taxes on binge drinking, building on the work of Dave et a. (2024). We replicate their findings over the 2015-2019 period. We show that over time, the estimated association between ENDS taxes and binge drinking becomes somewhat smaller in magnitude, though it remains statistically distinguishable from zero at the 10 percent level over the 2015-2023 period. With respect to marijuana use, the findings in column (3) are consistent with those reported in Dave et al. (2025) and also with evidence that ENDS tax effects are declining over time, though we note that the estimate in column (1) row (2) is very sensitive to controlling for local ENDS flavor bans (particularly in California) in 2019; the current specification shown in Appendix Table 10 excludes that control from the specification, consistent with the NBER version of Dave et al. (2025) posted two years prior. Prior work, and the results updated through 2023 in Appendix Table 10, confirm that ENDS use is economically

5.7 Comparison of Effects on Youths to Adults

The above estimates have focused on ENDS tax effects on high school-aged teenagers. In the remaining tables and figures, we explore the effects of ENDS taxation on adult ENDS use over time. Table 8 provides estimates of the effect of ENDS taxes on ENDS participation on young adults aged 18-30 years using our full set of controls.[31] Not surprisingly, our estimates suggest much smaller and more stable effects of ENDS taxes on adult ENDS use over time in the PATH and BRFSS data. In the PATH data, the estimated treatment effect does not show any declines from 2013-2019 to 2013-2023 and in the BRFSS, the estimated treatment effect is approximately 30 percent smaller, though not statistically different from the earlier period.[32,33]

Event-study analyses in Figure 9 show a pattern of findings consistent with the hypothesis that ENDS tax effects are not necessarily declining (in absolute magnitude) over time.[34,35] We note however, that in contrast to these two datasets, findings from the CPS-TUS do show a sharp decline in the estimated semi-elasticity over time (row 3 of Appendix Table 16), though the estimates are not sufficiently precise for us to conclude that there is a significant difference in the ENDS tax effect.

For adult ENDS users over age 30 (Appendix Table 16), we find no evidence that ENDS taxes were effective at curbing ENDS participation.[36] This finding is consistent with older ENDS users having more disposable income (and, therefore, being less responsive to tax hikes) and their motives for ENDS use (e.g., smoking cessation or reduction) resulting in their having a more inelastic demand for e-cigarettes.

Together, our findings on adults suggest that the mechanisms at work for youths is likely not the effects of increased market competition on the pass-through of ENDS taxes to ENDS prices; if

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complementary to binge drinking and marijuana use; expectedly, as the decline in ENDS use (from higher own-taxes) abates over time, this weakening response appears to extend to complementary spillover effects as well.

[31] Appendix Table 11 provides the estimates of the effect of ENDS taxes on young adults using baseline controls.

[32] Discrete-time hazard models of initiation and cessation of ENDS use among young adults are shown in Appendix Table 12.

[33] Appendix Table 13 shows estimates of the effects of ENDS taxes on frequent ENDS use among young adults aged 18-30 in the BRFSS and PATH with a similar pattern of findings. Appendix Table 14 shows discrete-time hazard estimates for frequent ENDS use for young adults aged 18-30 using the PATH.

[34] We also look at event-study analyses for frequent ENDS use in Appendix Figure 6 that also show no pattern of diminishing effect of ENDS taxes over time.

[35] Using the PATH data in Appendix Table 15, we find no meaningful differential tax response between low- and high-risk adults, with ENDS taxes exhibiting muted and statistically weaker effects across both groups.

[36] Event-study analyses in Appendix Figure 7 show that ENDS tax effects are not declining over time.

it were, we would likely see similar declining effectiveness of ENDS taxes on ENDS participation over time for youths and adults, and (2) policies designed to curb ENDS use during the early 2020s (e.g., minimum legal purchasing ages, K-12 campus vaping restrictions, restrictions on sales of flavored ENDS products) were largely targeting teenagers.

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6. Conclusion

ENDS products remain the most common tobacco product used by youth, with approximately three-quarters (77 percent) of tobacco users reporting past-month ENDS use in 2023 (Centers for Disease Control and Prevention 2024). As a result of stricter regulations on youth access to ENDS, such as minimum legal purchasing ages and e-cigarette tax hikes — as well as rising anti-vaping sentiment and the COVID-19 pandemic — vaping rates among youths declined by over 70 percent between 2019 and 2023 (CDC 2024b). It remains unclear, however, if this shift in the pool of youth ENDS users has impacted the effectiveness of ENDS taxation.

Nonetheless, the push to increase taxes on e-cigarettes continues. The Association of State and Territorial Health Officials, for instance, recommended increases in ENDS taxes to raise the price of e-cigarette products as part of a cornerstone set of policies to limit youth access. And, since 2021, at least 21 states and D.C. have imposed new taxes or increased existing tax rates. However, this policy guidance relies on older evidence on how youth vapers are responding to ENDS taxes.

This study is the first to explore whether the effectiveness of ENDS taxation has changed over time. Using data from five nationally representative sources, we document that the impact of ENDS taxes in reducing youth ENDS use has substantially weakened since 2019. Employing generalized and stacked difference-in-differences models, we document that the effect of a one-dollar increase has declined by about 50 percent in the post-2019 period, as youth vaping declined. Specifically, we find that a one-dollar increase in ENDS taxes (2023$) reduced the likelihood of prior-month ENDS use by 5.7 percentage points (28 percent) during the period 2015–2019, but by only 2.4 percentage points (13 percent) when extending the sample through 2023 in YRBSS. Parallel evidence from MTF and the PATH youth surveys also shows that the responsiveness of youth vaping to tax increases has diminished markedly in the post-2019 period.

An exploration of the mechanisms underlying this robust finding reveals that the composition of youth vapers has changed over time, with ENDS users becoming more nicotine dependent and risk-tolerant in their participation in other substance use. We find less evidence of

differential tax pass-through effects due to increased market competition, which should be present for both youths and adults.

For adults, the impact of ENDS taxes over time is quite different relative to youths. Estimated tax effects are small in magnitude, often not statistically distinguishable from zero, and occasionally positive. These findings are consistent with higher incomes among adults making users less tax sensitive and with smoking cessation-related motives dampening tax responsiveness. Moreover, in sharp contrast to youths, we find little evidence that the composition of adult ENDS users has changed over time with respect to risky health behaviors, addictive stock, or beliefs about the health risks associated with ENDS use.

Our primary results underscore that commensurately higher rates of ENDS taxation are eliciting much weaker declines in youth vaping in recent periods compared to earlier, pre-2019 periods. The welfare calculus for ENDS taxation depends integrally on the extent to which own-tax induced declines in ENDS use imply an overall decrease in tobacco and nicotine use. To this end, our results indicate that while the own-tax response to ENDS taxes has considerably lessened over time, the spillover substitution into cigarettes has not and instead remained stable. This pattern is consistent with the pool of youth vapers becoming less risk-averse and more likely to be nicotine dependent in recent years, as indicated by a progressively larger share of current youth vapers consuming ENDS more frequently (and presumably also more intensively) and in conjunction with marijuana. For this population of more "hardcore" users, ENDS taxes are much less effective. Moreover, while the tax response is smaller, on average, in recent years, for those users who, on the margin, reduced their ENDS use due to increased taxes are also now more likely to substitute into cigarettes. These considerations point to taxation as a relatively ineffective youth anti-tobacco tool, accounting for the recent changes.

More promising alternative policies may include supply-side restrictions, including comprehensive school, workplace, and dining vaping restrictions (Dave et al. 2025) and minimum legal purchasing ages. Additionally, accurate and targeted messaging may complement fiscal policy in reducing the residual core of "hardcore" youth vapers who remain even as taxes rise and overall prevalence falls.

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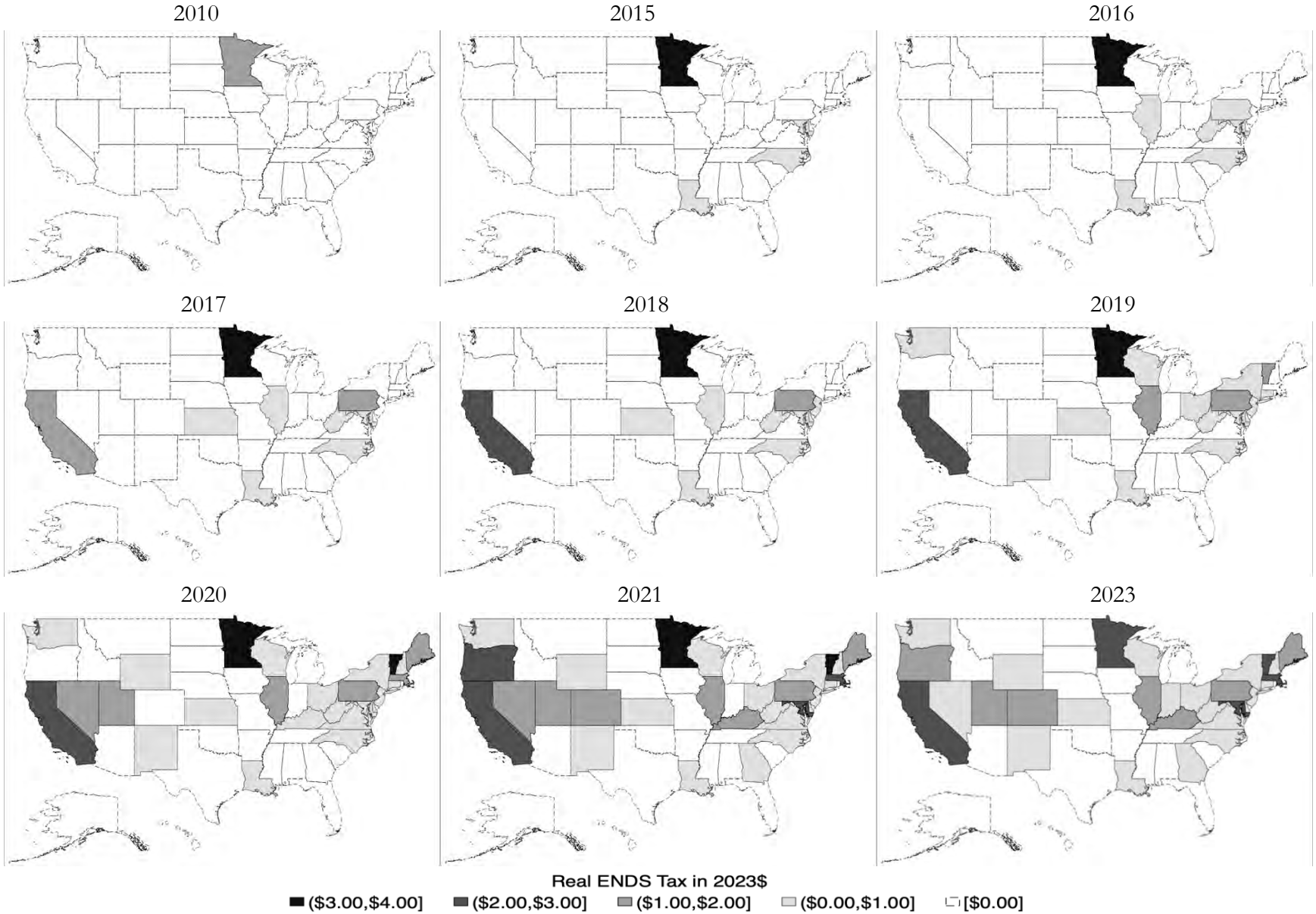
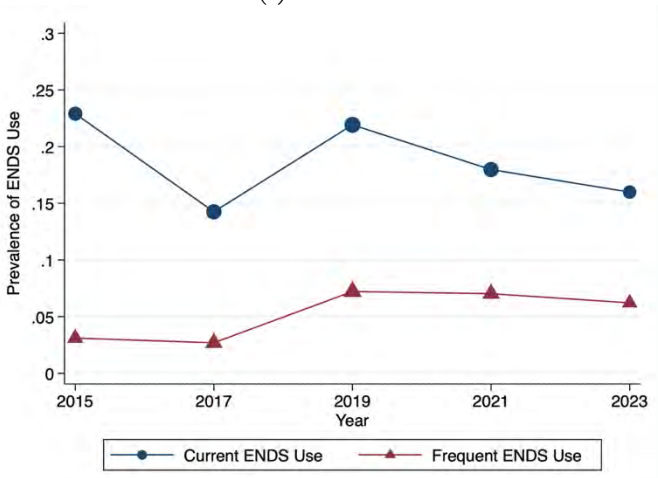
Figure 1. Geographic and Temporal Variation in ENDS Taxes, 2010-2023



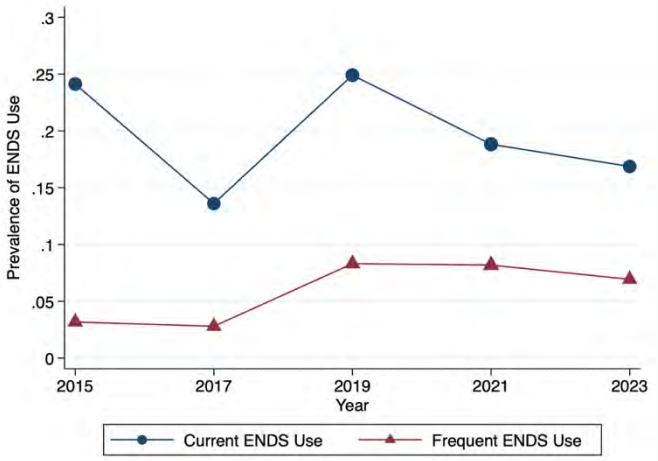
Source: Cotti et al (2023,2024).

Figure 2. Trends in Youth ENDS Use, YRBSS Surveys

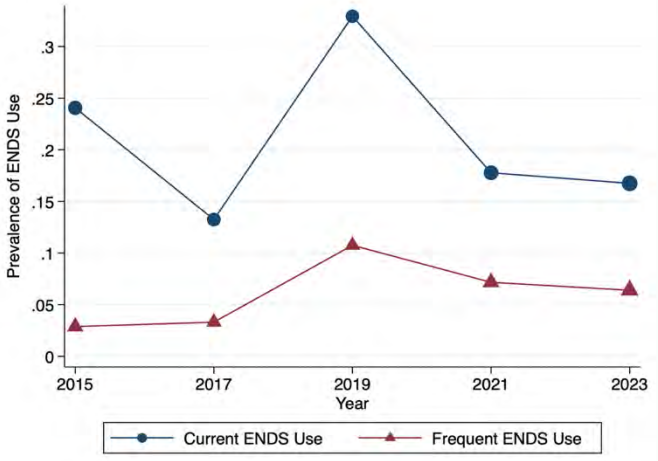
Panel (a): State YRBSS



Panel (b): Combined YRBSS



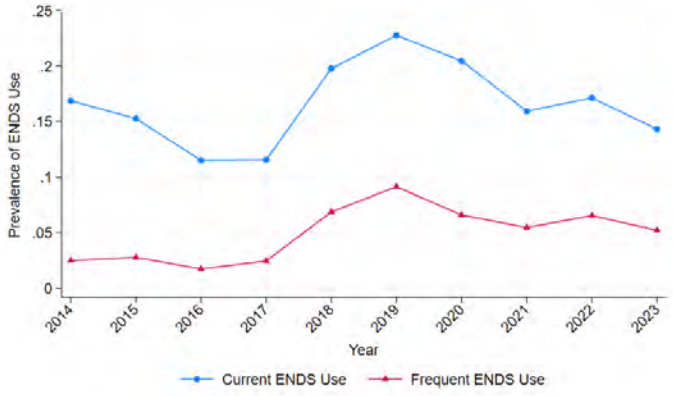
Panel (c): National YRBSS



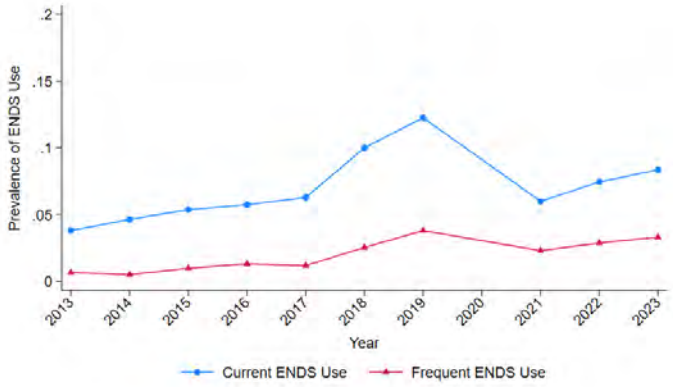
Notes: Weighted estimates are provided from State, National and Combined YRBSS, 2015-2023.

Figure 3. Trends in Youth ENDS Use, MTF and PATH

Panel (a): MTF



Panel (b): PATH

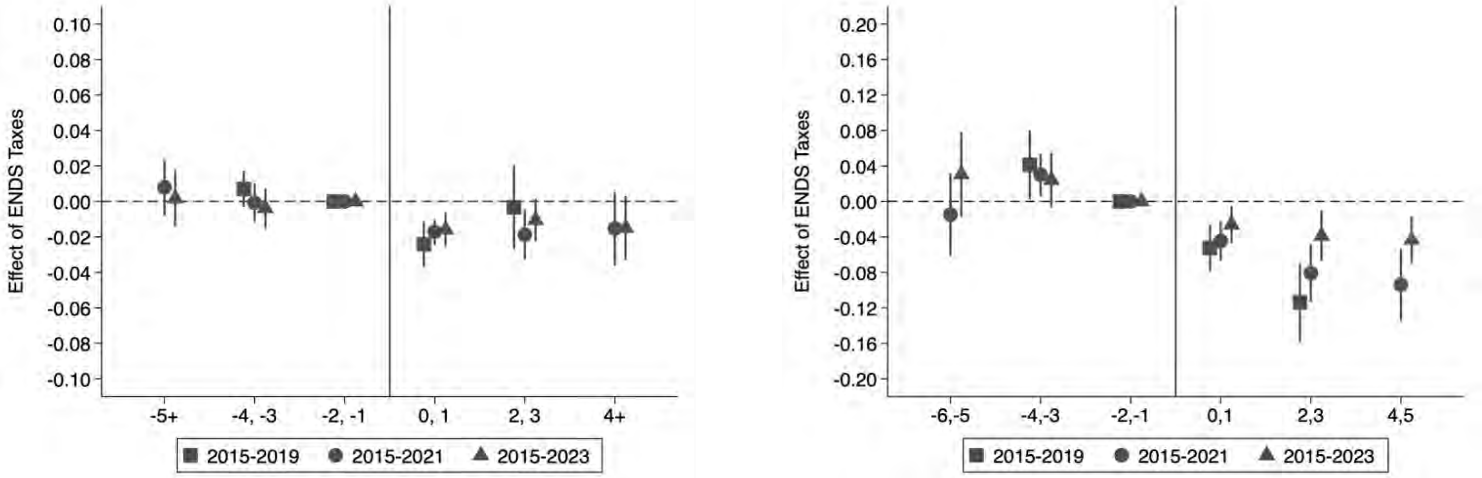


Notes: Weighted estimates are provided from the 2014-2023 Monitoring the Future Surveys & 2013-2023 Population Assessment and Tobacco Health Surveys.

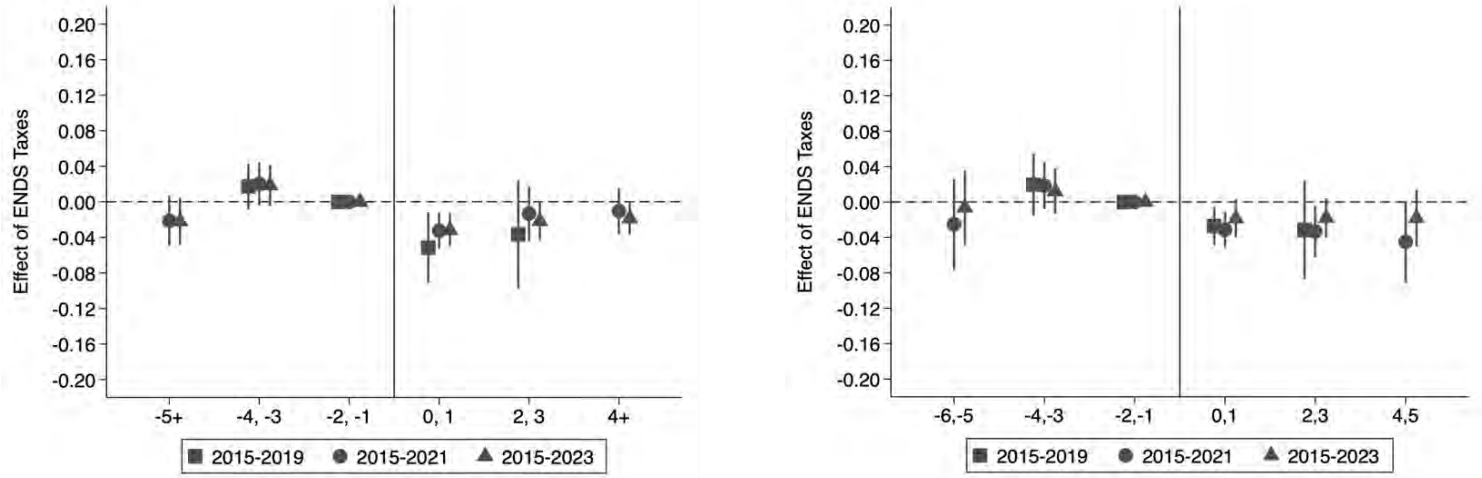
Figure 4. Event-Study Analysis of ENDS Taxes and Youth ENDS Use, YRBSS

(I) TWFE Estimates (II) Stacked DiD Estimates

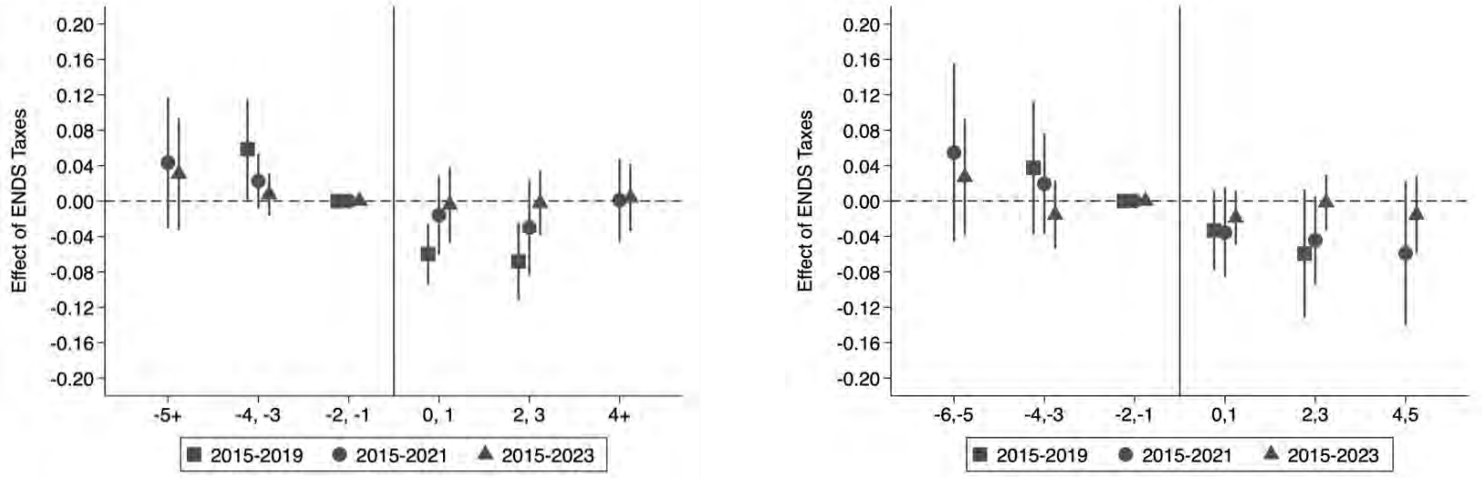
Panel (a) State YRBS



Panel (b) Combined YRBS



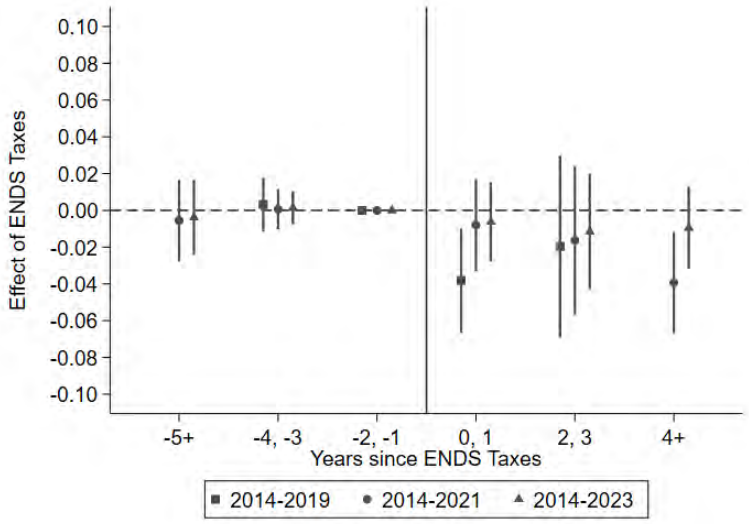
Panel (c): National YRBS



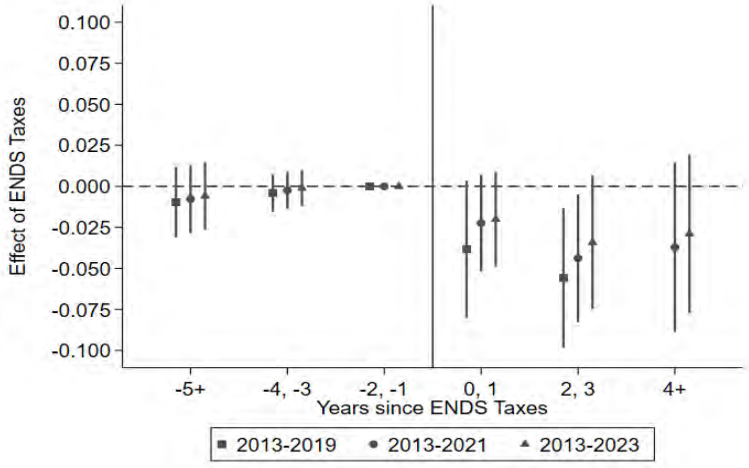
Notes: Estimates are obtained using data from the 2015-2019, 2015-2021, and 2015-2023 State, National and Combined Youth Risk Behavior Surveys. Results on the left are from TWFE event-study regression estimates whereas results on the right are stacked DiD estimates where the treatment is a prominent increase of $0.20 per mL in ENDS Taxes ($2023). All figures include fixed effects for state, year and semester (additional stack cohort specific fixed effects for stacked DiD estimates included). All models also include controls for individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

Figure 5. Event-Study Analysis of ENDS Taxes and Youth ENDS Participation, Using TWFE Estimates, MTF and PATH

Panel (a): MTF



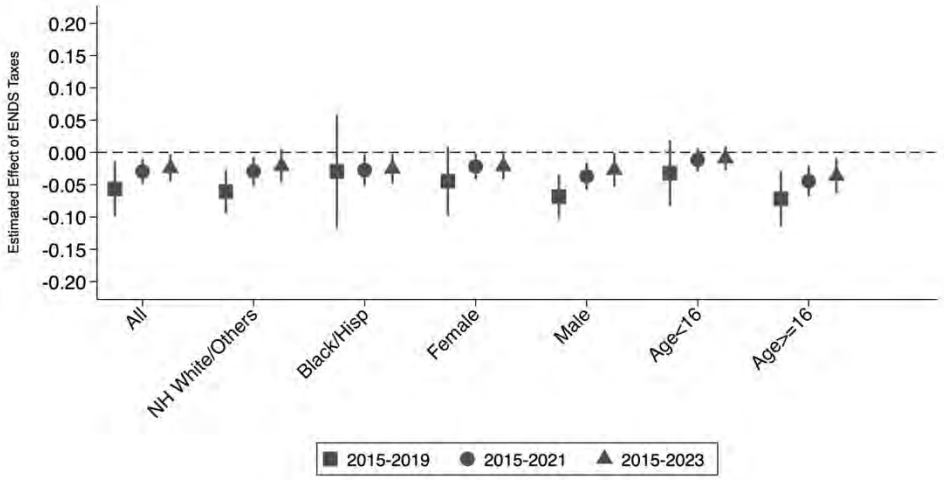
Panel (b): PATH



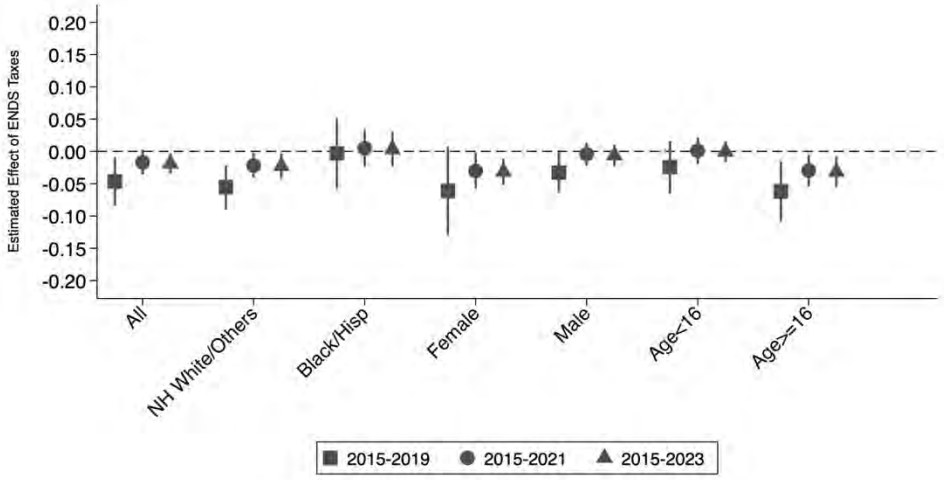
Notes: Estimates are obtained from event-study regression estimates using data from the 2014-2019, 2014-2021, and 2014-2023 Monitoring the Future Surveys & 2013-2019, 2013-2021, and 2013-2023 Population Assessment and Tobacco Health Surveys. Figures include fixed effects for state, year and quarter (additional individual fixed effects for PATH data). All models also include controls for individual demographic characteristics (age, race/ethnicity, grade, and gender -only age in PATH), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. Regressions are weighted using sample weights provided in the dataset.

Figure 6. Heterogeneity in Effects of ENDS Taxes on Youth ENDS Participation, by Demographic Characteristics, YRBSS, MTF & PATH

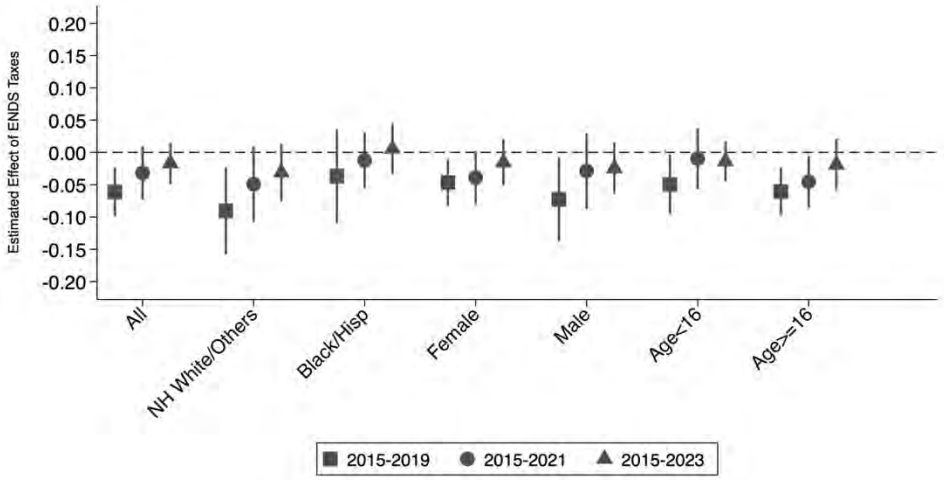
Panel (a) State YRBS



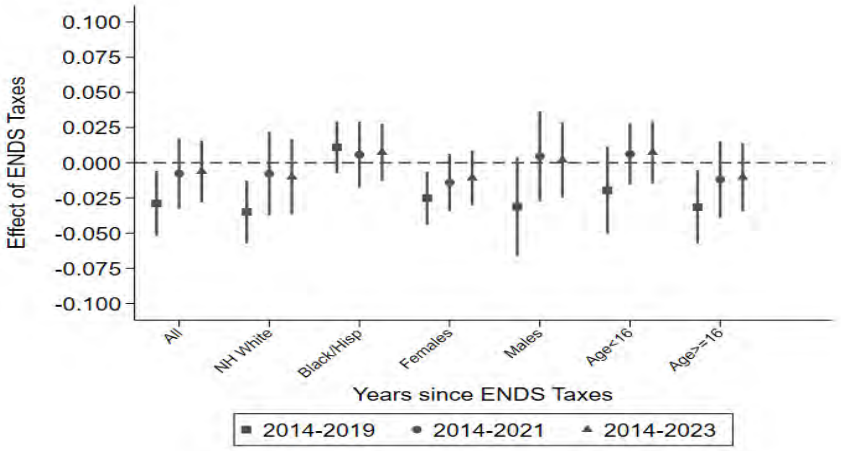
Panel (b) Combined YRBS



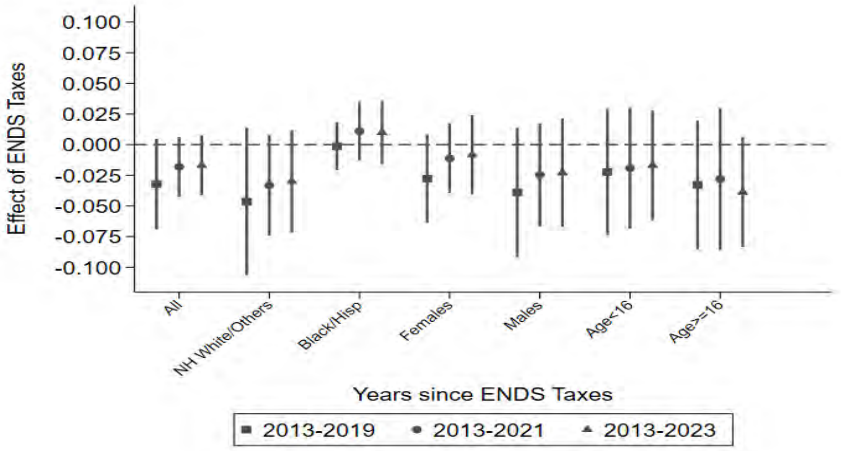
Panel (c) National YRBS



Panel (d) MTF



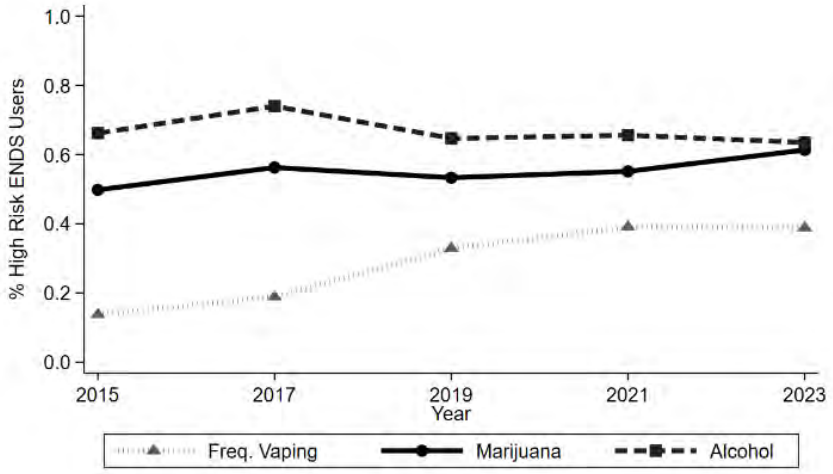
Panel (e) PATH



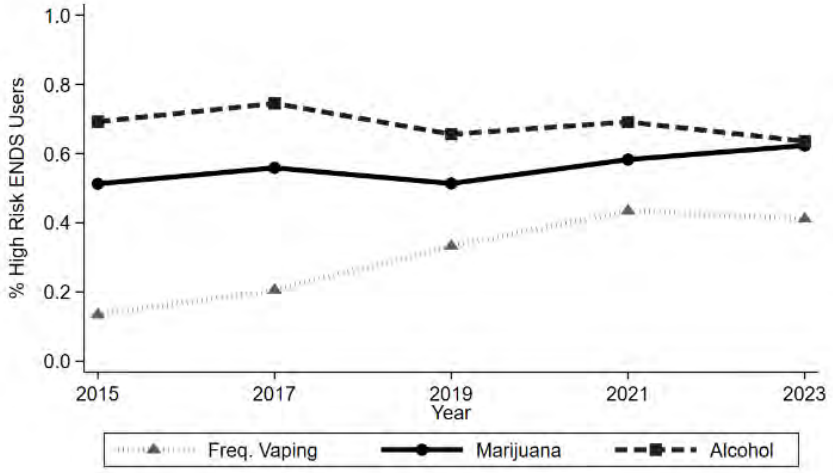
Notes: Estimates are obtained from weighted OLS regressions using data from the 2015-2019, 2015-2021, and 2015-2023 State, National & Combined Youth Risk Behavior Surveys for panels (a-c), and 2014-2019, 2014-2021, and 2014-2023 Monitoring the Future survey for panel (d) and 2013-2019, 2013-2021 and 2013-2023 Population Assessment and Tobacco Health survey for panel (e). Coefficients are represented with geometric shapes, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. The model includes fixed effects for state, year, and semester (YRBS)/quarter (MTF/PATH) and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. All models also include controls for individual demographic characteristics (age, race/ethnicity, grade, and gender -only age in PATH), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS and the sample weights provided in the dataset for MTF & PATH surveys.

Figure 7. Changing Composition of Youth ENDS Users Over Time, YRBSS, MTF, and PATH

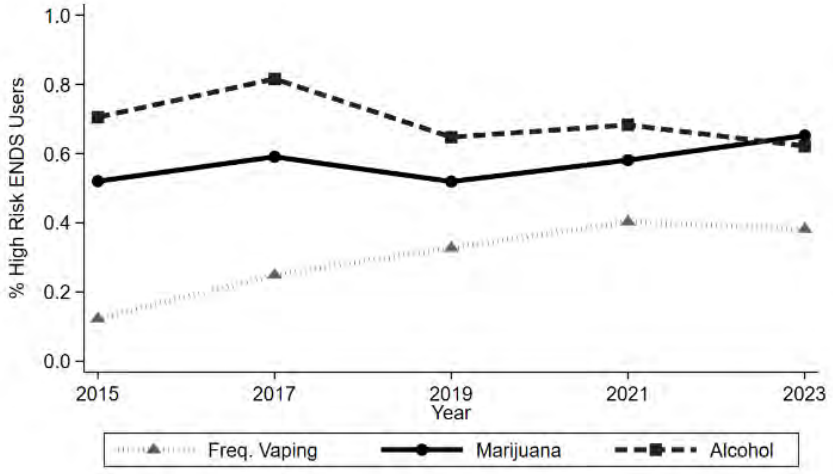
Panel (a): State YRBSS



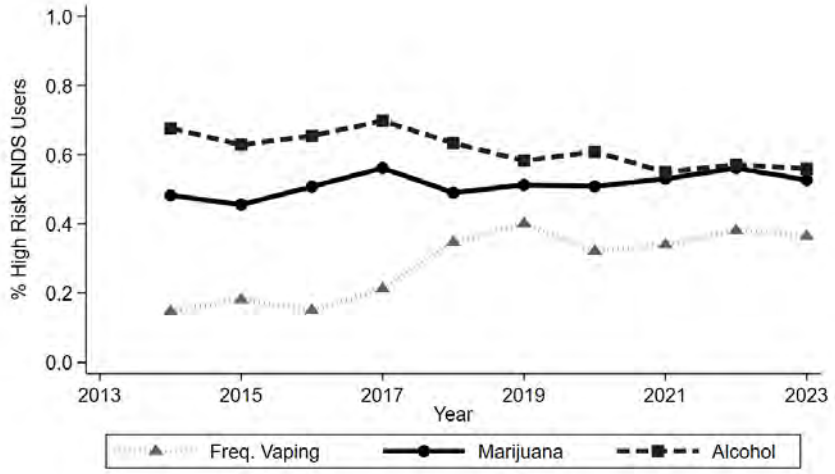
Panel (b): Combined YRBSS



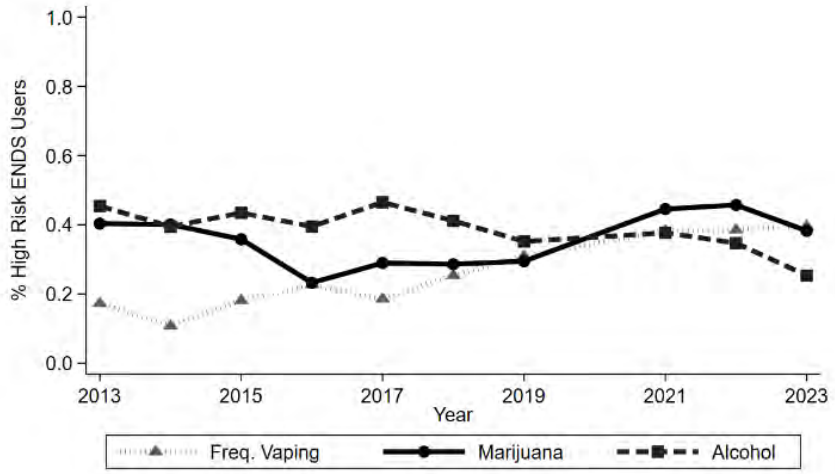
Panel (c): National YRBSS



Panel (d): MTF



Panel (f): PATH

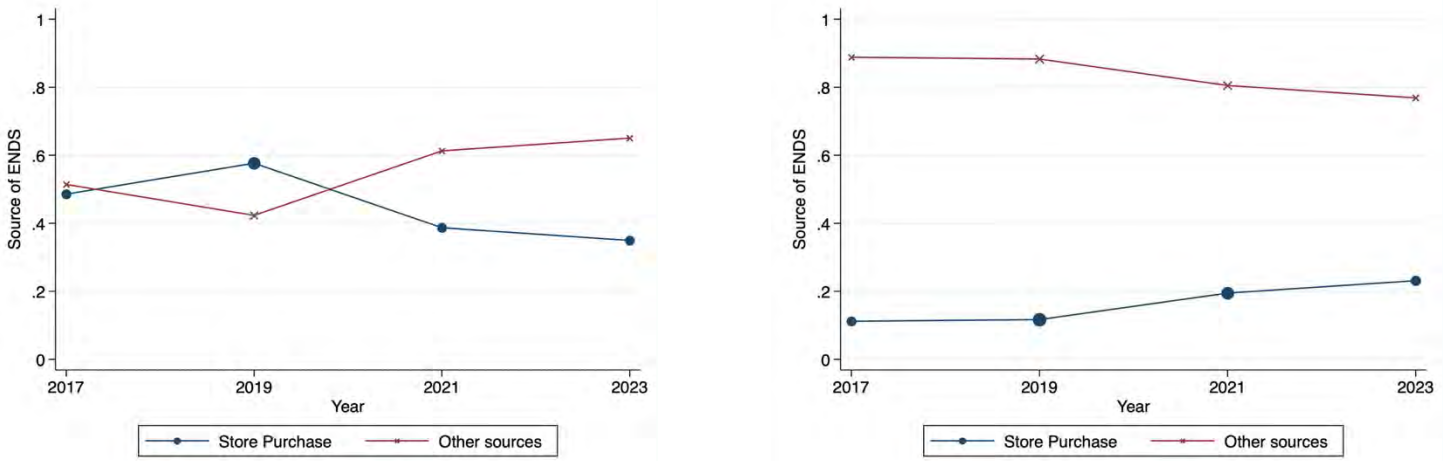


Source: Youth Risk Behavior Surveillance System Surveys, 2015-2023, Population Assessment of Tobacco and Health, 2013-2023, Monitoring the Future Surveys, 2014-2023.

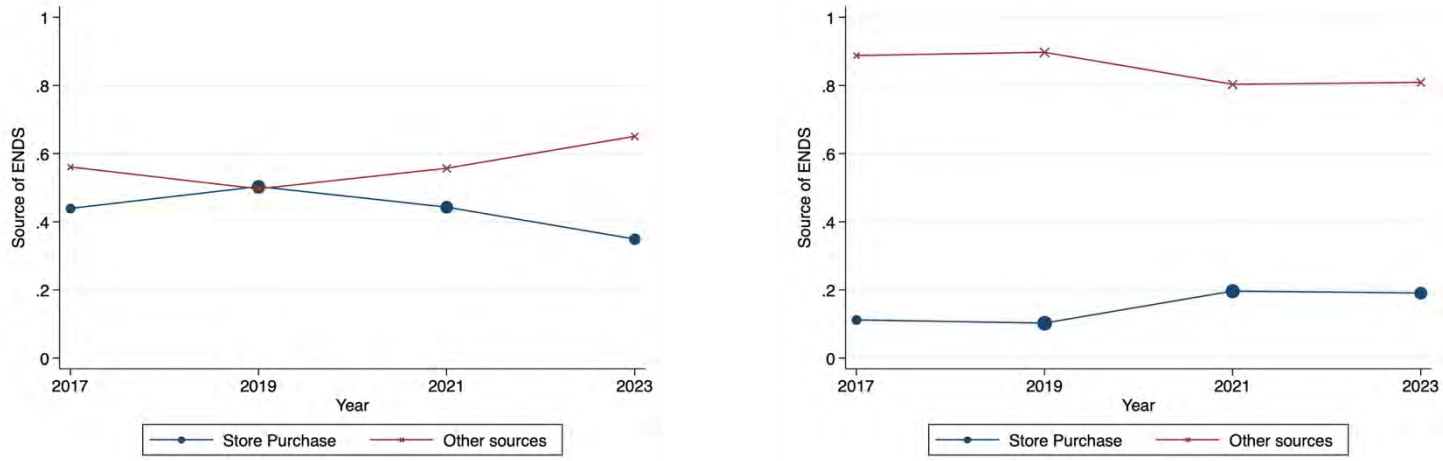
Figure 8. Purchasing E-Cigarettes in a Store vs Obtaining via Other Sources among Current ENDS Users, by Age, YRBSS

(I) Age ≥ 18 years (II) Age < 18 years

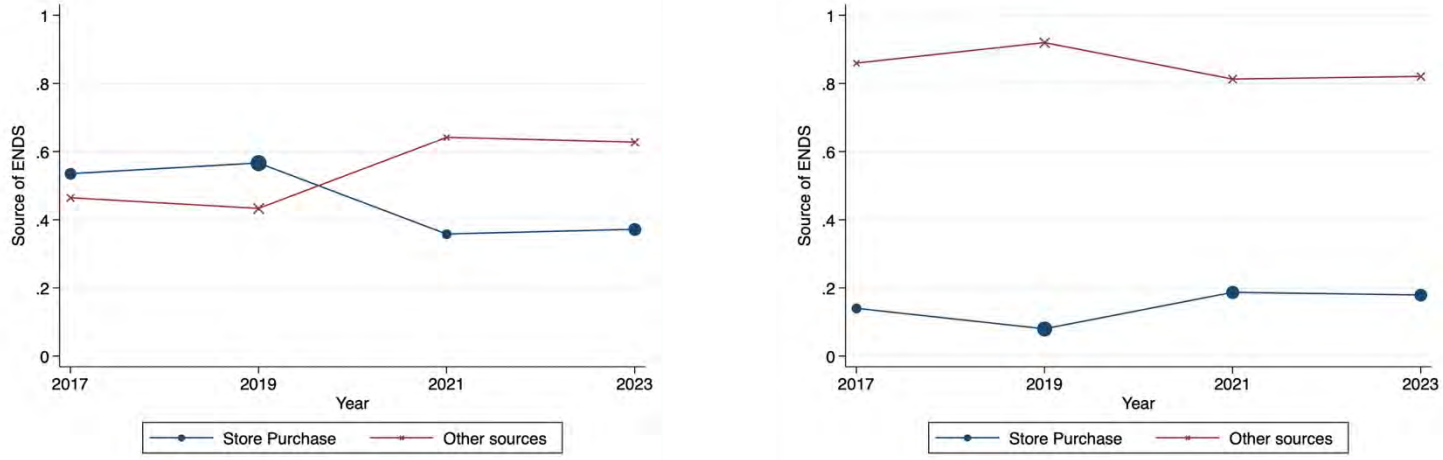
Panel (a) State YRBS



Panel (b) Combined YRBS



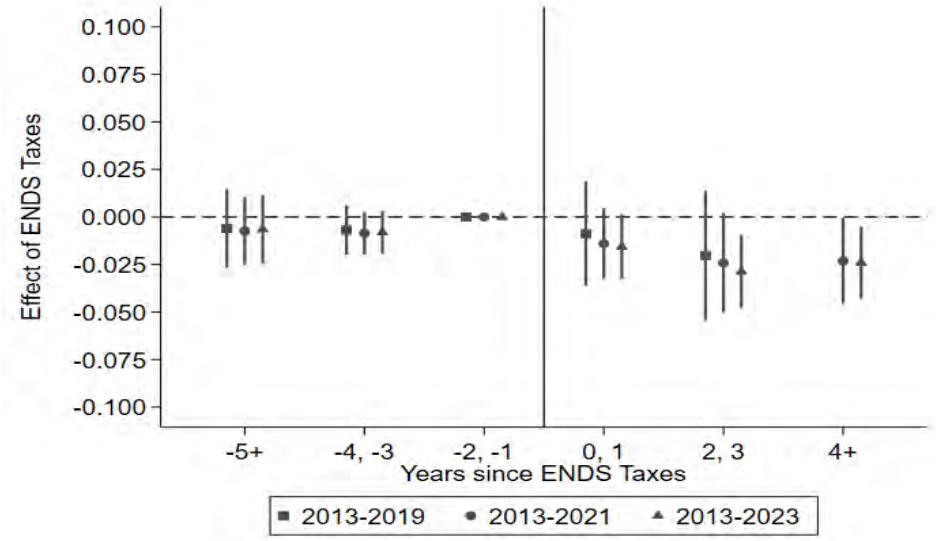
Panel (c): National YRBS



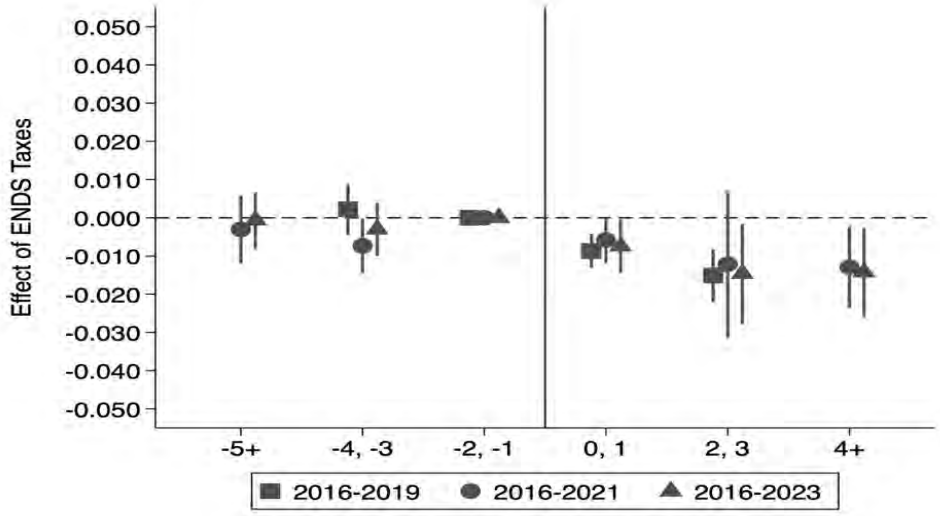
Notes: Weighted estimates are provided from State, National and Combined YRBSS, 2017-2023.

Figure 9. Event-Study Analysis of ENDS Taxes and Prior-Month Nicotine Vaping Among Young Adults Aged 18-30, PATH and BRFSS

Panel (a) PATH



Panel (b) BRFSS



Notes: Estimates are obtained from event study regressions using data from the Population Assessment & Tobacco Health survey over the period 2013-2019, 2013-2021 and 2016-2019, 2016-2021 and 2016-2023 Behavioral Risk Factor Surveillance System Surveys. We include the state, year, and quarter fixed effects (individual fixed effects additionally for PATH data). All models also include controls for individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Regressions are weighted using the sample weights provided in the dataset.

Table 1. Estimates of the Effect of ENDS Taxes on Youth ENDS Use, YRBSS

	(1)	(2)	(3)	(4)	(5)
	2015-2019	2015-2021	2015-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2015-2019[a]) = $\beta^{\text{ENDS Tax}}$ (2015-2023)
Panel I: Baseline Controls					
State YRBSS	-0.0566**	-0.0296***	-0.0241**	p = 0.0366**	p = 0.0899*
	(0.0211)	(0.0095)	(0.0106)		
Semi-Elasticity	-27.92	-14.99	-12.64		
N	493,799	622,122	735,109		
Combined YRBSS	-0.0424**	-0.0199*	-0.0194**	p = 0.0057***	p = 0.1019+
	(0.0179)	(0.0101)	(0.0073)		
Semi-Elasticity	-19.51	-9.53	-9.71		
N	532,952	676,563	807,753		
National YRBSS	-0.0612***	-0.0318	-0.0170	p = 0.2123	p = 0.0159**
	(0.0186)	(0.0204)	(0.0159)		
Semi-Elasticity	-26.80	-15.16	-8.49		
N	39,153	54,441	72,644		
Panel II: Extended Controls					
State YRBSS	-0.0574***	-0.0276***	-0.0227*	p = 0.0377**	p = 0.0832*
	(0.0200)	(0.0096)	(0.0113)		
Semi-Elasticity	-28.28	-14.01	-11.93		
N	493,799	622,122	735,109		
Combined YRBSS	-0.0374**	-0.0191**	-0.0138**	p = 0.0003***	p = 0.1361+
	(0.0179)	(0.0089)	(0.0068)		
Semi-Elasticity	-17.22	-9.18	-6.93		
N	532,952	676,563	807,753		
National YRBSS	-0.0501*	-0.0328	-0.0101	p = 0.1945	p = 0.0945*
	(0.0269)	(0.0237)	(0.0176)		
Semi-Elasticity	-21.95	-15.64	-5.05		
N	39,153	54,441	72,644		

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Youth Risk Behavior Surveillance System Surveys, 2015-2023

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ENDS taxes on current ENDS use, column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019 and column (5) shows the significance of tests of difference between the impact of ENDS taxes between 2015-2019 vs 2015-2023. The model includes fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. Controls in panel I include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Controls in panel II additionally include more tobacco/ENDS policies (ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the population aged 14-18 years at the state & national level for combined YRBS.

Table 2. Estimates of the Effect of ENDS Taxes on Youth ENDS Participation, MTF

	(1)	(2)	(3)	(4)	(5)
	2014-2019[a]	2014-2021	2015-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-March 2020) = $\beta^{\text{ENDS Tax}}$ (post- March 2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2014-2019[a]) = $\beta^{\text{ENDS Tax}}$ (2014-2023)
Panel I: Baseline Controls					
MTF	-0.0288**	-0.0077	-0.0063		
	(0.0115)	(0.0125)	(0.0109)	p = 0.4082	p = 0.0970*
Semi-Elasticity	-17.18	-4.67	-3.88		
N	82,755	100,927	133,913		
Panel II: Extended Controls					
MTF	-0.0326***	-0.0071	-0.0069		
	(0.0121)	(0.0129)	(0.0113)	p = 0.4578	p = 0.0888*
Semi-Elasticity	-19.42	-4.34	-4.28		
N	82,755	100,927	133,913		

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Monitoring the Future Surveys, 2014-2023

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ENDS taxes on current ENDS, column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019 and column (5) shows the significance of tests of difference between the impact of ENDS taxes between 2015-2019 Vs 2015-2023. The model includes fixed effects for state, year, and quarter. Controls in panel I include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Controls in panel II additionally include more tobacco/ENDS policies (ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using the sample weights provided.

[a] MTF data collected in the pre-COVID period (January 2020-March 2020) included in this sample.

Table 3. Estimates of the Effect of ENDS Taxes on Youth ENDS Use, PATH

	(1)	(2)	(3)	(4)	(5)
	2013-2019	2013-2021	2013-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2013-2019) = $\beta^{\text{ENDS Tax}}$ (2013-2023)
			Panel I: Baseline Controls		
Individual FE	-0.0273**	-0.0186**	-0.0141*		
	(0.0109)	(0.0089)	(0.0082)	p = 0.3076	p = 0.0430**
Semi-Elasticity	-35.34	-25.14	-19.08		
N	52,361	57,882	65,415		
State & Individual FE	-0.0322*	-0.0181	-0.0168		
	(0.0184)	(0.0121)	(0.0121)	p = 0.9839	p = 0.1550
Semi-Elasticity	-41.59	-24.35	-22.63		
N	52,361	57,882	65,415		
			Panel II: Extended Controls		
Individual FE	-0.0325**	-0.0209**	-0.0156*		
	(0.0124)	(0.0092)	(0.0086)	p = 0.1976	p = 0.0627*
Semi-Elasticity	-41.95	-28.23	-21.14		
N	52,361	57,882	65,415		
State & Individual FE	-0.0349*	-0.0189	-0.0170		
	(0.0180)	(0.0122)	(0.0123)	p = 0.9863	p = 0.1630
Semi-Elasticity	-45.11	-25.53	-23.02		
N	52,361	57,882	65,415		

Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Population Assessment of Tobacco and Health, 2013-2023.

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ENDS taxes on current ENDS use, column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019 and column (5) shows the significance of tests of difference between the impact of ENDS taxes between 2015-2019 Vs 2015-2023. The model includes fixed effects for individuals (and state where mentioned), year and quarter. Controls in panel I include individual's age, macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Controls in panel II additionally include more tobacco/ENDS policies (ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided.

Table 4. Discrete-Time Hazard Estimates of the Effects of ENDS Taxes on Initiation and Cessation of Youth ENDS Use, PATH

	(1)	(2)	(3)
	2013-2019	2013-2021	2013-2023
		Panel I: Initiation	
Baseline Non-Users	-0.0358***	-0.0204**	-0.0184*
	(0.0115)	(0.0084)	(0.0095)
Semi-Elasticity	-51.36	-30.20	-27.90
N	49657	54856	61920
		Panel II: Cessation	
Baseline Users	0.0935	0.0020	0.0059
	(0.2754)	(0.1459)	(0.1675)
Semi-Elasticity	19.52	0.40	1.27
N	1602	1818	2204

Significant at 1% level **at 5% level *at 10% level

Source: Population Assessment of Tobacco and Health, 2013-2023.

Notes: Estimates are generated from discrete time hazard models using TWFE. Panel I shows the impact of ENDS taxes on vaping initiation whereas Panel II shows the impact of ENDS taxes on vaping cessation. The model includes fixed effects for individual and state along with year and quarter. Controls include individual macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and per pack cigarette taxes in 2023) and alcohol and marijuana policies (beer taxes ($2023) and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided.

Table 5. Heterogeneity in the Effects of ENDS Taxes on Youth ENDS Participation, by Underlying Predicted Risk and Addictive Stock

	(1)	(2)	(3)	(4)	(5)
	State YRBSS	National YRBSS	Combined YRBSS	MTF	PATH
	Panel I: ENDS Users with Lower Underlying Risk and Addictive Stock vs Non-ENDS Users				
Lower Risk/Addiction	-0.0465**	-0.0453*	-0.0276	-0.0298***	-0.0261
	(0.0191)	(0.0253)	(0.0178)	(0.0098)	(0.0192)
Semi-Elasticity	-22.90	-19.82	-12.73	-17.75	-33.73
N	449,657	37,545	487,202	76,285	51,445
	Panel II: ENDS Users with Higher Underlying Risk and Addictive Stock vs Non-ENDS Users				
Higher Risk/Addiction	-0.0261***	-0.0170*	-0.0234**	-0.0130*	-0.0156**
	(0.0090)	(0.0099)	(0.0093)	(0.0069)	(0.0065)
Semi-Elasticity	-12.86	-7.44	-10.78	-7.76	-20.14
N	433,866	31,575	465,441	74,870	49,653

Significant at 1% level **at 5% level *at 10% level

Source: Youth Risk Behavior Surveillance System Surveys, 2015-2019, Population Assessment of Tobacco and Health, 2013-2019, Monitoring the Future Surveys, 2014-2020.

Notes: Estimates are based on pre-COVID samples. "High-risk" current ENDS users are defined as those above the median of the first principal component (PCA Component 1) among ENDS users, constructed from frequent vaping, marijuana use, and current alcohol use. The first component always explains more than 60% of the total variation. The fixed effects regressions shown above include fixed effects for state, year, and semester/quarter. The PATH also includes controls for individual fixed effects. Additional controls include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions), and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses.

Table 6A: Heterogeneity in the Effects of ENDS Taxes by whether Youth Typically Purchase E-Cigarettes at a Store, YRBSS

	(1)	(2)
	Youths Aged 18+	Youths Under Age 18
	Panel I: Effect of ENDS Tax on ENDS Users who Typically Purchase from Store vs Non-Users	
Purchase in Store	-0.0139	-0.0166**
	(0.0138)	(0.0064)
Semi-Elasticity	-11.53	-67.08
N	32,237	362,281
	Panel II: Effect of ENDS Tax on ENDS Users who Typically Obtain E-Cigarettes in Some Other Way vs Non-Users	
Obtain Some Other Way	0.0042	-0.0158
	(0.0232)	(0.0096)
Semi-Elasticity	2.78	-12.38
N	32,487	418,992

***Significant at 1% level **at 5% level *at 10% level

Source: National and State Youth Risk Behavior Surveillance System Surveys, 2017-2021.

Notes: Estimates are generated using a TWFE ordinary least squares regression. Panels I and II show the impact of ends taxes on current e-cigarette purchases in stores versus other sources compared to non-users. The model includes fixed effects for state, year, and semester for all regressions and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. Controls include individual macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and per pack cigarette taxes in 2023) and alcohol and marijuana policies (beer taxes ($2023) and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

Table 6B. Estimates of the Effect of ENDS Taxes on ENDS Use, by Whether Age 18, Combined YRBSS

	(1)	(2)	(3)	(4)	(5)
	2015-2019	2015-2021	2015-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2015-2019) = $\beta^{\text{ENDS Tax}}$ (2015-2023)
Age ≥ 18	-0.0484	-0.0336*	-0.0293**		
	(0.0337)	(0.0178)	(0.0117)	p = 0.0510*	p = 0.5482
Semi-Elasticity	-16.32	-11.70	-10.71		
N	47,614	55,698	66,192		
Age < 18	-0.0339**	-0.0154*	-0.0099		
	(0.0168)	(0.0080)	(0.0064)	p = 0.0406**	p = 0.0521*
Semi-Elasticity	-17.24	-8.18	-5.49		
N	485,338	620,865	741,561		

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: State & National Youth Risk Behavior Surveillance System Surveys, 2015-2023.

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ends taxes on current e-cigarette use, whereas columns (4) & (5) show the significance of tests of difference between the impact of ENDS taxes prior to March 2020 Vs post March 2020 and between 2014-2020 Vs 2014-2023. The model includes fixed effects for state, year, and semester for all regressions and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. Controls include individual macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and per pack cigarette taxes in 2023) and alcohol and marijuana policies (beer taxes ($2023) and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

Table 7. Estimated Effects of ENDS Taxes on Youth Combustible Cigarette Smoking

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2014-2019		2014-2021		2014-2023		p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2015-2019) = $\beta^{\text{ENDS Tax}}$ (2015-2023)
Combined YRBSS	0.0042	0.0097	0.0137***	0.0135**	0.0127***	0.0114**		
	(0.0029)	(0.0079)	(0.0044)	(0.0055)	(0.0038)	(0.0052)	p = 0.3439	p = 0.7978
Semi-Elasticity	5.3503	12.3400	20.0560	19.6959	20.3919	18.3644		
N	532,667	532,667	660,591	660,591	782,587	782,587		
MTF	0.0034**	0.0007	0.0037**	-0.0013	0.0035**	-0.0016		
	(0.0015)	(0.0037)	(0.0018)	(0.0030)	(0.0017)	(0.0032)	p= 0.3778	p = 0.4697
Semi-Elasticity	5.1848	1.1011	6.0992	-2.0618	6.3578	-2.9502		
N	162,219	162,219	180,407	180,407	213,441	213,441		
Controls?:								
Demo, macro, covid	Y	Y	Y	Y	Y	Y	Y	Y
Ecig policies	N	Y	N	Y	N	Y	Y	Y
Alcohol & MJ policies	N	Y	N	Y	N	Y	Y	Y
Combustible policies	N	Y	N	Y	N	Y	Y	Y

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: National and State Youth Risk Behavior Surveillance System Surveys, 2015-2023, Monitoring the Future Surveys, 2014-2023

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ends taxes on current cigarette use. The model includes fixed effects for state, year, and semester/quarter for all regressions and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. Controls include individual demographic conditions (age, gender, race and grade), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces), alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws) and combustible policies such as indoor smoking restrictions, and per pack cigarette taxes in $2023. Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS and sample weights provided in the MTF dataset.

Table 8. Estimated Effects of ENDS Taxes on ENDS Use Among Young Adults Aged 18-30, BRFSS and PATH

	(1)	(2)	(3)	(4)	(5)
	2013-2019	2013-2021	2013-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2016-2019[a]) = $\beta^{\text{ENDS Tax}}$ (2016-2023)
PATH	-0.0104	-0.0131	-0.0154*	p = 0.1733	p = 0.7510
	(0.0095)	(0.0080)	(0.0079)		
Semi-Elasticity	-07.02	-08.53	-09.45		
N	70,285	85,977	101,586		
BRFSS	-0.0085***	-0.0040	-0.0060	p = 0.2358	p = 0.9829
	(0.0028)	(0.0045)	(0.0046)		
Semi-Elasticity	-09.26	-03.38	-04.57		
N	128,704	190,630	285,118		

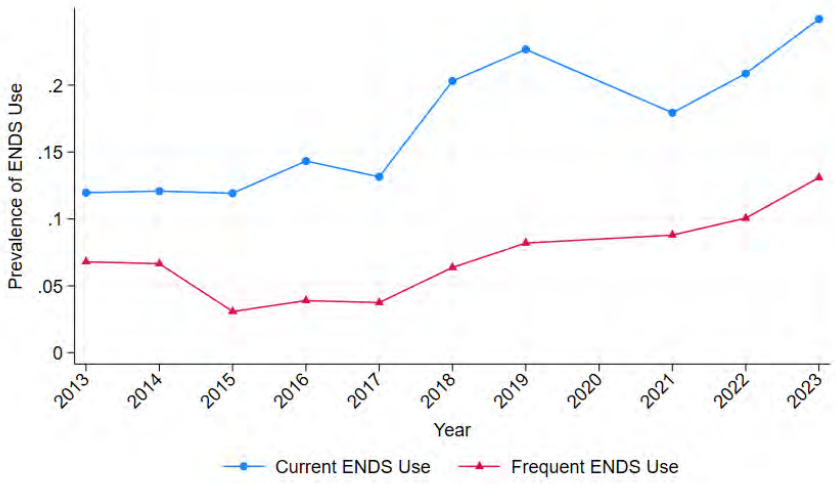
Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Behavioral Risk factor surveillance systems Survey, 2016-2023, Population Assessment of Tobacco and Health, 2013-2023.
Notes: TWFE estimates are generated using a weighted least squares regression. Columns (1) to (3) shows the impact of ends taxes on current ENDS , column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019 and column (5) shows the significance of tests of difference between the impact of ENDS taxes between 2015-2019 Vs 2015-2023. The model includes fixed effects for state, year, and quarter. PATH estimates additionally control for individual fixed effects. Controls in panel I include individual demographic characteristics (age, race/ethnicity, grade, and gender -only age in PATH), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Controls in panel II additionally include more tobacco/ENDS policies (ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided in the dataset.

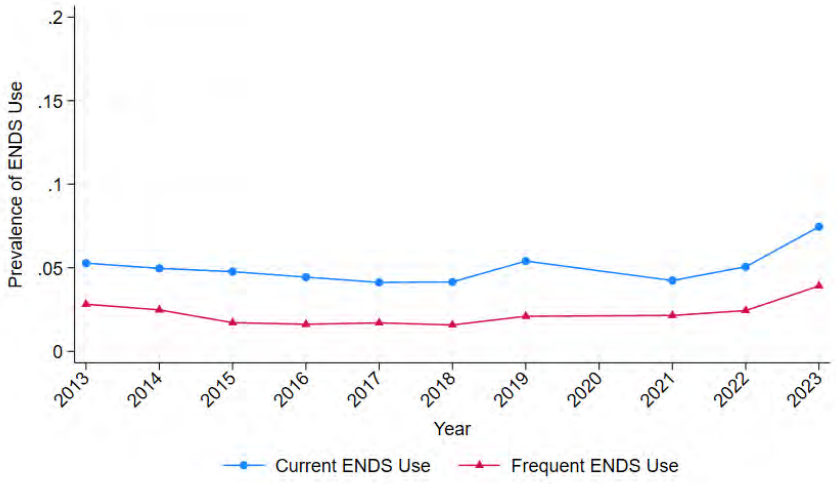
APPENDIX TABLES AND FIGURES

Appendix Figure 1. Trends in ENDS Use Among Adults, PATH

Panel (a) Young Adults Aged 18-30



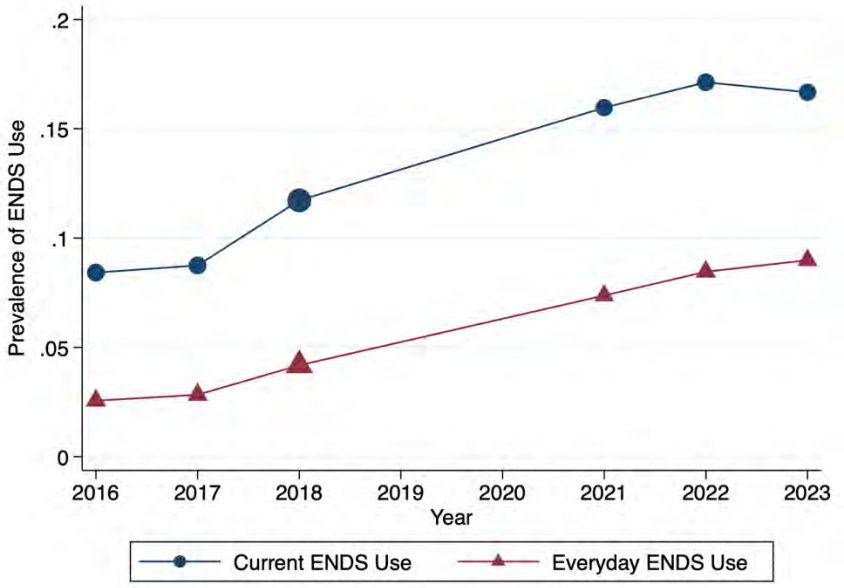
Panel (b) Adults Aged 31 and Older



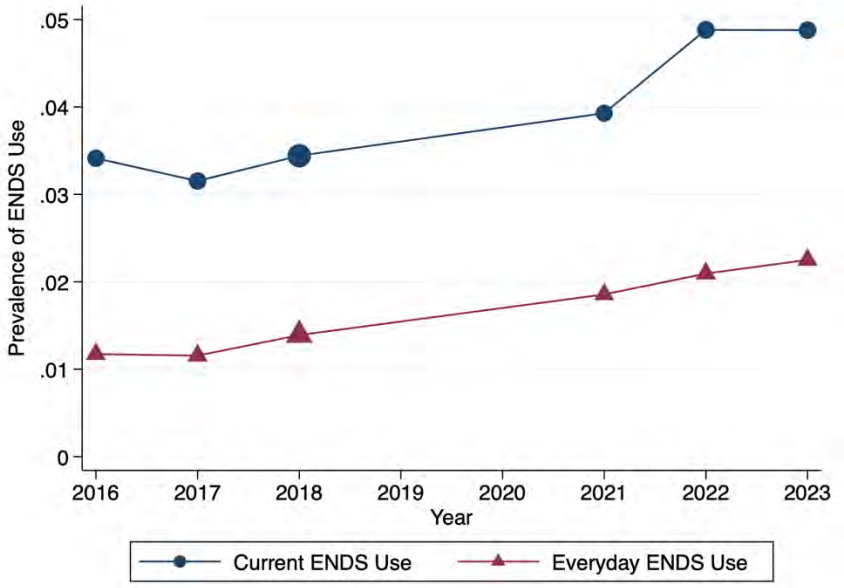
Notes: Weighted estimates are provided from the Population Assessment & Tobacco Health survey over the period 2013-2023.

Appendix Figure 2. Trends in ENDS Use Among Adults, BRFSS

Panel (a) Young Adults Aged 18-30



Panel (b) Adults Aged 31 and Older

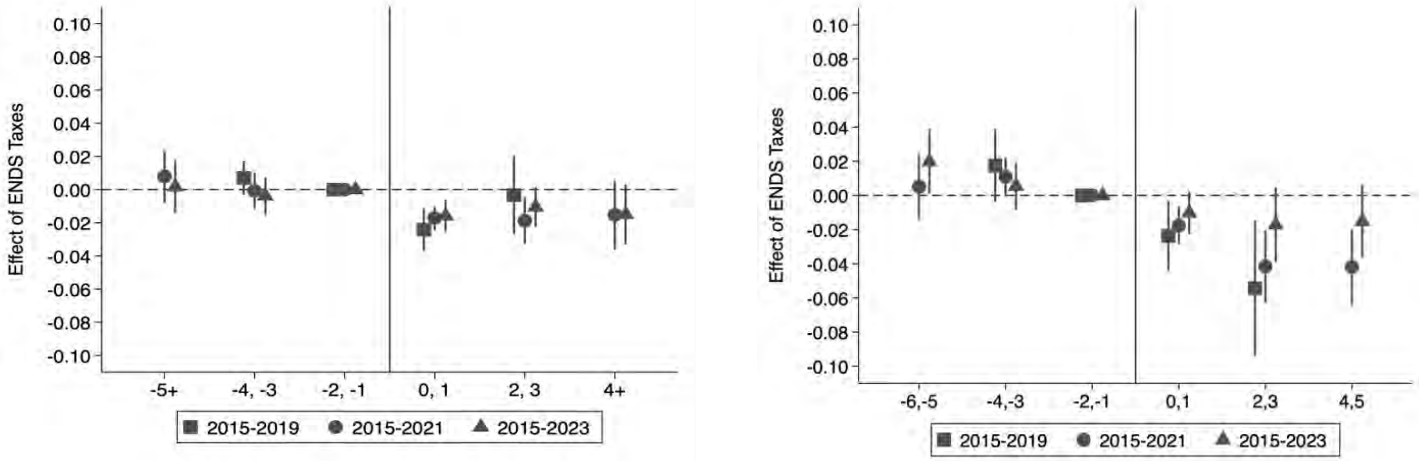


Notes: Weighted estimates are provided from the 2016-2023 Behavioral Risk Factor Surveillance System Surveys. BRFSS did not collect e-cigarette use data for the year 2019 and was asked of an extremely selective sample for the year 2020. Hence these two years' averages have been removed from the graph to avoid any misleading time trends.

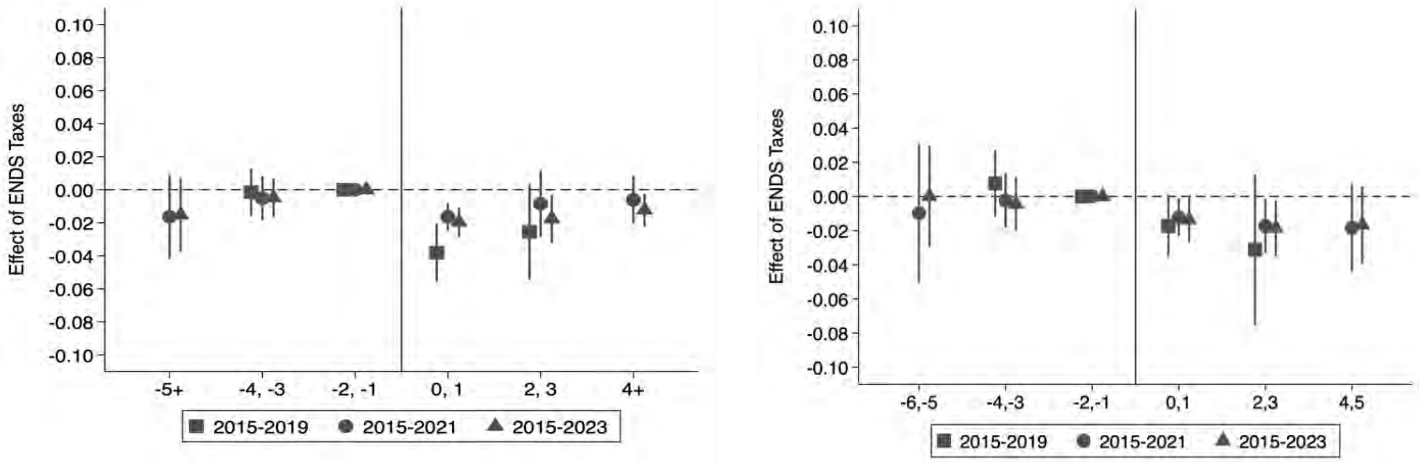
Appendix Figure 3. Event-Study Analysis of ENDS Taxes and Youth Frequent ENDS Use, YRBSS

(I) TWFE Estimates (II) Stacked DiD Estimates

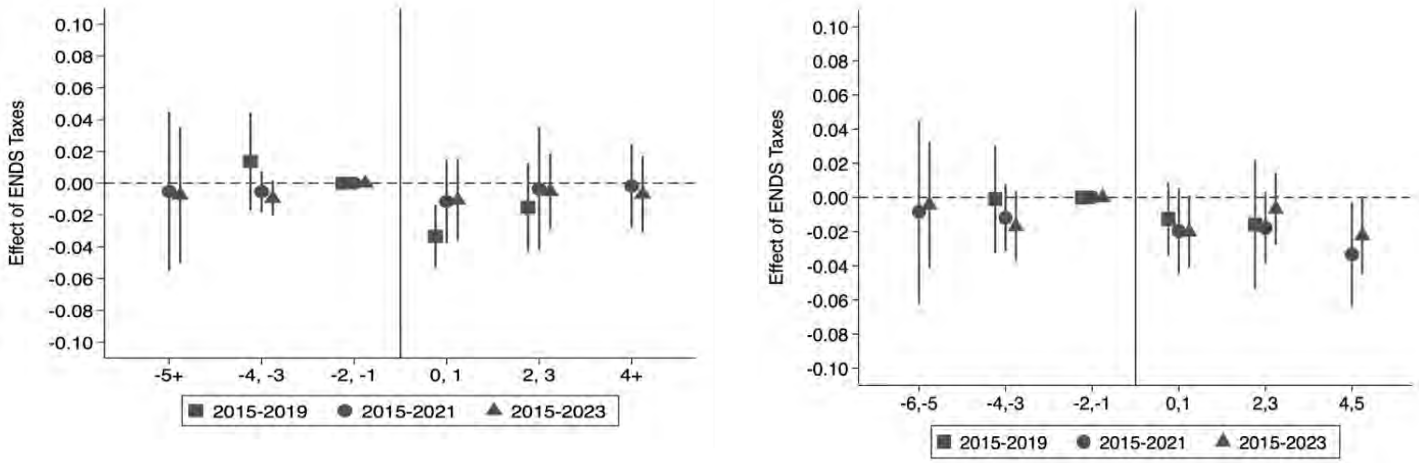
Panel (a) State YRBS



Panel (b) Combined YRBS



Panel (c): National YRBS

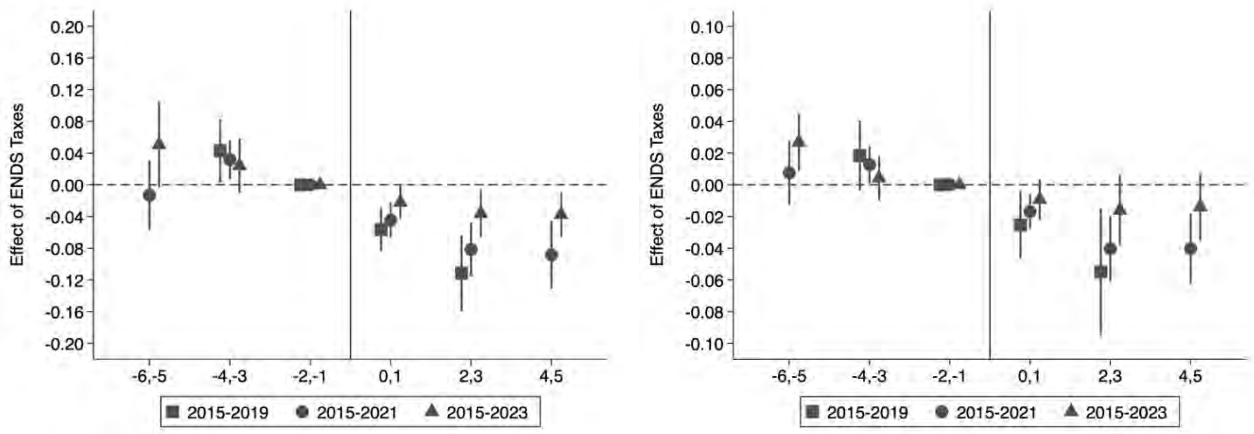


Notes: Estimates are obtained from TWFE event-study regressions on the left and stacked DiD regressions where the treatment is a prominent increase of $0.20 per mL in ENDS Taxes ($2023) for the right panel using data from the 2015-2019, 2015-2021, and 2015-2023 State, National and Combined Youth Risk Behavior Surveys. All figures include fixed effects for state, year and semester (additional stack cohort fixed effects for stacked DiD included). All models also include controls for individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

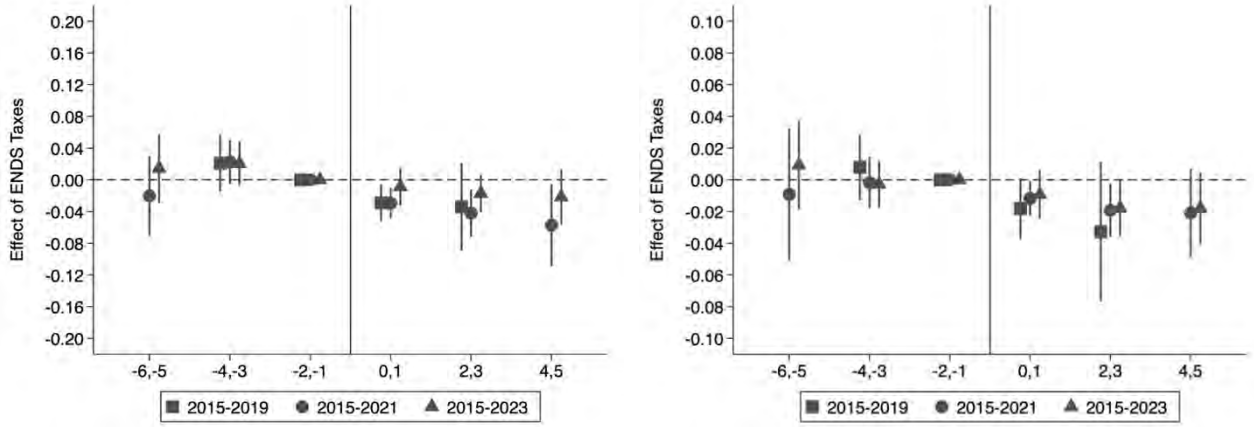
Appendix Figure 4. Event-Study Estimates of Prominent ENDS Tax Increase on Youth ENDS Use, Using Stacked DiD Estimates, YRBSS

(I) Current ENDS Use (II) Frequent ENDS Use

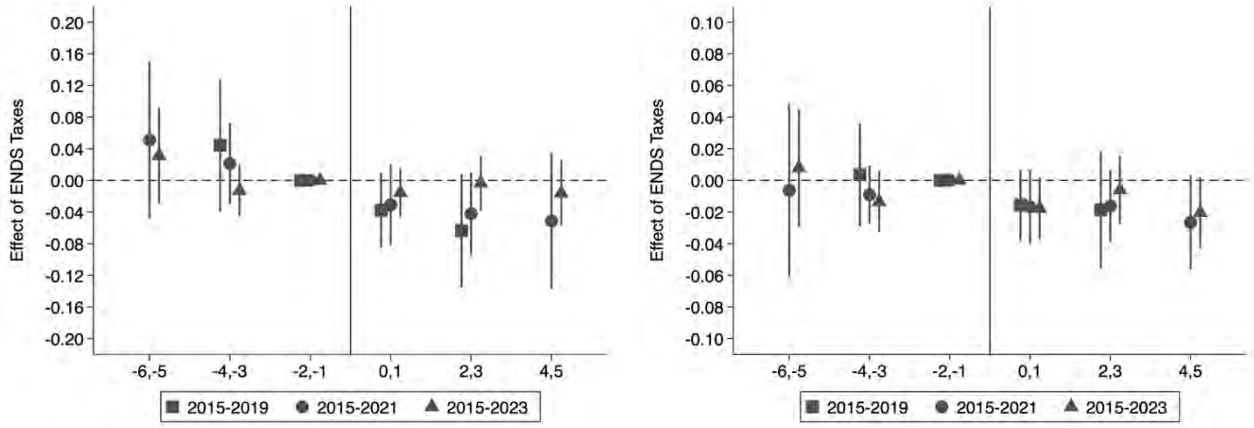
Panel (a): State YRBS



Panel (b): Combined YRBS



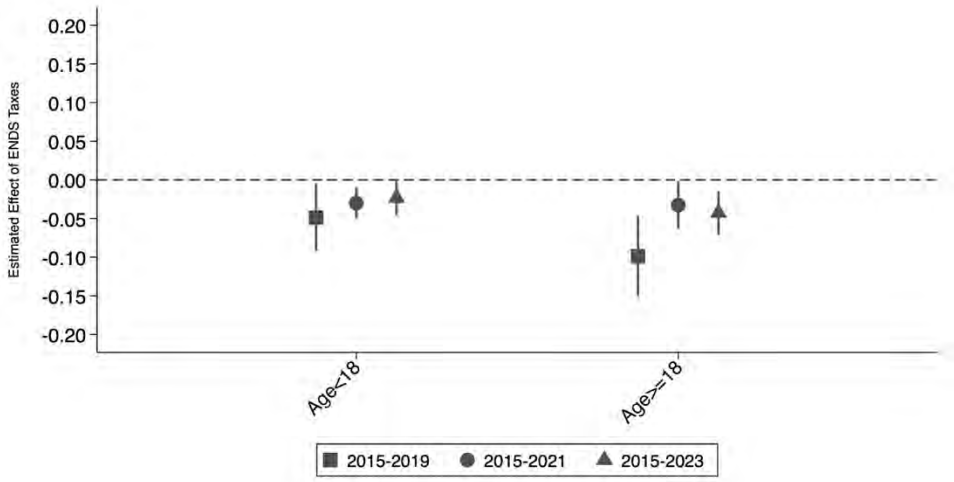
Panel (c): National YRBS



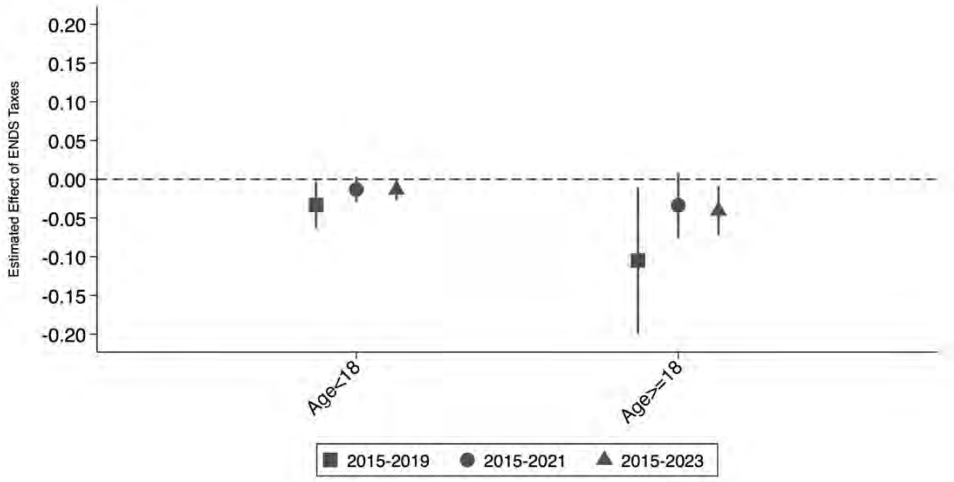
Notes: Stacked DiD estimates are obtained from event study regressions where the treatment is a prominent increase of $0.10 in ENDS Taxes ($2023) using data from the 2015-2019, 2015-2021, and 2015-2023 State, National & Combined Youth Risk Behavior Surveys. All figures include fixed effects for state, year and semester and stack cohort. Controls include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

Appendix Figure 5. Exploring Heterogeneity in the Effects of ENDS Taxes for Those Aged 18 Years or Younger, YRBSS

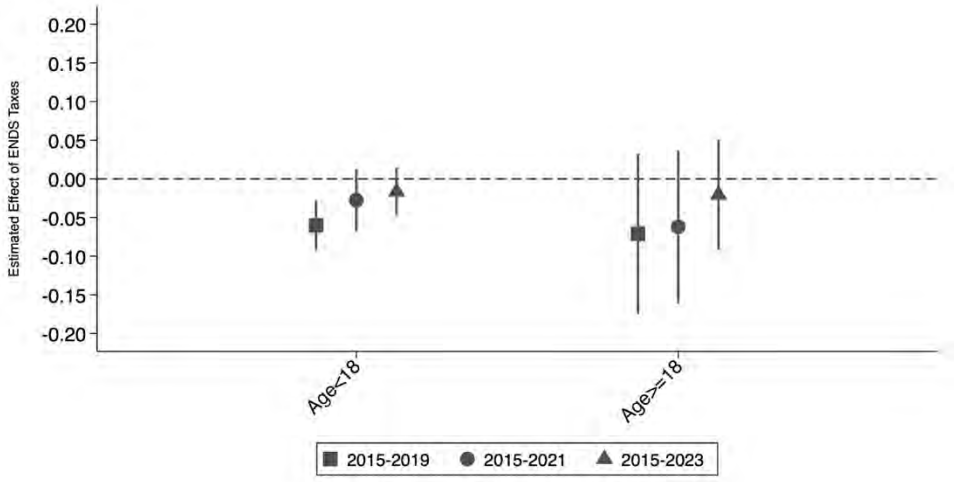
Panel (a) State YRBS



Panel (b) Combined YRBS



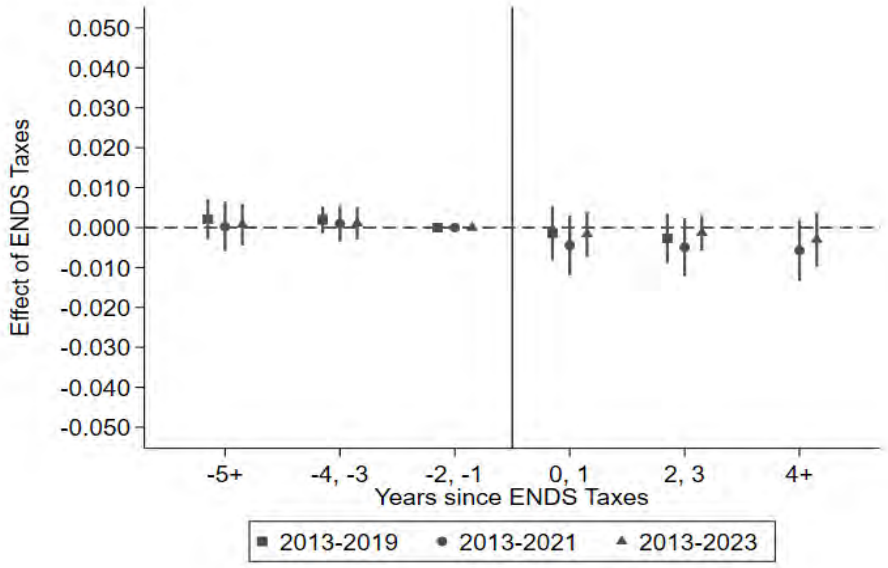
Panel (c) National YRBS



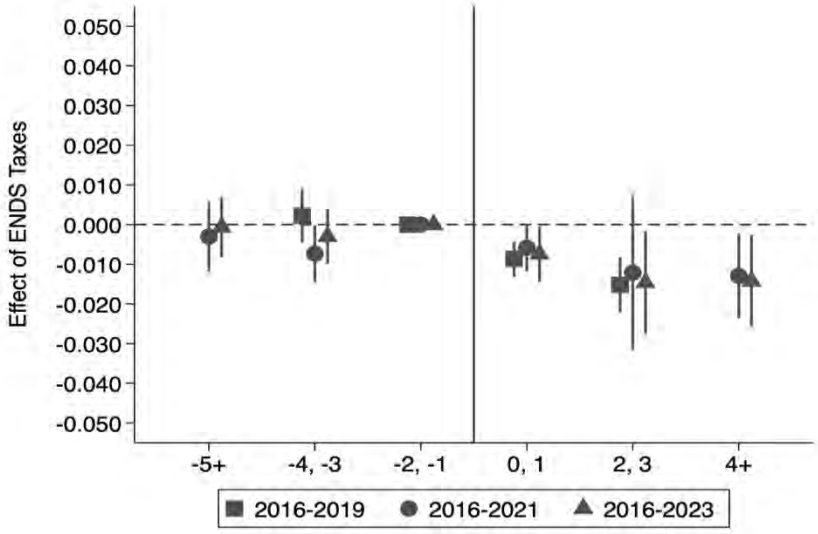
Notes: Estimates are obtained from weighted OLS regressions using data from the 2015-2019, 2015-2021, and 2015-2023 State, National & Combined Youth Risk Behavior Surveys. Coefficients are represented with geometric shapes, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. The model includes fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. All models also include controls for individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

Appendix Figure 6. Event-Study Analysis of ENDS Taxes and Frequent/Everyday ENDS Use Among Young Adults Aged 18-30, PATH and BRFSS

Panel (a) PATH

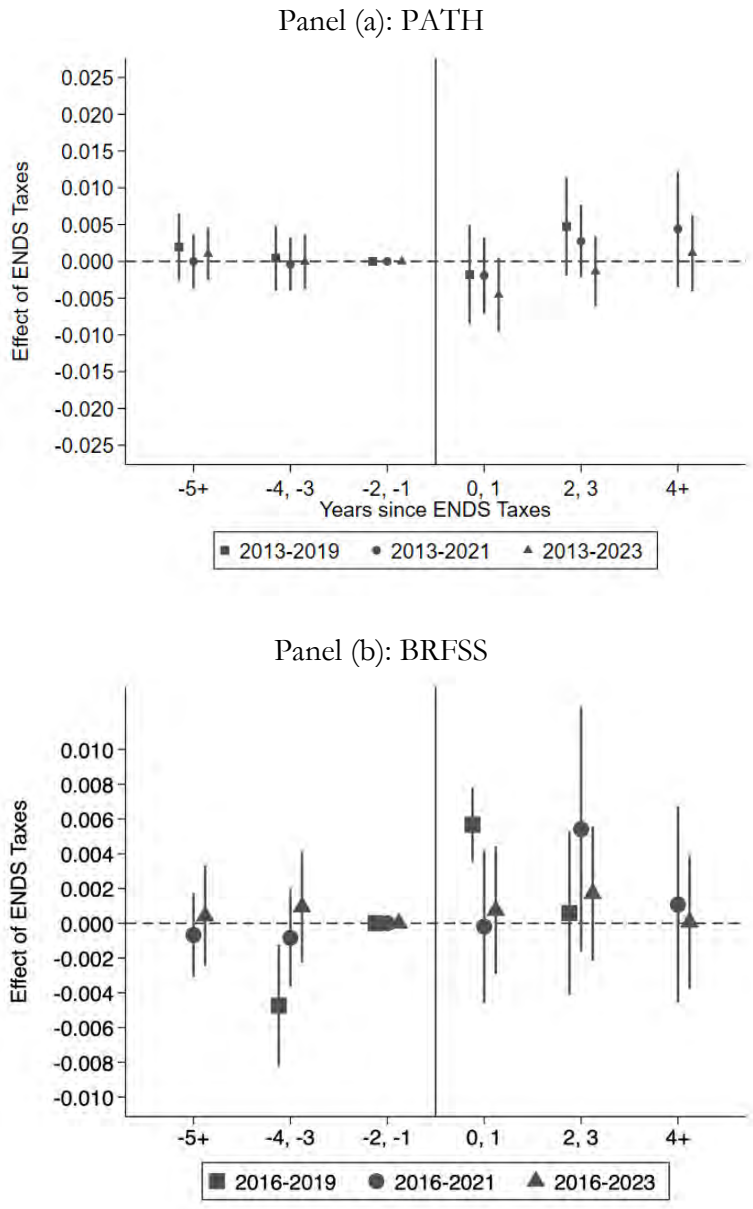


Panel (b) BRFSS



Notes: Estimates are obtained from event study regressions using data from the Population Assessment & Tobacco Health over the period 2013-2019, 2013-2021, and 2013-2023 for panel (a) and from Behavioral Risk Factor Surveillance System Surveys collected over the period 2016-2019, 2016-2021 and 2019-2023 for panel (b). We include the following controls: state, year, and quarter fixed effects, individual demographic characteristics (age, race/ethnicity, grade, and gender -only age in PATH), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). PATH estimates additionally control for individual fixed effects. Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Regressions are weighted using the sample weights provided in the dataset.

Appendix Figure 7. Event-Study Analysis of ENDS Taxes and Prior-Month Current ENDS Use Among Adults Aged 31 and Older, PATH & BRFSS



Notes: Estimates are obtained from event study regressions using data from the Population Assessment & Tobacco Health over the period 2013-2019, 2013-2021, and 2013-2023 for panel (a) and from Behavioral Risk Factor Surveillance System Surveys collected over the period 2016-2019, 2016-2021 and 2019-2023 for panel (b). We include the following controls: state, year, and quarter fixed effects, individual demographic characteristics (age, race/ethnicity, grade, and gender -only age in PATH), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). PATH estimates additionally control for individual fixed effects. Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, standard errors adjusted for clustering at the state level. Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Regressions are weighted using the sample weights provided in the dataset.

Appendix Table 1. Closed System ENDS Taxes (2023$) Across States and Years

State	Effective Date	Closed System ENDS Tax per mL Fluid, Q1-4 Average (2023 $)									
		2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
California	04/2017, 07/2017, 07/2018, 07/2019, 07/2020, 07/2021, 07/2022, 07/2023	$0.00	$0.00	$0.00	$1.49	$2.36	$2.21	$2.08	$2.05	$2.25	$2.30
Colorado	01/2021, 01/2022, 01/2023	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1.02	$1.11	$1.52
Connecticut	10/2019	$0.00	$0.00	$0.00	$0.00	$0.00	$0.12	$0.47	$0.45	$0.42	$0.40
Delaware	01/2018	$0.00	$0.00	$0.00	$0.00	$0.06	$0.06	$0.06	$0.06	$0.05	$0.05
D.C.	10/2015, 10/2016, 10/2017, 10/2018, 10/2019, 10/2021, 10/2022	$0.00	$0.65	$2.56	$2.41	$2.54	$3.43	$3.25	$3.01	$2.52	$2.40
Georgia	01/2021	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06	$0.05	$0.05
Illinois	01/2016, 04/2016, 07/2016, 01/2017, 01/2018, 01/2019, 07/2019, 01/2020, 01/2021, 01/2022, 01/2023	$0.00	$0.00	$0.41	$0.43	$0.42	$1.01	$1.28	$1.21	$1.12	$1.08
Indiana	07/2022	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.24	$0.46
Kansas	01/2017, 07/2017	$0.00	$0.00	$0.00	$0.16	$0.06	$0.06	$0.06	$0.06	$0.05	$0.05
Kentucky	07/2020, 10/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.65	$1.50	$1.39	$1.33
Louisiana	07/2015, 10/2015, 07/2023	$0.00	$0.03	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.05	$0.10
Massachusetts	04/2020, 07/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1.56	$2.56	$2.37	$2.28
Maine	01/2020, 04/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1.53	$1.46	$1.36	$1.31
Maryland	07/2015, 10/2015, 01/2016, 01/2017, 01/2018, 01/2019, 01/2020, 01/2021, 04/2021, 01/2022, 01/2023	$0.00	$0.07	$0.20	$0.20	$0.19	$0.19	$0.18	$2.15	$2.46	$2.37
Minnesota	07/2010, 10/2010, 01/2015	$1.24	$3.71	$3.66	$3.59	$3.50	$3.44	$3.40	$3.24	$3.00	$2.89
Nevada	01/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1.07	$1.02	$0.95	$0.91
New Hampshire	01/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35	$0.34	$0.31	$0.30
New Jersey	07/2018, 10/2018	$0.00	$0.00	$0.00	$0.00	$0.03	$0.12	$0.12	$0.11	$0.10	$0.10
New Mexico	07/2019	$0.00	$0.00	$0.00	$0.00	$0.00	$0.26	$0.52	$0.50	$0.46	$0.44
New York	10/2019, 01/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.08	$0.97	$0.92	$0.85	$0.82

State	Effective Date	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
North Carolina	04/2015, 07/2015	$0.00	$0.04	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.05	$0.05
Ohio	10/2019, 01/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.02	$0.12	$0.11	$0.10	$0.10
Oregon	01/2021	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2.21	$2.06	$1.97
Pennsylvania	07/2016, 10/2016	$0.00	$0.00	$0.72	$1.51	$1.47	$1.45	$1.43	$1.36	$1.26	$1.21
Utah	07/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1.00	$1.91	$1.77	$1.70
Vermont	07/2019	$0.00	$0.00	$0.00	$0.00	$0.00	$1.67	$3.29	$3.13	$2.91	$2.79
Virginia	07/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.04	$0.07	$0.07	$0.07
Washington	10/2019	$0.00	$0.00	$0.00	$0.00	$0.00	$0.08	$0.32	$0.30	$0.28	$0.27
West Virginia	07/2016	$0.00	$0.00	$0.05	$0.09	$0.09	$0.09	$0.09	$0.08	$0.08	$0.08
Wisconsin	10/2019	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.06	$0.06	$0.05	$0.05
Wyoming	07/2020	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.27	$0.51	$0.47	$0.46

Source: Standardized ENDS taxes are from Cotti et al (2023,2024).

Appendix Table 2. Open System ENDS Taxes (2023$) Across States and Years

State	Open System ENDS Tax, Q1-4 Average (2023 $)									
	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
California	$0.00	$0.00	$0.00	$0.33	$0.52	$0.49	$0.46	$0.46	$0.50	$0.51
Colorado	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.23	$0.25	$0.34
Connecticut	$0.00	$0.00	$0.00	$0.00	$0.00	$0.02	$0.08	$0.08	$0.07	$0.07
Delaware	$0.00	$0.00	$0.00	$0.00	$0.06	$0.06	$0.06	$0.06	$0.05	$0.05
District of Columbia	$0.00	$0.15	$0.57	$0.53	$0.56	$0.76	$0.72	$0.67	$0.56	$0.53
Georgia	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.05	$0.05	$0.05
Illinois	$0.00	$0.00	$0.41	$0.43	$0.42	$1.01	$1.28	$1.22	$1.12	$1.08
Indiana	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.07	$0.14
Kansas	$0.00	$0.00	$0.00	$0.16	$0.06	$0.06	$0.06	$0.06	$0.05	$0.05
Kentucky	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.05	$0.11	$0.11	$0.10
Louisiana	$0.00	$0.03	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.05	$0.10
Maine	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.34	$0.33	$0.30	$0.29
Maryland	$0.00	$0.07	$0.20	$0.20	$0.19	$0.19	$0.18	$2.16	$2.46	$2.37
Massachusetts	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35	$0.57	$0.53	$0.51
Minnesota	$0.27	$0.82	$0.81	$0.80	$0.78	$0.76	$0.75	$0.72	$0.67	$0.64
Nevada	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.24	$0.23	$0.21	$0.20
New Hampshire	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06	$0.06	$0.06	$0.05
New Jersey	$0.00	$0.00	$0.00	$0.00	$0.03	$0.11	$0.11	$0.10	$0.09	$0.09
New Mexico	$0.00	$0.00	$0.00	$0.00	$0.00	$0.05	$0.10	$0.09	$0.09	$0.08
New York	$0.00	$0.00	$0.00	$0.00	$0.00	$0.02	$0.21	$0.20	$0.19	$0.18
North Carolina	$0.00	$0.04	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.05	$0.05
Ohio	$0.00	$0.00	$0.00	$0.00	$0.00	$0.02	$0.12	$0.11	$0.10	$0.10
Oregon	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.49	$0.46	$0.44
Pennsylvania	$0.00	$0.00	$0.16	$0.34	$0.33	$0.32	$0.32	$0.30	$0.28	$0.27
Utah	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.22	$0.42	$0.39	$0.38
Vermont	$0.00	$0.00	$0.00	$0.00	$0.00	$0.37	$0.73	$0.70	$0.65	$0.62
Virginia	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.04	$0.07	$0.07	$0.07
Washington	$0.00	$0.00	$0.00	$0.00	$0.00	$0.03	$0.11	$0.10	$0.09	$0.09
West Virginia	$0.00	$0.00	$0.05	$0.09	$0.09	$0.09	$0.09	$0.08	$0.08	$0.08
Wisconsin	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.03	$0.00	$0.00	$0.00
Wyoming	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06	$0.11	$0.11	$0.10

Source: Standardized ENDS taxes are from Cotti et al (2023,2024)

Appendix Table 3. Sensitivity of Estimates in Table 1 to Using Open System ENDS Taxes and Logistic Regression, YRBSS

	(1)	(2)	(3)	(4)	(5)
	2015-2019	2015-2021	2015-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2015-2019[a]) = $\beta^{\text{ENDS Tax}}$ (2015-2023)
Panel I: Open System ENDS Taxes ($2023)					
State YRBSS	-0.0905***	-0.0302*	-0.0153	p = 0.6301	p = 0.0000***
	(0.0130)	(0.0157)	(0.0141)		
Semi-Elasticity	-44.61	-15.28	-8.03		
N	493,799	622,122	735,109		
Combined YRBSS	-0.0996***	-0.0162	-0.0102	p = 0.5103	p = 0.0001***
	(0.0231)	(0.0214)	(0.0160)		
Semi-Elasticity	-45.87	-7.79	-5.13		
N	532,952	676,563	807,753		
National YRBSS	-0.1595***	-0.0134	0.0061	p = 0.8644	p = 0.0002***
	(0.0388)	(0.0453)	(0.0261)		
Semi-Elasticity	-69.88	-6.39	3.06		
N	39,153	54,441	72,644		
Panel II: Logistic Estimator					
State YRBSS	-0.0498**	-0.0326***	-0.0269**	p = 0.5933	p = 0.2663
	(0.0206)	(0.0100)	(0.0107)		
Semi-Elasticity	-24.52	-16.53	-14.09		
N	493,799	622,122	735,109		
Combined YRBSS	-0.0451***	-0.0165*	-0.0167***	p = 0.3602	p = 0.0828*
	(0.0170)	(0.0090)	(0.0064)		
Semi-Elasticity	-20.75	-7.93	-8.38		
N	532,952	676,563	807,753		
National YRBSS	-0.0450**	-0.0240	-0.0093	p = 0.1741	p = 0.0496**
	(0.0206)	(0.0216)	(0.0161)		
Semi-Elasticity	-19.71	-11.42	-4.65		
N	39,153	54,441	72,644		

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Youth Risk Behavior Surveillance System Surveys, 2015-2023.

Notes: Estimates are generated using a TWFE ordinary least squares regression for panel I where the main variable of interest is Open ENDS taxes ($2023) and a logistic estimator for panel II where the main variable of interest is closed ENDS Taxes ($2023). Columns (1) to (3) shows the impact of ENDS taxes on current ENDS use, column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019 and column (5) shows the significance of tests of difference between the impact of ENDS taxes between 2015-2019 Vs 2015-2023. The model includes fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. Controls include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

Appendix Table 4. Estimates of the Effect of ENDS Taxes on Youth Frequent E-Cigarette Use, YRBSS

	(1)	(2)	(3)	(4)	(5)
	2015-2019	2015-2021	2015-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2015-2019) = $\beta^{\text{ENDS Tax}}$ (2015-2023)
Panel I: Baseline Controls					
State YRBSS	-0.0220***	-0.0195***	-0.0146**	p = 0.1693	p = 0.3125
	(0.0040)	(0.0047)	(0.0061)		
Semi-Elasticity	-50.55	-39.79	-28.97		
N	493,799	622,122	735,109		
Combined YRBSS	-0.0354***	-0.0106**	-0.0143***	p = 0.0792*	p = 0.0009***
	(0.0077)	(0.0043)	(0.0037)		
Semi-Elasticity	-74.30	-18.83	-24.17		
N	532,952	676,563	807,753		
National YRBSS	-0.0302***	-0.0087	-0.0049	p = 0.9874	p = 0.0142**
	(0.0082)	(0.0107)	(0.0079)		
Semi-Elasticity	-57.77	-15.22	-08.14		
N	39,153	54,441	72,644		
Panel II: Extended Controls					
State YRBSS	-0.0228***	-0.0166***	-0.0114*	p = 0.6097	p = 0.1751
	(0.0052)	(0.0039)	(0.0057)		
Semi-Elasticity	-52.23	-33.91	-22.56		
N	493,799	622,122	735,109		
Combined YRBSS	-0.0298***	-0.0118***	-0.0133***	p = 0.1020+	p = 0.0640*
	(0.0089)	(0.0038)	(0.0038)		
Semi-Elasticity	-62.63	-20.83	-22.52		
N	532,952	676,563	807,753		
National YRBSS	-0.0148	-0.0118	-0.0027	p = 0.7220	p = 0.2410
	(0.0095)	(0.0108)	(0.0084)		
Semi-Elasticity	-28.28	-20.50	-04.53		
N	39,153	54,441	72,644		

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: National and State Youth Risk Behavior Surveys, 2015-2023.

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ends taxes on frequent ENDS use, column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019 and column (5) shows the significance of tests of difference between the impact of ENDS taxes between 2015-2019 Vs 2015-2023. The model includes fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. Controls in panel I include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Controls in panel II additionally include more tobacco/ENDS policies (ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

Appendix Table 5. TWFE Estimates of the Effect of ENDS Taxes on Youth Frequent ENDS Use, MTF

	(1)	(2)	(3)	(4)	(5)
	2014-2019[a]	2014-2021	2015-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-March 2020) = $\beta^{\text{ENDS Tax}}$ (post- 2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2014-2020) = $\beta^{\text{ENDS Tax}}$ (2014-2023)
			Panel I: Baseline Controls		
MTF	-0.0154**	-0.0038	-0.0044		
	(0.0061)	(0.0064)	(0.0059)	p = 0.2030	p = 0.1020
Elasticity	-33.62	-8.12	-9.01		
N	82,755	100,927	133,913		
			Panel II: Extended Controls		
MTF	-0.0196***	-0.0047	-0.0049		
	(0.0051)	(0.0063)	(0.0056)	p = 0.3956	p = 0.0326**
Elasticity	-42.80	-10.01	-10.09		
N	82,755	100,927	133,913		

***Significant at 1% level **at 5% level *at 10% level

Source: Monitoring the Future Surveys, 2014-2023.

[a] Pre-COVID period (January 2020-March 2020) included in this sample.

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ENDS taxes on current ENDS use whereas columns (4) & (5) show the significance of tests of difference between the impact of ENDS taxes prior to March 2020 Vs post March 2020 and between 2014-2020 Vs 2014-2023. The model includes fixed effects for state, year, and quarter. Controls in panel I include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Controls in panel II additionally include more tobacco/ENDS policies (ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using the sample weights provided.

Appendix Table 6. TWFE Estimates of the Effect of ENDS Taxes on ENDS Participation Among 8th Graders, MTF

	(1)	(2)	(3)	(4)	(5)
	2014-2019[a]	2014-2021	2015-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-March 2020) = $\beta^{\text{ENDS Tax}}$ (post- 2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2014-2020) = $\beta^{\text{ENDS Tax}}$ (2014-2023)
Panel I: Baseline Controls					
MTF	-0.0294**	-0.0173*	-0.0171*		
	(0.0121)	(0.0102)	(0.0096)	p = 0.8208	p = 0.1603
Semi-Elasticity	-37.39	-23.11	-23.94		
N	33,468	43,448	57,577		
Panel II: Extended Controls					
MTF	-0.0287**	-0.0166*	-0.0141*		
	(0.0121)	(0.0095)	(0.0084)	p = 0.8727	p = 0.0695*
Semi-Elasticity	-36.44	-22.22	-19.73		
N	33,468	43,448	57,577		

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Monitoring the Future Surveys, 2014-2023.

[a] Pre-COVID period (January 2020-March 2020) included in this sample.

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ENDS taxes on current ENDS use whereas columns (4) & (5) show the significance of tests of difference between the impact of ENDS taxes prior to March 2020 Vs post March 2020 and between 2014-2020 Vs 2014-2023. The model includes fixed effects for state, year, and quarter. Controls in panel I include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Controls in panel II additionally include more tobacco/ENDS policies (ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using the sample weights provided.

Appendix Table 7. TWFE Estimates of the Effect of ENDS Taxes on Youth Frequent ENDS Use, PATH

	(1)	(2)	(3)	(4)	(5)
	2013-2019	2013-2021	2013-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2013-2019) = $\beta^{\text{ENDS Tax}}$ (2013-2023)
Panel I: Baseline Controls					
PATH	-0.0220***	-0.0156***	-0.0136***		
	(0.0074)	(0.0038)	(0.0039)	p = 0.4490	p = 0.4120
Semi-Elasticity	-122.19	-86.16	-68.90		
N	52,361	57,882	65,415		
Panel II: Extended Controls					
PATH	-0.0240***	-0.0170***	-0.0141***		
	(0.0081)	(0.0040)	(0.0039)	p = 0.4429	p = 0.3620
Semi-Elasticity	-133.28	-93.71	-71.72		
N	52,361	57,882	65,415		

Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Population Assessment of Tobacco and Health, 2013-2023.

Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ENDS taxes on frequent ENDS use whereas column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019. The model includes fixed effects for individual and state along with year and quarter. Controls in panel I include individual macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Controls in panel II additionally include more tobacco/ENDS policies (ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided.

Appendix Table 8. Discrete-Time Hazard Model Estimates of the Effect of ENDS Taxes on Youth Initiation & Cessation of Frequent ENDS Use, PATH

	(1)	(2)	(3)
	2013-2019	2013-2021	2013-2023
		Panel I: Initiation	
PATH: Baseline Non-Users	-0.0194***	-0.0129**	-0.0118**
	(0.0070)	(0.0048)	(0.0048)
Semi-Elasticity	-104.47	-70.39	-63.69
N	50354	55619	62713
		Panel II: Cessation	
PATH: Baseline Users	-0.0056	-0.1166	0.0102
	(0.4241)	(0.4054)	(0.3767)
Semi-Elasticity	-00.80	-16.76	01.55
N	234	272	398

Significant at 1% level **at 5% level *at 10% level

Source: Population Assessment of Tobacco and Health, 2013-2023.
Notes: Estimates are generated from discrete time hazard models using TWFE. Panel I shows the impact of ENDS taxes on frequent vaping initiation whereas Panel II shows the impact of ENDS taxes on frequent vaping cessation. The model includes fixed effects for individual and state along with year and quarter. Controls include individual's age, macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and per pack cigarette taxes in 2023) and alcohol and marijuana policies (beer taxes ($2023) and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided.

Appendix Table 9. Showing More Stable Effects of Effects of ENDS Taxes on Youth ENDS Participation When Restrict ENDS Users to Among High-Risk Users

	(1)	(2)	(3)
	2015-2019	2015-2021	2015-2023
ENDS Tax (2023$)	-0.0261***	-0.0203***	-0.0183**
	(0.0090)	(0.0075)	(0.0081)
Semi-Elasticity	-12.86	-10.30	-9.57
N	433,866	550,847	654,824

Significant at 1% level **at 5% level *at 10% level

Source: National and State Youth Risk Behavior Surveillance System Surveys, 2015-2023.

Notes: Estimates are generated using a TWFE ordinary least squares regression. "High-risk" current ENDS users are defined as those above the median of the first principal component (PCA Component 1) among ENDS users, constructed from frequent vaping, marijuana use, and current alcohol use. The first component always explains more than 60% of the total variation. The fixed effects regressions shown above include fixed effects for state, year, and semester/quarter. The PATH also includes controls for individual fixed effects. Additional controls include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions), and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses.

Appendix Table 10. Spillover Effects of ENDS Taxes on Binge Drinking and Marijuana Use

	(1)	(2)	(3)	**(4)**	**(5)**
	2015-2019	2015-2021	2015-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2013-2019) = $\beta^{\text{ENDS Tax}}$ (2013-2023)
Binge Drinking	-0.0224***	-0.0066	-0.0081*		
	(0.0057)	(0.0074)	(0.0045)	p = 0.0391**	p = 0.0180**
Semi-Elasticity	-16.02	-4.89	-6.25		
N	485,720	611,496	721,290		
Marijuana Use	-0.0207	-0.0159**	-0.0169**		
	(0.0129)	(0.0077)	(0.0066)	p = 0.2074	p = 0.7318
Semi-Elasticity	-10.31	-8.30	-9.03		
N	530,476	669,033	790,381		

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: National and State Youth Risk Behavior Surveillance System Surveys, 2015-2023, Monitoring the Future Surveys, 2014-2023.
Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ends taxes on current cigarette use whereas columns (4) & (5) show the significance of tests of difference between the impact of ENDS taxes prior to March 2020 Vs post March 2020 and between 2015-2020 Vs 2015-2023. The model includes fixed effects for state, year, and semester for all regressions and an indicator for whether the observation comes from state or national YRBS in Combined YRBS. Controls include individual macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and per pack cigarette taxes in 2023) and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels for combined YRBS.

Appendix Table 11. Sensitivity of Estimated Effects of ENDS Taxes on Young Adults' ENDS Participation Using Baseline Controls, BRFSS and PATH

	(1)	(2)	(3)	(4)	(5)
	2016-2019	2016-2021	2016-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2016-2019) = $\beta^{\text{ENDS Tax}}$ (2016-2023)
PATH	-0.0085	-0.0101	-0.0125		
	(0.0112)	(0.0079)	(0.0076)	p = 0.2088	p = 0.7710
Semi-Elasticity	-5.74	-6.60	-7.71		
N	70,285	85,977	101,586		
BRFSS	-0.0092***	-0.0033	-0.0079*		
	(0.0029)	(0.0037)	(0.0044)	p = 0.1832	p = 0.8616
Semi-Elasticity	-10.08	-2.77	-5.98		
N	128,704	190,630	285,118		

Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Behavioral Risk factor surveillance systems Survey, 2016-2023, Population Assessment of Tobacco and Health, 2013-2023.
Notes: TWFE estimates are generated using a weighted least squares regression. Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ends taxes on everyday ENDS use, column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019 and column (5) shows the significance of tests of difference between the impact of ENDS taxes between 2016/2013-2019 Vs 2016/2013-2023. The model includes fixed effects for state, year, and quarter. PATH estimates additionally control for individual fixed effects. Controls include individual demographic characteristics (age, race/ethnicity, grade, and gender -only age in PATH), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided in the dataset.

Appendix Table 12. Discrete-Time Hazard Model Estimates of the Effect of ENDS Taxes on Young Adults' Initiation & Cessation of ENDS Use, PATH

	(1)	(2)	(3)
	2013-2019	2013-2021	2013-2023
		Panel I: Initiation	
Baseline Non-Users	-0.0152	-0.0094	-0.0139
	(0.0115)	(0.0089)	(0.0083)
Semi-Elasticity	-18.63	-11.97	-17.64
N	53315	63622	74203
		Panel II: Cessation	
Baseline Users	0.0534	-0.0179	-0.0162
	(0.0655)	(0.0351)	(0.0318)
Semi-Elasticity	11.58	-3.98	-3.98
N	9086	10823	12517

Significant at 1% level **at 5% level *at 10% level

Source: Population Assessment of Tobacco and Health, 2013-2023.
Notes: Estimates are generated from discrete time hazard models using TWFE. Panel I shows the impact of ENDS taxes on vaping initiation whereas Panel II shows the impact of ENDS taxes on vaping cessation. The model includes fixed effects for individual and state along with year and quarter. Controls include individual's age, macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and per pack cigarette taxes in 2023) and alcohol and marijuana policies (beer taxes ($2023) and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided.

Appendix Table 13. TWFE Estimates of the Effect of ENDS Taxes on Young Adults' Everyday/Frequent ENDS Use, BRFSS and PATH

	(1)	(2)	(3)	(4)	(5)
	2016-2019	2016-2021	2016-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2016-2019) = $\beta^{\text{ENDS Tax}}$ (2016-2023)
PATH	-0.0044	-0.0062	-0.0061		
	(0.0056)	(0.0051)	(0.0044)	p = 0.9154	p = 0.4810
Semi-Elasticity	-8.51	-10.92	-9.60		
N	70,285	85,977	101,586		
BRFSS	-0.0007	-0.0000	-0.0030		
	(0.0015)	(0.0028)	(0.0025)	p = 0.5937	p = 0.3064
Semi-Elasticity	-2.24	-0.01	-5.22		
N	128,704	190,630	285,118		

***Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Behavioral Risk factor surveillance systems Survey, 2016-2023.
Notes: Estimates are generated using a TWFE ordinary least squares regression. Columns (1) to (3) shows the impact of ends taxes on everyday ENDS use, column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019 and column (5) shows the significance of tests of difference between the impact of ENDS taxes between 2016-2019 Vs 2016-2023. The model includes fixed effects for state, year, and quarter. PATH estimates additionally control for individual fixed effects. Controls include individual demographic characteristics (age, race/ethnicity, grade, and gender -only age in PATH), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and per pack cigarette taxes in 2023) and alcohol and marijuana policies (beer taxes ($2023) and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided in the dataset.

Appendix Table 14. Estimates of the Effect of ENDS Taxes on Young Adults' Initiation & Cessation of Frequent ENDS Use, PATH

	(1)	(2)	(3)
	2013-2019	2013-2021	2013-2023
		Panel I: Initiation	
Baseline Non-Users	-0.0039	-0.0058**	-0.0065**
	(0.0044)	(0.0029)	(0.0026)
Semi-Elasticity	-19.30	-26.92	-29.38
N	56110	67715	79531
		Panel II: Cessation	
Baseline Users	0.0040	-0.0096	-0.0343
	(0.1751)	(0.1256)	(0.1374)
Semi-Elasticity	0.61	-1.61	-6.43
N	3651	4265	4970

Significant at 1% level **at 5% level *at 10% level

Source: Population Assessment of Tobacco and Health, 2013-2023.
Notes: Estimates are generated from discrete time hazard models using TWFE. Panel I shows the impact of ENDS taxes on vaping initiation whereas Panel II shows the impact of ENDS taxes on vaping cessation. The model includes fixed effects for individual and state along with year and quarter. Controls include individual age, macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and per pack cigarette taxes in 2023) and alcohol and marijuana policies (beer taxes ($2023) and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided.

Appendix Table 15. Heterogeneity in the Effects of ENDS Taxes on Adult ENDS Participation by Underlying Risk and Addictive Stock, PATH

	(1)	(2)
	Adults Aged 18-30 years	Adults Over Age 30
	Panel I: ENDS Users with Lower Underlying Risk and Addictive Stock vs Non-ENDS Users	
ENDS Tax (2023$)	-0.0119	-0.0015
	(0.0088)	(0.0020)
Semi-Elasticity	-8.05	-3.40
N	63,931	82,476
	Panel II: ENDS Users with Higher Underlying Risk and Addictive Stock vs Non-ENDS Users	
ENDS Tax (2023$)	-0.0020	-0.0016
	(0.0093)	(0.0023)
Semi-Elasticity	-1.35	-3.36
N	63,557	80,020

Significant at 1% level **at 5% level *at 10% level

Source: Population Assessment of Tobacco and Health, 2013-2019.

Notes: Estimates are based on pre-COVID samples. "High-risk" current ENDS users are defined as those above the median of the first principal component (PCA Component 1) among ENDS users, constructed from frequent vaping, marijuana use, and current alcohol use. The first component always explains more than 60% of the total variation. The fixed effects regressions shown above include fixed effects for state, year, and semester/quarter. The PATH also includes controls for individual fixed effects. Additional controls include individual demographic characteristics (age, race/ethnicity, grade, and gender), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$, ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions), and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses.

Appendix Table 16. Estimates of Effects of ENDS Taxes on Current ENDS Use Among Adults Aged 31 and Older, BRFSS, PATH, CPS-TUS

	(1)	(2)	(3)	(4)	(5)
	2016-2019	2016-2021	2016-2023	p-value on $\beta^{\text{ENDS Tax}}$ (pre-2020) = $\beta^{\text{ENDS Tax}}$ (post-2020)	p-value on $\beta^{\text{ENDS Tax}}$ (2016-2019) = $\beta^{\text{ENDS Tax}}$ (2016-2023)
PATH	-0.0006	-0.0020	-0.0043*		
	(0.0026)	(0.0021)	(0.0022)	p = 0.4010	p = 0.0113**
Semi-Elasticity	-1.29	-4.67	-9.95		
N	85,610	100,415	115,590		
BRFSS	0.0056***	-0.0001	0.0008		
	(0.0009)	(0.0017)	(0.0014)	p = 0.8978	p = 0.0072***
Semi-Elasticity	18.23	-00.29	02.00		
N	993,038	1,374,816	2,054,196		
CPS-TUS	-0.0171***		0.0005		
(Age ≤ 30 years)	(0.0055)	N/A	(0.0551)	p = 0.6633	p = 0.8553
Semi-Elasticity	-43.34		0.68		
N	45,522		60,344		
CPS-TUS	0.0044**		0.0241***		
(Age>30 years)	(0.0020)	N/A	(0.0068)	p = 0.0123**	p = 0.0944*
Semi-Elasticity	25.30		137.09		
N	251,736		349,675		

Significant at 1% level **at 5% level *at 10% level +at 15% level

Source: Behavioral Risk factor surveillance systems Survey, 2016-2023, Current Population Survey-Tobacco use supplement data, 2014-2023
Notes: TWFE estimates are generated using weighted least squares regression. Columns (1) to (3) shows the impact of ends taxes on current ENDS use whereas column (4) shows the significance of tests of difference between the impact of ENDS taxes prior to 2020 Vs post 2019. The model includes fixed effects for state, year, and quarter (additionally, individual for PATH). Controls include individual demographic characteristics (age, race/ethnicity, grade, and gender – only age in PATH), macroeconomic conditions (unemployment rate, poverty rate), the COVID-19 pandemic (cumulative state COVID-19 death rate per 100,000 population and the University of Oxford Government Stringency Index), and ENDS/tobacco policy controls (minimum legal sales age for ENDS products, tobacco 21 laws, restrictions on the sales of flavored ENDS, and per pack cigarette taxes in 2023$), ENDS licensure laws, indoor vaping restrictions in schools, indoor vaping restrictions in restaurants, bars, or workplaces, indoor smoking restrictions, and alcohol and marijuana policies (beer taxes ($2023), and medical and recreational marijuana laws). Standard errors are adjusted for clustering at the state level and presented in parentheses. Regressions are weighted using sample weights provided in the dataset.