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NICOTINE VAPING AND YOUTH MENTAL HEALTH: NEW EVIDENCE FROM E-CIGARETTE REGULATIONS

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ABSTRACT

The confluence of a youth mental health crisis and high rates of teenage nicotine vaping has led some U.S. tobacco control advocates to argue that reducing access to electronic nicotine delivery systems (ENDS) — through policies such as ENDS taxation — may improve youth and young adult mental health. Using data from several nationally representative surveys (Youth Risk Behavior Survey, Behavioral Risk Factor Surveillance System, and Population Assessment of Tobacco and Health) and a generalized difference-in-differences approach, we find no evidence that ENDS taxation improves youth and young adult mental health. With 95 percent confidence, we can rule out that the mean state ENDS tax increase adopted during our analysis sample ($0.34 per mL of e-liquid in 2023$) reduces persistent depressive symptoms among youths by more than 0.3 percent and suicide ideation by more than 1.0 percent. Moreover, discrete-time hazard models provide little evidence that ENDS taxes affect dynamics in youth mental health. A similar pattern of results emerges when we examine a wider set of ENDS regulations, including minimum legal purchasing ages, e-cigarette licensure laws, online sales restrictions, and restrictions on indoor nicotine vaping.

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1. Introduction

> "Two health crises among youth — a mental health crisis and a vaping epidemic — pose increasing threats to a generation of young people. They are also linked in ways many may not realize."
>
> - Truth Initiative (2021)

There is a teenage mental health crisis in the United States (National Institute of Mental Health 2023; American Psychological Association 2023). Approximately four in ten high school students persistently feel sad or hopeless, two in ten seriously consider suicide, and among those who do, nearly half attempt suicide (CDC 2024). Eighteen percent (4.5 million persons) of those aged 12-17 experienced at least one major depressive episode in 2023 (National Survey on Drug Use and Health 2023). Suicide is the second leading cause of death among those aged 10-24 (11.0 deaths per 100,000) with suicide rates increasing by approximately 62 percent between 2007 and 2021 (CDC 2024).[1] In response, the U.S. Preventive Services Task Force (USPSTF) has recommended that all teenagers undergo regular screening for major depressive disorder (Mangione et al. 2022).

This crisis is not simply limited to youths. In 2020, 20 percent of American adults experienced a mental health disorder (MHD) and five percent experienced a serious MHD (National Alliance on Mental Illness, 2024).[2] Among adults under 40, seven percent (6.5 million persons) reported suicidal thoughts in the past year (Ivey-Stephenson 2022), and young adults aged 18-25 have a suicide rate 4.2 times higher than that of adults over age 25 (National Institute of Mental Health 2024).

The causes of declines in youth and young adult mental health have been the subject of much debate, with research exploring the roles of (1) the rise of social media (U.S. Surgeon General 2023; Bursztyn et al. 2023), (2) bullying in schools (Hansen et al. 2024; Liang et al. 2023; Rees et al. 2022), (3) substance use disorder (Dave et al. 2024; Hines et al. 2020), (4) availability of firearms (Anderson & Sabia 2018; Vitt et al. 2018), (5) the COVID-19 pandemic (Gotlib et al. 2023; CDC

[1] Historically marginalized youths, including those who identify as lesbian, gay, bisexual, transgender, and questioning (LGBTQ), have been at the forefront of the ongoing public health discussion about teens' psychological health (Chuo et al. 2025; Hastings et al. 2023; The Trevor Project 2022).

[2] Suicide is the 10th leading cause of death among adults and their suicide rates have increased continually over the last two decades, with younger adults hardest hit (National Alliance on Mental Illness, 2024; Centers for Disease Control and Prevention, 2023; Marcotte and Hansen, 2024).

2024), and (6) the lack of availability of effective mental health treatment (Conroy et al 2020).[3] However, another potential factor highlighted by tobacco control advocates is the rise of electronic nicotine delivery systems (ENDS) use among youth and young adults.

ENDS are devices in which nicotine and other ingredients, notably flavors, are heated into a vapor and inhaled (CDC 2024). ENDS were introduced to the U.S. market in late 2006 and 2007 (National Cancer Institute 2024) and marketed, in part, as a smoking cessation tool. While ENDS use may be associated with diminished respiratory and heart health (CDC 2024; Allcott & Rafkin 2021), increased access to ENDS may also allow for important harm reduction behaviors through inducing substitution away from combustible cigarettes smoking, the leading cause of preventable death among U.S. adults. Cigarette smoking is responsible for 480,000 deaths per year as well as an increased likelihood of (1) cancers of the lung, neck, and mouth; (2) heart disease; (3) severe respiratory ailments; and (4) stroke (CDC 2024).

In sharp contrast, the National Academies of Sciences, Engineering, and Medicine (2018) concludes that electronic cigarettes (e-cigarettes) cause less health-related harm than cigarettes because they contain fewer toxicants (i.e., tar and other cancer-causing agents). Surveys of tobacco experts suggest that e-cigarettes generate 5-37 percent of the harm of combustible cigarettes. Indeed, there is evidence that increased access to e-cigarettes via advertising of ENDS products (see, for example, Dave et al. [2019]) reduces the intensity and frequency of cigarette smoking.

Nonetheless, there is concern that availability of ENDS products in the U.S. may have created an "on-boarding effect" for teenagers who would have otherwise abstained from e-cigarettes and avoided cigarette smoking (Martinelli et al. 2023; CDC 2021). Moreover, some public health researchers and advocates worry that the availability of ENDS products could serve as a gateway to more harmful combustible tobacco products (CDC 2024; Antman et al. 2014).

Between 2011 and 2019, the share of U.S. high school students who vaped nicotine rose from 1.5 percent to 28.5 percent (National Youth Tobacco Survey 2023). Due in part to the COVID-19 pandemic as well as a variety of policy strategies designed to curb teenagers' access to e-cigarettes — notably, the enactment of a minimum legal purchasing age for e-cigarettes (Friedman 2015) and then for all tobacco products (Hansen et al. 2023) — e-cigarette use among high school students declined to 7.8 percent by 2024 (National Youth Tobacco Survey 2024). Still, tobacco

[3] Other notable works on the impact of these factors on mental health are Allcott et al. (2020), Twenge & Campbell (2018), Rees et al. (2022), Hawke et al. (2018), Patton et al. (2002), Rey et al. (2002), Fergusson et al. (2002), and Fergusson & Horwood (1997).

control advocates remain concerned about high rates of youth ENDS use, particularly given the availability of flavored ENDS in many jurisdictions, as well as the potential impact of ENDS use on youth psychological well-being (Truth Initiative 2024; CDC 2024; Javed et al. 2022; Khan et al. 2023; Becker et al. 2021).

The effect of nicotine consumption on youth and young adult mental health is, a priori, unclear. Nicotine use may improve psychological health, at least in the short run, by relieving stress and anxiety. The release of dopamine and serotonin triggered by nicotine use (Stolerman & Shoaib 1991; Burgdorf & Panksepp 2006; Yuan et al. 2015) may alleviate short-term acute distress and serve as a coping mechanism for anxiety (Friedman 2020). Indeed, according to the Truth Initiative's Continuous Tracking Online Survey, 81 percent of current nicotine vapers aged 15-24 report that they initiated vaping to "decrease stress, anxiety, or [pre-existing] depression" (Truth Initiative 2021b). Just over half (50.3 percent) of those who vaped nicotine on at least 20 of the prior 30 days reported that they "need to vape to cope with stress or anxiety" (Truth Initiative 2021b)[4] and those who already suffer acute MHDs also report that nicotine may alleviate psychiatric symptoms (Kumari & Postma 2005; Smith et al. 2002; Glynn & Sussman 1990).[5]

On the other hand, the presence of trace metals in many ENDS products may generate adverse health consequences (Obisesan et al 2019; Olmedo et al. 2018). Moreover, the release of dopamine and serotonin following nicotine consumption may also increase the risk of addiction (NHS Inform 2025; Yale Medicine 2019; Balfour & Ridley 2000; Piccioto et al. 2002; Quattrocki et al. 2000). Realization of one's addiction to nicotine — including difficulty in quitting and longer-run adverse health implications — could lead to reductions in users' medium- and longer-run psychological health (American Heart Association 2023; American Psychiatric Association 2023; Hanna & Grant 1998; Gruber & Köszegi 2004; Gruber & Mullainathan 2005; Newport Institute 2022; Patton et al. 1998). Additionally, youths and young adults, whose prefrontal cortexes are not fully developed (Casey et al. 2008; Steinberg 2007; Banks et al. 2007; Gongora et al. 2019; Giedd 2004; Arain et al. 2013), may be more likely to become addicted to nicotine given that (1) ENDS initiation is more common among teens and young adults relative to those over age 40 (CDC 2024; American Psychiatric Association 2023), and (2) teens may be more likely to hyperbolically discount the future health risks of current addictive behaviors (Hammond et al. 2015; Casey et al. 2011).

[4] Along the same lines, a national online survey shows that one of the most commonly reported advantages to e-cigarette use was "stress relief and relaxation" (Sangalang et al. 2019).
[5] Relatedly, restricting access to ENDS may also induce withdrawal, which could also diminish psychological health.

An emerging literature in medicine and epidemiology finds strong evidence that e-cigarette use is associated with poor psychological health among both youths (Javed et al. 2022; Khan et al. 2023; Becker et al. 2021) and adults (Taylor et al. 2023; Grant et al. 2019; Obisesan et al. 2019). However, whether this relationship is causal in nature is unclear. Two threats to identification emerge from these (largely cross-sectionally based) studies: (1) difficult-to-measure (or observe) individual-level characteristics such as personality, personal discount rates, household resources, or hereditary predisposition to addiction may be associated with both nicotine vaping decisions and with psychological well-being (MacKillop et al. 2010; Becker et al. 2021); and (2) reverse causality, whereby poorer mental health causes ENDS use.

Despite the lack of causal evidence, findings from the studies such as those described above have been used by tobacco control advocates to push for restrictions in access to ENDS products via policies such as taxation (Truth Initiative 2024a). As of February 2025, 33 states and the District of Columbia have enacted taxes on ENDS products. There is strong evidence that ENDS taxes reduce nicotine vaping among teenagers and young adults (Pesko et al. 2020; Abouk et al. 2023; Dave et al. 2024; 2025). Therefore, ENDS tax-induced declines in nicotine consumption from ENDS could impact mental health through the above channels.

However, the mental health effects of ENDS taxation may materialize not only through impacts on ENDS use, but also through general equilibrium effects. ENDS taxation may induce substitution toward combustible cigarette smoking among youths (Abouk et al. 2023; Dave et al. 2025) and young adults (Pesko et al. 2020), though the strength of this substitution may have diminished in more recent years – see, for example, Chuo et al. (2025). Such substitution to another nicotine delivery product could mitigate any net reduction in nicotine consumption and generate muted effects on mental health. On the other hand, there is emerging evidence that ENDS taxation reduces youth marijuana use (Dave et al. 2025) as well as binge drinking (Dave et al. 2024), suggestive of complementary relationships between ENDS and these substances. Given that alcohol and marijuana use may adversely affect mental health (Carpenter 2004; Fone et al. 2023; van Ours & Williams 2011; van Ours & Williams 2009; Lacruz & Lacruz 2010; Chatterji et al. 2003), reductions in vaping and alcohol use may be additional channels through which ENDS taxation could affect mental health. Finally, ENDS taxes could affect youth mental health directly through their income effects, even if net ENDS use remained largely unchanged.

This study is the first to explore how ENDS taxation — as well as a broader set of e-cigarette regulations — affects youth and young adult psychological well-being. Using data from two

nationally representative cross-sectional surveys (Youth Risk Behavior Survey [YRBS] and Behavioral Risk Factor Surveillance System [BRFSS]), we first document that while ENDS taxes reduce youth nicotine vaping, they do not have a statistically significant or economically important impact on the psychological health of teenagers. With 95 percent confidence, we can rule out that a $0.34 increase in ENDS taxes — the average increase that we observe in our data — reduces persistent depressive symptoms among U.S. high school students by more than 0.3 percent and reduces suicide ideation by more than 1.0 percent. For young adults, the evidence is mixed but vary from largely null effects to only small impacts that are sensitive to model specification.

Next, we turn to data from the Population Assessment of Tobacco and Health (PATH), an individual-level longitudinal survey that allows us to explore whether the net mental health effects of ENDS taxes mask important dynamics. Estimates from individual fixed effects models as well as discrete time hazard models provide no support for the hypothesis that ENDS tax increases decrease the onset of or increase the cessation of mental health conditions despite impacting youth vaping. Consistent with findings from the BRFSS, we find only weak evidence that ENDS taxes affect young adult mental health, but this result is also sensitive to model specification.

When we extend our analysis to cover a wider set of ENDS regulations, we uncover little additional evidence that ENDS-specific minimum legal purchase ages, Tobacco-21 (T-21) laws, ENDS licensure laws, clean indoor vaping laws, or online sales bans impact youth or young adult mental health. Similar to taxes, while there is some evidence that ENDS flavor restrictions are related to small improvements in youth and young adult psychological health, these findings are sensitive to model specification and may not be causal in nature given an evaluation of event-studies.

Our study's main finding — that restrictive ENDS regulations have little effect on youth and young adult mental health — is consistent with several hypotheses. First, it may be that prior estimates of a positive association between e-cigarette use and adverse mental health are contaminated by selection on unobservables and/or reverse causality. Additionally, general equilibrium effects of ENDS regulations — such as spillovers to drinking, substance use, and combustible cigarettes — may mitigate any beneficial mental health effects of reducing ENDS use. For example, both ENDS and cigarettes contain nicotine, thus ENDS-tax induced substitution from vaping to smoking may not lead to a meaningful change in nicotine intake. Finally, nicotine vaping *may* adversely impact mental health among some persons, but not among those whose ENDS use is affected by ENDS regulations.

2. Background

2.1 U.S. Mental Health Crisis

Nearly one-quarter (23 percent) of U.S. adults, or 59.3 million persons, have a mental health disorder (National Institute of Mental Health 2024). Of these, only about half receive any treatment each year. The prevalence of mental health disorder is higher among young adults aged 18-25 (36 percent) and adolescents aged 13-18 (49.5 percent) (National Institute of Mental Health 2024, National Alliance on Mental Illness 2024). About half of all MHDs emerge by age 14, with over three-quarters developing before age 24 (National Alliance on Mental Illness 2024).

Approximately 11 percent of adults with a MHD lack health insurance, limiting their access to care (National Alliance on Mental Illness 2024). Untreated serious MHDs have been estimated to generate annual earnings losses of over $193 billion in the United States alone, while depression and anxiety disorders cost the global economy more than a trillion dollars each year (National Alliance on Mental Illness 2024).

There are also important health and labor market effects of mental illness. Those with depression face a higher risk of developing cardiovascular conditions, while one in three adults with a MHD also has a substance use disorder (National Alliance on Mental Illness 2024). Labor market effects of MHD are also stark: adults with MHDs experience unemployment at twice the rate of their peers (National Alliance on Mental Illness 2024) and high school students with MHDs are twice as likely to drop out of school (National Alliance on Mental Illness 2024).

2.2 Smoking and Psychological Health

A large epidemiological and medical literature has studied the association between cigarette smoking and psychological health (Taylor et al. 2014). Most studies have relied on cross-sectional data and find that cigarette smoking is negatively related to youth and adult mental health (Chang et al. 2005; Mino et al. 2001; Jorm et al. 1999; Lawrence et al. 2013). Mental health disorders such as anxiety and depression are also more common among smokers than non-smokers (Steinberg et al. 2015; Cook et al. 2014; Minichino et al. 2013; Smith et al. 2014). However, whether these cross-sectional associations should be causally interpreted is unclear given that (1) psychological well-being could influence smoking decisions (Friedman 2020), and (2) difficult-to-measure characteristics of persons who smoke — such as discount rates, prior family trauma, and personality — could be correlated with both cigarette smoking decisions and mental health.

To address the endogeneity of smoking decisions, three approaches have been taken in the literature: (1) using longitudinal data to address the temporal ordering of smoking and mental health, (2) using changes in cigarette taxes, and (3) randomized control trials (RCTs). With respect to the first approach, Steuber & Danner (2006) use the National Longitudinal Study of Adolescent Health (Add Health) and examined four groups: (1) smoking starters, those who reported not being smokers in the first wave of data collection, but who were smokers by the second wave; (2) never smokers, those who did not smoke in either wave; (3) always smokers, those who smoked in both waves; and (4) quitters, those who were smokers in the initial wave and non-smokers in the second wave. The authors find that the smoking starters, the always smokers, *and the quitters* were 1.5, 2.0 and 1.4 times more likely to feel depressed in the follow up period compared to the never smokers.

With respect to the second approach, Plurphanswat et al. (2017) use instrumental variables to overcome the endogeneity of cigarette smoking. Pooling repeated cross-sectional data from the 2000-2010 BRFSS and a two-way fixed effects (TWFE) instrumental variable approach — using (within-state variation in) cigarette taxes as an instrument for cigarette smoking — they find that cigarette smoking increases the number of prior-month poor mental health days among adults aged 18-64 by 1.86.[6] Gruber and Mullainathan (2005) use TWFE regressions and show that happiness among smokers increases following a cigarette tax hike.[7] The authors argue that happiness captures aspects of mental well-being along with other factors.

Finally, a few studies have used RCTs to estimate the effect of randomly assigning smokers to smoking cessation treatments on mental health metrics. Meckel and Rittenhouse (2022) use data from the Lung Health Study, a trial aimed at increasing smoking cessation among participants. Smokers were assigned to one of three groups: two intervention groups ("SI-A" and "SI-P") and a control group. Both intervention groups took part in a rigorous 12-week smoking cessation program, received complimentary nicotine gum, and had regular support from assigned personnel. One of the intervention groups (SI-A) was randomly selected to use an inhaled bronchodilator (Atrovent) with a prescribed dosage of three times daily, intended to slow lung function decline in individuals at high risk for COPD. The other intervention group (SI-P) was given a placebo. Meckel

[6] Instrumental variable approaches have also been used to attempt to identify the effect of mental health on smoking behavior. For instance, Yang & Zikos (2023) use data from the Household Income and Labour Dynamics of Australia (HILDA) survey over the years 2002 to 2017 and address the endogeneity of mental health by instrumenting mental health with the death of a close friend. They find that better mental health leads to a reduction in cigarette smoking.
[7] The authors also use taxes to instrument for respondent smoking in an appendix and the results are similar.

and Rittenhouse (2022) find that each intervention is successful in increasing smoking cessation.[8] Their findings on psychological health differ somewhat with respect to the short- and longer-run.[9] One year following treatment, those assigned to treatment (SI-A or SI-P) experience *worse* mental health. Meckel and Rittenhouse (2022) report that relative to the control group, treated individuals experience an 11 percent increase in any mental distress, an eight percent increase in mild distress scale, and a 12 percent increase in moderate distress scale relative to the control group by 11, 8 and 12 percent respectively in the short-term (one year post treatment). However, in the longer-run, the differences in mental health between treatment and control groups diminish substantially.[10]

On the other hand, Baker et al. (2018) conduct a RCT aimed at smoking cessation among smokers with pre-existing serious psychotic disorders such as schizophrenia or bipolar disorder. They randomized participants to receive either (1) a healthy lifestyles intervention (16 face-to-face 1-hour counselling sessions delivered over nine months), or (2) a minimal telephone-delivered intervention comprising of 14 ten-minute phone calls and two face-to-face 30-minute sessions, in addition to the base nicotine replacement therapy aimed at smoking cessation among both groups. They find that the healthy lifestyles intervention does not have a statistically significant impact on smoking cessation or mental health relative to the telephone-based intervention.[11]

2.3 Nicotine Vaping and Mental Health

While newer, the literature on nicotine vaping and mental health is also well-developed in epidemiology and medicine. A handful of studies evaluate the relationship between vaping and mental health among adults (Xie et al. 2022; Grant et al. 2019), and most focus on adolescents and

[8] Each intervention (SI-A and SI-P) generates a 27-28 percentage point increase in smoking cessation probability, reduced daily cigarette consumption by 11-12 cigarettes, and lowered body carbon monoxide (CO) levels by eight parts per million (ppm) within the first year. After five years, the likelihood of smoking cessation in the intervention groups remains 21 percentage points higher than the control group, with cigarette consumption dropping by nine per day and CO levels decreasing by 6-7 ppm. No significant difference is observed between the two intervention groups, indicating that access to a bronchodilator has minimal impact.

[9] The authors create a primary mental health outcome, *distress scale*, by summing responses that varies from 0 "Not at all" to 3 "Severe" for the mental state of the respondents in the following medical conditions: irritability, insomnia, mood changes, nervousness and psychological illnesses. To examine the heterogeneous treatment effect based on the margin of the distress scale, they create additional outcome variables – mild distress scale, defined as the proportion of mental health conditions for which respondents indicate either mild, moderate or severe levels of distress, or moderate distress scale, defined as the share of mental health conditions for which the respondents indicate moderate to severe levels of distress.

[10] Only for the mild distress scale do the authors see a significant reduction of six percent relative to the control group (while the participants also show declines in overall distress scale and the moderate distress scales, these are not statistically significant.)

[11] Longitudinally, Baker et al. (2018) find that those assigned to either of the treatment experience a decline in depressive symptoms 1-3 years following treatment.

young adults. Truong and Cotton (2023) conduct a comprehensive literature review on the association between youth e-cigarette use and mental health, as measured by depressive symptoms, stress, anxiety, and suicide-related behaviors. Most of these studies rely on cross-sectional identification approaches that fail to account for the endogeneity of vaping. These studies find strong evidence that nicotine vaping is positively related to depressive symptoms among youths (see, for example, Clendennen et al., 2023, Jacobs et al., 2023, Baiden et al., 2022, Cambron, 2022, Gorfinkel et al., 2022, Patanavanich et al., 2022, and Sumbe et al., 2022). Baiden et al. (2022) use YRBS data and find that prior-month youth ENDS users had a 1.5 to 1.8 higher odds of persistent depressive symptoms or suicide ideation than non-users.

There is also evidence that e-cigarette users are more likely to report anxiety, attention deficit hyperactivity disorder (ADHD), and post-traumatic stress disorder (PTSD) than non-vapers (Grant et al. 2019). Pham et al. (2020) use data from the Canadian Health Survey and find that e-cigarette usage among youth and adults is associated with adverse mental health outcomes, including increased odds of experiencing mood disorders, anxiety disorders, poor perceived mental health, elevated depressive symptoms, and serious suicide thoughts and suicide attempts.

Other studies have used longitudinal data that allow one to explore whether mental health outcomes change among those who were initially non-users of e-cigarettes (or cigarettes). Lechner et al. (2017) utilize data from a longitudinal survey with a 6-and 12- month follow up measuring mental health outcomes and substance use among high school students in the Los Angeles, California metropolitan area over the years 2013 and 2014. They use adolescents reporting having never smoked a cigarette nor used an e-cigarette in the initial assessment as their analysis sample. The authors find sustained e-cigarette use (e-cigarette use at both follow up waves) is associated with a higher increase in depressive symptoms over time.

Finally, a working paper by Qiu & Sung (2024) explores the relationship between T-21 laws — which raise the minimum legal purchasing age for all tobacco products to 21 — and mental health of young adults aged 18-20. They find that the adoption of T-21 laws reduces reports of frequent mental distress[12,] among teens by 2.1 percentage points (Qiu and Sung 2024).[13] However,

[12] Frequent mental distress is defined by Qiu & Sung (2024) as experiencing more than 14 days of poor mental health days in the past month.

[13] Cobar (2024) explores a similar question but conditions the sample on different types of tobacco users (current smokers, former smokers, quitters, and never smokers) and explores the relationship between T-21 laws and mental health among these four types. Cobar finds that T-21 laws are associated with a 51.7 percent decline in the probability of reporting more than seven days of poor mental health in the last month among recent quitters (quit in the past 30 days). Given that T-21 laws could impact the likelihood of being a recent quitter, the interpretation of this result is not clear.

the extent to which T-21 laws reduce vaping is not clear. While some work shows that adoption of a T-21 law reduces self-reported vaping among youth (e.g., Hanson et al. 2023), a recent study demonstrates that there is no change in biomarkers for recent nicotine or tobacco exposure (Cotti et al. 2024). If there is no change in vaping following adoption of a T-21 law, how best to interpret the documented reduction in mental distress reported by Qui & Sung (2024) is not entirely clear.

2.4 Contributions

We make four important contributions to the literature on nicotine vaping and mental health. This study is the first to estimate the impact of ENDS taxation, a plausibly exogenous negative shock to ENDS access and a popular policy tool recommended by tobacco control advocates to curb nicotine vaping (Truth Initiative 2024; CDC 2024; Javed et al. 2022; Khan et al. 2023; Becker et al. 2021), on youth and young adult mental health. Moreover, while our primary focus is on ENDS taxes given strong evidence of "first-stage" effects, we also explore how an additional set of ENDS regulations — including minimum legal purchasing age laws for ENDS, T-21 laws, ENDS licensure laws, clean indoor vaping laws, restrictions on the sales of flavored ENDS, and bans on the delivery of ENDS products purchased online[14] — impacts youth and young adult mental health. This approach will also allow us to explore whether policy environments characterized by intensive (multiple) anti-ENDS regulations are more effective. Second, this study is the first to use nationally representative longitudinal data to test the effects of ENDS taxes on mental health outcomes, and incorporate individual fixed effects and hazard models in estimating these relationships. Individual fixed effects arguably allow us to better control for omitted variables and hazard models provide an opportunity to examine the effects of ENDS taxes on dynamics in youth and young adult mental health (e.g., the onset of mental health problems as well as the cessation of such problems). Third, we explore heterogeneity in the psychological effects of ENDS regulations among historically marginalized demographic groups with higher propensities for poor psychological health.

[14] By 2016, every U.S. state and the District of Columbia had established a minimum legal sales age (MLSA) of at least 18, and in December 2019, the federal government raised the nationwide purchasing age for all tobacco products — including ENDS, combustible tobacco, and smokeless tobacco — to 21. Prior to the federal T-21 law taking effect on December 20, 2019, a total of 19 states, along with Washington, D.C., and two U.S. territories, had already implemented their own T-21 laws, with 13 of them doing so in 2019. As of 2024, 20 states and the District of Columbia had expanded clean indoor air laws to cover ENDS (Centers for Disease Control and Prevention, 2024), eight states had implemented flavor bans targeting ENDS (Truth Initiative 2024b), and 36 states plus the District of Columbia required state licenses in order to sell ENDS products over the counter (Centers for Disease Control and Prevention, 2024).

3. Data

To measure the impact of ENDS taxes on mental health outcomes, we utilize multiple datasets, including data spanning the State and National YRBS, BRFSS, and PATH. Each survey has advantages and disadvantages that complement the other, which we detail below.

3.1 YRBS

We begin by using repeated cross-sectional data from the State and National YRBS spanning the period 2003-2023. Coordinated by the CDC, the YRBS is a school-based biennial survey administered to U.S. high school students attending grades 9 through 12. When appropriately weighted, these surveys can be made representative of 14-18-year-olds at both the state and national levels.[15] We use the combined State and National surveys to maximize identifying policy variation, but also present estimates where we separately analyze the State and National YRBS Surveys.

For the purposes of our study, the YRBS data are useful because they include information on teenagers' prior month ENDS use, several measures of mental health outcomes, and other risky health behaviors that could be impacted by spillover effects of ENDS regulations, including alcohol, marijuana, and harder drug use. One limitation is that while we have data on mental health over the full 2003-2023 period, we only have data on ENDS use beginning in the 2015 wave and continuing through 2023. Thus, we also conduct sensitivity analysis on our mental health outcomes using the sample period for which we have non-missing information on ENDS use.

To measure youth ENDS use, we use responses to the following questionnaire items:

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

[15] The CDC recommends not combining the state and national YRBS surveys because the provided sample weights should not be combined. We do not combine sample weights, but rather construct sample weights to make the sample demographically representative of 14-18-year-olds using information on individual-level demographic characteristics race/ethnicity, gender, and age at the state and national levels. Adjusted population weights are generated from the Surveillance Epidemiology and End Results Program (http://seer.cancer.gov/popdata/). We calculate the state-by-year share of the youth population that falls in each age-by-gender-by-race/ethnicity bin *i*, s_{ist} (age 12-14, age 15, age 16, age 17, age 18, male, female, non-Hispanic White, non-Hispanic Black, Hispanic, and other race/ethnicity). We then calculate each respondent's sample weight as $[s_{ist}/n_{ist}]$*StatePop14_18$_{st}$, where n_{ist} is the number of YRBS sampled individuals in age-by-gender-by-race-ethnicity bin *i* in state *s* at year *t* and StatePop14_18$_{st}$ is the SEER estimated population of 14-to-18-year-olds in state *s* at year *t*. In this construction, we are following the recent literature that applies similar SEER-constructed weights in analyses of the combined YRBS data -- see for example, Sabia & Anderson (2016), Abouk et al. (2023), Cotti et al. (2024), and Matsuzawa et al. (2020).

[Examples: electronic vapor product includes e-cigarettes, vapes, vape pens, e-cigars, e-hookahs, hookah pens, and mods (such as JuuL, SMOK, Suorin, Vuse, and blu)]

If the respondent reports using an ENDS product at least once in the prior 30 days, we create an indicator variable, *Current ENDS Use*, that is set as one; it is set equal to zero otherwise. Over the 2015-2023 period, we find that 19.8 percent of youth vape nicotine (see Appendix Table 1A).

In addition to measuring any ENDS use in the last month, we also generate measures of more habitual ENDS use. Specifically, the variable *Frequent ENDS Use* is set equal to one if the respondent reported using an ENDS product on at least 20 of the past 30 days, and zero otherwise. *Everyday ENDS Use* is set to one for those who responded as having used ENDS products on all 30 of the past 30 days and 0 otherwise. Over the 2015-2023 period, we find that 6.0 percent of youth report frequent ENDS use, and 4.3 percent report daily use.

We then turn to measures of youth psychological wellbeing. First, respondents are asked:

"During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities??"

Persistent Depressive Symptoms is set as one if the youth answers "yes" and is set equal to zero otherwise. We find that 31.2 percent of respondents report persistent sadness or hopelessness in the prior year. In addition, we measure youth suicidality using responses to the following survey items:

"During the past 12 months, did you ever seriously consider attempting suicide?"
"During the past 12 months, did you make a plan about how you would attempt suicide?"
"During the past 12 months, how many times did you actually attempt suicide?"

Using responses to the above items, we generate three dichotomous outcome variables: *Suicide Ideation*, *Suicide Plan*, and *Suicide Attempt*. The first two items are set equal to one if the respondent replied "yes" and is set equal to zero if they answered "no." The final item is set equal to one if the respondent reported a suicide attempt in the prior 12 months and zero otherwise. We find that 16.7 percent of youths in our sample reported seriously considering suicide, 13.8 percent report a suicide plan, and 8.5 percent report a suicide attempt (see Appendix Table 1A).

Finally, we generate the variable *Suicide Injury* using responses to the following item:

> "If you attempted suicide during the past 12 months, did any attempt result in an injury, poisoning, or overdose that had to be treated by a doctor or nurse?"

If the respondent reported that "yes," they had experienced an injury, poisoning, or overdose requiring treatment by a healthcare professional, we set *Suicide Injury* equal to one; it is set equal to zero if the response to the item was "no" or the respondent indicated that they "did not attempt suicide." We find that 2.3 percent of teens reported a suicide injury.

Finally, we generate a composite *Any Adverse Mental Health* variable, which is set equal to one if *Persistent Depressive Symptoms, Suicide Ideation, Suicide Plan, Suicide Attempt*, or *Suicide Injury* is equal to one. *Adverse Mental Health* is set equal to zero if each variable is equal to zero. We find that 36.8 percent of youth experienced a mental health problem in the prior year (Appendix Table 1A).

3.2 BRFSS

To measure the mental health of adults (including young adults), we supplement our analysis of YRBS data with repeated cross-sectional data from the BRFSS. The BRFSS is a nationally representative telephone survey that, when weighted, is designed to be representative of health outcomes and behaviors of adults aged 18 and older. Our analysis focuses on those aged 18-24, 25-34, and 35-80. Stratifying the data in this manner will allow us to explore heterogeneity in the effects of ENDS taxes by age. We focus our BRFSS analysis on the period 2011-2023. Through 2010, the BRFSS was conducted using only landlines, but following this, cell phones (including smartphones) were also included. Thus, following CDC recommendations, we focus our analysis on a consistent representative sample of adults that include adults contacted via cell phones.

Information on ENDS use in the BRFSS survey is available for the period 2016-2023. Respondents 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?"

Current ENDS Use, that is set to one if the respondent reported using ENDS every day or on some days; it is set equal to zero otherwise. *Everyday ENDS Use* is set to one if the respondents answered

using e-cigarettes daily and zero otherwise. We find that 15.5 (6.8) percent of 18-24-year-olds were current (everyday) ENDS users, 10.5 (4.7) percent of 25-34-year-olds were current (everyday) ENDS users, and 3.7 (1.5) percent of 35-80-year-olds were current (everyday) ENDS users (Appendix Table 1B).

The BRFSS is more limited in terms of mental health measures as compared to the YRBS. We use responses to the following questionnaire item to generate our mental health outcomes:

> "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?"

First, we create a measure of *Any Poor Mental Health Days*, set equal to one if the respondent reported 1-30 days of prior month mental health problems and zero otherwise. We find that 50.7 percent of adults aged 18-24, 43.0 percent of 25–34-year-olds, and 32.1 percent of 35–80-year-olds report a positive number of poor mental health days in the last month.

Next, we generate continuous unconditional and conditional (*Any Poor Mental Health Days* > 0) measures of *Number of Poor Mental Health Days*. The unconditional (conditional) number of days in poor mental health is 5.0 (9.9), 4.4 (10. 3), and 3.6 (11.2) among adults aged 18-24, 25–34, and 35–80-years. Finally, we generate a measure of *Persistent Adverse Mental Health*, set equal to one if the respondent reported poor mental health days on all 30 days of the last month and zero otherwise. We find 5.6 percent of 18–24-year-olds, 5.9 percent of 25–34-year-olds, and 5.6 percent of 35–80-year-olds report experiencing *persistent adverse mental health* (Appendix Table 1B).

3.3 PATH

Finally, we use data on youth ages 14 to 17 and young adults ages 18 to 24 from the 2013-2023 PATH (U.S. Department of Health and Human Services, 2023). PATH data are a collaboration between the National Institutes of Health (NIH) and the Food and Drug Administration, and include detailed information about tobacco product use for both youth and adults as well as information on mental health issues. While PATH have a smaller sample size than YRBS and BRFSS, PATH data are valuable for our study as these data are longitudinal and allow us to track respondents over time, permitting us to study ENDS use and mental health transitions.

To measure vaping, we first create an indicator variable parallel to those we construct in YRBS and BRFSS measuring whether individuals report ENDS use in the past 30 days (*Current*

ENDS Use). We then expand this variable to measure vaping transitions, which we define as follows: (1) vaping initiation – not reporting vaping in *t-1* and reporting vaping in *t*, and (2) vaping cessation – reporting vaping in *t-1* and not reporting vaping in *t*.

To measure mental health of youth and young adults, we rely on PATH included questions adapted from the Global Appraisal of Individual Needs Short Screener (GAIN-SS) (Dennis et al. 2006). The PATH include four questions designed to detect internalizing disorders, five questions about externalizing disorders, and two questions from an additional dimension of hyperactivity disorders. The GAIN-SS questions in PATH comprise the following:

> Last time you had significant problems with:
>
> 1. Feeling very trapped, lonely, sad, blue, depressed or hopeless about the future.
> 2. Sleep trouble - such as bad dreams, sleeping restlessly or falling asleep during the day.
> 3. Feeling very anxious, nervous, tense, scared, panicked or like something bad was going to happen.
> 4. Becoming very distressed and upset when something reminded you of the past.
> 5. Lied or conned to get things you wanted or to avoid having to do something.
>
> Last time you did the following two or more times:
>
> 6. Had a hard time paying attention at school, work or home.
> 7. Had a hard time listening to instructions at school, work, or home.
> 8. Were a bully or threatened other people.
> 9. Started physical fights with other people.
> 10. Felt restless or the need to run around or climb on things.
> 11. Gave answers before the other person finished asking the question.

We first use the responses to each item to generate indicator variables measuring whether the respondent reported the problems or behaviors *within the past two weeks*. We adapt previous work using the GAIN data in PATH (e.g., Conway et al. 2017) to construct three indices by summing up different subsets of questions. The *Comprehensive Mental Health Index* is generated as the sum of each of the 11 indicator variables (which ranges from zero to 11). The Mental Health Index is generated as the sum of the indicators from items (1) through (4) (with the index ranging from zero to four), which follow questions in GAIN question measuring "internalizing disorders" (Conway et al. 2017; Dennis et al. 2006). Finally, the ADHD Index is generated by summing up the indicator variables for questions (6), (7), (10), and (11) (with the index ranging from zero to four). These questions comprise a subset of the "externalizing disorders" along with the two added questions from the "hyperactivity module" (Conway et al. 2017; Dennis et al. 2006).

Appendix Table 1C shows summary statistics from the PATH sample. About five percent of youth respondents report current ENDS use across all waves, while nearly 18 percent of young adults report ENDS use. The average count of mental health issues across all 11 dimensions is 2.7 for youth and 2.1 for young adults, while on average both youth and young adults report about one mental health condition in the mental health and ADHD categories.

3.4 ENDS Regulations

Our primary policy variable of interest is the ENDS tax (in 2023$) per milliliter (mL) of e-liquid equivalent using the state-by-quarter measure generated by Cotti et al. (2023).[16] These authors use NielsenIQ retail scanner data on e-cigarette prices and, assuming a 35 percent retailer markup, convert ad valorem and sales taxes to their equivalent value of excise tax per milliliter of e-liquid.

Our analysis uses the tax rate for "closed system" products (e.g., pre-filled cartridges such as those manufactured by JUUL) because they are far more commonly used among youths than "open system" ENDS products (e.g., non-pe-filled e-cigarettes) (Gardener et al. 2022). [17] However, our findings using "open system" taxes are very similar and available upon request.[18]

Minnesota was the first state to enact an ENDS tax in 2010 of $1.24 (in $2023) per mL of e-liquid. In 2015, three additional states (Louisiana, Maryland, and North Carolina) and the District of Columbia adopted ENDS taxes. Between 2016 and 2023, 28 additional states adopted ENDS taxes. As of 2023 (which is the last year observed in our analysis), California, Massachusetts, Maryland, Minnesota, Vermont, and District of Columbia had some of the highest levels of taxes at each above $2 per mL of e-liquid, whereas, Delaware, Georgia, Kansas, North Carolina, and Wisconsin were tied for the lowest tax rate of $0.05 per mL of e-liquid. Appendix Figure 1 and Appendix Table 2 document geographic, temporal, and intensity (variation) in our tax variable over the sample period.

While ENDS taxes are our primary policy of interest because of the prior literature showing strong evidence that such taxes reduce youth and young adult ENDS use (Dave et al. 2024, 2025; Abouk et al. 2023), we also explore other regulations that restrict access to ENDS, including

[16] While 17 states and the District of Columbia imposed ad valorem taxes based on percentage of wholesale/retail value, 9 imposed an excise tax per mL of e-liquid irrespective of the type of ENDS products. Seven states have a hybrid model utilizing a combination of ad valorem taxes for open systems and excise tax per mL of e-liquid for closed ENDS products Except Nebraska, which utilizes tax rates of $0.05 per mL if the e-liquid is less than or equal to three mL and 10 percent of retail value if the e-liquid is greater than 3 mL irrespective of the type of ENDS product.

[17] The prevalence among youth of using closed ENDS products to open ENDS products is approximately 2:1. (Gardner et. al. 2022).

[18] There are primarily two types of ENDS products. Open systems are ENDS products that are refillable giving customers more control over quantity of nicotine and flavors whereas closed systems are pre-filled disposable cartridges.

restrictions on the sales of flavored ENDS (Cotti et al. 2024; Saffer et al. 2024), T-21 laws (Hansen et al. 2023; Friedman et al. 2020), minimum legal sales ages for ENDS products of 18 (Friedman 2015; Abouk & Adams 2017), bans on the delivery of ENDS products purchased online, and e-cigarette retail licensure laws (Courtemanche et al. 2024). In Appendix Figure 2, we document geographic and temporal variation in these other regulations that restrict access to ENDS.

4. Empirical Methodology

4.1 Repeated Cross-Sectional Regression Analysis Using YRBS and BRFSS

For our repeated cross-sectional datasets (YRBS and BRFSS), we estimate a two-way fixed effects (TWFE) regression model using ordinary least squares (OLS):

$$Y_{ismt} = \gamma_0 + \gamma_1 \text{ENDSTax}_{smt} + \mathbf{EREG}_{smt}\boldsymbol{\gamma_2} + \boldsymbol{X}_{ismt}\boldsymbol{\gamma_3} + \boldsymbol{Z}_{smt}\boldsymbol{\gamma_4} + \alpha_s + \pi_m + \theta_t + \varepsilon_{ismt} \quad (1)$$

where Y_{ismt} denotes our mental health outcome of interest for individual *i* residing in state *s* in semester *m* (Fall or Spring in YRBS, and quarter in BRFSS) in year *t*. Our key policy variable is ENDSTax_{smt}, the tax per mL of e-liquid for closed system ENDS products in 2023 dollars. The vector $\mathbf{X}_{ismt}$ includes individual demographic controls (race/ethnicity, age, sex, grade in school, and whether the observation was drawn from the state versus national YRBS). $\mathbf{EREG}_{smt}$ is a vector of state-level ENDS policies (minimum legal sales age for ENDS products of 18, T-21 laws, restrictions on the sales of flavored ENDS products, ENDS licensure laws, clean indoor vaping laws, and bans on the delivery of ENDS products purchased online). The vector $\mathbf{Z}_{smt}$ includes state-level controls for (1) combustible tobacco policies (cigarette taxes, clean indoor air laws for smoking, and bans on the sale of menthol flavored cigarettes), (2) macroeconomic conditions (poverty rate and unemployment rate), COVID-19 shocks (cumulative COVID-19 death rate), and substance use-related policies (medical and decriminalization marijuana laws, recreational marijuana laws, prescription drug monitoring program laws, naloxone access laws and beer taxes). Finally, α_s, π_m, and θ_t are state, semester (or quarter), and year fixed effects. We weight regressions using individually constructed sample weights (as described above to make the sample representative at

both the state and national levels) and cluster standard errors at the state level (the level of policy variation under study) following Bertrand et al. (2004).[19]

Our main parameter of interest, γ_1, is the effect of ENDS taxes on youth (or young adult) mental health. Estimates of $\boldsymbol{\gamma_1}$ and $\boldsymbol{\gamma_2}$ will only be unbiased in the absence of (1) reverse causality whereby mental health affects the adoption and levels of ENDS taxes, (2) time-varying state-level unobservables that are correlated with both ENDS tax increases and mental health, and (3) heterogeneous and dynamic treatment effects. We undertake several strategies to descriptively explore whether our identification assumptions are valid.

First, to test for parallel pre-treatment trends (and reverse causality), we estimate event-studies. For example, to estimate event-study coefficients for our ENDS tax treatment, we follow the approach of Schmidheiny and Siegloch (2023).

$$Y_{ismt} = \mu_0 + \sum_{j=-5}^{2} \beta_j \, D^{j}_{\text{smt}} + \mathbf{EREG}_{\mathbf{smt}} \, \boldsymbol{\mu_1} + \boldsymbol{X}_{\text{ismt}} \, \mu_2 + Z_{\text{smt}} \, \mu_3 + \alpha_s + \pi_{\text{m}} + \theta_t + \varepsilon_{ismt}, \quad (2)$$

where D^{j}_{smt} is the difference in the real ENDS tax between year *t* and *t-1*. Note that for our YRBS analysis, the leads and lags are comprised of two-year bins to match the biennial nature of the survey. For all mental health outcomes, the reference period is 1-2 years prior to the ENDS tax increase and the event window ranges from five or more years prior to an ENDS tax change to two or more years following the tax change. In robustness checks, we extend this event window to seven years before treatment to six years following treatment to both test for longer lead effects and to allow for longer-run mental health effects of ENDS taxes. If we find that $\hat{\beta}_j = 0$ for all $j < 0$, this would tend to support the common trends assumption and suggest that reverse causality is an unimportant source of bias in our coefficient estimates.

To explore the sensitivity of our estimates to time-varying unobservables, we add controls to the right hand-side of equation (1) for census region-specific year fixed effects, and (2) state-specific

[19] We also estimate instrumental variables (IV) models, where we examine the effect of ENDS use on mental health, instrumenting for ENDS use with ENDS taxes. The validity of these IV regressions relies on stronger assumptions for identification than do our difference-in-differences methods. For example, we must assume that that the only channel through which ENDS taxes impact mental health is through ENDS use (i.e., the exclusion restriction). This assumption may be violated if, for example, ENDS taxes impact the use of other substances (e.g., alcohol) that may also influence mental health. These results, available upon request, produce little evidence of a causal link between ENDS tax-induced reductions in ENDS use and youth psychological health, though these estimates are merely descriptive given such threats to the exclusion restriction.

linear time trends. The set of variables in (1) control for unmeasured time shocks that commonly affect states within a census region, thereby forcing "closer controls" of treatment and control states. This has the advantage of potentially comparing states that are more alike (at least geographically). However, geographically proximate states do not always comprise the most credible counterfactuals (Neumark et al. 2014; Burkhauser et al. 2024). In addition, controlling for treatment state-specific linear time trends will capture unobservables trending linearly at the state level. But again, we view estimates including these controls as more descriptive than dispositive given that state-specific linear time trends may obscure true dynamic effects of policy (Meer & West 2016; Wolfers 2006) as well as potentially isolate variation in treatment that is less plausibly exogenous to the outcome under study (Neumark et al. 2014).

Finally, in the presence of heterogeneous and dynamic treatment effects, TWFE estimates may be biased. Thus, as additional robustness checks, we use an alternate difference-in-differences estimator, the stacked difference-in-differences estimator (Cengiz et al. 2019). This approach avoids so-called "forbidden comparisons" by restricting our set of counterfactuals to not yet as well as never-adopters of ENDS taxes and standardizing our treatment window to the period six years before a tax increase to three years after the increase. After stacking the data, we estimate our stacked difference-in-differences estimator using OLS estimates that include year state and semester fixed effects and our full set of controls. Standard errors are clustered at the state level.

We conduct our stacked difference-in-differences approach in two ways: (1) using the continuous ENDS tax and allowing all taxes to unfold after the first increase (and restricting counterfactuals to never- or net-yet-adopters), and (2) focusing on prominent nominal increases in ENDS taxes of at least $0.25 per mL of e-liquid and $.50 per mL of e-liquid (and using a similar set of counterfactuals.

4.2 Longitudinal Analysis Using PATH

The longitudinal nature of the PATH allows us to estimate specifications that include individual fixed effects and also capture initiation and cessation of ENDS use and mental health issues. We begin by estimating the effect of ENDS taxes on youth ENDS use using an equation similar to equation (1), but also including individual fixed effects. Then, when we turn to mental health outcomes, we estimate a Poisson regression using a quasi-maximum likelihood estimator (QMLE):

$$\ln(\lambda_{isqt}) = \gamma_0 + \gamma_1 \text{ENDSTax}_{sqt} + \mathbf{EREG}_{sqt}\,\boldsymbol{\gamma_2} + \boldsymbol{X}_{isqt}\,\gamma_3 + Z_{sqt}\,\gamma_4 + \theta_t + \mu_i \qquad (3)$$

where λ_{ist} is our mental health count variable described above. Our controls include individual level fixed effects (μ_i) to account for stable person-specific heterogeneity, such as underlying risk for mental health issues[20] and θ_t is a year-by-quarter fixed effect.

We then further exploit the longitudinal structure of the PATH and examine how ENDS taxes affect the probability of the onset or cessation of mental health problems (as well as initiation and cessation of ENDS use) using a discrete-time hazard model of the following form:

$$\text{Prob}(S_{isqt}=1 \mid t-1<T<t) = \delta_0 + \delta_1 \text{ENDSTax}_{sqt} + \mathbf{EREG}_{sqt}\,\boldsymbol{\delta_2} + \boldsymbol{X}_{isqt}\boldsymbol{\delta_3} + Z_{sqt}\,\boldsymbol{\delta_4} + \theta_t + \mu_i + \varepsilon_{iqt}. \quad (4)$$

To implement this model, we create dichotomous indicators from our continuous mental health indexes described above. That is, if a respondent reports at least one positive response that contributes to the index, then *Mental Health Problem* is set equal to one. If there are no positive responses to the index, then *Mental Health Problem* is set equal to zero. In our sample, 70 percent of adolescent and 60 percent of young adult respondents report a mental health problem as measured by responses to the 11 index questions.[21]

The discrete time hazard specification in equation (4) models the conditional probability of switching across margins of ENDS use or mental health states (S) between periods *t-1* and *t*. When studying initiation, the sample is restricted to individuals who had not used ENDS or reported any mental health issues at baseline, and an indicator is defined for transitioning to ENDS use or mental health issues in period *t*, conditional on being a non-user or having no mental health issues in period *t-1*. Similarly, when studying cessation, the sample is restricted to ENDS users or those with mental health issues at baseline, and an indicator is defined for transitioning to no reported use or issues in period *t*, conditional on being a user or reported mental health issues in period *t-1*. The parameter of interest, δ_1, above can be interpreted as the change in the transition probability between states of consumption or mental health issues as affected by ENDS taxes. This approach will allow

[20] When including individual fixed effects, any time invariant individual characteristics are excluded from the regression.
[21] Specifically for the more specific dimensions of mental health, 53 and 43 percent of adolescent and young adults any report mental health problems and 55 and 47 percent report ADHD problems. We also re-estimate the regressions described in Table 3 using these dichotomous measures of mental health. These results, available upon request, show no statistically significant relationship between ENDS taxes and mental health outcomes.

us to uncover important underlying dynamics in the effect of ENDS taxes on youth and young adult mental health.

5. Results

Our key findings are shown in Figures 1-7 and Tables 1-11. The online appendix tables and figures contain supplemental materials.

5.1 "First-Stage" YRBS Estimates of Effects of ENDS Taxes on Youth ENDS Use

In Table 1, we show TWFE estimates of the effects of ENDS taxation on current (panel I), frequent (panel II), and daily (panel III) youth ENDS use. As noted above, this analysis is based on data from 2015-2023. The first set of columns present findings from regressions with parsimonious controls such as state, year, and semester fixed effects and we then build toward our fully saturated (or "full controls") model in column (7), which includes controls for demographics, macroeconomic conditions, ENDS policies, combustible tobacco policies, and substance use policies. Across each of these specifications, we find robust evidence that youth ENDS use responds to changes in ENDS taxes. In panel I, we find that a one dollar per mL of e-liquid increase in ENDS taxes is associated with a 1.3-2.5 percentage-point (6.3-12.0 percent) decline in youth ENDS use. Turning to more habitual use, frequent (panel II) and daily (panel III) use, we find that a one dollar increase in ENDS taxes is associated with a 1.0-1.3 percentage point (18.2-23.6 percent) in frequent ENDS use and with a 1.0-1.3 percentage point (25.0-32.5 percent) in daily ENDS use among teens.[22] This pattern of findings is consistent with the hypothesis that ENDS taxes have "bite" among youths. The findings also suggest that relative to prior estimates of the impact of ENDS taxes on youth ENDS use (Abouk et al. 2023; Dave et al. 2024;2025), ENDS tax effects may have fallen in absolute magnitude in the post-pandemic period (Chuo et al. 2025). This result is in line with the hypothesis that as ENDS use among high school students has declined in the post-2019 period (from a peak of 27.8 percent in 2019 to 8.0 percent in 2023 according to the National Youth Tobacco Survey), the marginal youth ENDS user is likely to be more price inelastic (tax insensitive) than the marginal ENDS user in 2019 because they derive more utility from nicotine vaping (or more disutility from quitting vaping/substituting to alternative tobacco products).

[22] Appendix Table 3 provides stacked difference-in-differences estimates of the effect of ENDS taxes on ENDS use and show similar results.

Event-study analyses in Figure 1 suggest that the coefficient estimates in Table 1 have a causal interpretation. An examination of the pre-treatment trends produces findings that are consistent with the parallel trends assumption. Moreover, youth ENDS use declines in treatment vs control state-years following (rather than preceding) an ENDS tax increase. These results persist across event-study regressions that use differing sets of controls (columns 1-3) and across our three measures of ENDS use (panels a-c). In addition, these findings do not appear to be contaminated by heterogeneous and dynamic treatment effects. Stacked difference-in-differences estimates using not-yet and never adopters of ENDS taxes as counterfactuals using both continuous tax and prominent nominal tax increases of $0.5 per mL of e-liquid (see Appendix Figure 3) continue to provide support for the parallel trends assumption.

5.2 ENDS Taxes and Youth Mental Health

Having established that ENDS taxes have "bite" for youths, we next turn to the estimates of the impact of ENDS taxes on youth mental health.[23] We conduct this analysis for both the same period over which we have ENDS use data (2015-2023 in Table 2) as well as an expanded sample period over which we have mental health data (2003-2023 in Table 3). Each panel shows findings from a different mental health outcome while each column shows the estimated ENDS tax effect across alternate empirical specifications. Across both tables, the pattern is clear: ENDS taxation has no statistically significant or economically important effect on youth mental health across each of our measures and across all specifications.

For example, panel I examines persistent depressive symptoms. Focusing on the longer sample window (Table 3), in our baseline regression model (column 1), we find that a one dollar increase in the ENDS tax is associated with a statistically insignificant 0.8 percentage-point increase in the probability of persistent depressive symptoms. The addition of controls for macroeconomic conditions, COVID-19 shocks, combustible tobacco policies, ENDS regulations, and substance use policies have very little effect on the estimated treatment effect. In our preferred specification in

[23] Before presenting our primary analysis on the effects of ENDS taxes, we first document that our repeated cross-sectional YRBS sample can replicate the epidemiological literature's naïve "causal" finding that youth e-cigarette use is negatively related to psychological health. In Appendix Table 4, we find results that are largely consistent with the prior literature (see studies cited in Section 2.3). For instance, we find that prior-month youth e-cigarette use is associated with a 20.5 percentage-point (60.8 percent) increase in the probability of persistent sadness or anxiety (column 1) and a 15.9 percentage-point (87.8 percent) increase in the probability of suicide ideation (column 2), and a 21.8 percentage-point (56.0 percent) increase in the probability of any mental health problem (column 6). However, whether these coefficient estimates should be interpreted causally is unclear.

column (5), we can, with 95 percent confidence, rule out that a one dollar increase in ENDS taxes reduces persistent depressive symptoms by more than 0.3 percentage points (or 1.0 percent relative to the pre-treatment mean in ENDS tax enacting states). This is a relatively precise estimate, suggesting that even though ENDS taxes are effective at curbing youth ENDS use, they do little to alleviate persistent depressive symptoms. Moreover, among treatment states, the average year-over-year closed system real ENDS tax increase (in our analysis sample) is $0.34 per mL of e-liquid. Thus, a one dollar increase in the ENDS tax is quite large, adding to evidence that restricting access to ENDS via higher taxes does little to improve persistent depressive symptoms among youths. If we instead focus on the average tax increase, we can rule out effects sizes larger than 0.3 percent at the 95 percent confidence level.

In addition, the estimates in panel I show that with 95 percent confidence, we can rule out that a one dollar increase in ENDS taxes increases persistent depressive symptoms by more than 2.4 percentage points (8.0 percent). Scaling these estimates to the average tax increase observed in our data ($0.34) suggests that we cannot rule out (with 95 percent confidence) a 0.8 percentage point (2.8 percent) increase in this metric. These findings suggest that we are more confident that ENDS taxes fail to alleviate persistent depressive symptoms than we are that ENDS taxes fail to *increase* persistent depressive symptoms.

In panels II through V of Table 3, we turn to measures of suicidality. The estimated effects of ENDS taxes are uniformly small in magnitude; estimated negative effects are never more than 0.6 percentage points. In our fully specified model (column 5), we can, with 95 percent confidence, rule out that the average increase in ENDS taxes observed in our sample ($0.34) is associated with more than a 0.2 percentage-point (1.1 percent) reduction in the probability of suicide ideation (panel II, column 5), a 0.4 percentage-point (2.8 percent) reduction in the probability of suicide planning (panel III, column 5), a 0.2 percentage-point (2.8 percent) reduction in the probability of a suicide attempt (panel IV, column 5), and a 0.1 percentage-point (5.9 percent) reduction in the probability of a suicide injury (panel V, column 5).[24] Finally, in panel VI, we explore the effect of ENDS taxes on the likelihood of any adverse mental health event, as measured by reported persistent sadness or suicidality. In our fully specified regression model (panel VI, column 5), we can, with 95 percent

[24] In addition, in our fully specified regression model, we can, with 95 percent confidence, rule out that a $0.34 increase in ENDS taxes is associated with increases of more than 0.6 percentage-points (3.6 percent) in the probability of suicide ideation (panel II, column 5), 0.3 percentage-point (2.6 percent) in the probability of suicide planning (panel III, column 5), 0.1 percentage-points (1.2 percent) in the probability of a suicide attempt (panel IV, column 5), and 0.1 percentage-point (1.5 percent) in the probability of a suicide injury (panel V, column 5).

confidence rule out that the mean real ENDS tax increase observed in our analysis sample reduces or increases adverse mental health by more than 0.4 percentage points (1.1 percent) or 0.6 percentage points (1.8 percent) relative to the pre-treatment mean respectively. Together, the pattern of findings reported in Tables 2 and 3 provide little support for the hypothesis that curbing nicotine vaping among youths via higher ENDS taxes generates net improvements in youth mental health.

Event-study analyses using TWFE estimates (Figure 2) are consistent with the parallel trends assumption and provide little support for the hypothesis that ENDS taxes increase the probability of persistent depressive symptoms (panel a), suicidality (panels b-e) or aggregate adverse mental health events (panel f). This pattern is generally true in both the shorter- and longer-runs. If we extend our event-study window to allow longer pre-treatment trends and to permit for longer-run mental health effects, the pattern of findings is similar as presented in Figure 3.[25]

Finally, we explore if our estimated ENDS tax effects in Tables 2 and 3 — and event-study coefficients in Figures 2 and 3 — are biased due to heterogeneous and dynamic treatment effects. We restrict our set of counterfactuals to not yet or never adopters of ENDS taxes and limit the analysis window to the period from six years prior to an ENDS tax increase to three years after an ENDS tax increase. Table 4 shows stacked difference-in-differences estimates of the effects of ENDS taxes (1) using prominent nominal increases in the ENDS tax of $0.50 per mL of e-liquid in panel I, and (2) using the continuous ENDS tax measure in panel II. Our findings provide little support for the hypothesis that our TWFE estimates were biased due to heterogeneous and dynamic treatment effects. Event-study estimates in Figure 4A and 4B confirm there is little evidence that ENDS taxation improves (or harms) youth psychological health.[26]

5.3 Sensitivity and Heterogeneity by Demographic Groups

Next, we explore the sensitivity of our above estimates to a variety of specification checks. In Appendix Figure 6, we examine whether our null findings on the mental health effects of ENDS taxes are driven by any particular treatment state. We fail to find that any one treatment state is driving our null findings.

[25] Only for suicide attempts is there evidence of a (marginally significant) longer-run effect -- Figure 3 Panel (d), but this effect is not observed for either suicide ideation or suicide plans among youths.

[26] Appendix Figure 4 shows the stacked difference-in-differences estimates of prominent ENDS tax increases of $0.5/mL of e-liquid and youth mental health using longer leads and lags and Appendix Figure 5 shows the stacked difference-in-differences estimates of prominent ENDS tax increases of $0.25/mL of e-liquid and youth mental health and find similar results.

In Table 5, we examine whether our findings on ENDS taxes are altered by forcing geographically proximate states to serve as controls for ENDS tax-adopting states through the inclusion of census region-specific year fixed effects[27] as right-hand side variables (panel I) or including controls for state-specific linear time trends (panel II). Our findings provide little support for the hypothesis that spatial heterogeneity is leading to biased TWFE estimates.

In Appendix Table 5, we explore whether our findings on youth mental health using the combined State and National YRBS surveys differ if we separately examine the State and National surveys. Our findings provide no evidence that ENDS taxes significantly improve mental health in either dataset and some evidence (though only via marginally significant estimates) that ENDS taxes adversely affect youth mental health in the State YRBS.

Finally, in Figure 5, we explore heterogeneity in the effects of ENDS taxes by demographic characteristics of students, including age (those under vs over age 16), sex (males vs females), and race (non-Hispanic White vs Black or Hispanic). Across youth demographic groups, there is little evidence that ENDS taxes consistently improve mental health outcomes.

5.4 Explanations for Null Effects and Exploration of Spillover Effects

Together, the above tables and figures provide robust evidence that ENDS taxes fail to improve youth mental health despite reducing youth ENDS use. There are a number of explanations for these findings. First, the negative association between youth e-cigarette use and psychological well-being (Appendix Table 4) may be driven entirely by selection on unobservables. Second, the margin of ENDS use affected by ENDS taxes has a different effect on youth mental health than the margin of ENDS use unaffected by taxes. Third, spillover effects of ENDS taxes on related goods (e.g., alcohol, cigarettes, marijuana, and harder drugs) or income effects that could have countervailing effects on mental health, a possibility that we explore below.[28] We explore several of these pathways below with results reported in Table 6.

One explanation for our finding that ENDS taxes have no effect on youth mental health is that there are spillover effects of ENDS taxes that impact behaviors other than ENDS consumption

[27] More specifically, we replace year fixed effects with region-by-year fixed effects.
[28] Note that the general equilibrium effects of ENDS taxes are an important reason why we do not use taxes as an instrumental variable for ENDS use in our main analyses. These given that these other pathways could violate the exclusion restriction.

that affect mental health.[29] Panel I provides overall treatment effects and panel II shows lagged estimates. Consistent with the findings of Abouk et al. (2023a) and Courtemanche et al. (2024), we find that a one dollar increase in ENDS taxes is associated with a 1.0 to 1.1 percentage-point (13.5-14.9 percent) increase in youth cigarette smoking. This finding is in line with the hypothesis that e-cigarettes and combustible cigarettes are economic substitutes for youths. Thus, to the extent that some youths obtain their nicotine from other sources, we might expect any mental health effects of nicotine consumption (and addiction) to be, to at least some extent, offset, which could offer one explanation for a net null impact on mental health.

In addition, we also detect some evidence that ENDS taxes are negatively related to marijuana use (column 2) and binge drinking (column 3), consistent with the hypothesis that these substances are economic complements to e-cigarettes as documented in Dave et al. (2024; 2025). To the extent that problem drinking and early initiation of marijuana use carry adverse mental health effects for teens (Fone et al. 2023; van Ours & Williams 2011; van Ours & Williams 2009; Lacruz & Lacruz 2010; Chatterji et al. 2003), these spillovers could generate positive mental health gains from ENDS taxes.

In the remaining column (column 4), we explore the impacts of ENDS taxes on harder substance use, focusing on "ever use" of these substances (meaning that the estimated treatment effect will pick up the initiation margin of use). We focus on "ever" use, in part, because mean rates of prior-month hard drug use among teens are extremely low (under five percent). We find no evidence that ENDS taxes impact cocaine/heroin use among teens.

[29] First, we measure combustible cigarette smoking using responses to the following survey item: "During the past 30 days, on how many days did you smoke cigarettes?" If the student responds with zero, the outcome variable, *Current Cigarette Use* is set to zero and set to one if the respondent reports a positive number of days of smoking. In our sample, we find on average, 13.2 percent of youth report smoking cigarettes (Appendix Table 1A). Questions on binge drinking patterns and marijuana consumption are also explored in the survey: "During the past 30 days, on how many days did you have 4 or more drinks of alcohol in a row, that is, within a couple of hours (if you are female) or 5 or more drinks of alcohol in a row, that is, within a couple of hours (if you are male)?" and "During the past 30 days, how many times did you use marijuana?" *Binge Drinking* is set to one if the respondent reported drinking four or more drinks in a single occasion (five drinks for men) on at least one day in the last 30 days and zero otherwise. In our sample, we find that 11.8 percent of youths report binge drinking in the last month. With respect to *Marijuana Use*, which is coded similarly, 19.7 percent of youths reported marijuana use in the last 30 days. Finally, we measure whether the youth ever used any cocaine or heroin, methamphetamines, or ecstasy in their lifetime and set the necessary outcomes of the particular substance use as one if they responded with yes and zero otherwise. We find that 5.9 percent, 2.4 percent, 4.0 percent, and 6.0 percent of youth, respectively, had report consuming cocaine, heroin, methamphetamines, or ecstasy at least once in their lifetime.

In summary, our findings on the spillover effects of ENDS taxes on combustible tobacco, marijuana, and alcohol show that there may be important spillover effects of ENDS taxation that generate mental health effects.

5.5 Comparisons of Effects of ENDS Taxes to Other ENDS Regulations

In Figure 6 and Appendix Table 6, we compare the effects of ENDS taxes on youth mental health to the effects of other public policies that were designed to curb access to ENDS. First examining minimum legal purchasing age laws (including ENDS-specific minimum legal purchasing age [MLPA] laws and T-21 laws), our results provide little support that these laws affect youth mental health. For instance, with respect to ENDS-specific MLPA laws, we can, with 95 percent confidence, rule out any decrease (increase) in the probability of any adverse mental health symptoms by more than 1.2 (2.0) percentage points or 1.5 (2.4) percent.

Turning to e-cigarette retail licensure laws, we also find no evidence that requiring vendors to obtain a state license before they are legally allowed to sell e-cigarettes over the counter improves youth mental health. Moreover, adoption of clean indoor vaping laws — defined as regulations that restrict or prohibit the use of e-cigarettes in bars, restaurants, and workplaces — does not appear to improve youth mental health. With 95 percent confidence, we can rule out that clean indoor vaping laws reduce persistent depressive symptoms by more than 1.2 percentage points (4.3 percent) and suicide ideation by more than 1.2 percentage points (8.0 percent).

We also do not find any significant improvement in youth mental health from banning online sales of ENDS products. With 95 percent confidence, we can rule out that the online sales ban of ENDS products reduces the probability of persistent depressive symptoms by more than 2.9 percentage points (10.6 percent). Although we find some evidence that ENDS flavor restrictions are positively related to youth mental health, this result is sensitive to model specification (Appendix Table 7) and does not appear to be causal given an evaluation of event-studies (Appendix Figure 7).

Finally, while each ENDS policy has little individual effect on youth mental health, the enactment of a set of multiple policies could have an impact. Thus, we generate an index equal to the sum of all state ENDS restrictions which ranges from zero to seven.[30] Our results, shown in Appendix Table 8, provide little support for the hypothesis that multiple policies that restrict access to ENDS improves youth mental health.

[30] To be coded as having an ENDS tax as part of this index, we require the state to have implemented a prominent increase in taxes equal to $0.5.

5.6 Effects of ENDS Regulations on Adults

Next, we explore the effects of ENDS regulations on adult psychological well-being. Before doing so, in Table 7, we examine the impact of ENDS taxation on current (columns 1 to 3) and daily (columns 4 to 6) adult ENDS use to establish whether this policy has "bite" among adults. Our results suggest that young adults' ENDS use is impacted by ENDS taxes. In panel I (which focuses on those aged 18-24), we find that a one dollar per mL of e-liquid increase in ENDS taxes is associated with a 0.5-1.4 percentage-point (4.6-11.5 percent) decline in young adult current ENDS use. Turning to daily ENDS use (columns 4-6), we find that a one dollar increase in ENDS taxes is associated with a 0.8-1.2 percentage point (20.5-32.4 percent) decline in everyday ENDS use among young adults. In addition, for those aged 25-34 (panel II), we find that a one dollar increase in the ENDS tax is associated with statistically insignificant declines of 0.27 (3.5) and 0.04 (1.4) percentage points (percent) in current and everyday ENDS use, respectively. Among those aged 35 and older, we find little evidence that ENDS taxes impact ENDS use.

In Table 8, we turn to mental health effects of ENDS taxes for those aged 18-24 years. The findings in column (1) suggest that a one dollar increase in ENDS taxes is associated with a statistically significant 1.7 percentage-point (3.4 percent) decrease in the probability of reporting any poor mental health days. However, when we add either census region specific year fixed effects (panel II) or state specific linear time trends (panel III), the coefficient estimate is statistically indistinguishable from zero. Appendix Table 9 sheds some light on why we might expect a modest improvement in mental health of young adults beyond the reductions we observed in ENDS use.[31] We find evidence consistent with the hypothesis that ENDS and alcohol (as well as ENDS and marijuana) are economic complements. The remainder of the columns of Table 8 explore the more

[31] To help us understand spillover mechanisms driving our results, we also utilize data in the BRFSS on adults' smoking, marijuana, and drinking habits with the help of the following questions: "Do you now smoke cigarettes every day, some days, or not at all?," "During the past 30 days, on how many days did you use marijuana or hashish?," "During the past 30 days, how many days per week or per month did you have at least one drink of any alcoholic beverage?," and "Considering all types of alcoholic beverages, how many times during the past 30 days did you have X [X = 5 for men, X = 4 for women] or more drinks on an occasion?" We create binary variables for current cigarette, marijuana, and alcohol use and set them to one if respondents replied with smoking cigarettes some days or every day and having marijuana and alcohol for at least one day in the past week or month and zero otherwise. We find that 15.5 percent of adults currently smoke cigarettes, 11.6 percent of adults smoked marijuana at the time of survey, and 52.5 percent of adults had consumed an alcoholic drink at least once in the month preceding the survey. We also create additional variables to measure daily smoking and current binge drinking that are set to one if the respondent answered smoking cigarettes daily and having consumed more than five for men and four for women drinks at least once in the past month respectively and set to zero otherwise. We find that 10.8 percent of adults smoke cigarettes daily and 16.5 percent of adults participated in binge drinking at least once in the month preceding the survey.

intensive margin of poor mental health among younger adults (columns 2-4). We uncover little evidence that ENDS taxation is significantly related to these outcomes.

In Figure 7, we compare the effects of ENDS taxation to other ENDS regulations. Our findings provide no support for the hypothesis that ENDS policies intended to curb access to ENDS — including minimum legal sales ages, T-21 laws, bans on the delivery of ENDS purchased online, and ENDS licensure laws — affect young adult mental health. Only for ENDS flavor restrictions is there some support for the hypothesis that these policies may lead to small improvements in young adult psychological health, though evidence of a causal interpretation is clearer than for teenagers, particularly with respect to persistent poor mental health days (see Appendix Table 10 and Appendix Figure 8).[32] Finally, our findings in Appendix Tables 11 and 12 suggest that older adults' mental health is largely unaffected by ENDS taxation.

5.6 Evidence from Longitudinal PATH Data

We next turn to our analyses using PATH data. Table 9 reports the estimated effects of ENDS taxes on ENDS use in the PATH. All columns include the full set of observable controls and time (year-by-quarter) fixed effects, with odd-numbered columns including state fixed effects and even-numbered columns including individual fixed effects. Our findings in columns (1) and (2) document that a one dollar per mL of e-liquid increase in ENDS taxes leads to a 1.8 and 2.0 percentage point reduction in ENDS use among youth. The results for young adults show a statistically significant relationship between ENDS taxes and current ENDS use when including state fixed effects. However, once individual fixed effects are included in the regression, the coefficient estimate declines in magnitude slightly and is no longer statistically significant.

We next further leverage the longitudinal nature of the PATH data to estimate discrete time hazard models for both vaping initiation and cessation. For youth, a one dollar tax increase per mL of e-liquid increase in ENDS taxes leads to a 1.3 to 1.9 percentage point reduction in ENDS initiation. The coefficient for ENDS cessation is large and positive but not statistically significant at the ten percent level. For young adults, ENDS taxes are again associated with a decrease in ENDS initiation when state fixed effects are included, but the coefficient estimate loses statistical

[32] Appendix Table 10 shows that the estimated effect of ENDS flavor bans on youth mental health is very sensitive to the inclusion of state specific linear time trends. Event-study estimates, shown in Appendix Figure 8, suggests little evidence that the negative TWFE coefficient estimate should be causally interpreted.

significance when including individual fixed effects. Cessation results for young adults are not statistically significant across specifications.

In Table 10, we examine the association between ENDS taxes and youth mental health. The structure of this table is similar to Table 9 in that the first two columns show the relationship between ENDS taxes and the levels of mental health indexes while the last four columns use hazard models to estimate the relationship between ENDS taxes and initiation into or cessation out of mental health issues. Across all but one specification in Table 10 (which includes controls for state, but not individual, fixed effects), the magnitudes of estimated ENDS tax effects are small and the coefficient estimates are not statistically significant at conventional levels. For example, in the first two columns (where regressions are estimated using Poisson QMLE), a one dollar per mL increase in ENDS taxes is associated with a statistically insignificant 0.1 (1.4) unit increase (decrease) in the overall mental health index.

In columns (3) and (4), we find that ENDS taxes are associated with very small decreases in mental health problem initiation, but these decreases are not statistically distinguishable from zero at conventional levels. We also find that ENDS taxes are not associated with statistically significant increases in cessation of mental health issues. In fact, in one specification (panel II, column 6), we find that ENDS taxes are associated with a reduction in the mental health index and this coefficient estimate is statistically different from zero at conventional levels. In Table 11, we report symmetric results for young adults. Because ENDS taxes have a smaller impact on ENDS use in this age group in the PATH data, we expectedly find little consistent evidence of a relationship between ENDS taxes and mental health outcomes in this age group.

6. Conclusions

According to the Mayo Clinic, there is a youth mental health crisis in the United States, which may have only deepened during the COVID-19 pandemic (CDC 2022). Tobacco control advocates argue that many teens and young adults may be "self-medicating" with e-cigarettes, leading to a vicious circle that adversely affects their mental health (Truth Initiative 2021). They argue that ENDS regulations restricting access to e-cigarettes, particularly among youth, may help to improve youth mental health.

This paper is among the first to comprehensively study the effects of ENDS regulations on youth and young adult mental health. Using multiple nationally representative datasets, and a

generalized difference-in-differences approach, our paper provides evidence that despite effectively reducing ENDS use, ENDS taxation has no discernable impact on youth mental health. For teens, we can rule out that a $0.34 increase in ENDS taxes (the average tax increase observed in our sample) reduces persistent depressive symptoms by 0.3 percent and suicide ideation by 1.0 percent. This null finding may be explained by countervailing direct effects of ENDS taxes on nicotine consumption from ENDS, and (2) indirect effects via spillover effects of ENDS taxes on combustible cigarette smoking, binge drinking, and marijuana use

For younger adults aged 18-24, we detect some evidence of a small ENDS tax-induced improvement in mental health, an effect that could, in part, be explained by both reductions in nicotine consumption from ENDS as well as a reduction in binge drinking, consistent with Dave et al. (2024). However, auxiliary analyses from the PATH show that, while ENDS taxes lead to statistically significant reductions in ENDS use among youth and have some possible effect on ENDS cessation in young adults, we do not see a relationship between ENDS taxes and measures of mental health in either youth or young adults.

While our findings indicate that restricting access to ENDS through taxation and other types of regulation does not meaningfully improve psychological well-being, future research should continue to explore whether alternative policy interventions—such as increased access to mental health services—offer more effective solutions to addressing the ongoing youth mental health crisis (Deza et al. 2022, Ali et al. 2024). Our results suggest that policymakers should carefully consider both the intended and unintended consequences of ENDS regulations in assessing their likely effects on youth and young adult mental health. Our paper also does not speak to whether declining mental health among youth and young adults might have contributed to the rise of ENDS use in these groups. Further research into a relationship between ENDS use and mental health in this direction may yield important insights.

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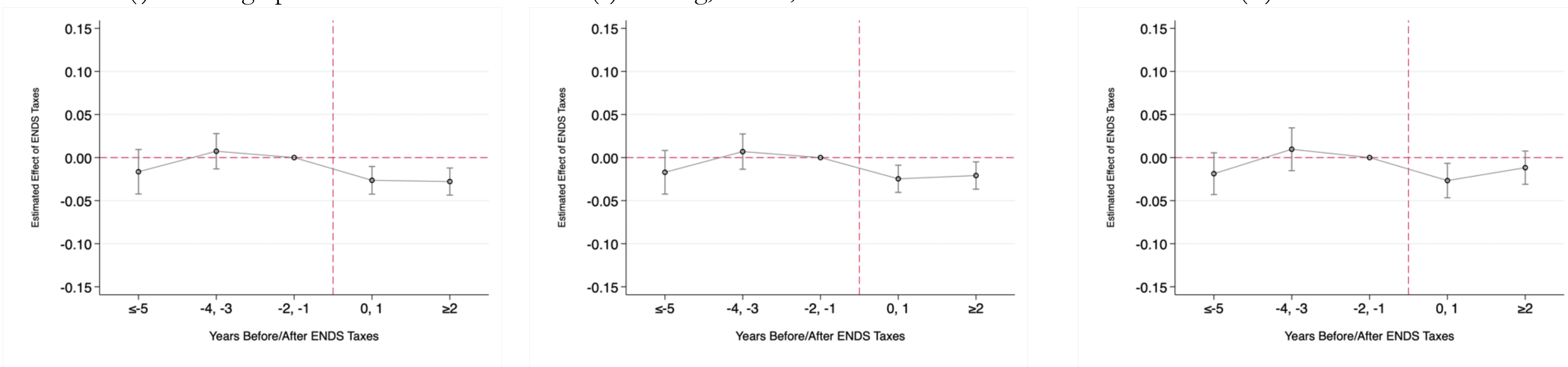
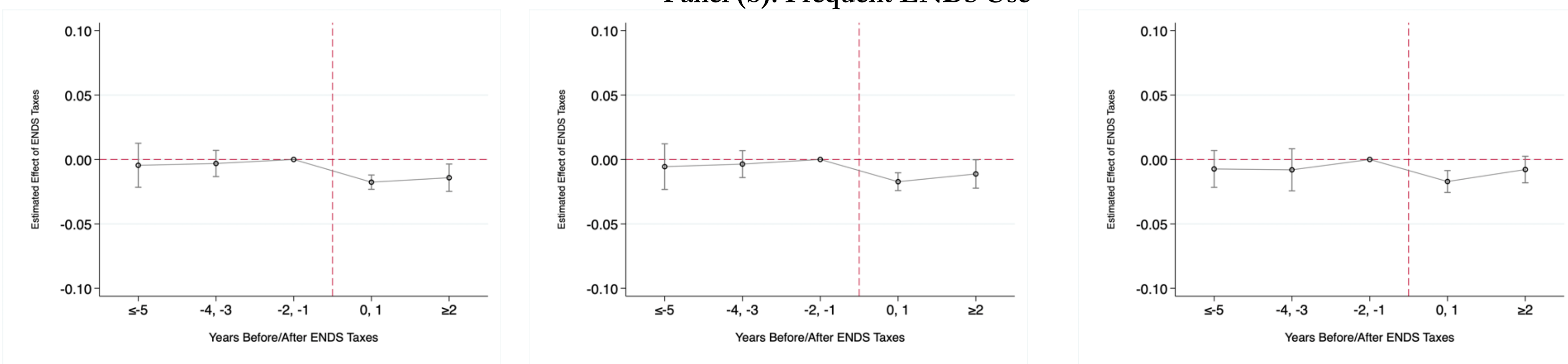
Figure 1. Event-Study Estimates of ENDS Taxes and Youth ENDS Use, YRBS, 2015-2023

Panel (a): Current ENDS Use

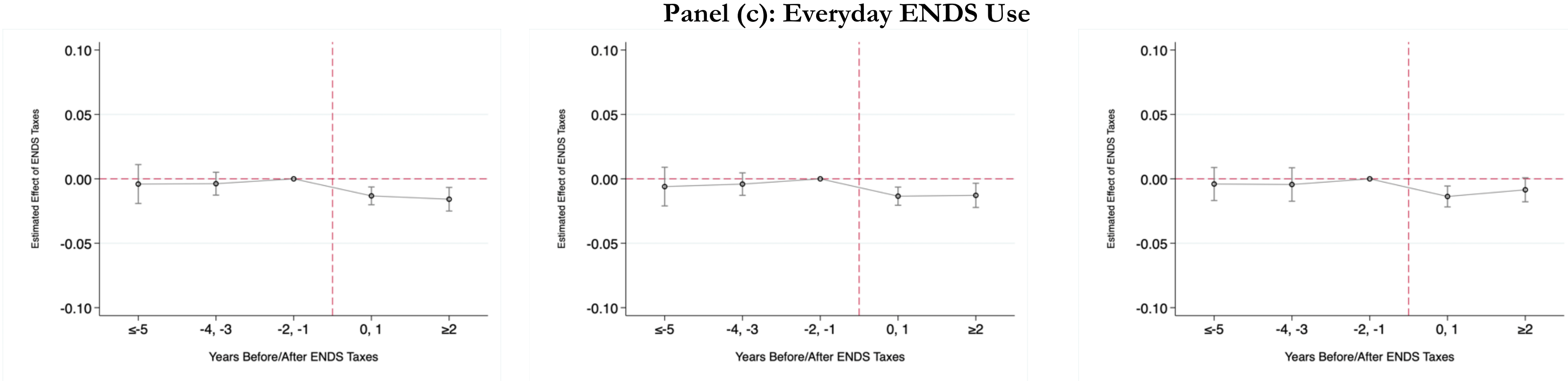
(i) Demographic Controls | (ii) Demog, Macro, & COVID Controls | (iii) Full Controls



Panel (b): Frequent ENDS Use

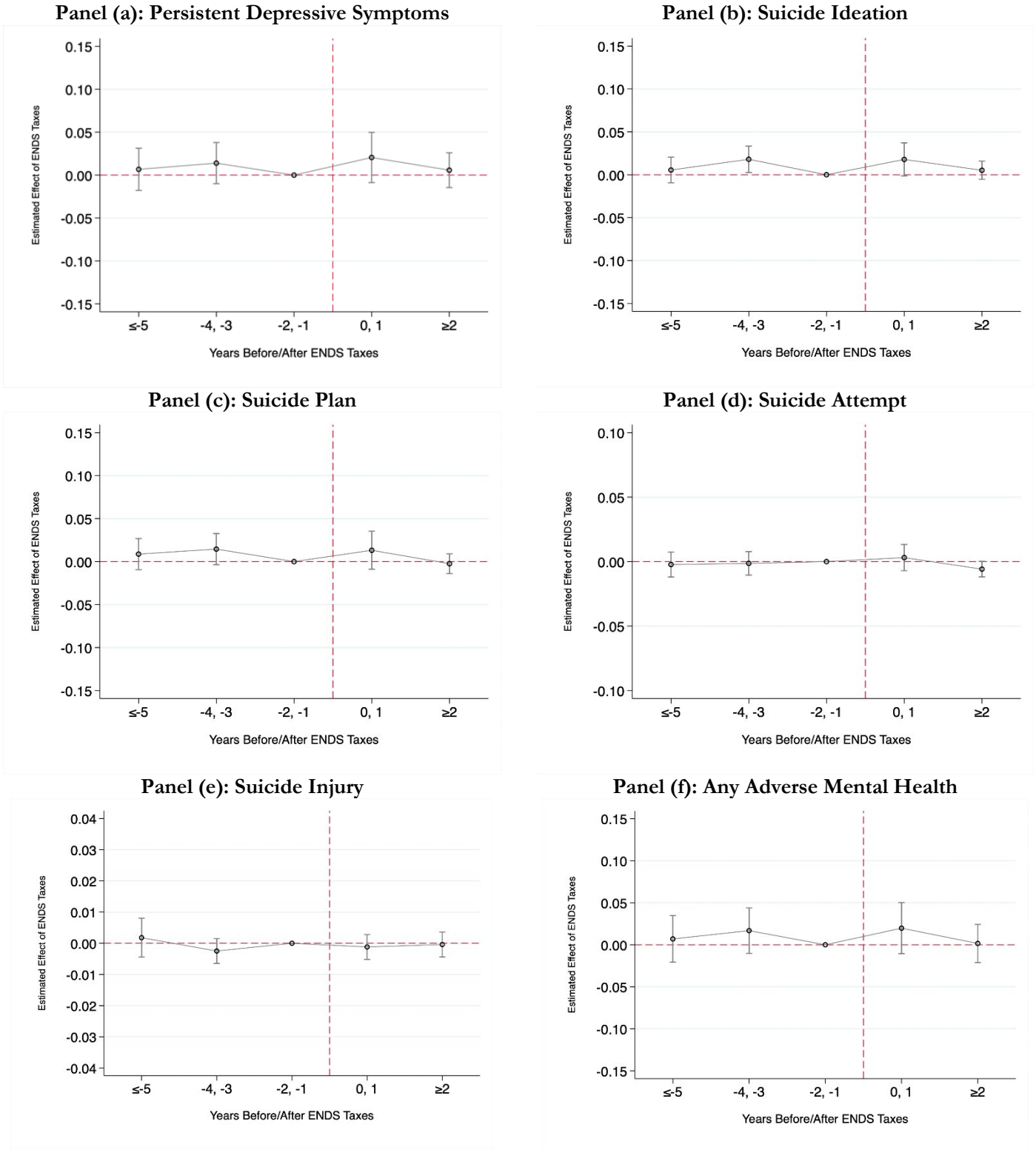


Panel (c): Everyday ENDS Use



Notes: Estimates are obtained from weighted OLS regressions using data from the 2015-2023 Combined State and National Youth Risk Behavior Surveys. All models include fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS. In the event-study, column (i) controls for demographics (age, race/ethnicity, grade, and gender), column (ii) adds controls for the unemployment rate, poverty rate, and cumulative state COVID-19 death rates. The full controls model – column (iii) -- incorporates additional controls for tobacco control policies, beer taxes, medical and recreational marijuana laws, as well as prescription drug monitoring and naloxone laws. Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, 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.

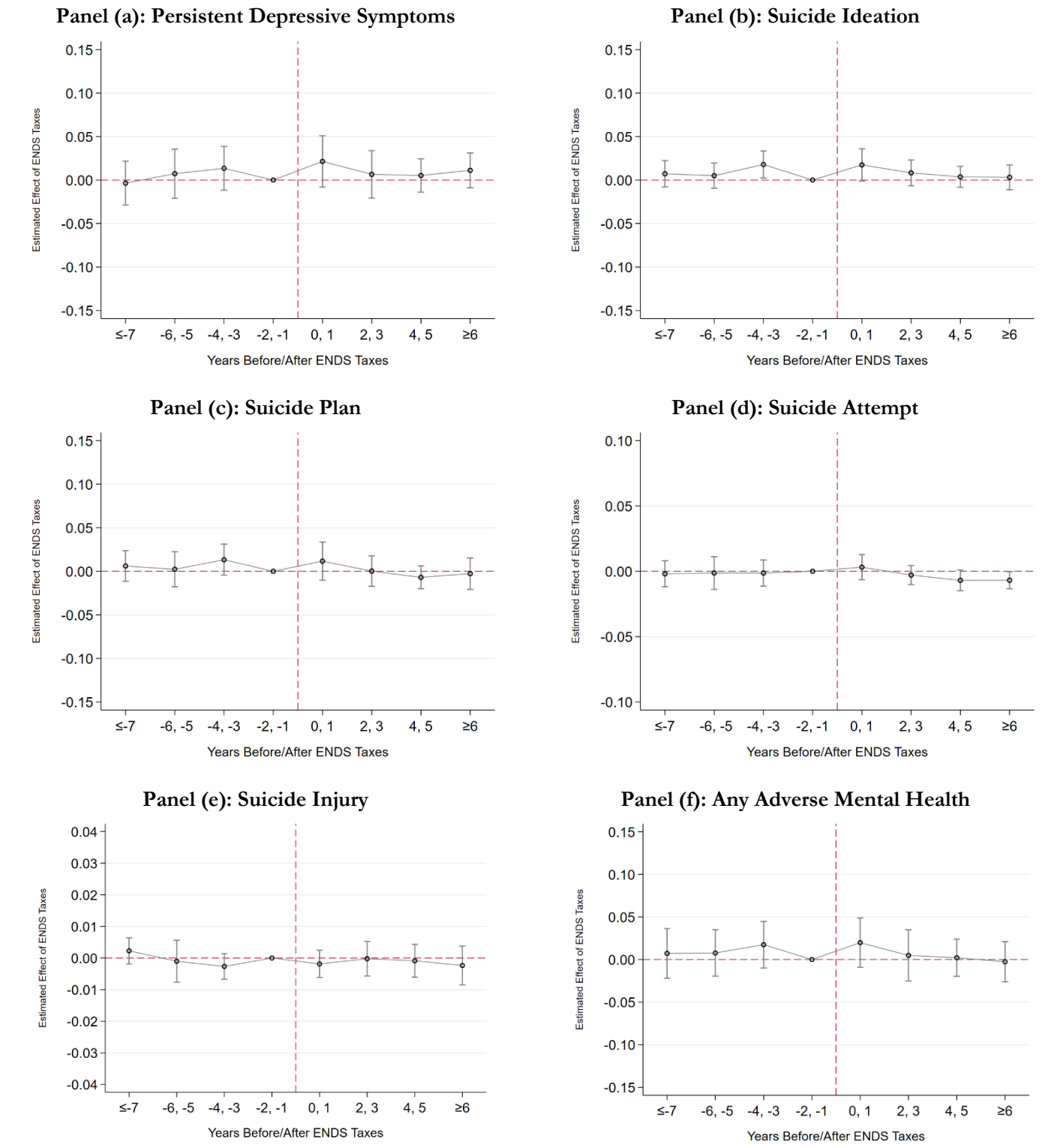
Figure 2. Event-Study Estimates of ENDS Taxes and Youth Mental Health, YRBS, Using TWFE Estimates



Notes: Estimates are obtained from weighted OLS regressions using data from the 2003-2023 Combined State and National Youth Risk Behavior Surveys. The model contains full controls which include fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS, demographic controls (sex, grade, age, and race), macroeconomic controls (poverty and unemployment rates), COVID controls (cumulative COVID-19 death rate), combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include medical, decriminalization and recreational marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax (in $2023). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, 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.

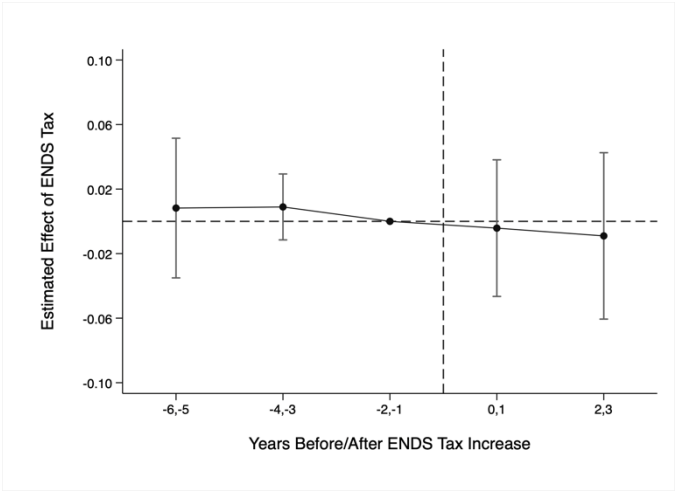
Figure 3. Sensitivity of Event-study Estimates in Figure 2 to Longer Lead and Lag Window, YRBS



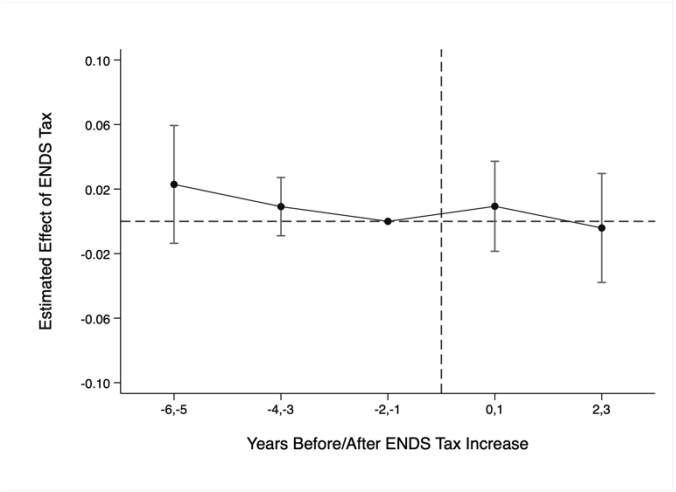
Notes: Estimates are obtained from weighted OLS regressions using data from the 2003-2023 Combined State and National Youth Risk Behavior Surveys. The model contains full controls which include fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS, demographic controls (sex, grade, age, and race), macroeconomic controls (poverty and unemployment rates), COVID controls (cumulative COVID-19 death rate), combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include medical, decriminalization and recreational marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax (in $2023). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, 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.

Figure 4A. Event-Study Estimates of Prominent ENDS Tax Increase ($0.5 per mL of e-liquid) and Youth Mental Health, using a Stacked Difference-in-differences Estimator, YRBS, 2003-2023

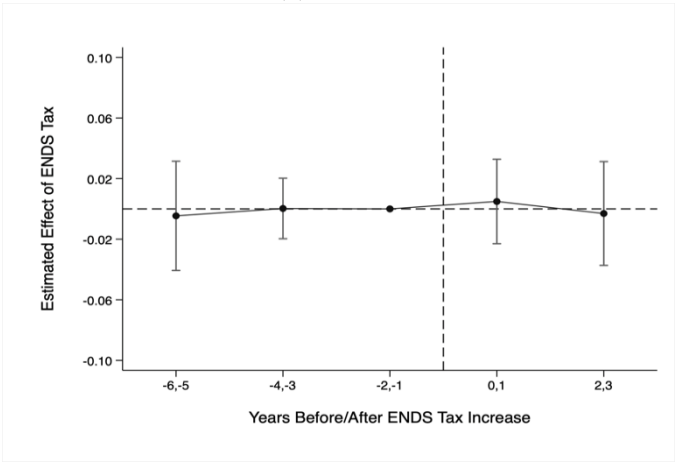
Panel (a): Persistent Depressive Symptoms



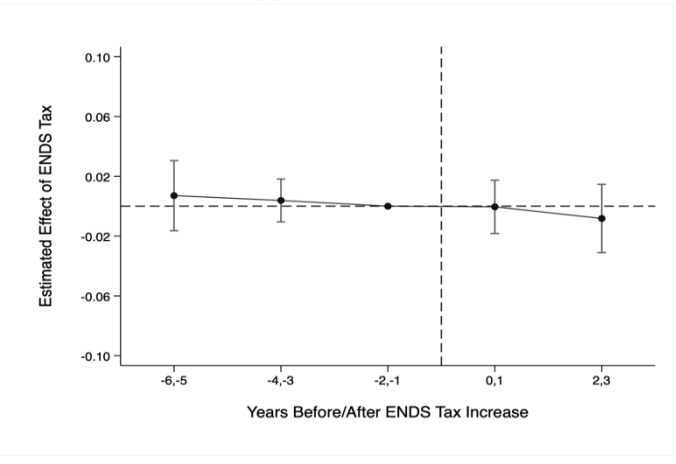
Panel (b): Suicide Ideation



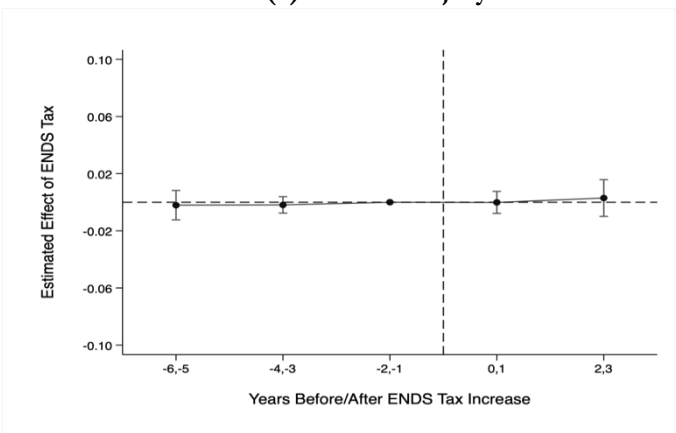
Panel (c): Suicide Plan



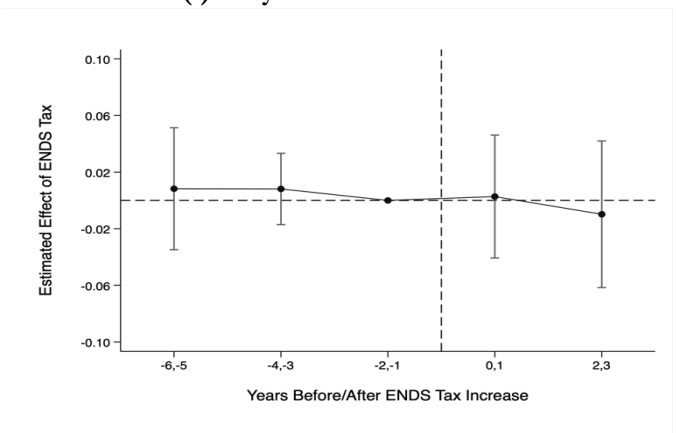
Panel (d): Suicide Attempt



Panel (e): Suicide Injury



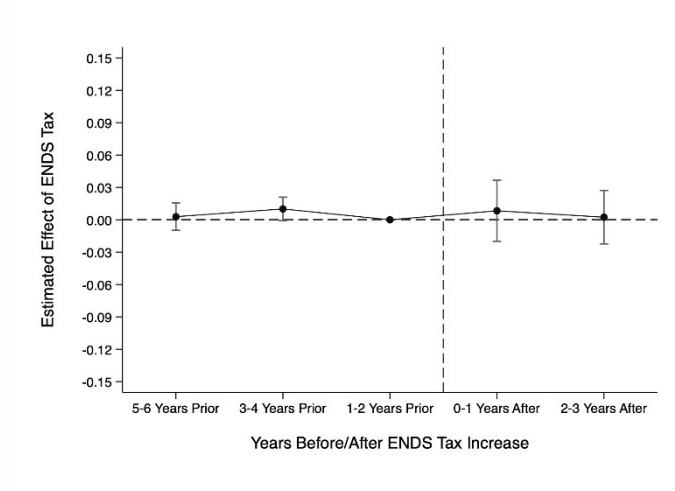
Panel (f): Any Adverse Mental Health



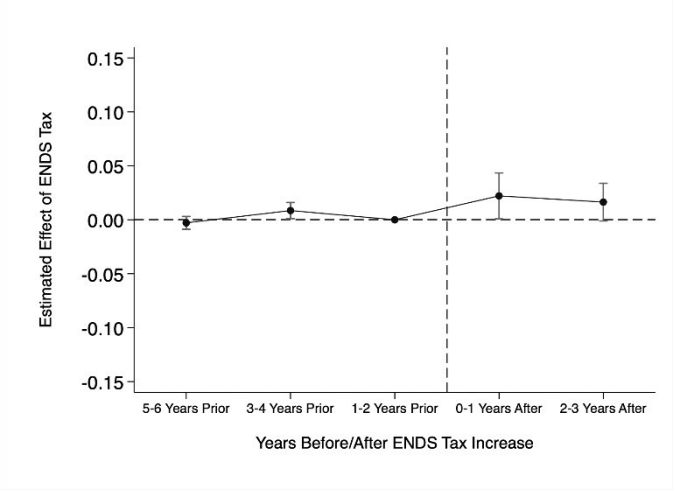
Notes: Estimates are obtained from stacked difference-in-differences regressions using data from the 2003-2023 State and National Youth Risk Behavior Surveys. A $0.5 (in nominal terms) increase in ENDS taxes is defined to be a prominent increase. Model includes fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS. Controls include demographic controls (sex, grade, age, and race), macroeconomic controls (poverty and unemployment rates), COVID controls (cumulative COVID-19 death rate), combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include medical, decriminalization and recreational marijuana laws, prescription drug monitoring laws, naloxone access laws, beer tax. Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, 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.

Figure 4B. Event-Study Estimates of Continuous ENDS Taxes and Youth Mental Health, using Stacked a Difference-in-differences Estimator, YRBS 2003-2023

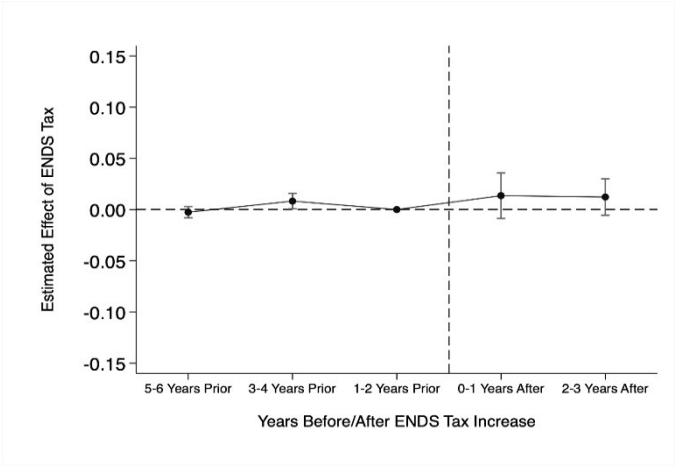
Panel (a): Persistent Depressive Symptoms



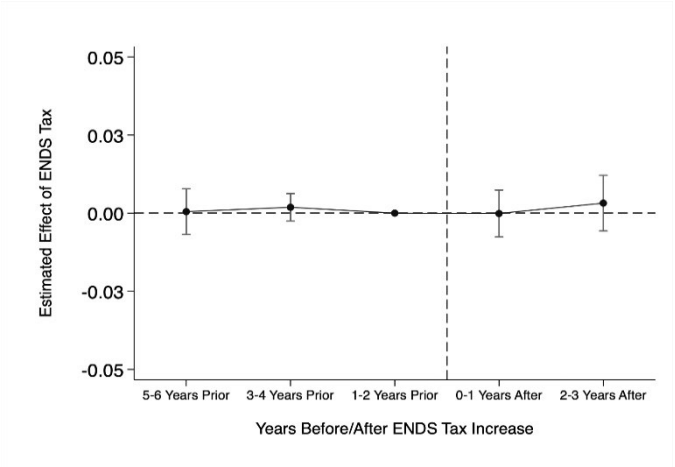
Panel (b): Suicide Ideation



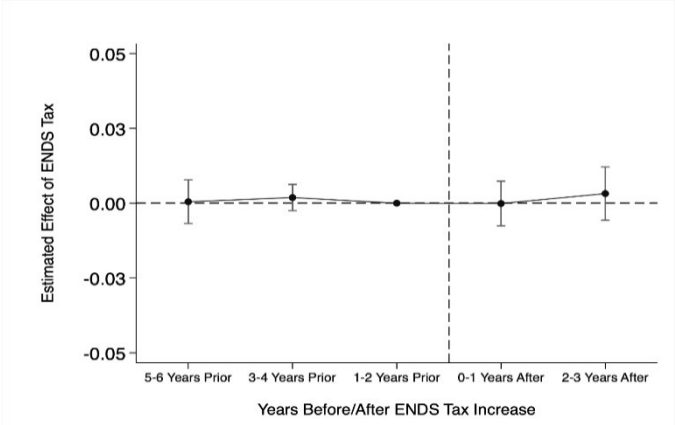
Panel (c): Suicide Plan



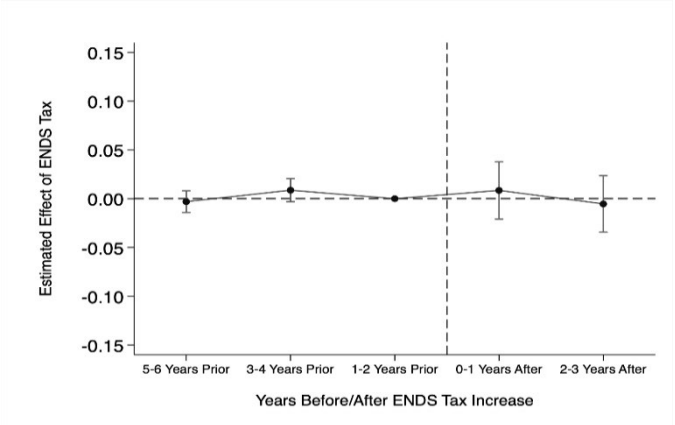
Panel (d): Suicide Attempt



Panel (e): Suicide Injury

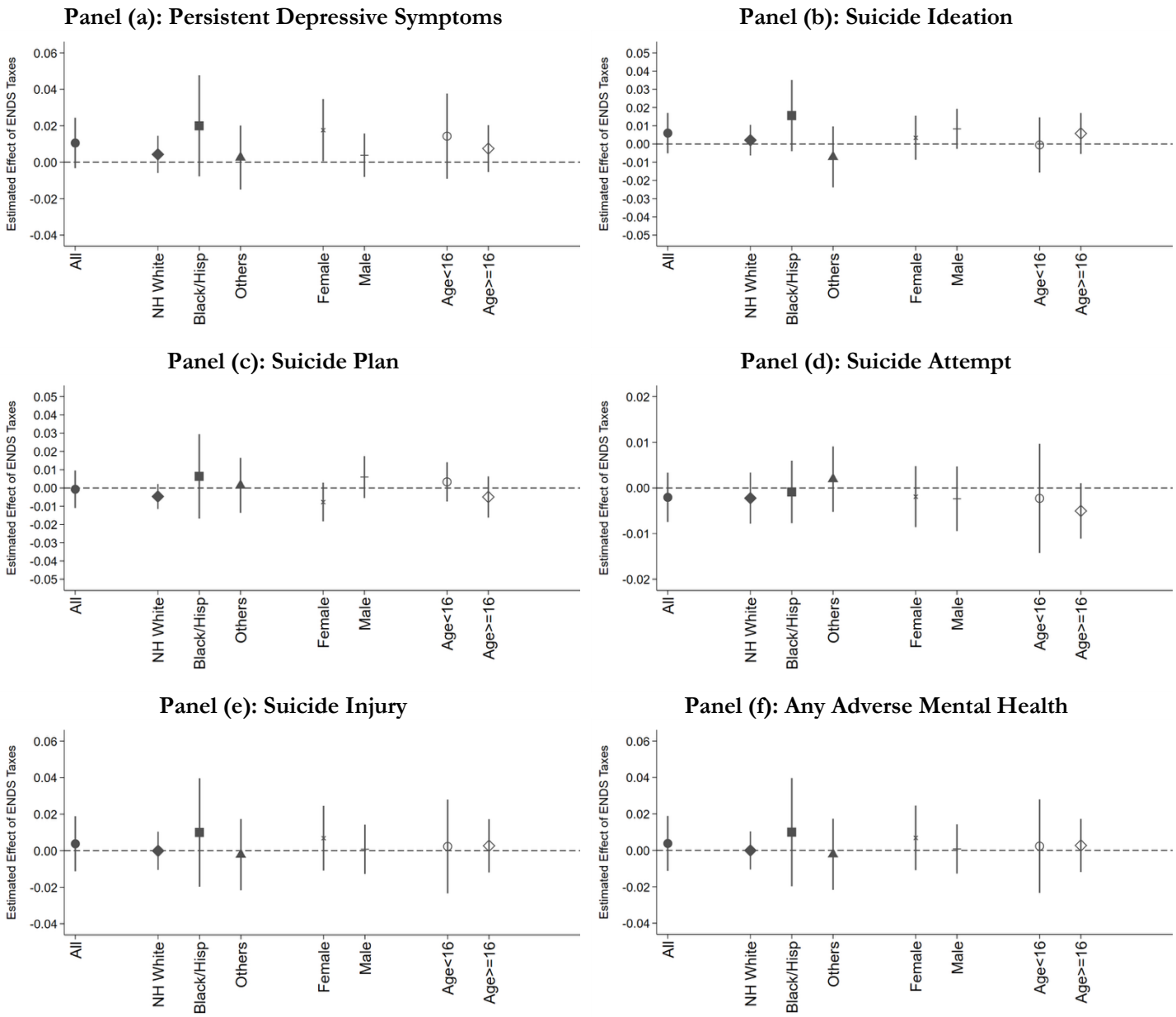


Panel (f): Any Adverse Mental Health



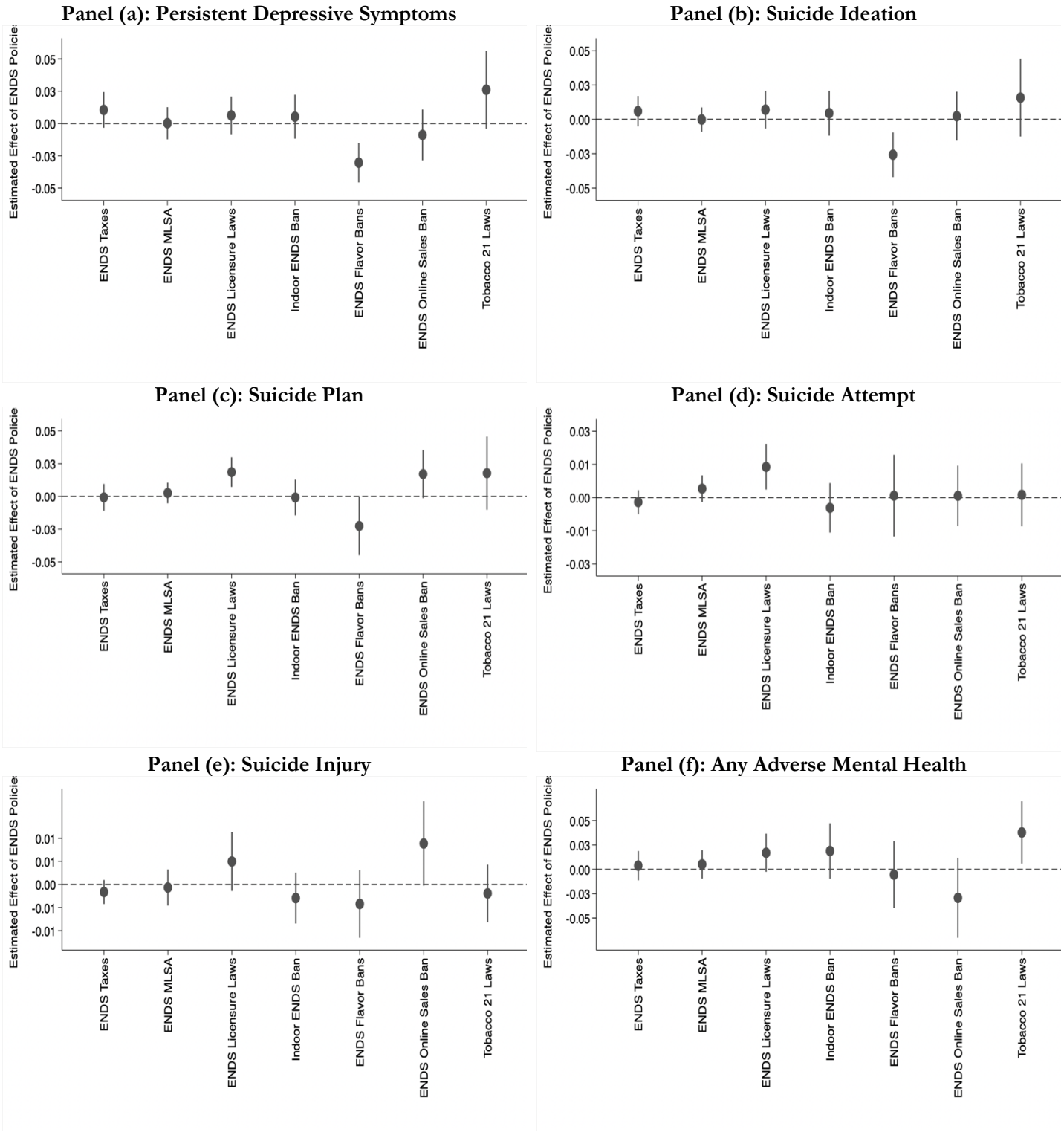
Notes: Estimates are obtained from continuous stacked difference-in-differences regressions using data from the 2003-2023 State and National Youth Risk Behavior Surveys. Model includes fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS Controls include demographic controls (sex, grade, age, and race), macroeconomic controls (poverty and unemployment rates), COVID controls (cumulative COVID-19 death rate), combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include medical, decriminalization and recreational marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax (in $2023). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, 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.

Figure 5. Heterogeneity in Effects of ENDS Taxes on Mental Health Outcomes, by Race/Ethnicity, Gender, and Age, YRBS, 2003-2023



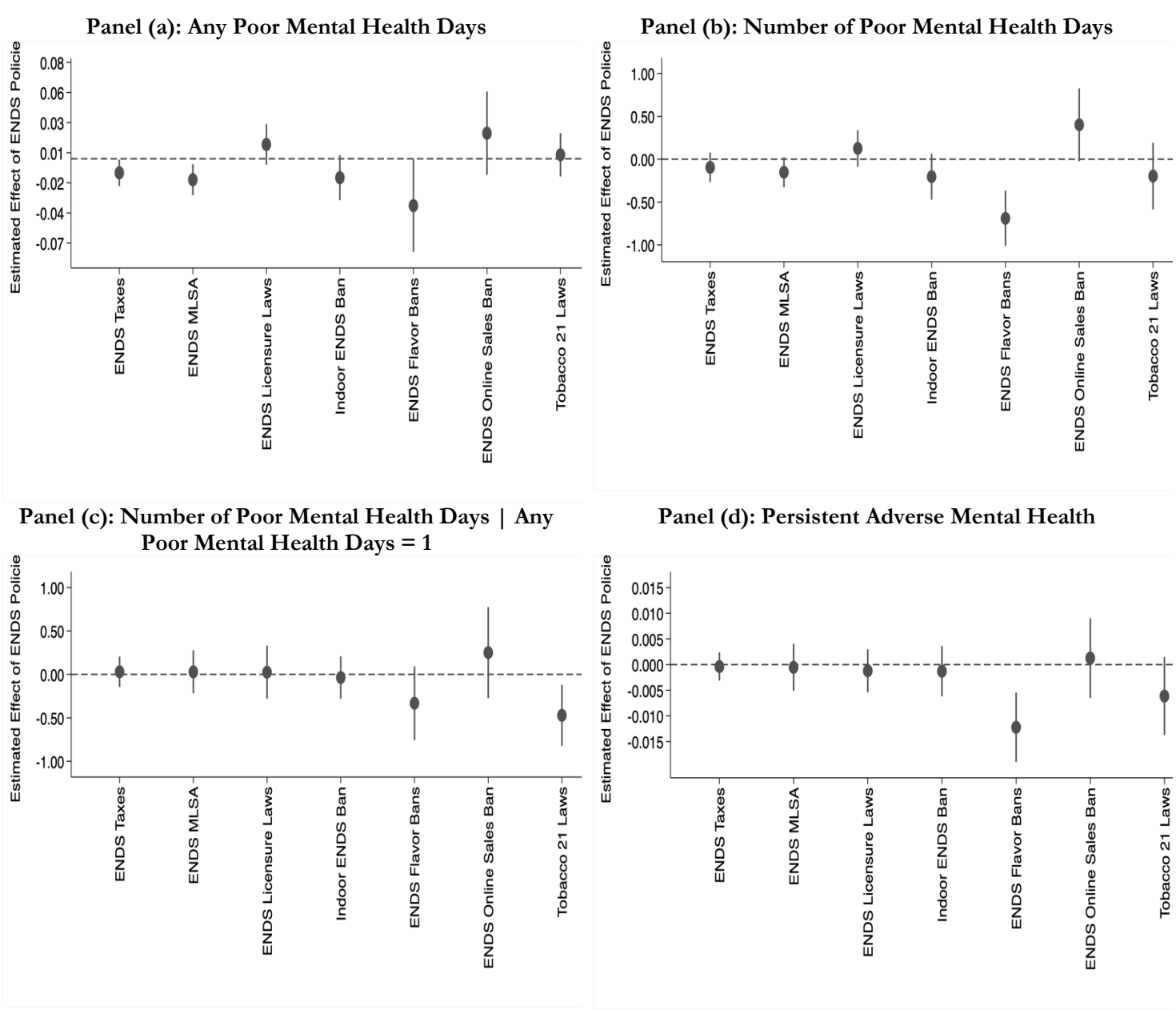
Notes: Estimates are obtained from weighted OLS regressions using data from the 2003-2023 Combined State and National Youth Risk Behavior Surveys. The model contains full controls which include fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS, demographic controls like grade, age, and race, macroeconomic controls such as the poverty and unemployment rate, COVID controls like cumulative COVID-19 death rate, combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax (in $2023). Coefficients are represented with geometric shapes, and vertical lines indicate 95% confidence intervals, 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.

Figure 6. Estimated Effects of Other ENDS Regulations on Youth Mental Health, YRBS, 2003-2023



Notes: Estimates are obtained from weighted OLS regressions using data from the 2003-2023 Combined State and National Youth Risk Behavior Surveys. The model contains fixed effects for state, year, and semester, an indicator for whether the observation comes from state or national YRBS and full controls which include demographic controls like grade, age, and race, macroeconomic controls such as the poverty and unemployment rate, COVID controls like cumulative COVID-19 death rate, combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax (in $2023). Coefficients are represented with geometric shapes, and vertical lines indicate 95% confidence intervals, 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.

Figure 7. Estimated Effects of Other ENDS Regulations on Mental Health of Adults Aged 18-24, BRFSS, 2011-2023



Notes: TWFE estimates are obtained using weighted least squares and generated from Behavioral Risk Factor Surveillance System Surveys collected over the period 2011-2023. We include the following controls: age, state, year, and quarter fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Coefficients are represented with geometric shapes, and vertical lines indicate 95% confidence intervals, adjusted for clustering at the state level. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset .

Table 1. TWFE Estimates of Effect of ENDS Taxes on Youth Prior-Month ENDS Use, YRBS, 2015-2023

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel I: Current ENDS Use							
ENDS Tax ($2023)	-0.025***	-0.021***	-0.017***	-0.016***	-0.016*	-0.016**	-0.013*
	(0.004)	(0.004)	(0.006)	(0.006)	(0.008)	(0.007)	(0.007)
	[-0.033,-0.018]	[-0.028,-0.013]	[-0.029,-0.005]	[-0.028,-0.004]	[-0.032,0.001]	[-0.030,-0.002]	[-0.027,0.001]
Pre-Treat Mean DV	0.208	0.208	0.208	0.208	0.208	0.208	0.208
N	807753	807753	807753	807753	807753	807753	807753
Panel II: Frequent ENDS Use							
ENDS Tax ($2023)	-0.013***	-0.011***	-0.013***	-0.012***	-0.013***	-0.011**	-0.010**
	(0.002)	(0.002)	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)
	[-0.017,-0.009]	[-0.016,-0.007]	[-0.020,-0.006]	[-0.019,-0.006]	[-0.023,-0.004]	[-0.020,-0.003]	[-0.019,-0.002]
Pre-Treat Mean DV	0.055	0.055	0.055	0.055	0.055	0.055	0.055
N	807753	807753	807753	807753	807753	807753	807753
Panel III: Everyday ENDS Use							
ENDS Tax ($2023)	-0.012***	-0.011***	-0.012***	-0.012***	-0.013***	-0.011***	-0.010***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)	(0.003)	(0.004)
	[-0.016,-0.008]	[-0.015,-0.006]	[-0.017,-0.007]	[-0.016,-0.007]	[-0.021,-0.006]	[-0.018,-0.004]	[-0.017,-0.003]
Pre-Treat Mean DV	0.040	0.040	0.040	0.040	0.040	0.040	0.040
N	807753	807753	807753	807753	807753	807753	807753
Controls:							
Demographic?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic and COVID-19?	No	Yes	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	No	No	Yes	Yes	Yes	Yes	Yes
Other Tobacco Policies?	No	No	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	No	No	Yes	Yes	Yes
MJ & Substance Policies?	No	No	No	No	No	Yes	Yes
Beer Tax?	No	No	No	No	No	No	Yes

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

Notes: TWFE estimates, using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2015-2023. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and demographic controls. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, online sales ban and flavored ENDS restrictions. Marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Table 2. TWFE Estimates of Effect of ENDS Taxes on Youth Mental Health, YRBS, 2015-2023

	(1)	(2)	(3)	(4)	(5)
Panel I: Persistent Depressive Symptoms					
ENDS Tax ($2023)	-0.012	-0.011	0.005	0.003	0.005
	(0.009)	(0.009)	(0.014)	(0.015)	(0.015)
	[-0.029,0.006]	[-0.030,0.008]	[-0.023,0.033]	[-0.026,0.032]	[-0.025,0.034]
Pre-Treat Mean DV	0.337	0.337	0.337	0.337	0.337
N	877189	877189	877189	877189	877189
Panel II: Suicide Ideation					
ENDS Tax ($2023)	-0.003	-0.003	0.012	0.011	0.010
	(0.006)	(0.007)	(0.009)	(0.010)	(0.010)
	[-0.016,0.009]	[-0.017,0.010]	[-0.007,0.031]	[-0.008,0.031]	[-0.009,0.030]
Pre-Treat Mean DV	0.181	0.181	0.181	0.181	0.181
N	784502	784502	784502	784502	784502
Panel III: Suicide Plan					
ENDS Tax ($2023)	-0.002	-0.002	0.006	0.007	0.009
	(0.006)	(0.006)	(0.009)	(0.010)	(0.010)
	[-0.013,0.009]	[-0.014,0.010]	[-0.012,0.025]	[-0.013,0.027]	[-0.010,0.028]
Pre-Treat Mean DV	0.151	0.151	0.151	0.151	0.151
N	786352	786352	786352	786352	786352
Panel IV: Suicide Attempt					
ENDS Tax ($2023)	-0.001	-0.001	0.002	0.001	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
	[-0.009,0.006]	[-0.009,0.007]	[-0.005,0.010]	[-0.007,0.009]	[-0.006,0.009]
Pre-Treat Mean DV	0.092	0.092	0.092	0.092	0.092
N	670878	670878	670878	670878	670878
Panel V: Suicide Injury					
ENDS Tax ($2023)	0.001	0.000	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	[-0.004,0.005]	[-0.004,0.004]	[-0.003,0.005]	[-0.003,0.006]	[-0.003,0.006]
Pre-Treat Mean DV	0.024	0.024	0.024	0.024	0.024
N	890570	890570	890570	890570	890570
Panel VI: Any Adverse Mental Health					
ENDS Tax ($2023)	-0.014	-0.013	0.002	0.001	0.002
	(0.009)	(0.009)	(0.014)	(0.015)	(0.015)
	[-0.032,0.004]	[-0.032,0.005]	[-0.026,0.030]	[-0.029,0.031]	[-0.028,0.032]
Pre-Treat Mean DV	0.389	0.389	0.389	0.389	0.389
N	890570	890570	890570	890570	890570
Controls:					
Demographic, Macro, COVID?	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes
Other Tobacco Policies?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
MJ & Substance Policies?	No	No	No	Yes	Yes
Beer Tax?	No	No	No	No	Yes

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

Notes: TWFE estimates, using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2015-2023. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and demographic controls. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, online sales ban and flavored ENDS

restrictions. Marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Table 3. TWFE Estimates of Effect of ENDS Taxes on Youth Mental Health, YRBS, 2003-2023

	(1)	(2)	(3)	(4)	(5)
Panel I: Persistent Depressive Symptoms					
ENDS Tax ($2023)	0.008	0.005	0.010	0.010	0.011
	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
	[-0.004,0.019]	[-0.007,0.017]	[-0.003,0.023]	[-0.003,0.024]	[-0.003,0.024]
Pre-Treat Mean DV	0.297	0.297	0.297	0.297	0.297
N	1601954	1601954	1601954	1601954	1601954
Panel II: Suicide Ideation					
ENDS Tax ($2023)	0.005	0.004	0.006	0.006	0.006
	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)
	[-0.006,0.015]	[-0.007,0.014]	[-0.005,0.018]	[-0.005,0.017]	[-0.005,0.017]
Pre-Treat Mean DV	0.162	0.162	0.162	0.162	0.162
N	1479899	1479899	1479899	1479899	1479899
Panel III: Suicide Plan					
ENDS Tax ($2023)	-0.001	-0.002	-0.002	-0.001	-0.001
	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)
	[-0.008,0.005]	[-0.009,0.005]	[-0.011,0.007]	[-0.011,0.009]	[-0.011,0.010]
Pre-Treat Mean DV	0.133	0.133	0.133	0.133	0.133
N	1468538	1468538	1468538	1468538	1468538
Panel IV: Suicide Attempt					
ENDS Tax ($2023)	-0.003	-0.001	-0.003	-0.002	-0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
	[-0.007,0.002]	[-0.006,0.004]	[-0.008,0.003]	[-0.008,0.003]	[-0.007,0.003]
Pre-Treat Mean DV	0.084	0.084	0.084	0.084	0.084
N	1270085	1270085	1270085	1270085	1270085
Panel V: Suicide Injury					
ENDS Tax ($2023)	-0.002	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
	[-0.005,0.001]	[-0.005,0.002]	[-0.005,0.001]	[-0.004,0.001]	[-0.004,0.001]
Pre-Treat Mean DV	0.023	0.023	0.023	0.023	0.023
N	1631516	1631516	1631516	1631516	1631516
Panel VI: Any Adverse Mental Health					
ENDS Tax ($2023)	0.006	0.003	0.001	0.003	0.004
	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)
	[-0.004,0.017]	[-0.007,0.013]	[-0.010,0.013]	[-0.011,0.018]	[-0.011,0.019]
Pre-Treat Mean DV	0.356	0.356	0.356	0.356	0.356
N	1631,516	1631516	1631516	1631516	1631516
Controls:					
Demographic, Macro COVID?	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes
Other Tobacco Policies?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
MJ & Substance Policies?	No	No	No	Yes	Yes
Beer Tax?	No	No	No	No	Yes

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

Notes: TWFE estimates, using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2003-2023. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and demographic controls. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, online sales ban and flavored ENDS

restrictions. Marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Table 4. Stacked Difference-in-differences Estimates of the Effect of ENDS Taxes on Youth Mental Health, YRBS, 2003-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Persistent Depressive Symptoms	Suicide Ideation	Suicide Plan	Suicide Attempt	Suicide Injury	Any Adverse Mental Health
			Panel I: Prominent ($0.25 per mL of e-liquid) ENDS Tax Increase			
ENDS Tax ($2023)	-0.009	0.002	-0.004	-0.006	-0.001	-0.002
	(0.013)	(0.006)	(0.008)	(0.006)	(0.003)	(0.016)
	[-0.035,0.016]	[-0.011,0.014]	[-0.019,0.012]	[-0.018,0.006]	[-0.008,0.006]	[-0.033,0.030]
Pre-Treat Mean DV	0.321	0.172	0.145	0.082	0.020	0.375
N	464611	462594	460744	444757	473207	473207
			Panel II: Prominent ($0.5 per mL of e-liquid) ENDS Tax Increase			
ENDS Tax ($2023)	-0.005	0.009	0.001	-0.005	0.000	0.007
	(0.018)	(0.008)	(0.010)	(0.007)	(0.004)	(0.020)
	[-0.041,0.030]	[-0.007,0.025]	[-0.020,0.021]	[-0.019,0.009]	[-0.008,0.009]	[-0.032,0.046]
Pre-Treat Mean DV	0.310	0.165	0.139	0.079	0.019	0.363
N	334156	332346	332282	319951	340417	340417
			Panel III: Continuous ENDS Tax			
ENDS Tax ($2023)	0.002	0.015	0.011	-0.000	0.001	0.000
	(0.014)	(0.010)	(0.010)	(0.004)	(0.002)	(0.015)
	[-0.026,0.030]	[-0.006,0.035]	[-0.009,0.030]	[-0.008,0.007]	[-0.002,0.005]	[-0.031,0.031]
Pre-Treat Mean DV	0.324	0.174	0.144	0.090	0.025	0.378
N	10515352	9871524	9583787	9227593	10706722	10706722

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

Notes: Stacked difference-in-differences estimates, using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2003-2023. Panel I and II provide stacked difference-in-differences estimates for a prominent nominal increase of $0.25/ml and $0.5/ml of e-liquid in ENDS taxes and Panel III provides the continuous stacked difference-in-differences estimates. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, online sales ban and flavored ENDS restrictions. Marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Table 5. Sensitivity of Estimates in Table 3 to Census Region-Specific Year FE and State-Specific Linear Time Trends, YRBS, 2003-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Persistent Depressive Symptoms	Suicide Ideation	Suicide Plan	Suicide Attempt	Suicide Injury	Any Adverse Mental Health
			Panel I: Include Census Region-Specific Year Fixed Effects			
ENDS Tax ($2023)	0.009*	0.004	-0.003	-0.002	-0.001	0.006
	(0.005)	(0.004)	(0.004)	(0.003)	(0.001)	(0.007)
	[-0.000,0.018]	[-0.004,0.013]	[-0.011,0.005]	[-0.007,0.004]	[-0.004,0.002]	[-0.008,0.020]
Pre-Treat Mean DV	0.297	0.162	0.133	0.084	0.023	0.356
N	1601954	1479899	1468538	1270085	1631516	1631516
			Panel II: Include State-Specific Linear Trends			
ENDS Tax ($2023)	0.005	0.009	0.005	0.001	0.003	0.012
	(0.013)	(0.008)	(0.010)	(0.003)	(0.002)	(0.013)
	[-0.020,0.031]	[-0.008,0.025]	[-0.014,0.024]	[-0.005,0.007]	[-0.001,0.007]	[-0.015,0.038]
Pre-Treat Mean DV	0.297	0.162	0.133	0.084	0.023	0.356
N	1601954	1479899	1468538	1270085	1631516	1631516

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

Notes: TWFE estimates obtained using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2003-2023. Panel I provide the weighted regression estimates controlling for region-specific year fixed effects and Panel II provides the weighted regression estimates controlling for state specific linear time trends. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, online sales ban and flavored ENDS restrictions. Marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Table 6. Exploration of Other Mechanisms: Smoking, Marijuana, Alcohol, and Harder Drug Use, YRBS, 2003-2023

	(1)	(2)	(3)	(4)
	Cigarette	Marijuana	Binge Drink	Cocaine/ Heroin
		Panel I: Contemporaneous Effects		
ENDS Tax ($2023)	0.011**	-0.012**	-0.007	-0.006
	(0.005)	(0.006)	(0.005)	(0.006)
	[0.000,0.022]	[-0.024,-0.001]	[-0.016,0.003]	[-0.017,0.005]
		Panel II: Lagged Effects		
ENDS Tax 0-1 Years After	0.008	-0.020**	-0.011**	-0.007
	(0.005)	(0.008)	(0.005)	(0.005)
	[-0.003,0.019]	[-0.037,-0.003]	[-0.021,-0.001]	[-0.018,0.004]
ENDS Tax 2+ Years After	0.010*	-0.013*	-0.007	-0.007
	(0.005)	(0.007)	(0.005)	(0.007)
	[-0.000,0.021]	[-0.028,0.001]	[-0.017,0.003]	[-0.022,0.008]
Pre-Treat Mean DV	0.074	0.186	0.137	0.055
N	851179	858682	783345	703438

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

Notes: TWFE estimates obtained using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2015-2023. Panel I provides contemporaneous estimates, and Panel II provides the lagged estimates. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, online sales ban and flavored ENDS restrictions. Marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Table 7. TWFE Estimates of Effect of ENDS Taxes on Adult ENDS Use, BRFSS 2016-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Current ENDS Use			Everyday ENDS Use		
			Panel I: Adults Aged 18-24			
ENDS Tax ($2023)	-0.0136***	-0.0128***	-0.0054	-0.0123***	-0.0120***	-0.0078**
	(0.0040)	(0.0039)	(0.0055)	(0.0034)	(0.0034)	(0.0038)
	[-0.0217,-0.0055]	[-0.0207,-0.0050]	[-0.0165,0.0057]	[-0.0192,-0.0054]	[-0.0188,-0.0052]	[-0.0154,-0.0002]
Pre-Treat Mean DV	0.118	0.118	0.118	0.038	0.038	0.038
N	141004	141004	141004	141004	141004	141004
			Panel II: Adults Aged 25-34			
ENDS Tax ($2023)	-0.0055*	-0.0053*	-0.0027	-0.0028	-0.0027	-0.0004
	(0.0029)	(0.0029)	(0.0040)	(0.0024)	(0.0024)	(0.0030)
	[-0.0113,0.0003]	[-0.0112,0.0005]	[-0.0108,0.0054]	[-0.0076,0.0021]	[-0.0076,0.0021]	[-0.0064,0.0056]
Pre-Treat Mean DV	0.078	0.078	0.078	0.028	0.028	0.028
N	249429	249429	249429	249429	249429	249429
			Panel III: Adults Aged 35-80			
ENDS Tax 2 Years After Increase	0.0002	0.0002	0.0010	-0.0010*	-0.0010*	-0.0006
	(0.0015)	(0.0014)	(0.0013)	(0.0006)	(0.0005)	(0.0007)
	[-0.0027,0.0031]	[-0.0027,0.0030]	[-0.0016,0.0036]	[-0.0021,0.0001]	[-0.0021,0.0001]	[-0.0020,0.0008]
Pre-Treat Mean DV	0.031	0.031	0.031	0.012	0.012	0.012
N	1948881	1948881	1948881	1948880	1948880	1948880
Controls:						
Demographic, Macro and COVID?	Yes	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes	Yes
Other Combustible Policies?	No	Yes	Yes	No	Yes	Yes
ENDS Policies?	No	No	Yes	No	No	Yes
MJ and Substance Policies?	No	No	Yes	No	No	Yes
Beer Taxes?	No	No	Yes	No	No	Yes

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

Notes: TWFE estimates are obtained using weighted least squares and generated from Behavioral Risk Factor Surveillance System (BRFSS) Surveys collected over the period 2016-2023. We include the following controls: age, state, year, and quarter fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset.

Table 8. TWFE Estimates of the Effects of ENDS Taxes on Young Adult Mental Health, BRFSS 2011-2023

	(1)	(2)	(3)	(4)
	Any Poor Mental Health Days	Number of Poor Mental Health Days	Number of Poor Mental Health Days Among Affected	Persistent Poor Mental Health
	Panel I: Baseline TWFE Estimates			
ENDS Tax ($2023)	-0.0171**	-0.1592	0.0353	-0.0018
	(0.0080)	(0.1019)	(0.1627)	(0.0025)
	[-0.0332,-0.0010]	[-0.3640,0.0455]	[-0.2916,0.3621]	[-0.0068,0.0033]
Pre-Treat Mean DV	0.498	4.808	9.655	0.052
N	310320	310320	165674	310320
	Panel II: Include Census Region-Specific Year Fixed Effects			
ENDS Tax ($2023)	-0.0097	-0.1035	-0.0114	-0.0019
	(0.0076)	(0.1215)	(0.1625)	(0.0028)
	[-0.0250,0.0056]	[-0.3475,0.1405]	[-0.3379,0.3151]	[-0.0075,0.0036]
Pre-Treat Mean DV	0.498	4.808	9.655	0.052
N	310320	310320	165674	310320
	Panel III: Include State-specific Linear Trends			
ENDS Tax ($2023)	-0.0057	-0.1399	-0.1458	-0.0041
	(0.0085)	(0.1154)	(0.1738)	(0.0033)
	[-0.0227,0.0113]	[-0.3716,0.0918]	[-0.4950,0.2033]	[-0.0107,0.0025]
Pre-Treat Mean DV	0.498	4.808	9.655	0.052
N	310320	310320	165674	310320

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

Notes: TWFE estimates are obtained using weighted least squares and generated from Behavioral Risk Factor Surveillance System Surveys collected over the period 2011-2023. All panels use age, state, year, and quarter fixed effects. Panel II adds region-specific year fixed effects and Panel III adds state-specific linear time trends. We include the following controls: age, state, year, and quarter fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset.

Table 9. TWFE Estimates of the Effects of ENDS Taxes on ENDS Use, PATH, 2013-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Current ENDS Use (OLS)		Vaping Initiation (Hazard Model)		Vaping Cessation (Hazard Model)	
	Panel I: Youth Aged 14-17 Years					
ENDS Tax ($2023)	-0.020**	-0.018**	-0.013**	-0.019**	0.056	0.319
	-0.01	-0.008	(0.006)	(0.007)	(0.054)	(0.344)
Pre-Treatment Mean DV	0.07	0.071	0.042	0.041	0.762	0.693
Observations	63,507	65,451	59,832	61,637	1,205	1,211
	Panel II: Young Adults Aged 18-24 Years					
ENDS Tax ($2023)	-0.018**	-0.015	-0.016**	-0.005	0.003	-0.054
	-0.009	-0.009	(0.007)	(0.007)	(0.030)	(0.048)
Pre-Treatment Mean DV	0.161	0.161	0.076	0.064	0.742	0.707
Observations	68,554	68,554	52,379	52,361	4,577	4,501
Controls:						
Macro and COVID?	Yes	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes	Yes
Other Combustible Policies?	Yes	Yes	Yes	Yes	Yes	Yes
ENDS Policies?	Yes	Yes	Yes	Yes	Yes	Yes
MJ and Substance Policies?	Yes	Yes	Yes	Yes	Yes	Yes
Beer Taxes?	Yes	Yes	Yes	Yes	Yes	Yes
Year/Quarter Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects?	Yes	No	Yes	No	Yes	No
Individual Fixed Effects?	No	Yes	No	Yes	No	Yes

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

Notes: TWFE estimates in columns (1) and (2) are obtained using weighted least squares and generated from PATH data collected over the period 2013-2023. Panels (3) through (6) estimate discrete time hazard models using TWFE. All regressions include year, and quarter fixed effects. Columns (1), (3), and (5) include state fixed effects while columns (2), (4), and (6) include individual fixed effects instead. When including individual fixed effects we do not include time-invariant individual-level characteristics. All regressions include unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Standard errors are clustered at the state level and presented in parentheses. The dependent variable mean reports the weighted percentage of respondents who report vaping in the past 30 days in treatment states in time periods before treatment in the estimation sample. Regressions are weighted using the individual level sample weights provided in the PATH dataset.

Table 10. Effects of ENDS Taxation on Current Youth Mental Health Problems and Dynamics in Mental Health Problems, PATH, 2013-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Current Mental Health Problem (Using Continuous Index)		Initiation of Mental Health Problem (No Problem if Index = 0; Problem if Index > 0)		Cessation of Mental Health Problem (No Problem if Index = 0; Problem if Index > 0)	
Panel I: Comprehensive Mental Health Index						
ENDS Tax ($2023)	0.001	-0.014	-0.023	-0.044	0.008	0.008
	(0.021)	(0.017)	(0.018)	(0.042)	(0.011)	(0.011)
Pre-Treatment Mean DV	2.896	3.193	0.699	0.579	3.741	3.856
Observations	63,697	65,651	11,393	11,735	38,261	39,206
Panel II: Mental Health Index						
ENDS Tax ($2023)	-0.001	0.007	-0.002	-0.031	-0.007	-0.032**
	(0.026)	(0.023)	(0.015)	(0.026)	(0.012)	(0.015)
Pre-Treatment Mean DV	1.315	1.678	0.372	0.307	2.111	2.194
Observations	63,697	65,651	21,556	22,150	25,815	26,415
Panel III: ADHD Index						
ENDS Tax ($2023)	-0.002	-0.018	-0.015	-0.023	0.005	0.027
	(0.024)	(0.025)	(0.020)	(0.020)	(0.014)	(0.017)
Pre-Treatment Mean DV	1.23	1.516	0.366	0.291	1.844	1.922
Observations	63,697	65,651	19,604	20,264	27,685	28,275
Controls:						
Macro and COVID?	Yes	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes	Yes
Other Combustible Policies?	Yes	Yes	Yes	Yes	Yes	Yes
ENDS Policies?	Yes	Yes	Yes	Yes	Yes	Yes
MJ and Substance Policies?	Yes	Yes	Yes	Yes	Yes	Yes
Beer Taxes?	Yes	Yes	Yes	Yes	Yes	Yes
Year/Quarter Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects?	Yes	No	Yes	No	Yes	No
Individual Fixed Effects?	No	Yes	No	Yes	No	Yes

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

Notes: Estimates in columns (1) and (2) are obtained using weighted Poisson QMLE estimators and generated from PATH data collected over the period 2013-2023. Panels (3) through (6) estimate discrete time hazard models using TWFE. All regressions include year, and quarter fixed effects. Columns (1), (3), and (5) include state fixed effects while columns (2), (4), and (6) include individual fixed effects instead. When including individual fixed effects we do not include time-invariant individual-level characteristics. All regressions include unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Standard errors are clustered at the state level and presented in parentheses. The dependent variable mean reports the weighted number of mental health issues reported in each dimension in treatment states in time periods before treatment in the estimation sample. Regressions are weighted using the individual level sample weights provided in the PATH dataset.

Table 11. Effects of ENDS Taxation on Current Young Adult Mental Health Problems and Dynamics in Mental Health Problems, PATH, 2013-2023

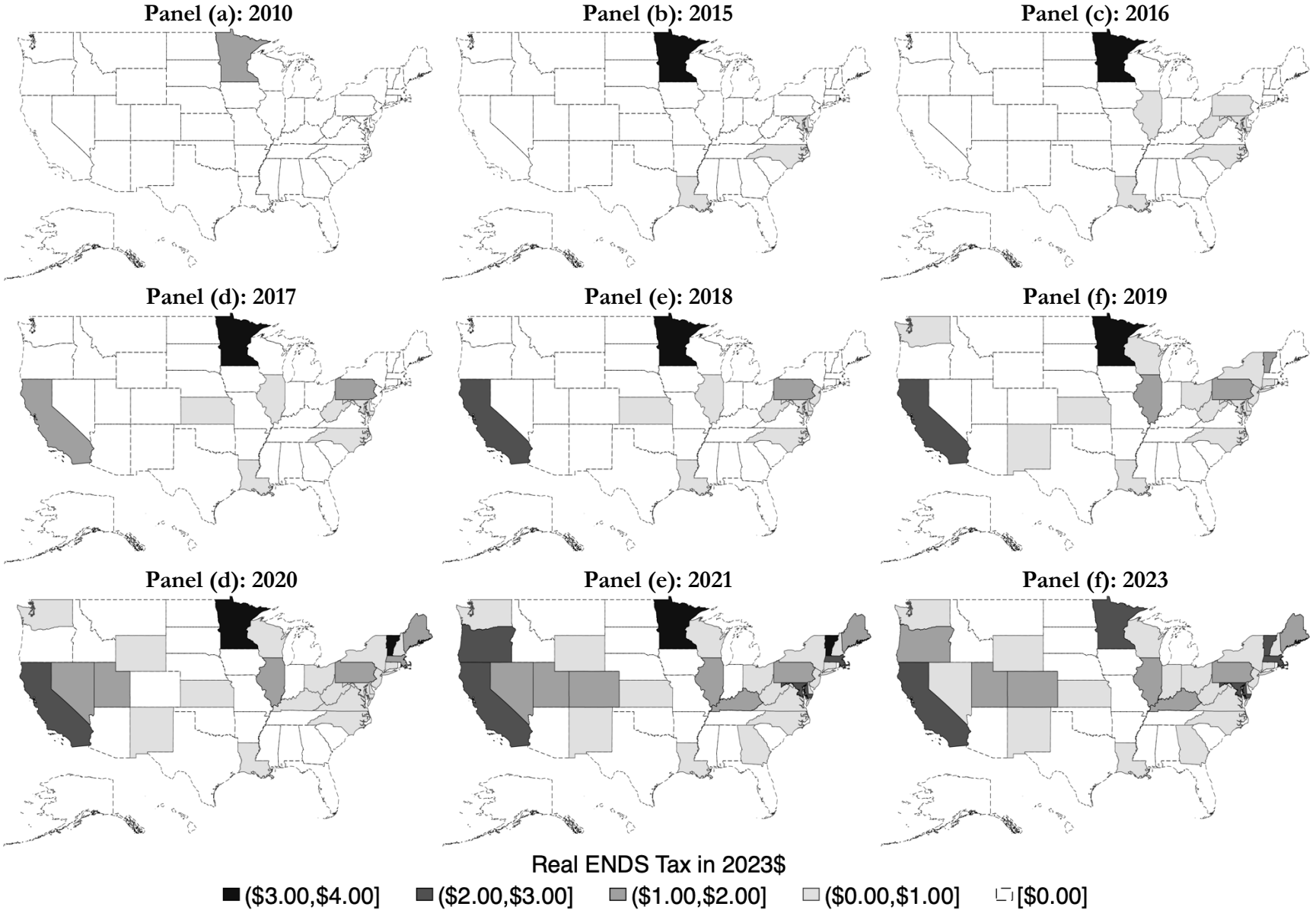
	(1)	(2)	(3)	(4)	(5)	(6)
	Current Mental Health Problem (Using Continuous Index)		Initiation of Mental Health Problem (No Problem if Index = 0; Problem if Index > 0)		Cessation of Mental Health Problem (No Problem if Index = 0; Problem if Index > 0)	
Panel I: Comprehensive Mental Health Index						
ENDS Tax ($2023)	-0.022	-0.002	-0.057**	-0.022	0.000	0.012
	(0.019)	(0.013)	(0.022)	(0.025)	(0.018)	(0.017)
Pre-Treatment Mean DV	2.1	2.447	0.447	0.504	2.959	3.031
Observations	68,752	68,669	11,856	11,805	34,262	33,980
Panel II: Mental Health Index						
ENDS Tax ($2023)	-0.030	0.003	-0.017	-0.004	-0.020	0.002
	(0.027)	(0.015)	(0.013)	(0.017)	(0.022)	(0.017)
Pre-Treatment Mean DV	0.998	1.407	0.252	0.267	1.892	1.942
Observations	68,752	68,669	22,265	22,133	21,173	20,934
Panel III: ADHD Index						
ENDS Tax ($2023)	-0.019	-0.010	-0.037**	0.008	-0.004	-0.007
	(0.025)	(0.016)	(0.015)	(0.020)	(0.019)	(0.015)
Pre-Treatment Mean DV	0.906	1.194	0.243	0.265	1.522	1.563
Observations	68,752	68,669	19,581	19,506	23,065	22,819
Controls:						
Macro and COVID?	Yes	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes	Yes
Other Combustible Policies?	Yes	Yes	Yes	Yes	Yes	Yes
ENDS Policies?	Yes	Yes	Yes	Yes	Yes	Yes
MJ and Substance Policies?	Yes	Yes	Yes	Yes	Yes	Yes
Beer Taxes?	Yes	Yes	Yes	Yes	Yes	Yes
Year/Quarter Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects?	Yes	No	Yes	No	Yes	No
Individual Fixed Effects?	No	Yes	No	Yes	No	Yes

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

Notes: Estimates in columns (1) and (2) are obtained using weighted Poisson QMLE estimators and generated from PATH data collected over the period 2013-2023. Panels (3) through (6) estimate discrete time hazard models using TWFE. All regressions include year, and quarter fixed effects. Columns (1), (3), and (5) include state fixed effects while columns (2), (4), and (6) include individual fixed effects instead. When including individual fixed effects we do not include time-invariant individual-level characteristics. All regressions include unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Standard errors are clustered at the state level and presented in parentheses. The dependent variable mean reports the weighted number of mental health issues reported in each dimension in treatment states in time periods before treatment in the estimation sample. Regressions are weighted using the individual level sample weights provided in the PATH dataset.

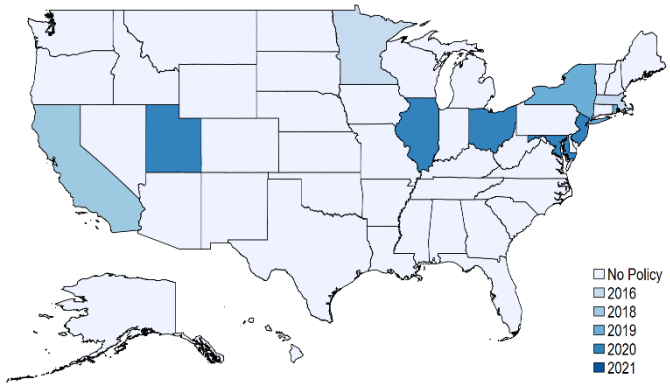
Online Appendix Figures and Tables

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

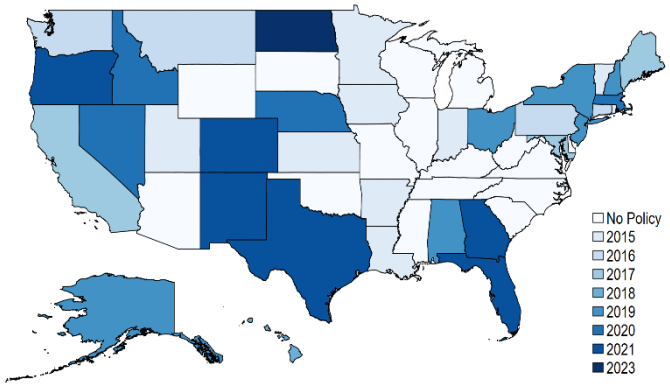


Appendix Figure 2. Geographic & Temporal Variation in Other ENDS Policies, 2015-2023

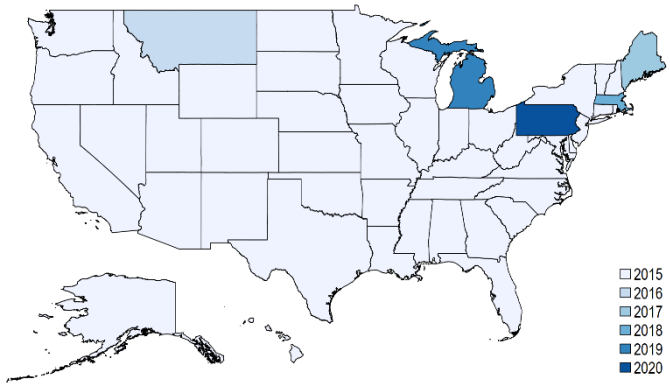
ENDS Flavor Ban



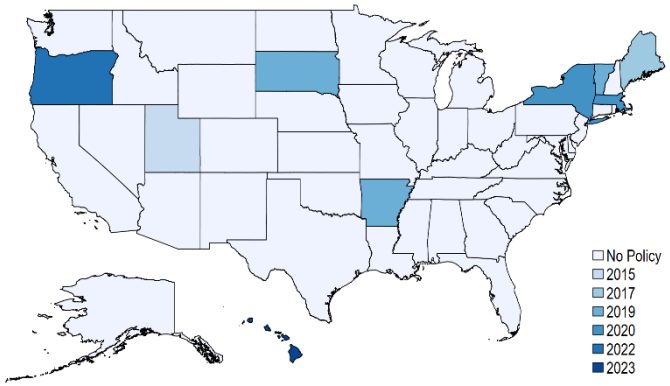
ENDS Licensure Laws



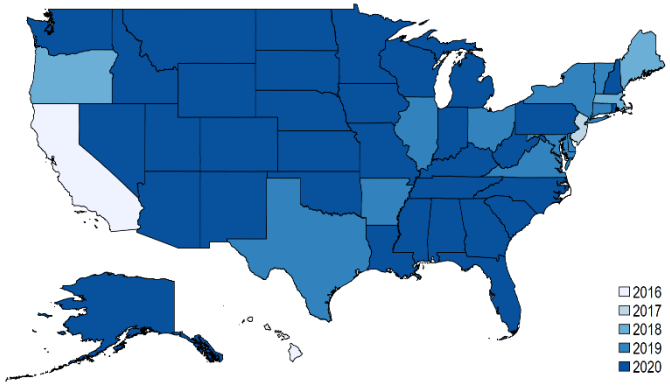
ENDS MLSA Laws



Online ENDS Sales Ban



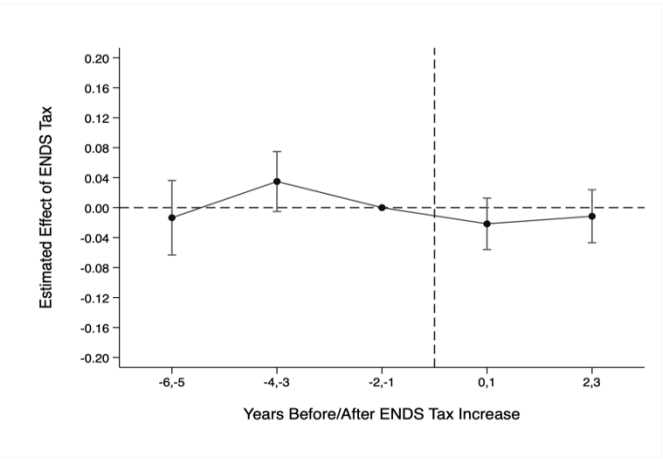
T-21 Laws

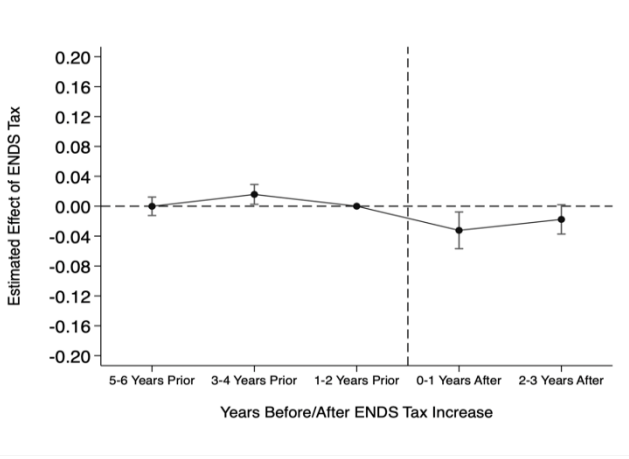


Appendix Figure 3. Event-Study Estimates of Youth Mental Health, Using a Stacked Difference-in-Differences Estimator, YRBS, 2015-2023

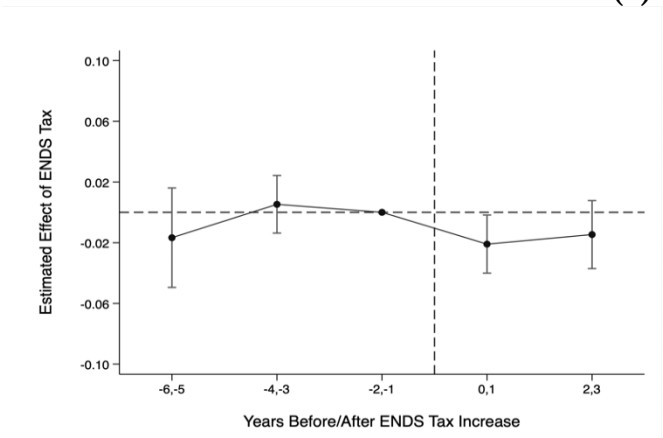
(i) Prominent Nominal ENDS Tax Hike ($0.5/mL of e-liquid) **(ii) Continuous**

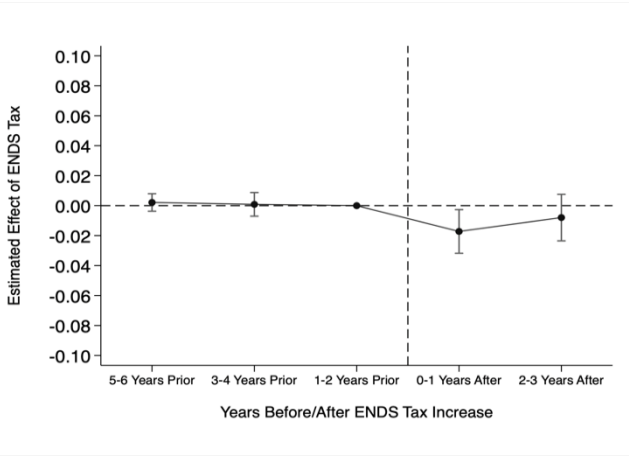
Panel (a): Current ENDS Use



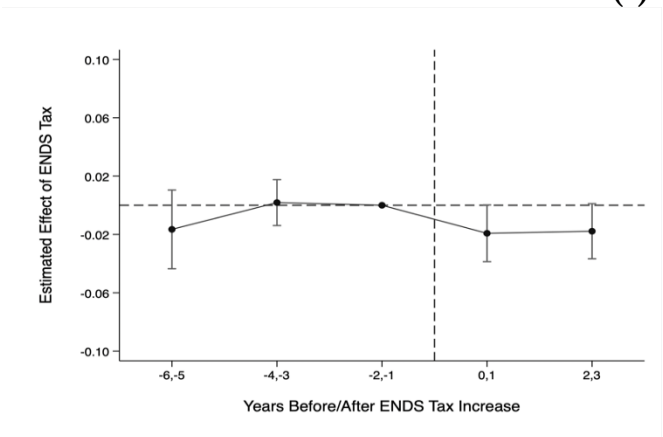


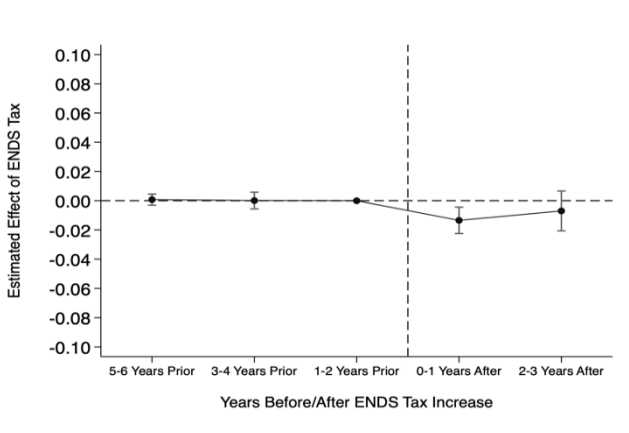
Panel (b): Frequent ENDS Use





Panel (c): Everyday ENDS Use



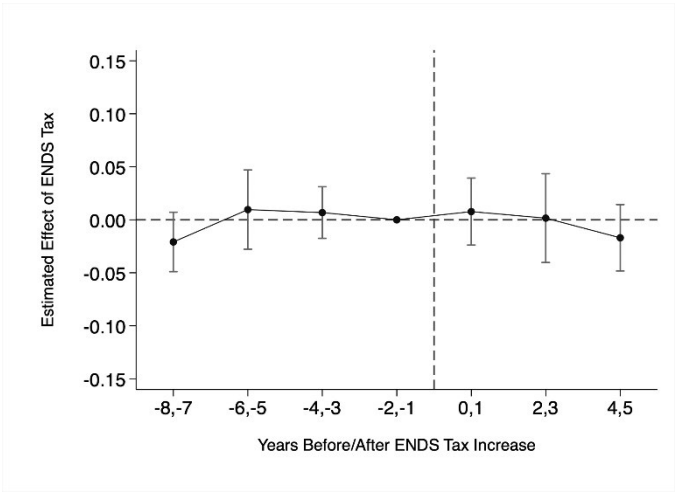


Notes: Estimates are obtained from weighted stacked difference-in-differences regressions using data from the 2015-2023 Combined State and National Youth Risk Behavior Surveys. All models include fixed effects for state, year, and semester and an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Each column controls for demographics (age, race/ethnicity, grade, and gender), unemployment rate, poverty rate, and cumulative state COVID-19 death rates and additional controls for tobacco control policies, beer taxes, medical and recreational marijuana laws, as well as naloxone and PDMPs. Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, adjusted for clustering at

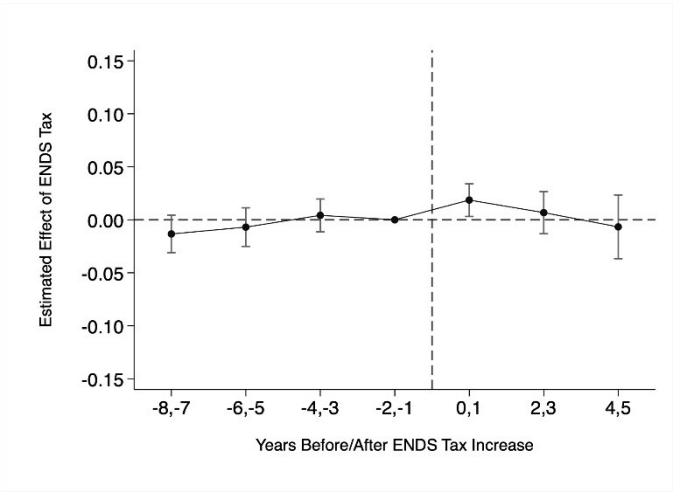
the state level. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Figure 4. Event-Study Estimates of Prominent ENDS Tax Increase ($0.5 per mL of e-liquid) and Youth Mental Health, Using Longer Leads and Lags, YRBS, 2003-2023

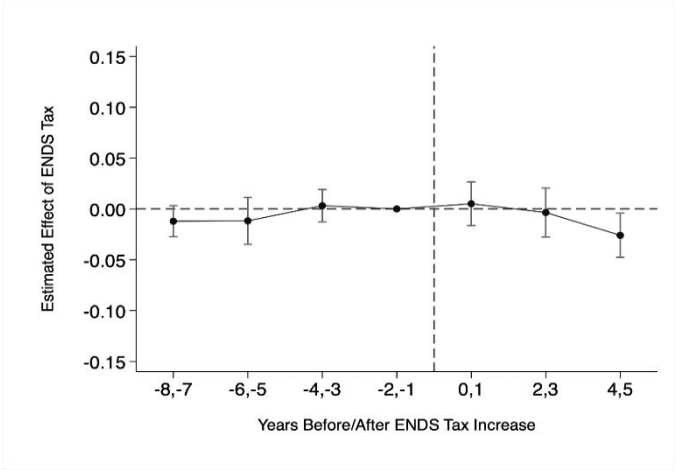
Panel (a): Persistent Depressive Symptoms



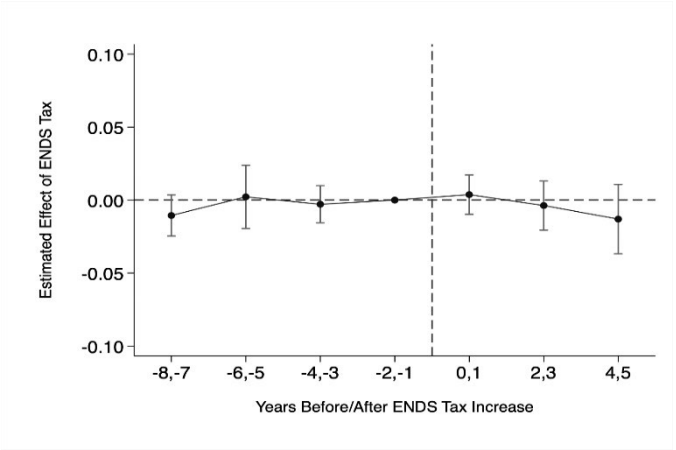
Panel (b): Suicide Ideation



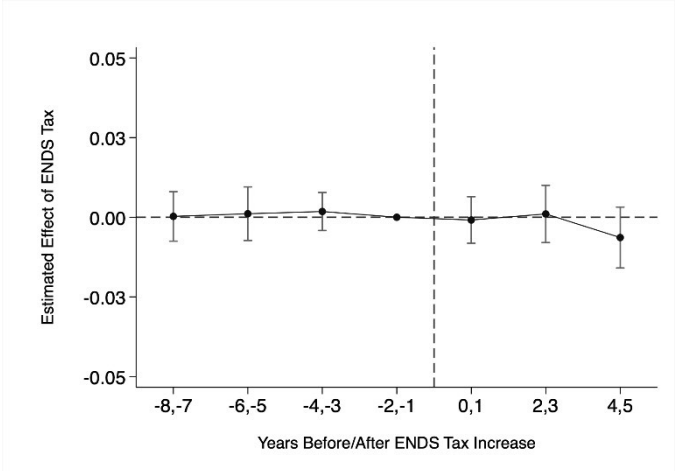
Panel (c): Suicide Plan



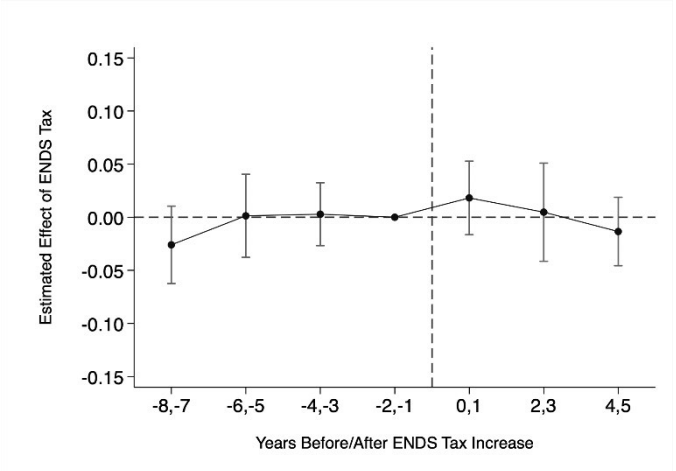
Panel (d): Suicide Attempt



Panel (e): Suicide Injury



Panel (f): Any Adverse Mental Health

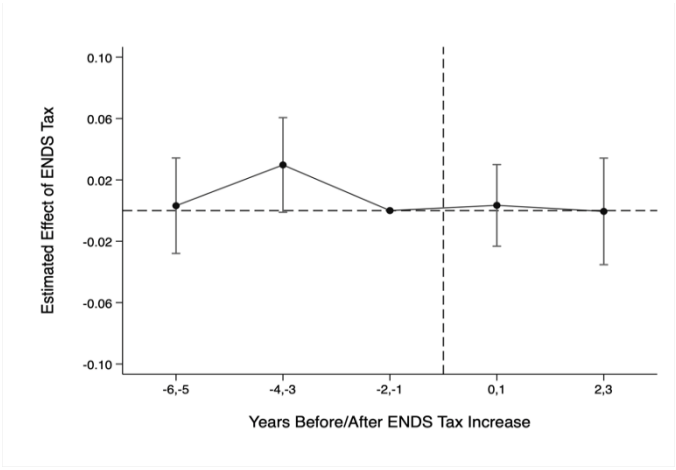


Notes: Estimates are obtained from stacked difference-in-differences regressions using data from the 2003-2023 State and National Youth Risk Behavior Surveys. A $0.5 (in nominal terms) increase in ENDS taxes is defined to be a prominent increase. Each model includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Controls include demographic controls (sex, grade, age, and race), macroeconomic controls (poverty and unemployment rates), COVID controls (cumulative COVID-19 death rate), combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include medical, decriminalization and recreational marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax (in $2023). Coefficients are represented with dots, and

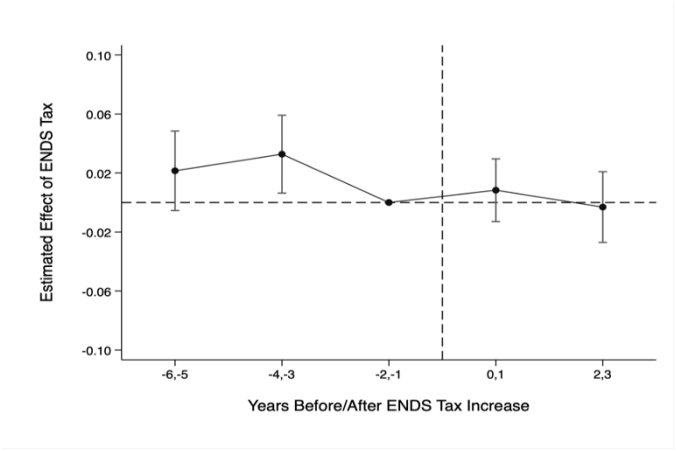
vertical lines indicate 95% confidence intervals, adjusted for clustering at the state level. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Figure 5. Event-Study Estimates of Prominent ENDS Tax Increase ($0.25 per mL of e-liquid) and Youth Mental Health, YRBS, 2003-2023

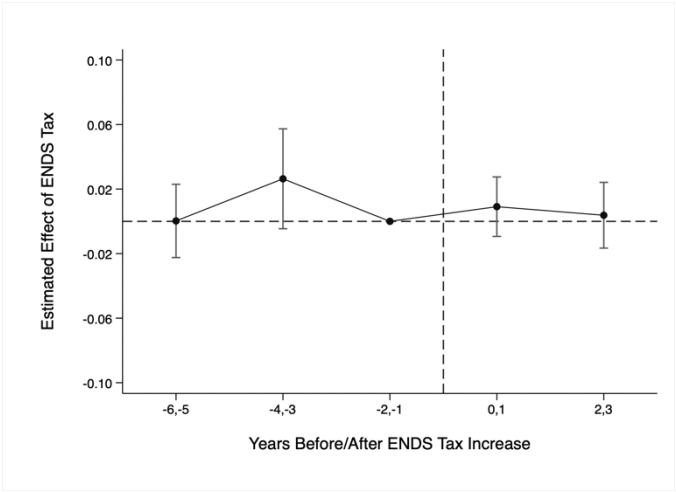
Panel (a): Persistent Depressive Symptoms



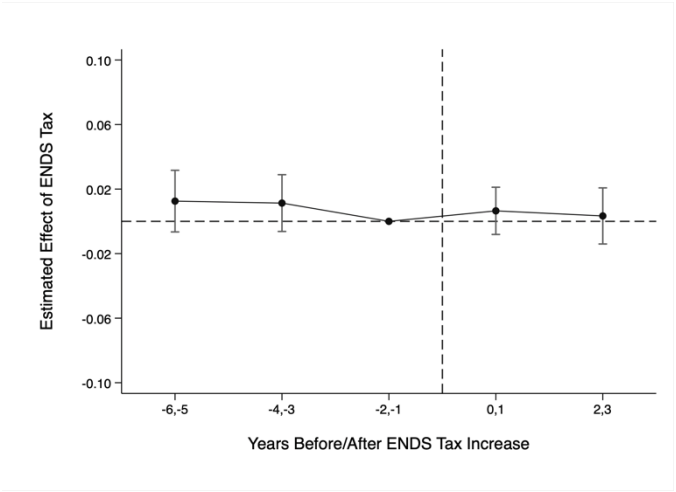
Panel (b): Suicide Ideation



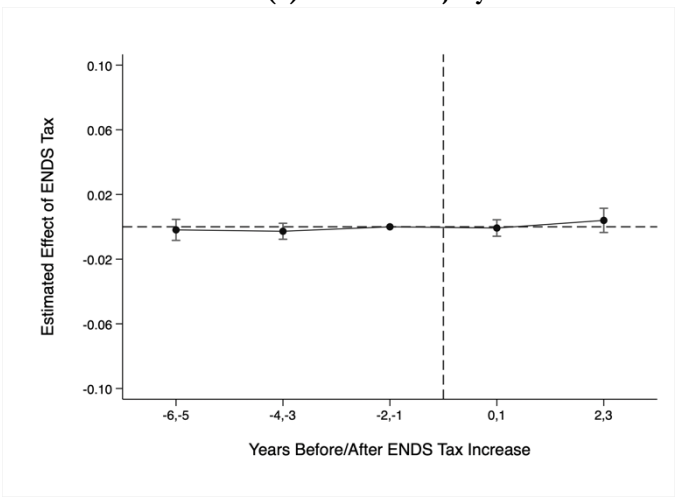
Panel (c): Suicide Plan



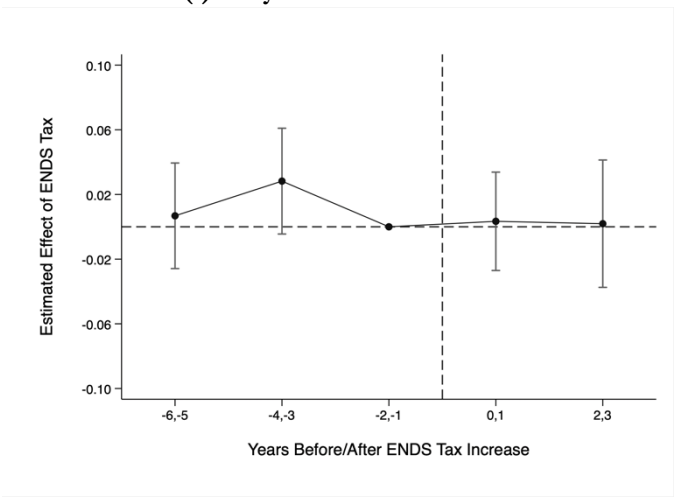
Panel (d): Suicide Attempt



Panel (e): Suicide Injury



Panel (f): Any Adverse Mental Health

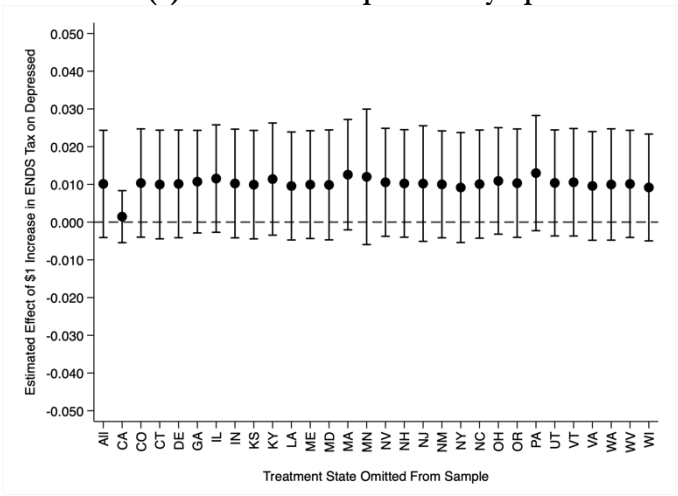


Notes: Estimates are obtained from stacked difference-in-differences regressions using data from the 2003-2023 State and National Youth Risk Behavior Surveys. A $0.25 (in nominal terms) increase in ENDS taxes is defined to be a prominent increase. Each model includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Controls include demographic controls (sex, grade, age, and race), macroeconomic controls (poverty and unemployment rates), COVID controls (cumulative COVID-19 death rate), combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include medical, decriminalization and recreational marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax (in $2023). Coefficients are represented with dots,

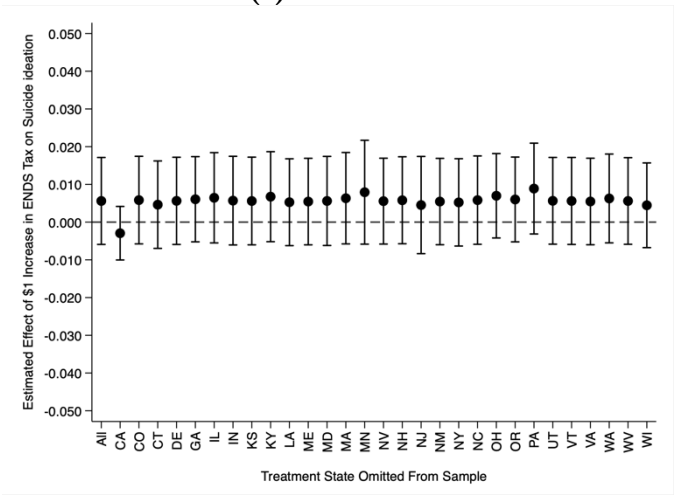
and vertical lines indicate 95% confidence intervals, adjusted for clustering at the state level. Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Figure 6. Sensitivity of ENDS Tax Effect to Leave-One-Treatment-State-Out-at-a-Time, YRBS, 2003-2023

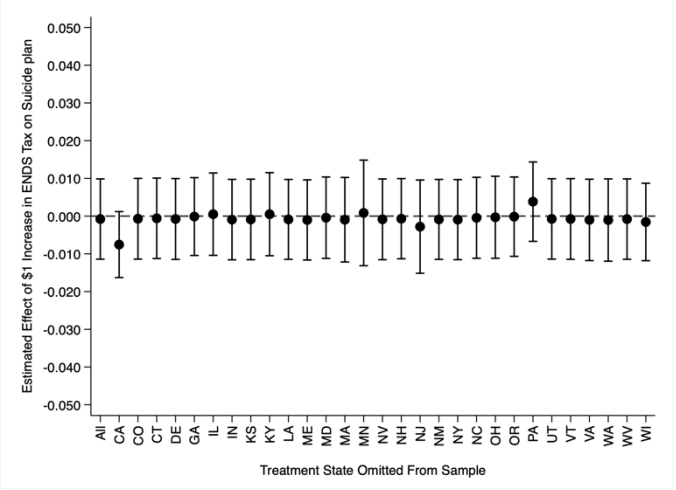
Panel (a): Persistent Depressive Symptoms



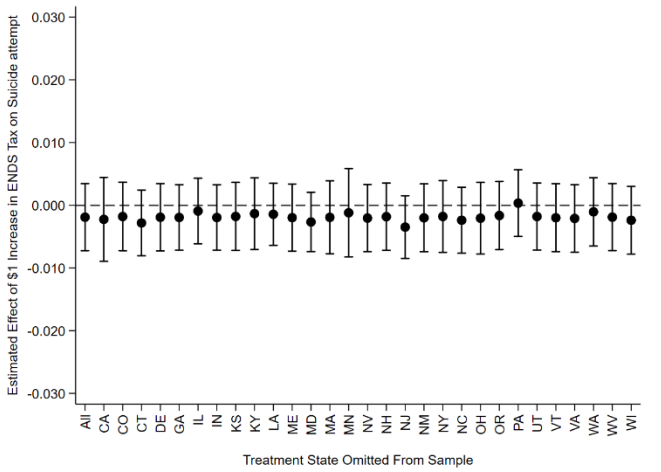
Panel (b): Suicide Ideation



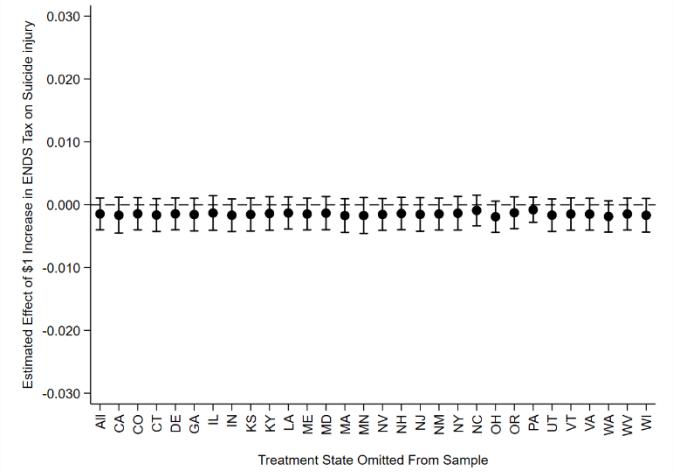
Panel (c): Suicide Plan



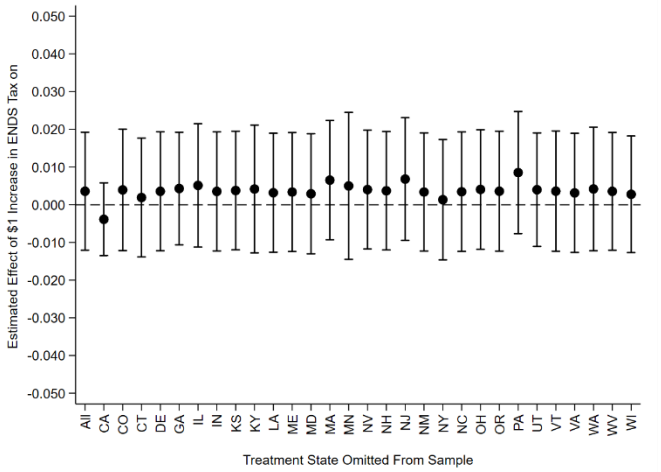
Panel (d): Suicide Attempt



Panel (e): Suicide Injury



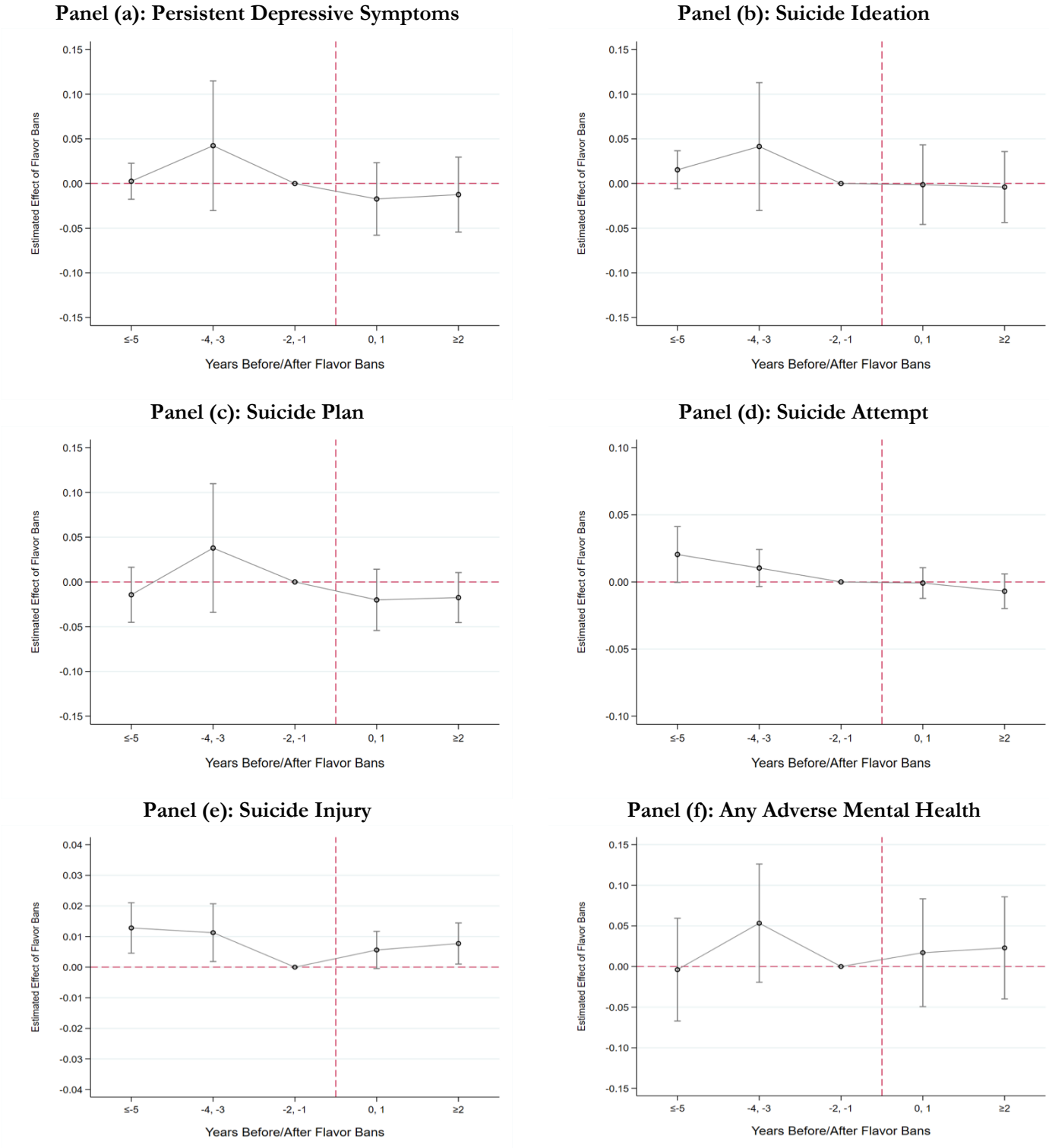
Panel (f): Any Adverse Mental Health



Notes: Estimates are obtained from weighted OLS regressions using data from the 2003-2023 Combined State and National Youth Risk Behavior Surveys. The model contains state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls which include demographic controls like sex, grade, age, and race, macroeconomic controls such as the poverty and unemployment rate, COVID controls like cumulative COVID-19 death rate, combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include recreational marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer taxes (in $2023). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, 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.

Appendix Figure 7. Event-Study Estimates of Flavor Bans and Mental Health Outcomes, YRBS, 2003-2023

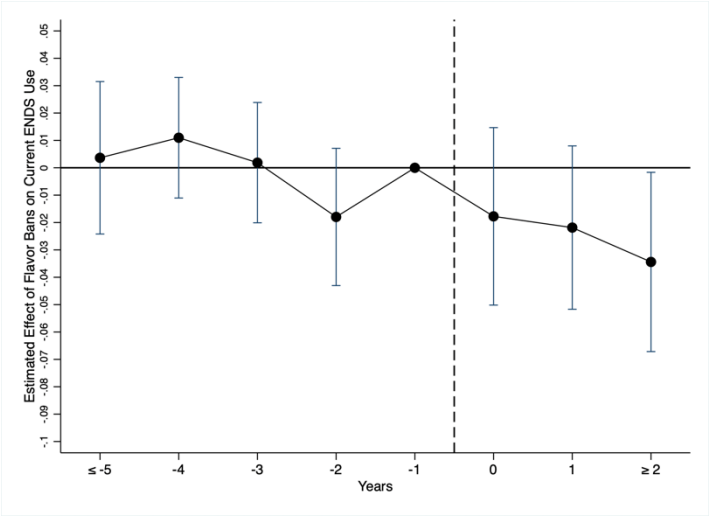


Notes: Estimates are obtained from weighted OLS regressions using data from the 2003-2023 Combined State and National Youth Risk Behavior Surveys. The model contains state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls which include demographic controls like grade, age, and race, macroeconomic controls such as the poverty and unemployment rate, COVID controls like cumulative COVID-19 death rate, combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans, ENDS policies including minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana & substance policies include recreational and decriminalization marijuana laws, medical marijuana laws, prescription drug monitoring laws, naloxone access laws, and beer tax (in $2023). Coefficients are represented with geometric shapes, and vertical lines indicate 95% confidence intervals, adjusted for clustering at the state level.

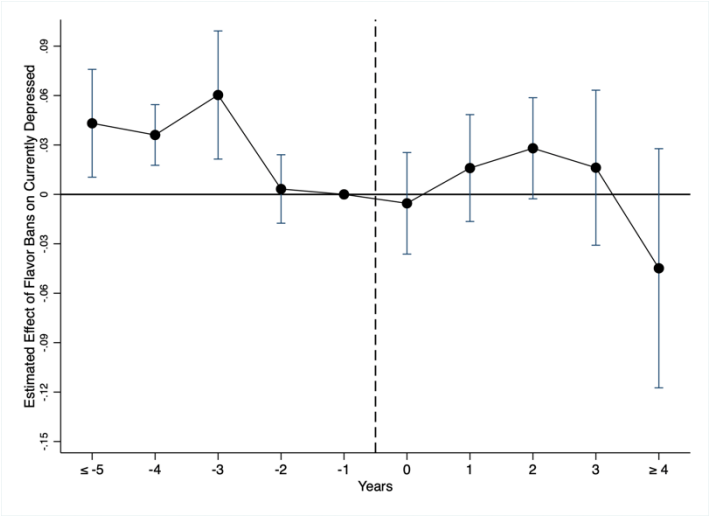
Regressions are weighted using age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Figure 8. Event-Study Estimates of Flavor Bans and Mental Health Outcomes, BRFSS, 2011-2023

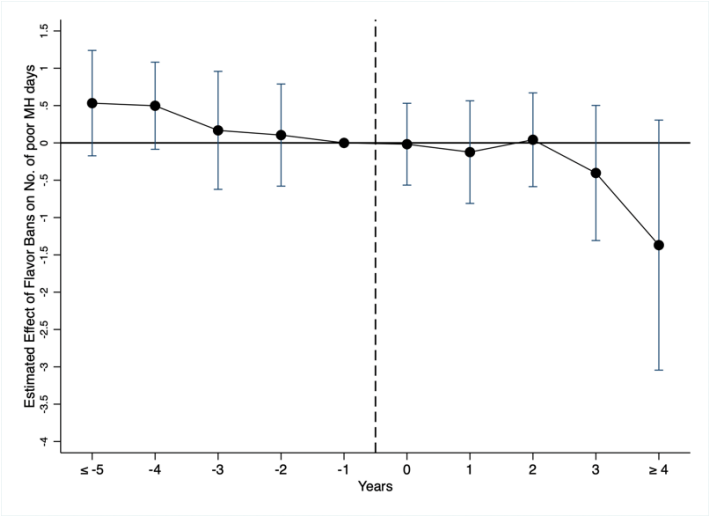
Panel (a): Current ENDS Use



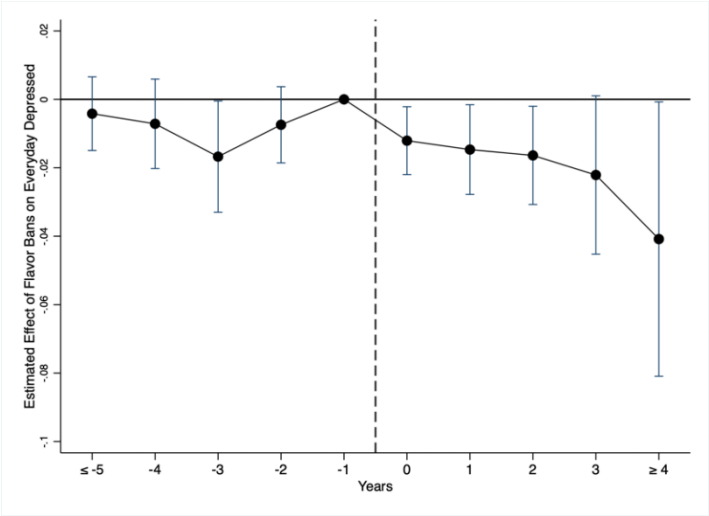
Panel (b): Any Poor Mental Health Days



Panel (c): Number of Poor Mental Health Days



Panel (d): Persistent Adverse Mental Health



Notes: TWFE estimates are obtained using weighted least squares and generated from Behavioral Risk Factor Surveillance System Surveys collected over the period 2011-2023. We include the following controls: age, state, year, and quarter fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Coefficients are represented with geometric shapes, and vertical lines indicate 95% confidence intervals, adjusted for clustering at the state level. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset.

Appendix Table 1A. Descriptive Statistics, YRBS, 2003-2023

Dependent Variables	Description	Means (SD)
Current ENDS Use	=1 if used ENDS product at least once in the past 30 days =0 otherwise	0.198
Frequent ENDS Use	=1 if used ENDS product at least on 20 days in the past 30 days =0 otherwise	0.060
Everyday ENDS Use	=1 if used ENDS product on all 30 days in the past 30 days =0 otherwise	0.043
Persistent Depress Symptoms	=1 if feeling sad/depressed for 2 weeks straight in past 12 months =0 otherwise	0.312
Suicide Ideation	=1 if considered attempting suicide at least once in past 12 months =0 otherwise	0.167
Suicide Plan	=1 if planned attempting suicide at least once in past 12 months =0 otherwise	0.138
Suicide Attempt	=1 if attempted suicide at least once in past 12 months =0 otherwise	0.085
Suicide Injury/Treatment	=1 if required treatment for suicide attempt in past 12 months =0 otherwise	0.023
Any Adverse Mental Health	=1 if responded yes to any of the above mental health questions =0 otherwise	0.368
Current Cigarette Use	=1 if used cigarettes at least once in the past 30 days =0 otherwise	0.132
Current Marijuana Use	=1 if used marijuana at least once in the past 30 days =0 otherwise	0.197
Current Binge Alcohol	=1 if had > 4/5 drinks at a time at least once in the past 30 days =0 otherwise	0.118
Lifetime Cocaine Use	=1 if used Cocaine at least once in their life =0 otherwise	0.059
Lifetime Heroin Use	=1 if used Heroin at least once in their life =0 otherwise	0.024
Lifetime Meth Use	=1 if used Meth at least once in their life =0 otherwise	0.040
Lifetime Ecstasy Use	=1 if used Ecstasy at least once in their life =0 otherwise	0.060
Independent Variables	Description	Mean (SD)
Female	=1 if sex is female =0 otherwise	0.488
Non-Hispanic White	=1 if race is non-Hispanic White =0 otherwise	0.537
Non-Hispanic Black	=1 if race is non-Hispanic Black =0 otherwise	0.147
Hispanic	=1 if ethnicity is Hispanic =0 otherwise	0.247
Non-Hispanic Others	=1 if race is non-Hispanic and neither White nor Black =0 otherwise	0.069
12-14 years old	=1 if youth is aged 12-14 years =0 otherwise	0.198
15 years old	=1 if youth is aged 15 years =0 otherwise	0.200
16 years old	=1 if youth is aged 16 years =0 otherwise	0.200

Independent Variables	Description	Mean (SD)
17 years old	=1 if youth is aged 17 years =0 otherwise	0.200
18-19 years old	=1 if youth is aged 18-19 years =0 otherwise	0.202
Grade 9	=1 if youth is in Grade 9 =0 otherwise	0.300
Grade 10	=1 if youth is in Grade 10 =0 otherwise	0.207
Grade 11	=1 if youth is in Grade 11 =0 otherwise	0.205
Grade 12	=1 if youth is in Grade 12 =0 otherwise	0.289
ENDS Tax, (2023 $)	=Average ENDS Tax ($2023)	0.199 (0.593)
Vaping MLSA Law	=1 if state enacted ENDS MLSA law =0 otherwise	0.472
Tobacco 21 Law	=1 if state enacted Tobacco21 law =0 otherwise	0.218
ENDS Licensure laws	=1 if state enacted requirement of ENDS licensure law =0 otherwise	0.183
Indoor Vaping Ban	=1 if state enacted indoor vaping ban =0 otherwise	0.138
ENDS Flavor Ban	=1 if state or large city enacted ENDS Flavor ban =0 otherwise	0.043
ENDS Online Sales Ban	=1 if state enacted online ENDS sales ban =0 otherwise	0.024
Cigarette Tax, (2023 $)	=State cigarette tax per pack ($2023)	1.849 (1.235)
Indoor Smoking Ban	=1 if state enacted indoor smoking ban =0 otherwise	0.521
Beer Tax, (2023 $)	=State beer tax per oz ($2023)	0.378 (0.340)
Recreational Marijuana Law	=1 if state enacted recreational marijuana law =0 otherwise	0.128
Medical Marijuana Law	=1 if state enacted medical marijuana law =0 otherwise	0.411
Marijuana Decriminalization Law	=1 if state enacted decriminalization marijuana law =0 otherwise	0.371
Naloxone Access Law	=1 if state enacted naloxone access law =0 otherwise	0.485
Prescription Drug Monitoring Program	=1 if state enacted must-access prescription drug monitoring prgm. =0 otherwise	0.299
Cumulative COVID death rate	= Cumulative Covid Deaths*100/State Population	0.051 (0.112)
Poverty Rate	=Percentage of households in state under the federal poverty threshold	12.888 (2.888)
Unemployment Rate	=State unemployment rate	5.883 (2.190)
Observations		1631516

Notes: Combined State and National Youth Risk Behavior Surveillance System Surveys data are used in each column Weighted means are shown for dichotomous variables, while weighted means and standard deviations are shown for continuous variables. Data 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. Summary statistics of primary dependent variables up to 'Everyday

ENDS Use' in the above list are using available years of data i.e., 2015-2023, all other variables that are mentioned below have summary statistics spanning the extended time period of 2003-2023 for YRBS. Cumulative Covid Death Rate variable is scaled up by a factor of 100 for display.

Appendix Table 1B. Means of Dependent Variables and Individual-Level Demographics, BRFSS, 2011-2023

Notes: Behavioral Risk Factor Surveillance System survey data is used for this table. Weighted means are shown for dichotomous variables, while weighted means and standard deviations are shown for continuous variables. Summary statistics of primary dependent variables up to 'Everyday ENDS Use' in the above list are using available years of data i.e., 2016-2023, all other variables that are mentioned below have summary statistics spanning the extended time period of 2011-2023 for BRFSS. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset.

	Means (SD)		
Dependent Variables	Ages 18-24	Ages 25-34	Ages 35-80
Current ENDS Use	0.155	0.105	0.037
Everyday ENDS Use	0.068	0.047	0.015
Any Poor Mental Health (PMH) Days	0.507	0.430	0.321
Number of PMH Days	5.030 (8.263)	4.428 (8.209)	3.579 (7.914)
Number of PMH Days Among Affected	9.925 (9.281)	10.293 (9.812)	11.157 (10.520)
Persistent Poor Mental Health	0.056	0.059	0.056
Current Cigarette Use	0.168	0.207	0.163
Everyday Cigarette Use	0.106	0.138	0.120
Current Marijuana Use	0.220	0.190	0.083
Current Alcohol	0.506	0.601	0.513
Current Binge Alcohol	0.252	0.248	0.124
Multiple Binge Alcohol	0.167	0.154	0.079
Demographic Controls			
Female	0.482	0.495	0.521
Non-Hispanic White	0.551	0.566	0.693
Non-Hispanic Black	0.122	0.119	0.109
Hispanic	0.217	0.220	0.127
Non-Hispanic (Others/Multiracial)	0.110	0.095	0.071
Married	0.102	0.485	0.637
Less than High School	0.134	0.121	0.126
High School	0.386	0.253	0.273
Some College	0.360	0.286	0.282
College	0.120	0.340	0.318
Observations	445788	911887	7087200

Appendix Table 1C. Means of Dependent Variables and Individual-Level Demographics, PATH, 2013-2023

	Age 14-17	Age 18-24
Dependent Variables		
Current ENDS Use	0.052	0.179
	[N=93,471]	[N=77,122]
MH Index (All)	2.714	2.103
	[N=93,811]	[N=77,356]
MH Index (MH)	1.209	1.008
	[N=93,811]	[N=77,356]
MH Index (ADHD)	1.172	0.912
	[N=93,811]	[N=77,356]
Independent Variables		
Female	0.487	0.492
	[N=93,562]	[N=77,293]
Non-Hispanic White	0.661	0.678
	[N=92,882]	[N=76,002]
Non-Hispanic Black	0.149	0.149
	[N=92,882]	[N=76,002]
Others	0.189	0.173
	[N=92,882]	[N=76,002]
Hispanic	0.24	0.218
	[N=91,318]	[N=76,921]

Notes: PATH data is used for this analysis. Weighted means are shown for variables along with the available sample size. The variables use the available PATH data comprising Waves 1 through 7 spanning the years 2013 to 2023. Regressions are weighted using the individual level sample weights provided in the PATH dataset.

Appendix Table 2. ENDS Taxes

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
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
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

State	Effective Date	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
District of Columbia	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
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

Notes: Standardized ENDS taxes are from Cotti et al (2022). Reprinted from Dave et al. (2025).

Appendix Table 3. Stacked Difference-in-differences Estimates of Effect of ENDS Taxes on Youth ENDS Use, YRBS, 2015-2023

	(1)	(2)	(3)
	Current ENDS Use	Frequent ENDS Use	Everyday ENDS Use
Panel I: Prominent ($0.25/mL of e-liquid) ENDS Tax Increase			
ENDS Tax ($2023)	-0.009	-0.008	-0.011
	(0.015)	(0.008)	(0.008)
	[-0.039,0.020]	[-0.025,0.009]	[-0.026,0.005]
Pre-Treat Mean DV	0.206	0.046	0.032
N	296010	296010	296010
Panel II: Prominent ($0.5/mL of e-liquid) ENDS Tax Increase			
ENDS Tax ($2023)	-0.019	-0.016*	-0.016*
	(0.015)	(0.010)	(0.009)
	[-0.050,0.013]	[-0.036,0.003]	[-0.035,0.002]
Pre-Treat Mean DV	0.218	0.044	0.032
N	214991	214991	214991
Panel III: Continuous ENDS Tax Increase			
ENDS Tax ($2023)	-0.019*	-0.013**	-0.011**
	(0.011)	(0.005)	(0.005)
	[-0.040,0.003]	[-0.024,-0.002]	[-0.020,-0.002]
Pre-Treat Mean DV	0.201	0.056	0.041
N	7033114	7033114	7033114
Controls:			
Demographic?	Yes	Yes	Yes
Macroeconomic and COVID-19?	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes
Other Combustible Tobacco Policies?	Yes	Yes	Yes
ENDS Policies?	Yes	Yes	Yes
MJ & Substance Policies?	Yes	Yes	Yes
Beer Tax?	Yes	Yes	Yes

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

Notes: Stacked difference-in-differences estimates, using weighted ordinary least squares regression, are generated from individual-level State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2015-2023. Panel I and II provide the stacked difference-in-differences estimates for a prominent increase of $0.25/ml and $0.5/ml of e-liquid in ENDS taxes and Panel III provides the continuous stacked DD estimates. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023), indoor smoking bans, and combustible tobacco licensure laws. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, decriminalization marijuana laws and medical marijuana laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Appendix Table 4. Estimated Association Between Current E-Cigarette Use and Youth Mental Health, YRBS, 2003-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Persistent Depressive Symptoms	Suicide Ideation	Suicide Plan	Suicide Attempt	Suicide Injury	Any Adverse Mental Health
Current ENDS Use	0.205***	0.159***	0.143***	0.123***	0.039***	0.218***
	(0.005)	(0.005)	(0.004)	(0.004)	(0.002)	(0.006)
	[0.196,0.215]	[0.148,0.170]	[0.134,0.151]	[0.116,0.131]	[0.035,0.044]	[0.206,0.230]
Pre-Treat Mean DV	0.337	0.181	0.151	0.092	0.024	0.389
N	798248	712244	716478	609508	807753	807753

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

Notes: TWFE estimates obtained using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2015-2023. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023), indoor smoking bans, and combustible tobacco licensure laws. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, decriminalization marijuana laws and medical marijuana laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Appendix Table 5. Sensitivity of Estimates to Use of State vs National YRBS, 2015-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Persistent Depressive Symptoms	Suicide Ideation	Suicide Plan	Suicide Attempt	Suicide Injury	Any Adverse Mental Health
Panel I: State YRBS						
ENDS Tax ($2023)	0.017	0.021*	0.023*	0.004	0.004**	0.009
	(0.012)	(0.012)	(0.013)	(0.003)	(0.002)	(0.010)
	[-0.006,0.041]	[-0.003,0.046]	[-0.002,0.049]	[-0.002,0.010]	[0.000,0.008]	[-0.012,0.030]
Pre-Treat Mean DV	0.343	0.182	0.152	0.094	0.025	0.396
N	800620	708095	712010	605271	813069	813069
Panel II: National YRBS						
ENDS Tax ($2023)	0.009	0.001	-0.024	-0.005	-0.006	0.007
	(0.018)	(0.014)	(0.016)	(0.010)	(0.005)	(0.021)
	[-0.027,0.044]	[-0.027,0.030]	[-0.056,0.007]	[-0.025,0.015]	[-0.015,0.003]	[-0.034,0.049]
Pre-Treat Mean DV	0.347	0.192	0.160	0.093	0.024	0.398
N	76569	76407	74342	65607	77501	77501

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

Notes: Average TWFE estimates, using weighted ordinary least squares regression, are generated from individual-level State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2015-2023. Sample weights are generated using the individual State and National YRBS-provided weights and the Surveillance, Epidemiology, and End Results Program (SEER) data. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023), indoor smoking bans, and combustible tobacco licensure laws. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, decriminalization marijuana laws and medical marijuana laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Appendix Table 6. Comparisons of Effects of ENDS Regulations on Youth Mental Health, YRBS, 2003-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Persistent Depressive Symptoms	Suicide Ideation	Suicide Plan	Suicide Attempt	Suicide Injury	Any Adverse Mental Health
Panel I: Minimum Legal Sales Age law						
MLSA Laws	0.000	-0.000	0.003	0.004	-0.001	0.005
	(0.006)	(0.004)	(0.004)	(0.003)	(0.002)	(0.007)
	[-0.012,0.013]	[-0.009,0.009]	[-0.005,0.010]	[-0.002,0.010]	[-0.005,0.003]	[-0.009,0.020]
Pre-Treat Mean DV	0.279	0.153	0.125	0.081	0.023	0.340
N	1601954	1479899	1468538	1270085	1631516	1631516
Panel II: T-21 Laws						
T-21 Laws	0.026*	0.016	0.018	0.001	-0.002	0.038**
	(0.015)	(0.014)	(0.014)	(0.007)	(0.003)	(0.016)
	[-0.004,0.056]	[-0.012,0.044]	[-0.010,0.046]	[-0.013,0.015]	[-0.008,0.004]	[0.006,0.070]
Pre-Treat Mean DV	0.288	0.158	0.130	0.083	0.023	0.348
N	1601954	1479899	1468538	1270085	1631516	1631516
Panel III: ENDS Licensure laws						
EL Laws	0.006	0.007	0.019***	0.014***	0.005	0.017*
	(0.007)	(0.007)	(0.006)	(0.005)	(0.003)	(0.010)
	[-0.008,0.021]	[-0.007,0.021]	[0.007,0.030]	[0.004,0.024]	[-0.001,0.011]	[-0.003,0.037]
Pre-Treat Mean DV	0.288	0.155	0.128	0.081	0.022	0.345
N	1601954	1479899	1468538	1270085	1631516	1631516
Panel IV: Clean Indoor Air Laws						
CIA Laws	0.005	0.005	-0.001	-0.005	-0.003	0.019
	(0.008)	(0.008)	(0.007)	(0.006)	(0.003)	(0.014)
	[-0.012,0.022]	[-0.012,0.021]	[-0.014,0.013]	[-0.016,0.007]	[-0.008,0.003]	[-0.010,0.047]
Pre-Treat Mean DV	0.279	0.150	0.126	0.078	0.022	0.334
N	1601954	1479899	1468538	1270085	1631516	1631516
Panel V: Online ENDS Sale Ban						
OES Ban	-0.009	0.002	0.017*	0.001	0.009*	-0.029
	(0.010)	(0.009)	(0.009)	(0.007)	(0.005)	(0.020)
	[-0.029,0.011]	[-0.015,0.020]	[-0.001,0.035]	[-0.013,0.014]	[-0.000,0.018]	[-0.070,0.012]
Pre-Treat Mean DV	0.274	0.142	0.119	0.075	0.021	0.333
N	1601954	1479899	1468538	1270085	1631516	1631516
Panel VI: ENDS Flavor Ban						
Flavor Ban	-0.030***	-0.026***	-0.023**	0.001	-0.004	-0.005
	(0.008)	(0.008)	(0.011)	(0.009)	(0.004)	(0.017)
	[-0.046,-0.015]	[-0.042,-0.009]	[-0.045,-0.000]	[-0.018,0.019]	[-0.012,0.003]	[-0.040,0.029]
Pre-Treat Mean DV	0.283	0.153	0.127	0.082	0.022	0.336
N	1601954	1479899	1468538	1270085	1631516	1631516

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

Notes: TWFE estimates, using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2003-2023. Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023), indoor smoking bans, and combustible tobacco licensure laws. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana and substance use policies include recreational, decriminalization marijuana laws and medical marijuana laws, naltrexone laws, prescription drug monitoring laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Appendix Table 7. Sensitivity of Flavor Ban Effects to Census Region-Specific Year FE and State-Specific Linear Time Trends, YRBS, 2003-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Persistent Depressive Symptoms	Suicide Ideation	Suicide Plan	Suicide Attempt	Suicide Injury	Any Adverse Mental Health
Panel I: Include Census Region-Specific Year Fixed Effects						
Flavor Ban	-0.011	-0.024**	-0.014	0.005	-0.005	0.005
	(0.009)	(0.009)	(0.009)	(0.009)	(0.005)	(0.018)
	[-0.028,0.006]	[-0.043,-0.006]	[-0.032,0.003]	[-0.014,0.023]	[-0.014,0.004]	[-0.032,0.042]
N	1601954	1479899	1468538	1270085	1631516	1631516
Panel II: Include State-specific Linear Trends						
Flavor Ban	-0.014	-0.023**	-0.007	-0.000	-0.003	-0.006
	(0.010)	(0.009)	(0.011)	(0.007)	(0.005)	(0.016)
	[-0.035,0.007]	[-0.040,-0.005]	[-0.028,0.014]	[-0.013,0.013]	[-0.012,0.007]	[-0.038,0.026]
N	1601954	1479899	1468538	1270085	1631516	1631516

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

Notes: TWFE estimates obtained using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2003-2023. Panel I provide the weighted regression estimates controlling for region-specific year fixed effects and Panel II provides the weighted regression estimates controlling for state specific linear time trends. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. Each column includes an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. We include the following controls: age, state, year, and semester fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer 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.

Appendix Table 8. TWFE Estimates of the Effects of ENDS Restrictions Policy Index (RPI) on Youth Mental Health, YRBS, 2003-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Persistent Depressive Symptoms	Suicide Ideation	Suicide Plan	Suicide Attempt	Suicide Injury	Any Adverse Mental Health
ENDS RPI	0.005	0.004	0.006***	0.002	0.000	0.010**
	(0.004)	(0.003)	(0.002)	(0.001)	(0.001)	(0.005)
	[-0.003,0.013]	[-0.002,0.010]	[0.002,0.010]	[-0.001,0.004]	[-0.002,0.002]	[0.000,0.020]
Pre-Treat Mean DV	0.297	0.162	0.133	0.084	0.023	0.356
N	1601954	1479899	1468538	1270085	1631516	1631516

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

Notes: TWFE estimates obtained using weighted ordinary least squares regression, are generated from individual-level Combined State and National Youth Risk Behavior Surveillance System Surveys collected over the period 2003-2023. It provides the weighted regression estimates assuming linear effects of Restriction Policy Index (RPI). Each column includes state, year, and semester fixed effects, an indicator for whether the observation comes from state or national YRBS and full controls mentioned below. Demographic controls include sex, grade, age, and race. Macroeconomic controls include the unemployment rate, and COVID controls include the cumulative COVID-19 death rate. Combustible tobacco policies include cigarette taxes (in $2023), indoor smoking bans, and combustible tobacco licensure laws. ENDS policies include minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, decriminalization marijuana laws and medical marijuana laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. 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.

Appendix Table 9. Exploration of Mechanisms through which ENDS Taxes May Affect Adult Mental Health, BRFSS, 2011-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	Current Cigarette Smoking	Everyday Cigarette Smoking	Current Marijuana Use	Alcohol Use	Binge Drinking	Multiple Binge Drinking
			Panel I: Adults Aged 18-24			
ENDS Tax ($2023)	0.0027	0.0030	-0.0075	-0.0091	-0.0087*	-0.0001
	(0.0034)	(0.0029)	(0.0287)	(0.0060)	(0.0050)	(0.0036)
	[-0.0041,0.0095]	[-0.0027,0.0088]	[-0.0661,0.0510]	[-0.0211,0.0030]	[-0.0187,0.0013]	[-0.0073,0.0070]
Pre-Treat Mean DV	0.110	0.064	0.177	0.513	0.251	0.161
N	192981	192981	41038	182172	182966	182966
			Panel II: Adults Aged 25-34			
ENDS Tax ($2023)	-0.0047	-0.0046	-0.0080	0.0013	0.0006	0.0012
	(0.0043)	(0.0045)	(0.0064)	(0.0054)	(0.0043)	(0.0036)
	[-0.0133,0.0040]	[-0.0136,0.0044]	[-0.0211,0.0050]	[-0.0095,0.0121]	[-0.0080,0.0091]	[-0.0060,0.0084]
Pre-Treat Mean DV	0.185	0.121	0.150	0.623	0.264	0.164
N	343030	343030	73710	324280	324695	324695
			Panel III: Adults Aged 35-80			
ENDS Tax ($2023)	0.0028	0.0011	0.0029	-0.0022	-0.0001	0.0005
	(0.0024)	(0.0016)	(0.0020)	(0.0021)	(0.0020)	(0.0021)
	[-0.0020,0.0077]	[-0.0021,0.0043]	[-0.0012,0.0070]	[-0.0064,0.0021]	[-0.0041,0.0040]	[-0.0037,0.0046]
Pre-Treat Mean DV	0.145	0.105	0.064	0.523	0.127	0.081
N	2703626	2703626	652662	2585660	2586456	2586456

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

Notes: TWFE estimates are obtained using weighted least squares and generated from Behavioral Risk Factor Surveillance System Surveys collected over the period 2016-2023. Standard errors and confidence intervals are in parentheses and clustered at the state level. We include the following controls: age, state, year, and quarter fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset.

Appendix Table 10. Sensitivity of Flavor Ban Effects Among Young Adults Aged 18-24 to Controls for State-Specific Linear Time Trends, BRFSS, 2011-2023

	(1)	(2)	(3)	(4)
	Any Poor Mental Health Days	Number of Poor Mental Health Days	Number of Poor Mental Health Days Among Affected	Persistent Poor Mental Health
Flavor Ban	-0.0177	0.0413	0.3500	-0.0019
	(0.0133)	(0.2028)	(0.2459)	(0.0038)
	[-0.0443,0.0089]	[-0.3661,0.4487]	[-0.1438,0.8438]	[-0.0095,0.0057]
N	310320	310320	165674	310320
Controls:				
Demographic, Macro, COVID?	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes
Other Combustible Policies?	Yes	Yes	Yes	Yes
ENDS Policies?	Yes	Yes	Yes	Yes
MJ and Substance Policies?	Yes	Yes	Yes	Yes
Beer Taxes?	Yes	Yes	Yes	Yes

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

Notes: TWFE estimates are obtained using weighted least squares and generated from Behavioral Risk Factor Surveillance System Surveys collected over the period 2011-2023. We include the following controls: age, state, year, and quarter fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset.

Appendix Table 11. TWFE Estimates of the Effects of ENDS Taxes on Adults Aged 25-34-Year Mental Health, BRFSS, 2011-2023

	(1)	(2)	(3)	(4)
	Any Poor Mental Health Days	Number of Poor Mental Health Days	Number of Poor Mental Health Days Among Affected	Persistent Poor Mental Health
Panel I: Baseline TWFE Estimates				
ENDS Tax ($2023)	-0.0126	-0.0966	0.1291	0.0015
	(0.0082)	(0.1224)	(0.1746)	(0.0026)
	[-0.0290,0.0038]	[-0.3424,0.1493]	[-0.2216,0.4799]	[-0.0037,0.0068]
Pre-Treat Mean DV	0.422	4.335	10.281	0.058
N	568009	568009	264935	568009
Panel II: Include Census Region-Specific Year Fixed Effects				
ENDS Tax ($2023)	-0.0110	-0.0911	0.1075	0.0010
	(0.0083)	(0.1258)	(0.1581)	(0.0025)
	[-0.0277,0.0057]	[-0.3438,0.1617]	[-0.2100,0.4249]	[-0.0040,0.0059]
Pre-Treat Mean DV	0.422	4.335	10.281	0.058
N	568009	568009	264935	568009
Panel III: Include State-specific Linear Trends				
ENDS Tax ($2023)	-0.0049	-0.0075	0.1363	0.0023
	(0.0048)	(0.1220)	(0.2448)	(0.0030)
	[-0.0145,0.0048]	[-0.2525,0.2375]	[-0.3553,0.6279]	[-0.0038,0.0083]
Pre-Treat Mean DV	0.422	4.335	10.281	0.058
N	568009	568009	264935	568009

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

Notes: TWFE estimates are obtained using weighted least squares and generated from Behavioral Risk Factor Surveillance System Surveys collected over the period 2011-2023. All panels use age, state, year, and quarter fixed effects. Panels I and III add region-specific year fixed effects and Panel II adds state-specific linear time trends. We include the following controls: age, state, year, and quarter fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset.

Appendix Table 12. TWFE Estimates of the Effects of ENDS Taxes on Adults Aged 35-80 Mental Health, BRFSS, 2011-2023

	(1)	(2)	(3)	(4)
	Any Poor Mental Health Days	Number of Poor Mental Health Days	Number of Poor Mental Health Days Among Affected	Persistent Poor Mental Health
Panel I: Baseline TWFE Estimates				
ENDS Tax ($2023)	-0.0087*	-0.0687	0.1421	0.0002
	(0.0044)	(0.0503)	(0.0865)	(0.0010)
	[-0.0174,0.0000]	[-0.1697,0.0323]	[-0.0317,0.3158]	[-0.0018,0.0022]
Pre-Treat Mean DV	0.319	3.564	11.178	0.056
N	4559409	4559409	1412630	4559409
Panel II: Include Census Region-Specific Year Fixed Effects				
ENDS Tax ($2023)	-0.0065	-0.0503	0.0920	0.0000
	(0.0044)	(0.0463)	(0.0774)	(0.0010)
	[-0.0154,0.0024]	[-0.1434,0.0427]	[-0.0635,0.2476]	[-0.0020,0.0020]
Pre-Treat Mean DV	0.319	3.564	11.178	0.056
N	4559409	4559409	1412630	4559409
Panel III: Include State-specific Linear Trends				
ENDS Tax ($2023)	-0.0027	0.0127	0.1413	0.0014
	(0.0030)	(0.0472)	(0.1062)	(0.0010)
	[-0.0087,0.0033]	[-0.0822,0.1076]	[-0.0719,0.3546]	[-0.0006,0.0034]
Pre-Treat Mean DV	0.319	3.564	11.178	0.056
N	4559409	4559409	1412630	4559409

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

Notes: TWFE estimates are obtained using weighted least squares and generated from Behavioral Risk Factor Surveillance System Surveys collected over the period 2011-2023. All panels use age, state, year, and quarter fixed effects. Panel I adds region-specific year fixed effects and Panel II adds state-specific linear time trends. We include the following controls: age, state, year, and quarter fixed effects, demographics (race, age, education, marital status), unemployment rates, poverty rates, cumulative COVID-19 death rates, cigarette taxes (in $2023), indoor smoking bans, minimum legal sales age (MLSA) laws, T-21 laws, indoor vaping bans, ENDS licensure laws, flavored ENDS restrictions, recreational marijuana laws, medical and decriminalization marijuana laws, naloxone access laws, prescription drug monitoring laws, and beer taxes (in $2023). Observations surveyed in January and February of 2024 for the 2023 survey wave are assigned December 2023 control values. Standard errors are clustered at the state level and are presented in parentheses; 95% confidence intervals around estimated treatment effects are shown in brackets. Regressions are weighted using the individual level sample weights provided in the BRFSS dataset.