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Do Vaping Taxes Tip the Scale?
The Effect of E-Cigarette Taxation on Obesity*

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Abstract. This study is the first to explore whether a leading policy tool to curb ENDS use – ENDS taxes – has the unintended consequence of causing weight gain. We find that despite reducing nicotine vaping, an appetite suppressant and metabolic stimulant, ENDS taxes lead to robust reductions in weight and body mass index among female teens. A one-dollar (per mL of e-liquid) increase in the ENDS tax rate (2023$) leads to a 0.8-1.0 percentage-point decline in the probability that a female youth is obese. For male teens and adults of both sexes, the estimated impacts are generally smaller and statistically indistinguishable from zero. An investigation of mechanisms reveals possible explanations for the absence of weight gain from ENDS taxes. The first is ENDS-tax-induced substitution to cigarettes, which offsets reductions in nicotine consumption from ENDS. The second is indirect effects on weight-related behaviors, including reductions in alcohol and marijuana use and increased healthier food consumption. We conclude that understanding the general equilibrium effects of ENDS taxes is critical for assessing their health and social welfare consequences.

Keywords: ENDS taxes; obesity; body weight; e-cigarettes; cigarettes
JEL codes: I12; I18

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1. Introduction

According to the Centers for Disease Control and Prevention (2024), 19.7 percent of U.S. children aged 2-19 years and 41.9 percent of U.S. adults aged 20 years and older are classified as obese.[1] The share of persons who are classified as severely obese — for adults, this translates to a body mass index (BMI) of 40 or higher — has grown more rapidly than any other category of body weight in the last decade (Ward et al., 2021), with approximately 10 percent of adults currently classified as such (Centers for Disease Control and Prevention [CDC], 2024a).[2] If current trends are uninterrupted, nearly 2 in 3 adults and 1 in 3 adolescents are projected to be obese by 2050 (Ng et al., 2024). Obesity reduces life expectancy, on average, by 6-7 years (Fock & Khoo, 2013) and increases the risk of a wide set of comorbidities including high blood pressure, type II diabetes (CDC, 2024a), non-alcoholic fatty liver disease, kidney disease, and cancer (Yang et al., 2022). Estimates of the annual medical care costs of obesity, including external costs, total over $340 billion (2024$) (Cawley et al., 2021) and over 20 percent of all U.S. health care spending is attributable to obesity-related ailments (Cawley & Meyerhoefer, 2012).[3,4]

Weight loss can be difficult for many reasons, including slow metabolism (Anderson et al., 2007; Bouchard et al., 1990; Farooqi, 2005), poor dietary and exercise habits (Field et al., 2003), addiction (Campana et al., 2019; Hodgkins et al., 2007), and the disutility of exercise and healthy eating (Courtemanche et al., 2016). To aid in weight loss efforts, the demand for appetite-suppressing drugs has skyrocketed, including the use of prescription pharmaceutical drugs designed to treat diabetes (such as Ozempic, Mounjaro, and Wegovy) (Han et al., 2024; Suran, 2023) or attention deficit hyperactivity disorder (Miller, 2023; Wolraich et al., 2019).[5] A more easily obtained over-the-counter appetite suppressant that has been used for decades to facilitate weight loss is

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[1] Nearly 3 in 4 adults aged 20 and older and 1 in 3 children aged 2-19 years are classified as overweight or obese (CDC, 2024a, b; Ng et al., 2024).

[2] Body mass index is calculated as a person's weight in kilograms divided by his/her height in meters squared. For children under age 20, severe obesity is classified as a person at or above 120 percent of the 95th percentile (the obesity marker) in the age-by-gender distribution of BMI (CDC, 2024b). Currently 7 percent of those under age 20 are classified as severely obese.

[3] In addition, obesity-related workplace absences generate costs to the U.S. economy of between $19.5 and $38.1 billion (in 2024$) each year (Cawley et al., 2021). Some workers, particularly non-Hispanic white women, face earnings penalties from excess body weight, perhaps due to higher worker medical costs, reduced productivity, diminished human capital acquisition, and labor market discrimination (Sabia & Rees, 2015; Mocan & Tekin, 2011; Cawley. 2004). There is also evidence that excess youth body weight may diminish academic performance (Cawley & Spiess, 2008; Sabia, 2007a, b) as well as enhance the likelihood of bullying victimization (Churchill et al., 2024).

[4] Estimates of the total economic costs attributed to obesity are projected to be $422 billion in 2018 (Woods & Miljkovic, 2022).

[5] See also Goldman (2023), Singh et al. (2022), Storebø et al. (2018), and Schwartz et al. (2014).

nicotine (Cawley et al., 2004; Mangubat et al., 2012; Schwartz & Bellissimo, 2021). Nicotine may reduce appetite through a number of channels, the most prominent of which is that nicotine interacts with acetylcholine receptors (nAChRs) situated in the hypothalamus, a region of the brain that regulates appetite (Schwartz & Bellissimo, 2021; Martínez de Morentin et al., 2012). Nicotine is also a stimulant, meaning it could also lead to weight loss by increasing calories burned (Singh et al., 2023). A large literature documents that people tend to gain weight after quitting smoking, with a meta-analysis finding an average increase of nine pounds (Tian et al., 2015).

Historically in the U.S., nicotine has been consumed via cigarette smoking (Cawley et al., 2016; Chao et al., 2019; Fulkerson & French, 2003; Strauss & Mir, 2001). Combustible tobacco use is the leading preventable cause of death and disease in the U.S. (CDC, 2024c). Cigarette smoking is responsible for 480,000 U.S. deaths each year (CDC, 2024c) and is associated with an increased risk of heart disease (Lushniak et al., 2014), cancers of the lungs, throat, neck, and head (Henley, 2016; U.S. Department of Health and Human Services [USDHHS], 2024), and a myriad of respiratory health ailments (USDHHS, 2012; Wheaton, 2019). There are also other health-related externalities associated with exposure to secondhand (or thirdhand) tobacco smoke (Flouris & Koutedakis, 2011; USDHHS, 2010a, b), as well as potential internalities associated with non-rational addiction to nicotine in cigarettes (Darden, 2024; Gruber & Köszegi, 2001; Gruber & Mullainathan, 2005). Thus, the decision to consume nicotine via cigarettes as a weight-loss tool involves tradeoffs with large adverse health consequences that are generally considered substantially larger than any health gains from the weight loss (Tian et al., 2015).

The introduction of electronic nicotine delivery systems (ENDS) to the U.S. tobacco market in around 2006 may have favorably impacted this tradeoff between obesity- and tobacco-related health harm.[6] ENDS are devices in which ingredients such as nicotine and flavors are heated into a vapor and inhaled. Relative to combustible tobacco products such as cigarettes, cigars, and cigarillos, the scientific evidence to date suggests that ENDS use causes 5 to 37 percent of the tobacco-related health harm (McNeill et al., 2018; National Academies of Science, Engineering and Medicine [NASEM], 2018; Nutt et al., 2014). If this relative harm is sufficiently low and the weight loss is sufficiently large, the use of ENDS to facilitate weight loss could be health-improving on net, in

[6] Prior to the invention of e-cigarettes Gurwitz (1999) suggested that safe, inexpensive, and effective nicotinic agonists to treat obesity could generate important public health benefits:

> "Certain nicotine formulations, and in particular distinct subtype-selective nicotine agonists, could be beneficial as research tools, as well as potential therapeutic agents, for the treatment of human obesity." (p. 754)

sharp contrast to using cigarettes for that purpose. Since, 2014, ENDS have replaced combustible cigarettes as the most commonly used tobacco product among teenagers (Birdsey et al., 2023).

Nonetheless, concerns that (1) ENDS use is not harmless and carry a higher risk of respiratory and heart health disease relative to abstinence (NASEM, 2018), (2) ENDS could serve as a "gateway" to combustible tobacco products for youth (USDHHS, 2016; Scheier & Griffin, 2021; Zhong et al., 2016), and (3) many producers of ENDS in the U.S. include prominent combustible tobacco companies that historically failed to disclose health risks of combustible tobacco products, has led policymakers to focus on restricting rather than expanding access to ENDS. One such tool to restrict access has been through the adoption of ENDS taxes. As of 2024, 32 states and the District of Columbia had adopted ENDS taxes.[7] The first such tax was adopted in 2010 in Minnesota, with an effective tax rate of $1.24 per mL of e-liquid (in 2023$). In 2023, the highest ENDS taxes were in Minnesota ($2.89 per mL of e-liquid) and Vermont ($2.79 per mL of e-liquid).

While there is strong evidence that ENDS taxes have been effective at curbing e-cigarette use among both youths (Abouk & Adams, 2017; Abouk et al., 2023a; Dave et al., 2024a, b) and adults (Pesko et al., 2020), no study has explored how ENDS taxes affect body weight. The prior economics literature on the link between nicotine and weight has focused on the effects of cigarette tax or price increases (Baum, 2009; Chou et al., 2004, 2006; Courtemanche, 2009; Gruber & Frakes, 2006; Tchernis et al., 2024; Wehby & Courtemanche, 2012). However, modern cigarette tax hikes have been found to have very little effect on smoking among youths (Hansen et al., 2017) or, in the main, among adults (MacLean et al., 2016). This is, in part, because smoking rates in the U.S. have fallen dramatically over the last decade (88 percent among high school students and 35 percent among adults aged 18 and older), leaving the marginal smoker to be a much more dedicated user and hence much less tax (price) responsive on the cessation margin.

This study is the first to estimate the effect of ENDS taxation on body weight. Using data from the State and National Youth Risk Behavior Surveillance Surveys (YRBSS), and a difference-in-differences approach, we find no evidence that ENDS taxes increase youth body weight. Rather, we find that a one dollar increase in ENDS taxes (2023$) is associated with an economically small but statistically significant 1 to 2 pound decrease in female body weight, 0.03 to 0.04 standard deviation decline in their adjusted BMI, and 0.8 to 1 percentage point drop in their probability of

[7] Other prominent ENDS regulations include adopting restrictions on the sales of flavored ENDS products, requiring retailers to obtain a state license before they are legally permitted to sell e-cigarettes, the adoption of ENDS-inclusive minimum legal purchasing ages, and the extension of clean indoor air laws to cover nicotine vaping aerosols.

being obese. The effects appear most pronounced at the right-tail of the BMI distribution, as the reduction in average female weight is only around 1 percent of the sample mean, whereas the effect on obesity is about 7 to 9 percent of the sample rate. For male youth, the estimated effects are generally smaller in magnitude and statistically indistinguishable from zero. We also find little evidence of effects on adults using data from the Behavioral Risk Factor Surveillance System (BRFSS).

What can explain the lack of weight gain from ENDS taxes given that they reduce ENDS use and nicotine reduces body weight? The answer appears to lie, at least in part, in indirect effects of ENDS taxes in adjacent markets for related substances. First, we document that ENDS taxes may induce youths to *substitute to combustibles cigarettes*, thus offsetting to at least some extent the reductions in nicotine consumption from less ENDS use. Second, we find evidence that ENDS tax increases are associated with reductions among teens in binge drinking, a high caloric activity (Dave et al., 2024a), and marijuana, a substance associated with enhanced degrees of unhealthy snacking (Dave et al., 2024b). Such spillovers could be attributable to inherent complementarities between ENDS products and these other substances or to income effects, as ENDS users whose usage does not change in response to taxes become effectively poorer and have less money to spend on other products (Rozema and Ziebarth, 2017; Darden et al., 2025).[8] Finally, we show that ENDS taxes increase vegetable consumption among teens, which could reflect inherent substitutability with ENDS or an income effect where less disposable income leads youth to eat less restaurant food and instead rely more on healthier home-cooked meals. For adults, we observe some evidence of an increase in everyday smoking, decrease in alcohol consumption, and decrease in french fry consumption, which is again suggestive of reduced intake of fast food.

Together, our findings suggest that ENDS taxes influence body weight through multiple channels that point on net towards weight loss for female teens and roughly cancel out for other groups. There is no evidence to support the fear that ENDS taxes have the unintended consequence of worsening the obesity epidemic. Instead, the more concerning unintended consequence is the possible substitution to more dangerous combustible cigarettes. On the other hand, the reductions in drinking and marijuana use and healthier eating habits along at least some dimensions appear to be unintended benefits. Our results contribute to a growing body of literature suggesting that general equilibrium effects of ENDS taxes on non-ENDS and non-tobacco health — including

[8] The papers cited here study the income effects of cigarette taxes, but the same logic and arguments apply to e-cigarette taxes.

behaviors that generate external costs — are important for assessing their efficacy from the perspective of social welfare.

2. Background

2.1 Social Costs of Obesity

Obesity is considered a chronic disease that leads to a wide array of adverse health conditions. It reduces average life expectancy by approximately 6 to 7 years (or 8 to 10 percent) (Fock & Khoo, 2013). Nearly 6 in 10 obese individuals are diagnosed with high blood pressure, a significant risk factor for hypertension, stroke, and coronary artery disease. Approximately 1 in 5 obese individuals have type II diabetes (CDC Adult Obesity facts, 2024; Yang et al., 2022). In addition, obesity is associated with higher risks of gastroesophageal reflux disease, gastrointestinal disease, osteoarthritis, venous stasis deep vein thrombosis, cholelithiasis, and metabolic disorders such as non-alcoholic fatty liver disease and kidney disease as well as certain types of cancers such as endometrial breast cancer and colorectal cancer (Fock & Khoo, 2013; Yang et al., 2022;).[9] In addition, there is evidence that obesity is associated with diminished mental health among both adults (Amin et al., 2020; Bargain & Zeidan, 2019; Galler et al., 2024; Jokela & Lakasuo, 2023; Willage, 2018) and teenagers (Sabia & Rees, 2015), with the effect being stronger for females.[10]

There are also well-documented adverse labor market effects of obesity among adults, usually due to adverse physical and mental health-induced productivity declines, increased health expenditure burdens on employers, and labor market discrimination. There is robust evidence that obese women (particularly non-Hispanic white women) are less likely to be employed and earn lower wages than their healthy weight counterparts (Baum & Ford, 2004; Cawley, 2004; Han et al., 2009, 2011; Mocan & Tekin, 2011; Moro et al., 2019; Morris, 2007; Pinkston, 2017; Rees & Sabia, 2015).[11]

There is also evidence that youth obesity may inhibit human capital acquisition and cause longer-run economic harm. For example, obesity may adversely affect verbal, motor, and social skills among children (Cawley & Spiess, 2008), diminish human capital acquisition (Sabia, 2007a, b), and reduce educational attainment, particularly among females (Classen, 2017; Kaestner et al., 2011). There is also some evidence that obesity reduces non-cognitive skills of children, that teachers may

[9] The side effects of being overweight or obese can be noticed at a relatively younger age (Brown et al., 2000).
[10] For instance, Sabia and Rees (2015) use an instrumental variables (IV) approach to estimate the causal impact of excess body weight on mental health and find that higher body weight leads to lower levels of self-esteem and higher probability of depression among female but not male teens.
[11] In addition, there is evidence that some of these costs are (at least partially) privately borne by obese individuals due to paying higher health insurance premiums (Bhattacharya & Bundorf, 2009).

discriminate against obese youths (MacCann & Roberts, 2013; Rouse & Hunziker, 2020[12]), and that overweight youths may be more likely to be victims of in-school bullying victimization (Churchill et al., 2024).

While many costs of obesity are privately borne by obese individuals, some may not be fully internalized by "rational" decisionmakers (Cawley, 2011). Market failures are generally considered to arise from four sources. The first is imperfect information in health insurance markets, which lead healthy weight individuals to subsidize unhealth diet and exercise behaviors of those in their insurance pool. The second is imperfect information about determinants of weight such as the nutritional content of restaurant meals or calories burned by exercise (e.g. Courtemanche et al., 2025; Elbel et al., 2009; Harris, 2017; Restrepo, 2017). Next is "non-rational" addiction to foods (or ingredients in foods, such as sugars) that generate increased body weight (Bhattacharya & Sood, 2011; Cawley, 2015; Cawley & Meyerhoefer, 2012).[13] Finally, time-inconsistent preferences lead to an undervaluing of future health costs when making eating or exercise decisions (Bradford et al., 2017; Courtemanche, Heutel & McAlvanah, 2015; Ikeda et al., 2010).[14]

2.2 Smoking and Body Weight

Nicotine can reduce body weight in several ways. Schwartz and Bellissimo (2021) conduct a meta-analysis of 65 medical and clinical studies and conclude that decreased appetite and food intake along with increased resting and physical activity energy expenditure are the primary causes of weight loss due to nicotine consumption. Nicotine consumption likely suppresses appetite by increasing fat metabolism resulting in mimicking satiation and inhibiting hunger (Nicklas et al., 1999; Rupprecht et al., 2018). Martínez de Morentin et al. (2012) provide a more technical description, reporting that nicotine-induced reductions in body weight are caused by:

> "inactivation of hypothalamic adenosine monophosphate-activated protein kinase (AMPK), decreased orexigenic signaling in the hypothalamus, increased energy expenditure as a result of increased locomotor activity, increased thermogenesis in brown adipose tissue (BAT), and alterations in fuel substrate utilization."

[12] Rouse and Hunziker (2020) examine how parents and teachers assess children's noncognitive skills and find teachers to be relatively more negative than parents, which would explain the disparity between obese boys' test scores and their teacher's assessment.
[13] However, addiction to exercise could also generate positive health "internalities" in adulthood.
[14] A similar concept has also been modeled in a dual-decision framework where decisions reflect both a rational self and a myopic self (Ruhm, 2012).

Numerous studies provide evidence that cigarette smoking and body weight are negatively correlated (e.g. Bush et al., 2016; Filozof et al., 2004; Julia et al., 2024; Klesges & Klesges, 1988; O'Hara et al., 1998; Rigotti et al., 2009). Tian et al. (2015) conduct a meta-analysis of 35 cohort studies and find an average weight gain after smoking cessation of nine pounds (Tian et al., 2015). Causally interpretable evidence is less common, but several studies have used either quasi-experimental methods that exploit shocks to cigarette costs or randomized control trials of smoking cessation programs.

Many of those studies that have pursued a quasi-experimental approach exploit plausibly exogenous across-state over-time variation in cigarette taxes or prices to identify their effects on body weight. Chou et al. (2004) utilize data on adults ages 18 and older from the 1984-1999 Behavioral Risk Factor Surveillance System. After controlling for state fixed effects, a quadratic national time trend, state-level socioeconomic and policy controls, and individual demographic characteristics, they find that a 10 percent increase in cigarette prices is associated with a 0.45 percentage point increase in the probability that an adult is obese.

Gruber and Frakes (2006) critique Chou et al. (2004) on three grounds. First, cigarette prices may be correlated with demand-side factors that affect smoking. Second, a quadratic national trend might inadequately control for the effect of time. Third, including elderly adults may lead to bias from endogenous death rates. Instead, Gruber and Frakes (2006) exploit state-level and temporal variation in cigarette taxes as the treatment variable, include year fixed effects, and focus on those aged 18-64. They find that these changes flip the sign to a counterintuitive negative. A one dollar increase in cigarette taxes *decreases* average BMI by 0.15 units and the odds of being obese by 1.5 percentage points.

In response to Gruber and Frakes (2006), Chou et al., (2006) defend their use of quadratic time trends to capture temporal variation in the underlying data generating process, critique Gruber and Frakes (2006) for (perhaps) excessive controls that could lead to model misspecification, and argue that cigarette prices may better capture the costs of cigarettes than taxes because cigarette taxes (1) fail to capture important (and plausibly exogenous) costs stemming from retailing costs, transportation, and shipping costs, and (2) fail to account for tobacco market structure in assessing tax-pass through to consumers. Moreover, changes in state cigarette taxes occur via a political process, which may be impacted by similar "demand-side" factors at the heart of critiques of the exogeneity of cigarette price changes.

Baum (2009) uses individual-level panel data from the National Longitudinal Survey of Youth and defining the treatment group as those who have ever been smokers, with the idea being that any "effects" among never-smokers are implausible and therefore spurious. Using this approach, he finds that the distinction between cigarette prices and taxes is inconsequential, as both increase BMI among the treatment group.

Courtemanche (2009) argues that long-run effects of changes in cigarette costs could differ from short-run effects. Economic models of addiction predict a gradual effect of cigarette costs on smoking, while the fact that body weight is a stock rather than a flow implies a gradual effect of smoking on weight. Allowing for the effect to evolve flexibly over up to six years, he finds that cigarette costs reduce BMI and obesity regardless of whether the other methodological details follow Chou et al., (2006), Gruber and Frakes (2006), or Baum (2009). Specifically, a one dollar increase in cigarette prices reduces average BMI by 0.13-0.59 units and the probability of being obese by 1.1-3.6 percentage points.

Wehby and Courtemanche (2012) extend Courtemanche (2009) by exploring heterogeneous treatment effects of cigarette taxes by race, gender, education, and age, as well as quintiles of the BMI distribution. They find that the six-year-moving average of cigarette price is associated with average BMI reductions for nearly all demographic groups, but this masks differences across the BMI distribution. For instance, a one dollar increase in cigarette prices is associated with a 0.38 kilogram per meter-squared decline in the BMI levels of Black individuals, evaluated at the mean, but a decline of 0.76 kg/m2 at the top decile. They also find that while cigarette price increases have reduced the disparity in the severe obesity rate between Black and White individuals (by about 4.8 percentage points), they have increased the disparity in the obesity rate between individuals with less than a high school degree and college degree or more (by 3.8 percentage points).

Courtemanche et al. (2016) include cigarette prices as one of 27 state-level economic variables in an effort to determine which have been the most important determinants of the rise in obesity. They find a positive relationship between cigarette prices and BMI and estimate that the rise in cigarette prices explains about 5 percent of the rise in obesity.

Other studies aim to identify the causal effect of smoking on weight using quasi-experimental approaches that rely on variation besides prices or taxes. The result that quitting smoking leads to weight gain has been found using worksite smoking bans in the U.S. (Liu et al., 2010), clean indoor air laws in Italy (Pieroni & Salmasi, 2015), and a combination of cigarette prices and group-specific smoking rates in Belarus (Amialchuk et al., 2018) as instruments. Similar results

have also been obtained using panel data approaches in China (Callison et al., 2021) and the United Kingdom (Pieroni & Salmasi, 2016) as well as a two-step estimation method introduced by Nguimkeu et al. (2019) that accounts for both endogenous treatment and misreporting (Tchernis et al., 2024). However, a study using a workplace smoking ban in Japan as an instrument found no evidence of an effect of smoking on weight (Zhang, 2022).

In addition to this quasi-experimental research, two studies utilize randomized variation from a smoking cessation program called the Lung Health Study (LHS) to investigate the causal effect of cigarette smoking on body weight. As part of this experiment, participants were assigned to one of three groups: two treatment groups (SI-A and SI-P) and a control group.[15] Both treatment groups received an intensive 12-week session smoking cessation program, free nicotine gum, and support personnel who were in frequent contact with participants. One of the treatment groups (SI-A) was randomly assigned to also receive an inhaled bronchodilator (Atrovent).

Eisenberg and Quinn (2006) use treatment and control groups' average changes in weight and smoking — as reported by O'Hara et al. (1998) — to compute a simple Wald instrumental variables (IV) estimate. This estimate implies that sustained smoking cessation for five years increases weight by 21 pounds, which is two-to-five times the weight gain usually found in the associational literature.

Courtemanche et al. (2018) argue that Eisenberg and Quinn's IV estimate is too large. Even though participants in the LHS were randomly assigned to the smoking cessation program was random, this does not automatically mean the program can be used to instrument for smoking status. The exclusion restriction requires that the program only influence weight via the specified endogenous variable, which in Eisenberg and Quinn's case is a binary smoking cessation variable. Courtemanche et al. (2018) point out that, if some treated participants reduce smoking but do not quit entirely, or if they quit and relapse over the five-year period, the exclusion restriction is violated if the endogenous variable captures only the extensive but not the intensive margin of smoking. Ignoring intensity will bias the IV estimator upwards.

Accordingly, Courtemanche et al. (2018) use the LHS microdata to estimate IV models with different smoking variables. They find that, after five years, the treatment (both SI-A and SI-P) increased the probability of smoking cessation by 27-28 percentage points, decreased the number of

[15] To be eligible for participation, people had to show signs of mild lung function impairment, could not have certain medications in their prior history, had to have consumed less than 25 drinks per week, and could not have other severe illnesses or chronic medical conditions. Participants were interviewed extensively annually from the special intervention (SI) period to up to five years later.

cigarettes smoked per day by 11-12, and decreased carbon monoxide levels by 8 parts per million (ppm) in the first year. At the end of 5 years, the treatment groups had an increased probability of smoking cessation by 21 points compared to the control group, with the number of cigarettes smoked per day reduced by 9 and the CO levels in the body by 6-7 ppm. The weakening of the effect over time indicates relapse, reinforcing their concerns about simply using an indicator for smoking cessation after five years in an IV framework. Instead, their preferred specifications instrument for average cigarettes smoked per day or CO levels over the entire five-year period. Their results imply a more modest weight gain from quitting smoking of 11-12 pounds.

In short, the associational evidence, quasi-experimental evidence using variation from sources other than prices or taxes, and evidence from a randomized intervention point towards weight gain from smoking cessation among adults, which is consistent with the aforementioned biological mechanisms. However, the literature on the impact of cigarette costs on weight is mixed, and most evidence using plausibly exogenous cigarette taxes rather than prices points towards a counterintuitive *negativ*e long-run effect – implying that quitting smoking leads to weight *loss*. What could explain this apparent paradox? Courtemanche (2009) provides evidence that higher cigarette taxes lead to healthier eating and exercise habits, implying complementarities between smoking, junk food, and sedentary activities. He notes that most of the evidence on weight gain after quitting smoking is short-run and argues that, over time, the healthier lifestyle habits could counteract the direct biological effects. Courtemanche et al. (2018) point out that cigarette taxes could influence weight *even holding smoking constant*. While some smokers quit when cigarette taxes rise, far more do not. These individuals are now effectively poorer, which could affect a wide range of other consumption choices. For instance, Darden et al. (2025) document income effects of cigarette taxes on smokers' expenditures across a wide range of categories, including entertainment, grocery, clothing, transportation, healthcare, and housing. Rozema and Ziebarth (2017) show that the financial strain from higher cigarette taxes increases the likelihood of households with smokers taking up Supplemental Nutrition Assistance Program benefits. Additionally, revenue from cigarette taxes often helps fund health promotion programs or Medicaid, both of which could plausibly lead to weight loss even among never-smokers.

All of the above studies focus on adults. Comparatively, the literature on the impact of exogenous determinants of smoking on the weight of teens is very small. The effect of cigarette taxes on teen smoking could differ from that on adults, as could the biological effects, income effects, and substitutionary or complementary behaviors among those who quit smoking or do not

initiate because of the taxes. Moreover, reduced smoking among parents could have spillover effects on children's health behaviors, and lower disposable income among parents who continue to smoke could influence household purchases. Mellor (2011) finds that higher cigarette taxes increase children's BMI but not obesity status. Guarnizo-Herreno et al. (2019) find no evidence that cigarette taxes influence children's weight in either direction.

2.3 Vaping versus Smoking

The picture is even more complicated with ENDS taxes. In addition to all of the above considerations, there is also the possibility of substitution towards an even more dangerous source of nicotine. Could the availability of ENDS deliver nicotine in a way to reduce body weight without large adverse public health effects (if not coupled with combustible tobacco)? ENDS were first introduced to U.S. tobacco markets in 2006. Initially marketed as a smoking cessation tool (CDC, 2020), ENDS products may be harm-reducing relative to combustible tobacco, but they do carry health risks, including respiratory disease, heart disease (NASEM, 2018), and cancer from carcinogens (USDHHS, 2016). However, the existing scientific evidence suggests that the adverse health effects of e-cigarette use are substantially smaller than combustible tobacco use (NASEM, 2018).

According to the median tobacco expert, the impact of ENDS use on quality-adjusted life expectancy is only 25 percent as large as the effect of cigarette smoking (Allcott & Rafkin, 2021). Nutt et al. (2014) examine both private and external health harm caused by nicotine vaping and find that the harm caused by e-cigarettes does not exceed 5 percent of the harm caused by cigarettes. The NASEM (2018) concluded:

> "…e-cigarettes appear to pose less risk to an individual than combustible tobacco cigarettes…e-cigarette aerosol contains fewer numbers and lower levels of toxicants than smoke from combustible tobacco cigarettes."

Additionally, there is evidence that substituting from combustible cigarettes to ENDS may improve tobacco-related health. In a randomized trial setting, Caponnetto et al. (2013) finds that providing access to ENDS is associated with reductions in cigarette smoking and adverse health events such as coughing and shortness of breath. Hajek et al. (2019) studies the health effects of randomly assigning smokers' access to ENDS as compared to traditional nicotine-replacement

products and finds that ENDS product access increases one-year smoking cessation rates as well as induces greater declines in coughing and phlegm production. Polosa et al. (2020) study smokers with chronic obstructive pulmonary disease (COPD) and explore the health effects of switching to ENDS as compared to continuing to smoke cigarettes; switchers see improvements in lung function and respiratory health, as well as improvements in physical activity.

2.4 Effects of ENDS Taxes on Tobacco and Non-Tobacco Health

While ENDS use could provide an important tobacco harm reduction strategy, U.S. policymakers concerned about their "gateway effects" to nicotine addiction and combustible tobacco use have continued to enact policies to restrict access to ENDS, including through minimum legal purchasing ages (DeSimone et al., 2023; Hansen et al., 2017), licensure laws (Courtemanche et al., 2024), flavor restrictions (Cotti et al., 2025; Friedman et al., Forthcoming; Saffer et al., 2024), and ENDS taxation (Abouk et al., 2023a, b). Thirty-two (32) states and the District of Columbia (D.C.) have adopted ENDS taxes between 2010 and 2023. While 16 states and D.C. enacted an ad valorem tax (according to value) as a percentage of sales price, 16 states have adopted excise taxes per ml of e-liquid (4 of which utilize excise taxes for closed systems and ad valorem tax for open systems).

There is strong evidence that ENDS taxes curb ENDS use among both youths (Abouk et al. (2023b) and adults (Dave et al., 2024a, b; Pesko et al., 2020). Using Monitoring the Future and Youth Risk Behavior Survey data, Abouk et al. (2023b) finds that a one dollar increase in ENDS taxes is associated with a 2-7 percentage-points in prior-month youth ENDS use. Pesko et al. (2020) use data from the Behavioral Risk Factor Surveillance System (BRFSS) and the National Health Interview Survey (NHIS) and find that a one dollar in ENDS taxes is associated with a 0.52 percentage point decline in adult ENDS usage. Dave et al. (2024a, b) find evidence that younger adults under age 30 are more ENDS tax sensitive than older adults. Chuo et al. (2025) show that the effect of ENDS taxes on ENDS use is stronger for heterosexual teens than for LGBQ teens. Additionally, Allcott and Rafkin (2022) and Cotti et al. (2022) find that ENDS taxes reduce ENDS sales in Nielsen Retailer Panel data.

There is also evidence that ENDS taxes induce substitution to combustible cigarettes. Among teenagers, Abouk et al. (2023b) finds that a one dollar increase in ENDS taxes (in 2019$) increases prior-month youth cigarette smoking by 0.5-1.5 percentage points across the MTF and YRBS data sources. Among young adults, Friedman and Pesko (2022) find that the same tax

increase raises the smoking rate by 3.7 percentage points. With respect to adults, Pesko et al. (2020) use the BRFSS and NHIS and find that a one dollar increase in ENDS taxes increases daily cigarette use by 0.6 percentage-points. Allcott and Rafkin (2022), Cotti et al. (2022), and Pesko and Warman (2022) also find that ENDS taxes increase cigarette sales in the Nielsen data, although Cotti et al. (2018) find the opposite effect.

Evidence of substitutability between ENDS and cigarettes has also been found using sources of variation besides ENDS taxes. These include ENDS prices (Cantrell et al., 2020), minimum legal sales age laws (Abouk & Adams, 2017; Dave et al., 2019; Pesko & Currie, 2019), flavor bans (Cotti et al., 2025; Friedman et al., forthcoming; Saffer et al., 2024), and using panel data methods (Cotti et al., 2018).

However, recent research suggests that there may be some evidence of positive public health spillovers of ENDS taxes when one considers their effects in non-tobacco markets. Dave et al. (2024a) uses data from the YRBS, BRFSS, and Fatality Analysis Reporting System (collected from the National Highway Traffic Safety Administration) and find evidence consistent with the hypothesis that e-cigarettes and alcohol are complements among teenagers and young adults. They find that a one dollar increase in ENDS taxes is associated with a 1-2 percentage-point decline in the probability of youth binge drinking and a 5-10 percent decline in traffic fatalities involving a youth with a positive blood alcohol content (BAC). This result suggests potentially important alcohol-related health benefits from e-cigarette taxation, given that problem drinking among youths is likely associated with negative externalities (such as drunk driving deaths involving non-drinking victims on the road).

Dave et al. (2024b) also study the effects of ENDS taxation on youth marijuana and harder drug use. The authors find that a one dollar increase in ENDS taxes is associated with 1-2 percentage-point decline in youth marijuana usage and 0.8 percentage-point decline in adult marijuana usage. Given that early initiation of marijuana use may lead to important adverse cognitive development (NIDA, 2024) and increased risk of substance use disorder (NIDA, 2024; Substance Abuse and Mental Health Services Administration, 2023), these findings point to important marijuana-related public health benefits of ENDS taxation.

2.4 Contributions

Our work contributes to the above literature by being, to our knowledge, the first to estimate the effects of ENDS taxes on body weight among either youth or adults, with special attention to

potential gendered effects. When doing so, we separately estimate both contemporaneous and longer-run effects in light of the previously discussed importance of allowing effects of tobacco costs on weight to emerge over several years (Courtemanche, 2009; Courtemanche et al., 2018; Wehby & Courtemanche, 2012). Importantly, this study also explores some of the mechanisms through which ENDS taxes could affect body weight. In so doing, we add to the emerging body of evidence on the effects of ENDS taxes on consumption of combustible cigarettes, marijuana, and alcohol. Additionally, to our knowledge, we provide the first estimates of the effects of ENDS taxes on dietary and exercise habits.

3. Analytical Framework

Motivated by the discussion in the previous section, we next develop a simple analytical framework to elucidate the various channels through which ENDS taxes could influence body weight. At first glance, one might expect ENDS taxes to reduce ENDS use and therefore lead to weight gain. However, a more comprehensive examination reveals that the direction of the effect on weight is theoretically ambiguous and depends on the relative magnitudes of the various possible mechanisms. In turn, these relative magnitudes could differ across groups of individuals – such as teens versus adults – implying a strong likelihood of heterogeneous impacts.

First, define weight *W* as an increasing function of calorie intake *CI* and decreasing function of calorie expenditure *CE*:

$$W = w(CI, CE);\ \frac{\partial W}{\partial CI} > 0;\ \frac{\partial W}{\partial CE} < 0 \tag{1}$$

Evidence on the biological effects of nicotine suggests that both ENDS use *E* and cigarette smoking S should decrease calorie intake via reduced appetite and increase calorie expenditure via increased metabolism. Additionally, assume alcohol *A* and marijuana *M* both increase calorie intake, the former directly and the latter via increased appetite. Finally, ENDS taxes *T* could matter even holding ENDS use constant, as users now have less disposable income. This means that ENDS taxes need to enter the calorie intake and expenditure equations *directly*. The income effect has ambiguous effects on both calorie intake and expenditure, as the additional money could be spent on healthy foods, unhealthy foods, goods that promote sedentary lifestyles like video games, or goods that promote active lifestyles like gym memberships. Therefore,

$$CI = ci(E, S, A, M, T);\ \frac{\partial CI}{\partial E} < 0;\ \frac{\partial CI}{\partial S} < 0;\ \frac{\partial CI}{\partial A} > 0;\ \frac{\partial CI}{\partial M} > 0;\ \frac{\partial CI}{\partial T} ?\ 0 \tag{2}$$

$$CE = ce(E, S, T);\ \frac{\partial CE}{\partial E} > 0;\ \frac{\partial CE}{\partial S} > 0;\ \frac{\partial CE}{\partial T} ?\ 0 \tag{3}$$

We next turn to the influence of ENDS taxes on use of the substances in the model. The extensive evidence discussed above shows that ENDS taxes reduce ENDS use:

$$E = e(T);\ \frac{dE}{dT} < 0 \tag{4}$$

As discussed in the previous section, there is substantial evidence that ENDS products are substitutes for cigarettes and suggestive evidence that ENDS products are complements for alcohol and marijuana. These estimates are reduced form, so they encompass any income effect. Therefore, assume that:

$$S = e(T);\ \frac{dS}{dT} > 0 \tag{5}$$

$$A = e(T);\ \frac{dA}{dT} < 0 \tag{6}$$

$$M = e(T);\ \frac{dM}{dT} < 0 \tag{7}$$

The above allow us to derive the overall effect of ENDS taxes on weight. Signs of each term — based on the assumptions made above — are shown below equation (8) are below the equation, with up and down arrows used to avoid confusion with addition and subtraction signs.

$$\frac{dW}{dT} = \frac{\partial W}{\partial CI}\left[\frac{\partial CI}{\partial E}\frac{dE}{dT} + \frac{\partial CI}{\partial S}\frac{dS}{dT} + \frac{\partial CI}{\partial A}\frac{dA}{dT} + \frac{\partial CI}{\partial M}\frac{dM}{dT} + \frac{\partial CI}{\partial T}\right] + \frac{\partial W}{\partial CE}\left[\frac{\partial CE}{\partial E}\frac{dE}{dT} + \frac{\partial CE}{\partial S}\frac{dS}{dT} + \frac{\partial CE}{\partial T}\right]$$

$$= \frac{\partial W}{\partial CI}\frac{\partial CI}{\partial E}\frac{dE}{dT} + \frac{\partial W}{\partial CI}\frac{\partial CI}{\partial S}\frac{dS}{dT} + \frac{\partial W}{\partial CI}\frac{\partial CI}{\partial A}\frac{dA}{dT} + \frac{\partial W}{\partial CI}\frac{\partial CI}{\partial M}\frac{dM}{dT} + \frac{\partial W}{\partial CI}\frac{\partial CI}{\partial T} + \frac{\partial W}{\partial CE}\frac{\partial CE}{\partial E}\frac{dE}{dT} + \frac{\partial W}{\partial CE}\frac{\partial CE}{\partial S}\frac{dS}{dT} + \frac{\partial W}{\partial CE}\frac{\partial CE}{\partial T}$$

$$= \uparrow \downarrow \downarrow \quad \uparrow \downarrow \uparrow \quad \uparrow \uparrow \downarrow \quad \uparrow \uparrow \downarrow \quad \uparrow ? \quad \downarrow \uparrow \downarrow \quad \downarrow \uparrow \uparrow \quad \downarrow ?$$

$$= \uparrow \quad \downarrow \quad \downarrow \quad \uparrow \quad ? \quad \downarrow \quad ? \tag{8}$$

The simplified form in the last line shows a mix of positive, negative, and ambiguous effects, making the overall effect of ENDS taxes on weight ambiguous.

The two forces pushing in the direction of weight gain are the two most direct biological effects. ENDS taxes reduce ENDS use, which increases appetite and therefore calorie intake, while slowing the metabolism, leading to fewer calories burned.

Four forces – all of which stem from indirect effects on other substances – push towards weight loss. ENDS-tax-induced substitution towards smoking decreases appetite and therefore calorie intake. It also stimulates metabolism, increasing calories burned. To the extent that such substitution exists, these effects offset those of reduced vaping. If, as recent studies suggest, ENDS

taxes decrease alcohol consumption, this lowers calorie intake. Similarly, if ENDS taxes reduce marijuana use, appetite should decrease, also reducing calorie intake.

The remaining two forces relate to the ambiguous income effects on calorie intake and expenditure. If the reduction in disposable income from ENDS taxes among continued users decreases food consumption across-the-board, we would expect fewer calories consumed and therefore weight loss. However, lower income could plausibly shift households away from expensive fresh, low-calorie foods towards cheaper, high calorie processed foods, increasing calorie intake on net. Another possibility is substitution away from relatively expensive but unhealthy restaurant food towards less expensive but healthier food prepared at home (e.g. Nguyen & Powell, 2014). Such substitution could be especially pronounced for teens, both because they tend to have limited spending money for fast food and other entertainment and because home-prepared meals may be free from their perspective (paid for by parents). Similarly, reduced purchasing power makes it more difficult to purchase both goods and activities that encourage sedentary lifestyles and those that encourage active lifestyles. Consistent with these theoretical ambiguities, Mathieu-Bolh (2022) notes that the causal effect of income on body weight is the subject of continued debate in the literature, with the effect varying across contexts in the limited quasi-experimental studies on the topic.

The direction of the net effect of ENDS taxes depends on the relative strength of these different mechanisms. The most direct and obvious explanations point towards weight gain from reduced nicotine consumption. However, a more careful analysis reveals that this effect could be partially or totally offset or even reversed by other factors. Substitution towards combustible cigarettes would offset at least some of this effect. Complementarities of ENDS products with alcohol and marijuana would push further in the direction of weight loss. Murky income effects could work in either direction.

4. Data

4.1 YRBSS Survey

The primary dataset we use to study the effect of ENDS taxes on body weight is the State and National Youth Risk Behavior Surveillance System Surveys (YRBSS). Coordinated by the Centers for Disease Control and Prevention, the YRBSS is a school-based biennial survey administered in odd-numbered years that, when weighted, is designed to be representative of high school students at the state level as well as high-school teenagers aged 14-18 years at the national

level.[16] These data are well-suited to carrying out this study because they include information on youth body weight, height, and tobacco use, including both ENDS use among youths as well as combustible tobacco use. These data also include information on health behaviors that may be important for studying relevant adjacent non-tobacco markets, including alcohol, marijuana, diet and exercise.

Following a number of studies of the effects of health policy shocks on risky health behaviors (Abouk et al., 2023b; Anderson et al., 2020; Cotti et al., 2025; Hansen et al., 2017), we use the combined YRBSS to maximize identifying variation. We overcome concerns raised by the CDC by not combining sample weights from each survey and instead constructing sample weights that appropriately weight age-by-gender-by-race/ethnicity-specific populations at the state and national levels. Over the period 2015-2023, when we have data on ENDS use, 23 states identify the effect of ENDS taxes in our sample.[17]

To measure ENDS use, we draw data from the 2015-2023 and use responses to the following YRBSS questionnaire item:

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

If a respondent reports use of an electronic vapor product on at least one day in the last 30 days, the variable *Current ENDS Use* is set equal to 1; it is set equal to zero otherwise. As shown in Table 1, we find that 20.0 percent of youths reported prior month ENDS use. For males, the current ENDS use rate is 19.5 percent while for females it is 20.6.

Following Abouk et al. (2023a), Courtemanche et al. (2024), and Cotti et al. (2025), we also measure more habitual ENDS use using the same above questionnaire item. *Frequent ENDS Use* is set equal to one if the respondent reports using e-cigarettes on at least 20 of the last 30 days and is

[16] 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 YRBSS sampled individuals in age-by-gender-by-race-ethnicity bin i in state s at year t and StatePop14_18$_{st}$ is the SEER estimated population of 14-to-18-year-olds in state s at year t. In this construction, we are following the recent literature that applies similar SEER-constructed weights in analyses of the combined YRBSS data (Hansen et al., 2023; Rees et al., 2021; Sabia & Anderson, 2016).

[17] 27 states identify the effect of ENDS taxes in our extended sample period of 2011-2023.

set equal to zero otherwise. *Everyday ENDS Use* is set equal to one if the respondent reports using e-cigarettes on all 30 of the last 30 days and is set to zero otherwise. We find that 6.0 percent of youth report frequent ENDS use, and 4.3 percent report everyday ENDS use.

We then turn to our main outcome of interest, body weight. These data are available over both the same period over which we measure ENDS use (2015-2023) as well as over an extended window that covers nearly all ENDS taxes (2011-2023). Respondents are asked to self-report their height and weight using the following questionnaire items:

"How tall are you without your shoes on?"
"How much do you weigh without your shoes on?"

Answers to these questions are provided in metric units, i.e., in meters (for height) and in kilograms (for weight) in the dataset. We convert these values to imperial units, i.e., inches (for height) and pounds (for weight). Our first measure, *Weight,* is coded as the respondent's self-reported weight in pounds. We find that the average weight for females is 136.7 pounds and 161.5 pounds for males in our sample.

Our other measures are derived from body mass index (BMI), calculated as the respondent's weight in kilograms divided by the respondent's height in meters squared. BMI is a valuable measure because it is inexpensive and easy to use (Daniels, 2009); useful in population-based studies due to its wide acceptance in defining and predicting health issues for specific categories of body mass (Nuttall, 2015; Miyake et al., 2013); has high specificity especially among children and teens (Adab & Pallan, 2018; Freedman & Sherry, 2009); correlates highly with direct measures of total body fat; and is the best available tool so far to monitor obesity (Hall & Cole, 2006). However, it is imperfect in that it does not differentiate between fat mass and muscle mass and hence can be a misleading indicator of whether someone is overweight/obese or not (Burkhauser and Cawley, 2008). While alternate measures such as skinfold thickness, waist circumference, or body roundness indicator (BRI) have advantages, such measures are not available in our data and there is evidence that BMI remains an informative measure of body weight-related health (Adab & Pallan, 2018; Miyake et al., 2013; Hall & Cole, 2006; Perrin et al., 2004).[18]

[18] Several studies have examined both measured and self-reported weight to explore systematic under- or over-reporting of body weight (Field et al., 2012; Morrissey et al., 2006; Gorber et al., 2007; Strauss, 1999; Villaneuva 2001). Hill and Roberts (1998) find that overweight/obese females are more likely to understate their weighs relative to

Because our YRBSS-based analysis focuses on teenagers under age 20, we follow the CDC guidelines in generating a *BMI Percentile* and *BMI Z-Score* (Daniels, 2009). The CDC calculates BMI percentiles by determining an individual's BMI relative to the age-by-gender BMI distribution developed for CDC growth charts using a nationally representative sample of youths.[19] Using this comparison, one can determine each person's percentile value in the BMI distribution and generate the dependent variable *BMI Percentile*. We find the mean value of *BMI Percentile* in our sample to be 65.0 without much difference between females (64.4) and males (65.5).

Next, we measure the *BMI Z-Score*, which measures how many standard deviations the respondent's BMI is from the average BMI for the age-by-gender distribution (Cole, 1990; Vidmar et al., 2004). We find that the average BMI Z-scores of our nationally representative sample covering 2011-2023 years is 0.54, with males having slightly higher values at 0.58 compared to females' 0.50.

We also classify the youth as either being *Underweight, Normal Weight, Overweight or Obese*, and *Obese* using CDC-recommended cutoffs such that: *BMI Percentile*. $<5^{th}$ percentile (*Underweight*), 5^{th} - $<85^{th}$ percentile (*Normal Weight*), 85^{th} percentile or higher (*Overweight or Obese*) and 95^{th} percentile or higher (*Obese*). Over the sample period under study, 63.4 percent of males and 69.6 percent of females are classified as normal weight; 32.3 percent of males and 28.0 percent of females are classified as overweight or obese, and 17.2 percent of males and 11.6 percent of females are classified as obese.[20]

The YRBSS is also useful for our analyses because surveys include information on key spillover effects of ENDS taxes that could also influence body weight. One such spillover is to combustible tobacco products. Respondents are asked the following questionnaire item:

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

overweight/obese males, while males (but not females) are more likely to over report their height. Correction methods for adults have been developed by Cawley (2004) and Courtemanche, Pinkston and Stewart (2015), who found employing these corrections can modestly influence point estimates but does not affect qualitative conclusions. Bias in our estimated effects of ENDS taxes (relative to the mean of the dependent variable) should be minimal unless misreporting is systematically correlated with ENDS taxes, which we do not expect.

[19] The reference population is the nationally representative sample from health surveys such as NHANES (National Health and Nutrition Examination Survey).

[20] We remove any observations from our sample that have BMI values exceeding beyond typical biological plausibility for a given age and gender as determined by the 2000 US CDC Growth Charts (CDC, 2022). By default, any z scores with absolute values greater than or equal to 5 are set to missing to eliminate extreme data entry errors (Vidmar et al., 2004, 2013).

Current Cigarette Smoking is then set equal to 1 if a respondent reports smoking cigarettes on at least 1 of the last 30 days and is set equal to 0 otherwise. In our sample period, 10.0 percent of males and 8.0 percent of females report cigarette smoking in the last 30 days. Respondents are also asked about their binge drinking and marijuana use behaviors:

> "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)?"
>
> "During the past 30 days, how many times did you use marijuana?"

Binge Drinking is set equal to 1 if the respondent reported drinking five or more drinks in a single occasion (four drinks for women) in the last 30 days and 0 otherwise. In our analysis sample, 15.2 percent of males and 15.5 percent of females report binge drinking. With respect to *Marijuana Use*, 19.7 percent of males and 19.1 percent of females report marijuana use in the last 30 days.

Finally, the YRBSS contains some information on exercise and diet. *Exercise* is measured dichotomously and set equal to 1 if the respondent reports being "physically active (for 60 minutes)" at least once in the last 7 days; it is set equal to 0 otherwise.[21] We find 84.9 percent of youth exercise for at least 60 minutes at least once in the week prior to survey. *Soda* is set equal to 1 if the respondent reported "drank any soda or pop such as Coke, Pepsi, Sprite,"; it is set equal to 0 otherwise.[22] Nearly three-quarters (73.2 percent) of youth report drinking these sweetened beverages. *Fruit and Juices* is set equal to 1 if the respondent reported consuming any fresh fruit or 100% fruit juices in the last 7 days and is set equal to 0 otherwise.[23] Our data show that 93.6 percent of youth report drinking fruit juices or consuming fruits on at least one day in the week prior to survey. We include a similar variable for *Vegetables*, and 90.5 percent of youth report consuming a healthy vegetable in the prior week.[24]

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[21] Respondents are asked, "During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?".

[22] Respondents are asked, "During the past 7 days, how many times did you drink a can, bottle, or glass of soda or pop, such as Coke, Pepsi, or Sprite?".

[23] Respondents are asked, "During the past 7 days, how many times did you eat fruit?", "During the past 7 days, how many times did you drink 100% fruit juices such as orange juice, apple juice, or grape juice?".

[24] Vegetables is set equal to 1 if a respondent reported eating potatoes (excluding french fries, hash browns, etc.), carrots, green salads, and other vegetables and is set equal to 0 otherwise Respondents are asked, "During the past 7 days, how

The YRBSS does not include information on the frequency of consuming restaurant food. However, it might be possible to infer some information about the likelihood of eating at restaurants based on the other dietary variables. As summarized by Gesteiro et al. (2022) in a review of 57 studies, consumption of restaurant meals is consistently associated with increased soda intake and lower fruit and vegetable intake. Therefore, while ENDS taxes reducing soda consumption and/or increasing fruit and vegetable consumption would not provide conclusive evidence of substitution away from restaurants, it would at least be consistent with such a hypothesis.

4.2 Behavioral Risk Factor Surveillance System Survey (BRFSS)

To supplement our analyses on youth, we explore the effects of ENDS taxes on adults using data on body weight drawn from the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a nationally representative telephone survey that provides information on ENDS use among adults ages 18 and older for the period 2016-2023. The survey includes self-reported body weight and weight-related behaviors available over the 2011-2023 period. 2011 is a natural starting place because that is the year the survey began to include cell phones in its sampling frame.

We restrict the sample to working-age adults aged 18-64 for two reasons. First, this follows Gruber and Frakes (2006), who excluded those 65 and older from their study on the impact of cigarette taxes on weight due to concerns about endogenous mortality. Second, rates of ENDS use are very low among seniors, so there is little reason to expect them to be meaningfully responsive to ENDS taxes.

Analogous to the YRBSS analysis, we measure ENDS use[25], body weight (in pounds), BMI, and measures of underweight, overweight/obese, obese, and healthy weight based on BMI category. We use the adult body mass index measures, which includes *BMI* following CDC guidelines for those aged 20 and older using raw BMI value: *Underweight* (BMI < 18), *Normal Weight* (list BMI range), *Overweight or Obese* (BMI >= 25), or *Obese* (BMI >=30).

many times did you eat green salad?", "During the past 7 days, how many times did you eat potatoes?", "During the past 7 days, how many times did you eat carrots?" and "During the past 7 days, how many times did you eat other vegetables?".

[25] Respondents are asked, "Do you now use e-cigarettes or other electronic vaping products every day, some days, or not at all?".

The BRFSS also includes information on several potential indirect mechanisms, including cigarette smoking, alcohol consumption, and diet (french fries and vegetable consumption).[26] The means for each key variable in our BRFSS-based analysis are shown in Table 1. We find that 7.8 percent and 3.4 percent of adults are current ENDS users and everyday ENDS users, respectively. We further find that the average adult male weighs 196.7 pounds, and the average adult female weighs 164.5 pounds. Further, 69.9 percent of men and 59.5 percent of females are classified as overweight or obese.

4.3 ENDS Taxes

We calculate a per milliliter (mL) of e-liquid equivalent value following Cotti et al. (2025), who use NielsenIQ retail scanner data and assume a 35 percent retailer markup (based on e-cigarette company purchasing forms); to convert ad valorem and sales taxes to their per mL of e-liquid excise tax equivalents. Our analysis uses "closed system" taxes, which apply to pre-filled cartridges such as JuuL. Results using "open system" taxes are qualitatively similar.

Figure 1 shows geographic and temporal variation in ENDS taxes over the 2010-2023 period. In addition, we show the magnitude of real taxes (in 2023$) that are used to identify the treatment effect. Values (averaged over the four quarters of the year) are shown in Appendix Table 1. To incorporate local taxes (in Cook County, Montgomery County, and Chicago), we generate a population-weighted effective state tax in order to merge to our datasets' state identifiers (as we do not have local identifiers).

5. Econometric Approach

We begin by employing a two-way fixed effects (TWFE) regression model estimated via ordinary least squares (OLS):

$$Y_{ismt} = \gamma_0 + \boldsymbol{\gamma_1}\,\text{ENDS Tax}_{smt} + \boldsymbol{X'_{is}}_{mt}\,\boldsymbol{\gamma_2} + \boldsymbol{Z'}_{smt}\,\boldsymbol{\gamma_3} + \alpha_s + \pi_m + \theta_t + \varepsilon_{ismt}, \quad (1)$$

[26] We define current and everyday cigarette smoking using the question, "Do you now smoke cigarettes every day, some days, or not at all?" Alcohol consumption and binge drinking are defined using responses greater than zero to the questions, "During the past 30 days, how many days per week or per month did you have at least one drink of any alcoholic beverage such as beer, wine, a malt beverage or liquor" and "Considering all types of alcohol beverages, how many times during the past 30 days did you have 5 or more drinks for men or 4 or more drinks for women on an occasion," respectively. Finally, monthly french fries' consumption is defined from the question, "How often did you eat any kind of fried potatoes, including french fries, home fries, or hash browns," and vegetable consumption is defined through multiple questions about bean, leafy green, orange-colored vegetable, potato, or other vegetable intake.

where Y_{ismt} is the outcome (our measures of ENDS use for 2015-2023, body weight, and alcohol and marijuana use for the period 2011-2023) for individual *i* residing in state *s* in semester (or quarter in the BRFSS) *m* in year *t*. Our main independent variable of interest is ENDS Tax_{smt}, which is the ENDS tax per mL of e-liquid in 2023 dollars. Thus, the parameter γ_1 denotes the "effect" of a one-dollar increase in ENDS taxes, identified from within-state over-time variation in ENDS taxes, as depicted in Figure 1 and outlined in Appendix Table 1. The vector $\mathbf{X}_{ismt}$ includes the individual demographic controls dummies for gender, age, grade (in school), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and Other), and an indicator for whether the observation is drawn from the state or national YRBS. The vector $\mathbf{Z}_{smt}$ includes a wide set of state-level controls that capture (1) macroeconomic conditions (poverty rate and unemployment rate), (2) differential effects of COVID-19 on states over time (cumulative COVID-19 case and death rates and policy stringency index), (3) a wide set of tobacco control policies (cigarette taxes, Tobacco-21 laws, clean indoor air laws for tobacco smoke, minimum legal sales age for ENDS of 18, ENDS flavor restrictions, ENDS licensure laws, clean indoor air laws covering ENDS aerosols), and (4) substance use policies (beer taxes, medical marijuana laws, recreational marijuana laws, and marijuana decriminalization laws).[27] Finally, α_s, π_m, and θ_t are state, semester (or quarter), and year fixed effects. All regressions are weighted using sample weights and standard errors are clustered at the state level (Bertrand et al., 2004).

Throughout the paper, we also estimate an alternate version of (1) in which the ENDS tax variable is a three-year moving average spanning years t, t-1, and t-2. This approach is motivated by the literature on cigarette taxes and body weight, which emphasizes the possibility for effects to emerge gradually over time. Addictive goods can take time to stop using, and body weight is a capital stock that does not fully respond immediately to changes in habits. Accordingly, Courtemanche (2009) shows that using a moving average for cigarette tax allows an effect to emerge that is not

[27] The poverty rate is obtained from the National Welfare Data collected by University of Kentucky's Center for Poverty Research. The unemployment rate is obtained from the Bureau of Labor Statistics. The COVID-19 case and death rates were obtained from *New York Times'* COVID-19 database. The COVID-19 stringency index is obtained from the Oxford Covid-19 Government Response Tracker project. Information on state Tobacco 21 laws is sourced from the Preventing Tobacco Addiction Foundation. Data on cigarette taxes, the minimum legal sales age for ENDS, and clean indoor air regulations are drawn from the CDC's STATE system. E-cigarette licensure information is based on data compiled by Courtemanche et al. (2024), and flavor ban policy variables used were collected by Cotti et al. (2025), while e-cigarette tax data are obtained from Cotti et al. (2023). Beer tax data originate from the Alcohol Policy Information System. Finally, marijuana law data were gathered by Anderson and Rees (2023) and Wen et al. (2021).

present using contemporaneous tax.[28] As his study explains, the coefficient for the moving average represents the effect of a $1 tax increase that was implemented at least three years ago, whereas the coefficient for the contemporaneous variable gives the effect of a $1 tax that could have been imposed at any time. Therefore, the coefficient for the moving average has somewhat closer to a long-run interpretation.[29]

In order for our estimate of γ_1 to be unbiased, there must be (1) no time-varying, state-level unobservables associated with ENDS taxes and the outcome, (2) no reverse causality whereby the outcome could influence ENDS taxes, and (3) no heterogeneous and dynamic treatment effects, which could lead to bias in our TWFE estimates. With respect to the first point, we include a wide set of observable tobacco and other health policy controls (as noted above) to disentangle the effects of ENDS taxes from other contemporaneously enacted policies. In addition, in a series of sensitivity checks we add controls for state-specific linear time trends and census region-specific year fixed effects to control for unmeasured jurisdiction shocks that could contaminate our estimates. However, we note that the inclusion of these controls could exacerbate bias by eliminating exogenous variation in our treatment variable (Burkhauser et al., 2025; Neumark et al., 2014).

To test for parallel pre-treatment trends as well as reverse causality, we estimate an event-study model in the spirit of Schmidheiny and Siegloch (2023) and Matsuzawa et al. (2025):

$$Y_{ismt} = \varphi_0 + \sum_{j=\underline{J};\, j\neq -1,-2}^{\bar{J}} \beta_j D^{j}_{smt} + \boldsymbol{X'}_{ismt}\boldsymbol{\varphi}_1 + Z'_{smt}\boldsymbol{\varphi}_2 + \alpha_s + \pi_m + \theta_t + \varepsilon_{ismt}, \qquad (2)$$

where D_{smt} is the difference in ENDS taxes between survey wave (year) *t* and *t-1*. Because of the biennial nature of the YRBSS, the reference period in our event study analyses is comprised of the two years (j = -1,-2) preceding the ENDS tax change. For our body weight analysis, which uses data from 2011-2023, $\underline{J}$ is equal to 5 or more years preceding ENDS tax changes, and $\bar{J}$ is equal to 4 or

[28] Courtemanche (2009) uses a six-year moving average, an approach also adopted by Wehby and Courtemanche (2012). This was more feasible in their analyses than ours, as their data spanned about twice as long a time period, with cigarette tax increases occurring frequently throughout. We therefore use a moving average covering half the number of years as theirs.

[29] To illustrate, a $1 tax imposed one year ago would increase the contemporaneous tax variable by $1 but the three-year moving average by only $0.33. While it would be interesting to model timing more exactly by including multiple lags rather than averaging over all three time periods, this is difficult to do with meaningful precision in a dataset with limited numbers of years and treatments. The event-study model that follows will examine dynamics in the treatment effect in more detail.

more years following ENDS tax changes. If $\beta_j = 0$ for $j < 0$, this would support the parallel trends assumption (in the pre-treatment period) and also provide evidence against reverse causality. In addition, the dynamic TWFE approach will allow us to explore how the effect of ENDS taxes unfolds over time, which could be particularly important for body weight since it is a capital stock that takes time to fully respond to changes in habits.[30]

An important concern with our TWFE models (including the event study) is that, in the presence of heterogeneous and dynamic treatment effects, estimates may be biased (Goodman-Bacon, 2021; Sun & Abraham, 2021). To account for this possibility and avoid the "bad comparisons" where early adopters are used as controls for later adopters, we implement a stacked difference-in-differences regression in the spirit of Cengiz et al. (2019). To implement this approach, we focus on prominent increases in ENDS taxes of at least $0.25 per mL (or, in an alternate specification, $0.50 per mL) of e-liquid (in nominal tax dollars), limit our set of counterfactuals to states that are not-yet or never adopters of any ENDS tax, and set a common treatment window from 5-6 years prior to tax adoption to 2-3 years after tax enactment using data over the 2011-2023 period. After defining each treatment state cohort with its respective counterfactuals, we combine the resulting datasets and estimate the following regression:

$$Y_{icmst} = \delta_0 + \boldsymbol{\delta_1}\, ProminentENDSTax_{cmst} + \boldsymbol{X'}_{icmst}\, \boldsymbol{\delta_2} + \boldsymbol{Z'}_{cmst}\, \boldsymbol{\delta_3} + \alpha_{cs} + \theta_{ct} + \pi_m + \varepsilon_{icmst}, \qquad (3)$$

where $ProminentENDSTax_{cmst}$ is an indicator for whether a state has implemented a prominent ENDS tax increase of $0.25 or higher (or in an alternate specification $0.50 per mL or higher), c denotes each cohort, α_{cs} is a cohort-specific state effect, and θ_{ct} is a cohort-specific year effect. We also perform an event-study analysis of our main outcomes using the stacked difference-in-differences approach.

A limitation of the YRBS ENDS use outcomes is that measures of intensity are relatively crude. Frequent and everyday use only capture number of days of ENDS use, not puffs per day or nicotine content of the ENDS product – both of which could plausibly be affected by ENDS taxes.

[30] Specifically, we interact the time-to-treatment indicators with first differences of the continuous real ENDS tax. Given our relatively short event panel, we adopt the approach of Miller (2023) and Serrato and Zidar (2016), reporting average event study coefficients using the delta method. Using this approach, event study coefficients reported at event time j=(-2,-1), the reference period, and (0,1) are standard event study coefficients. For event time $j^* < -2$ (leads), the marginal effect in period j^* that we report is the average marginal effect for all j in the interval $j = [j^*,0)$. For event time $j^\wedge > 1$ (lags), the marginal effect in period $j^\wedge$ that we report is the average marginal effect for all j in the interval $[0,j^*]$.

Moreover, frequent and everyday use are crude dichotomizations of number of days of use. Thus, we concede that our analyses do not provide a *complete* picture of changes in ENDS use.

One implication of this limitation is that it necessitates reliance on reduced-form models, as opposed to instrumental variables (IV) models where ENDS tax is an instrument for ENDS use. In their study leveraging a smoking cessation program to instrument for the effect of smoking on weight, Courtemanche et al. (2018) show that if the endogenous variable does not adequately account for intensity, IV estimates of its impact are exaggerated. In effect, intensity becomes an omitted variable in the body weight equation. The instrument likely affects the intensive margin of smoking/vaping in the same direction as the extensive margin, and the intensive margin of smoking/vaping likely affects weight in the same direction as the extensive margin. This means the exclusion restriction is violated in a way that biases IV estimators away from zero. An additional reason for avoiding IV models is that, as the analytical framework in Section 3 shows, ENDS taxes could influence weight-related outcomes *even holding ENDS use constant* via income effects, creating another violation of the exclusion restriction.

6. Results

Our main findings appear in Tables 1 through 10 and Figures 1 through 8. Supplementary analyses appear in the appendix.

6.1 ENDS Taxes and ENDS Use, YRBSS

In Table 2, we present estimates of the effects of ENDS taxes on youth e-cigarette use. For the reasons discussed at the end of Section 5, we caution against interpreting these results as a "first stage". With that said, the results still serve a useful purpose in helping to narrow down the mechanisms. For instance, if there is no effect on vaping but an effect on body weight, then income effects become the only plausible explanation. In contrast, if we observe a reduction in vaping that is sufficiently large to explain any observed effect on body weight, this would provide suggestive evidence that income effects are not of major importance.

Panel I shows the results using any current ENDS use as the outcome. Beginning with subpanel (a) for contemporaneous ENDS tax, we find that, controlling for state, year, and semester fixed effects as well as demographic controls (column 1), a one-dollar increase in ENDS taxes is associated with a 2.6 percentage-point reduction in prior-month youth ENDS use, or about 12 percent of the pre-treatment rate. Adding macroeconomic and COVID-19 controls (column 2),

cigarette taxes (columns 3), other combustible cigarette policies (column 4), other ENDS policies (column 5), marijuana and other substance use policies (column 6), and beer taxes (column 7) gradually attenuates the estimate down to 1.3 percentage points, or about 6% of the pre-treatment rate. The ENDS tax variable is statistically significant at the 5 percent level or better in all seven specifications and at the 1 percent level in six. The results using the moving average in subpanel (b) are very similar in the first four columns but attenuate somewhat more substantially in the last three.

For the two outcomes reflecting more habitual vaping, the estimates consistently show sizeable and statistically significant decreases. In panel II, we see that a one-dollar increase in ENDS taxes is associated with a 1 to 1.6 percentage point reduction in frequent ENDS use. These magnitudes are large, as they represent 18 to 29 percent of the pre-treatment sample rate of frequent vaping. Panel III shows the exact same range of point estimates for everyday ENDS use, but because everyday use is more rare than frequent use, these magnitudes now represent even larger declines of 26 to 41 percent relative to the pre-treatment rate. For both outcomes, there is no evidence that the effect systematically attenuates with additional controls or is meaningfully sensitive to the use of contemporaneous taxes versus the moving average.[31]

Event-study analyses in Figure 2 test for parallel pre-treatment trends and explore dynamics in estimated treatment effects. The findings in Figure 2 show that trends in youth ENDS use were similar in treatment and control states prior to ENDS tax increases, and that ENDS use declined in treatment states relative to control states in the years following these increases. Moreover, these declines occurred quickly, as there is no evidence that the effects grew in the second post-treatment period relative to the first. A relatively immediate impact is also consistent with the fact that the moving average estimates from Table 2 were not larger than those using contemporaneous taxes. Together, our results from Table 2 and Figure 2 are consistent with Abouk et al. (2023b), Dave et al. (2024a, b), and Chuo et al.'s (2025) findings that ENDS taxes caused a reduction in youth ENDS use.

Table 3 explores gender-specific estimates of the effects of ENDS taxes on youth ENDS use. The pattern of results suggests some interesting heterogeneity by margin of e-cigarette use. Females' any prior month e-cigarette use (panel I, columns 1-3) is much more affected than that of males (panel II, columns 1-3). We find that a one-dollar increase in ENDS taxes is associated with a

[31] An examination of the robustness of the findings shown in Table 2 to separate analyses of the State and National YRBSS (see Appendix Table 2) shows results that are broadly consistent with the findings of the Combined YRBSS sample. The results are somewhat more sensitive to specification for the National YRBSS, as it is only about 10% of the size of the State YRBSS.

1.7 to 2.6 percentage-point (8.6 to 12.6 percent) reduction in prior-month ENDS use among female youth, but smaller and statistically insignificant changes for males. This suggests that the extensive margin of ENDS use is most affected for females. On the other hand, when we explore more habitual ENDS use, the pattern of findings suggests that both genders are impacted. A one-dollar increase in ENDS taxes is associated with percentage-point reductions in frequent and everyday ENDS use of 1.2 to 1.8 (always statistically significant) for females and 0.5 to 1.5 (statistically significant in 11 of 12 specifications) for males.

Next, we explore whether our findings are contaminated by heterogeneous and dynamic treatment effects. To do this, we restrict our set of control states to not-yet-and never adopters of ENDS taxes, focusing on a treatment window of approximately 5-6 years prior to treatment to 2-3 years following treatment, and use a stacked difference-in-differences approach. In Appendix Tables 3A and 3B, we present TWFE and stacked DD estimates of the effects of prominent increases in ENDS taxes on youth ENDS use. The results show that prominent ENDS tax increases (at least $0.25 per mL or at least $0.50 per mL of e-liquid) are associated with a reduction in youth ENDS use.

6.2 ENDS Taxes and Body Weight, YRBSS

In Table 4A, we turn to estimated effects of ENDS taxes on body weight, first using data drawn from the same sample period over which we have ENDS use information. We focus on *Weight*, controlling for height. Our results for the pooled sample (panel I) show that a one dollar increase in contemporaneous ENDS taxes (subpanel a) is associated with about a 1 pound (or 0.7 percent) *reduction* in youth body weight. Although the effect size is modest, it is statistically significant at the 10 percent level or better in all specifications. The estimates continue to be negative using the moving average (subpanel b), although the effects are somewhat smaller and statistically insignificant in most cases. Regardless of whether the effect is zero or slightly negative, the most important takeaway is the lack of weight *gain*, since that is the direction implied by the most direct mechanisms.

Splitting the sample by gender in panels II and III show that the evidence of weight loss is clearer for females. Across the ten specifications in subpanels (a) and (b) of panel II, a one dollar increase in ENDS taxes reduces the weight of female teens by 1.1 to 2 pounds (0.8 to 1.4 percent). This effect is always statistically significant at the 5 percent level or better. In contrast, the effect for males is consistently smaller and statistically insignificant.

An examination of results from a TWFE event-study analysis in Figure 3 provides evidence consistent with parallel pre-treatment trends in youth female (panel a) and male (panel b) body weight prior to an ENDS tax increase. Following an ENDS tax increase, there is evidence of a significant decline in body weight for females that appears to grow over time (panel a). For males (panel b), if anything, the effect appears to weaken over time.[32]

Table 4B shows that the gender-specific results from panels II and III of Table 4A are robust to the use of the longer 2011-2023 sample window. We observe statistically significant reductions in weight from ENDS taxes of 1.1 to 1.6 pounds for females. The estimates for males continue to be smaller and statistically insignificant.[33]

In Table 5, we continue to use this longer sample period and show the impact of ENDS taxes across our other body weight measures.[34] For females (panel I), a one-dollar increase in ENDS taxes reduces BMI by about one percentile according to age-for-gender BMI charts (column 1) and by 0.033 to 0.043 standard deviations (column 2). Columns (3) and (4) show that a one-dollar increase in ENDS taxes is associated with one percentage-point reductions in the indicators for overweight or obesity, with the latter being statistically significant at the 10 percent level or better. Columns (5) and (6) show that these findings persist when we remove underweight youth from our sample.[35] For males, each estimate in the table is statistically insignificant at conventional levels, and almost all of them are smaller than the corresponding estimate for females.[36]

Figure 4 shows event-study analyses of the relationship between ENDS taxes and alternative measures of body weight using TWFE estimates. Our results continue to be consistent with the parallel trends assumption and stronger evidence of ENDS tax-induced body weight among females as compared to males.

6.3 Sensitivity Checks

[32] Appendix Figure 1 shows results from a TWFE event study with a dichotomized treatment defined as a prominent tax increase of at least $0.50 per mL of e-liquid.
[33] Results for the pooled sample of females and males are shown in Appendix Table 4.
[34] Appendix Table 5 shows corresponding results using the shorter 2015-2023 period.
[35] We also find no evidence that ENDS taxes impact the probability that a female youth is underweight, suggesting that taxes are not inducing an unhealthily low body weight. The results are reported in Appendix Table 6.
[36] Appendix Figure 2 compares the estimated effects of ENDS taxes to several other ENDS policies that could potentially generate effects on body weight and obesity. These include a MLSA for ENDS, ENDS licensure laws, ENDS flavor restrictions, and Tobacco-21 laws (which cover both combustible and ENDS products). Our findings point to little support for the hypothesis that these other ENDS restrictions increase body weight, with the exception of an increase in the female obesity rate from MLSAs. T-21 laws reduce female teen weight, which is consistent with Hansen et al. (2023), who found that T-21 laws not only reduced combustible tobacco and e-cigarette use among teenagers, but also reduced binge drinking.

One concern with the TWFE estimates described in Section 5.2 is that they may be biased in the presence of unobserved state-level time-varying variables associated with ENDS taxes and body weight. In Table 6, we explore the robustness of our findings to the inclusion of additional right-hand side controls for state-specific linear time trends and census region-specific year fixed effects.[37] The results are broadly similar to those discussed above. For females, the standard errors are generally larger, which leads to a loss of statistical significance in some of the specifications. Also, using the moving average of ENDS tax now leads to larger effects than those estimates using contemporaneous tax. However, the main conclusion remains the same: modest weight loss for females and no clear evidence of changes in weight for males.

Next, we present stacked DD estimates of the effects of prominent increases in ENDS taxes on youth body weight. In Appendix Table 7, we again see that prominent ENDS tax increases (at least $0.25 per mL of e-liquid) are associated with clearer declines in youth body weight for females than males. In Figure 5, we show event-study results using stacked DD estimates for two of our main outcomes: body weight and obesity. Figure 5A defines $0.25 per mL of e-liquid as a prominent increase, while Figure 5B uses $0.50 per mL instead. These findings are consistent with the hypothesis that ENDS taxes are associated with a reduction in body weight, particularly among females.

In Figure 6, we further explore demographic heterogeneity in the effects of body weight and obesity by gender. Notably, there is no evidence of weight loss for Black or Hispanic teens of either gender. The point estimates for those groups all point towards weight gain, and the increase for Hispanic males is statistically significant.[38]

Together, these findings suggest that, for the full sample of teenagers and most subgroups, ENDS tax increases do not lead to weight gain. Instead, there is robust evidence that they lead to modest weight loss for female teens.

6.4 ENDS Taxes and Adult Body Weight

Adults may use ENDS for different reasons than youth, including smoking cessation (USDHHS, 2020), and most of the prior literature on combustible cigarette taxes and body weight

[37] For this analysis, we focus on the longer treatment period (2011-2023), which allows for the inclusion of unmeasured jurisdiction-by-time trends.

[38] Finally, we conduct a "leave one treatment state out-at-a-time" analysis to explore whether the effects of ENDS taxes on youth body weight are driven by any particular treatment state. The findings, presented in Appendix Figure 3, show that the estimated treatment effect — particularly the weight loss among female teens — is not driven by a specific treatment state.

discussed in Section 2 has focused on adults. Thus, in Tables 7 and 8, we explore the effects of ENDS taxes on adult ENDS use and body weight, respectively, using data from the BRFSS.

Effects on ENDS use (Table 7) are smaller for adults than for teens, mirroring their lower pre-treatment rates. Estimated effects on any current ENDS use (columns 1 to 3) are negative in sixteen of the eighteen regressions, with the only exceptions being two of the moving average models for males, where the estimate is positive but extremely small. ENDS tax is statistically significant at the 10 percent level or better in two of the six regressions for the pooled sample, four for females, and none for males. Among females, a $1 increase in ENDS tax reduces current ENDS use by 0.22 to 0.29 percentage points, or 4.7 to 6.2 percent of the base rate.

For everyday ENDS use (columns 4 to 6), all eighteen point estimates are negative and fifteen are statistically significant at the 10 percent level of better – five each for the pooled sample, females, and males. The only exceptions are for the model with the full set of controls and contemporaneous (but not moving average) tax, where the effect size shrinks and becomes insignificant. It is important to note that the pre-treatment rate of everyday ENDS use is extremely small for adults – 1.5 percent for females and 2.7 percent for males – making it difficult for plausible effect sizes to be statistically significant. In this case, adding the extensive policy controls in column (6) may go too far towards eliminating useful identifying variation. The statistically significant reductions range from 0.27 to 0.49 percentage points for females (18 to 33 percent of the pre-treatment rate) and 0.23 to 0.36 for males (9 to 13 percent).

We estimate the impact of ENDS taxes on the various outcomes related to adult body weight and BMI in Table 8.[39] The above effects on ENDS use, which are a fraction of a percentage point, might not be sufficiently large to drive a statistically detectable effect on weight. The analytical framework from Section 3 shows that ENDS taxes could affect weight even holding ENDS use constant via income effects, but even those are likely smaller for adults than teens, as adults' rates of ENDS use are lower and their access to the family's financial resources is greater. It is therefore perhaps unsurprising that Table 8 shows no evidence that ENDS taxes reduce any of the adult weight or BMI outcomes. Point estimates are small relative to those for teens, and they are never statistically significant.

In Figure 7, we present TWFE event-study analyses for adult female and adult male body weight and probability of being obese. In all cases, pre-treatment trends are favorable to a causal

[39] Appendix Table 8 reports the results for the overweight and obesity outcomes with underweight individuals excluded from the sample.

interpretation. While there is some suggestive evidence of a reduction in female weight and probability of being obese after the implementation of an ENDS tax, the post-treatment coefficient estimates are always statistically insignificant.

6.5 Mechanisms

The above results for both teens and adults show that ENDS taxes, if anything, *reduce* weight despite curbing ENDS use. Since lower ENDS use presumably means less nicotine consumption and therefore less appetite suppression and metabolic stimulation, these results can be seen as surprising. Our analytical framework provides plausible explanations that this section aims to test to the extent possible.

The results already presented on ENDS use and weight provide preliminary clues about mechanisms. If we had found effects on weight but not vaping, this would have ruled out the mechanisms that come from reduced nicotine intake, leaving income effects as the most plausible explanation. However, since we *did* find impacts on vaping, we cannot make such a conclusion. On the other hand, a half-pound population-wide effect on female teen weight appears too large to be driven by the modest share of the sample that exhibits changed vaping behavior (roughly 2 to 3 percent for current ENDS use and 1 to 2 percent for frequent and everyday ENDS use), suggesting an important role for income effects among those whose vaping behavior does not change.

We next examine mechanisms in more detail by conducting additional analyses of other health behaviors. Table 9 reports the results for youths. The table contains four panels, with the first using the pooled sample and the shorter sample period of 2015-2023, the second using the pooled sample and the longer period of 2011-2023, and the third and fourth using this longer period and stratifying by gender. Our findings point to several important channels to help explain our findings. First, we find some evidence that ENDS taxes are associated with an increase in the probability that youths smoke cigarettes, particularly in the 2015-2023 sample period. These results are consistent with evidence from Abouk et al. (2023b) that e-cigarettes and combustible cigarettes are economic substitutes for youths. This substitution to another nicotine-containing product (cigarettes) would tend to mitigate any body weight increases that might result from the decline in ENDS use.

Second, we find evidence that e-cigarettes and alcohol consumption are complements, consistent with Dave et al. (2024a). That is, we find that increases in ENDS taxes are associated with a decline in teenage binge drinking. Such reductions in alcohol consumption may reduce total caloric

intake (Sabia et al., 2017), thus diminishing any potential weight gains that flow from reduced access to ENDS-related nicotine.

Third, consistent with Dave et al. (2024b), we find that ENDS taxes are negatively related to youth marijuana use, consistent with the hypothesis that e-cigarettes and marijuana are complements for youths. To the extent that youth marijuana use is positively related to snacking of unhealthy foods (i.e., "munchies") due to altered blood concentrations of certain appetitive and metabolic hormones, mainly insulin (Farokhnia et al., 2020), this could be another channel through which ENDS taxes fail to lead to weight gain.

With respect to exercise, we find little evidence that ENDS use-induced body weight decreases are driven by increases in physical activity among youths. All estimated effects are small and statistically indistinguishable from zero.

Finally, we examine dietary habits. The YRBSS only contains information on consumption of a few food types. We find no evidence of an effect of ENDS taxes on soda intake. The magnitudes are small, the signs are mixed, and there is no statistical significance. ENDS taxes increase fruit consumption in all regressions, but the effect size is small and all estimates are statistically insignificant. In contrast, we consistently observe statistically significant increases in vegetable consumption of 1 to 2 percentage points. This limited window into teen eating habits provides mixed evidence regarding the likely propensity to eat restaurant food. The increase in vegetables suggests less eating at restaurants, but the null result for soda does not.

Table 10 presents results for mechanisms for adults. We observe some evidence of increases in everyday smoking in response to ENDS taxes, particularly using the moving average specification. This is consistent with Friedman and Pesko (2022) and Abouk et al. (2023a). ENDS taxes consistently reduce alcohol consumption according to both the BRFSS measures: any use and binge drinking. French fry consumption and exercise both decline in all specifications but with mixed patterns of statistical significance. We find no evidence of an effect on vegetable intake.

Together, these results suggest that spillover effects of ENDS taxes — substitution to combustible cigarettes and reductions in higher-calorie consumption (i.e., through alcohol and unhealthy foods) — appear to be potentially important channels at work. Moreover, these findings are consistent with evidence by Courtemanche (2009), who found that by reducing smoking, higher cigarette taxes led to improvements in health behaviors that may reduce longer-run body weight.

7. Conclusion

One out of three U.S. children and three out of four U.S. adults are classified as overweight or obese, prompting the Centers for Disease Control and Prevention to recognize obesity as a significant public health threat (CDC, 2024a, b). Moreover, the World Health Organization (WHO) has declared obesity a global epidemic, imposing a substantial public health and economic burden on the world's population (WHO, 2024).

This study is, to our knowledge, the first to explore whether ENDS taxation has unintended consequences on body weight. Since 2010, 32 states and the District of Columbia have adopted ENDS taxes. Given that nicotine is an appetite suppressant and metabolic stimulant and ENDS consumption is less harmful than combustible cigarette smoking, reducing access to ENDS could have unintended effects that harm *both* tobacco-related and obesity-related public health. However, indirect effects on other health behaviors – which could occur either through inherent substitutability or complementarity with ENDS or through income effects – make the net effect of ENDS taxes on body weight theoretically ambiguous.

Our primary focus is on teens, as they have higher rates of ENDS use than adults and therefore greater potential responsiveness to ENDS taxes. We use data from the YRBSS and a generalized difference-in-differences approach. Among female teens, a one dollar (in 2023$) increase in ENDS taxes reduces the probability of any ENDS use by about 2 to 3 percentage points and the probabilities of both frequent and everyday use by about 1 to 2 percentage points. For male teens, the effects on frequent and everyday ENDS use are similar, but there is no evidence of an effect on the extensive margin (any use).

Turning to body weight, our findings provide robust evidence that ENDS taxes *do not* lead to weight gain, as might be feared based on the appetite suppressing and metabolic impacts of nicotine. Rather, among female teens, we find that a one dollar increase in ENDS taxes is associated with an average weight *loss* of about a pound and a reduction in the probability of being obese by about a percentage point. While this magnitude sounds small, it could generate annual obesity-related medical cost savings of approximately $126 million.[40] There is no discernable effect among male teens.

This result appears to be at least somewhat explained by general equilibrium effects of ENDS taxes on other behaviors that impact body weight. These include substitution to combustible

[40] This calculation is based on the approximate current population of 10.78 million 14–18-year-old females in the US (US Census Bureau, 2025), a one percentage point reduction in obesity, and annual incremental obesity-related youth medical costs around $1166 in 2023$ (number adjusted for inflation from Biener et al., 2020). This yields a medical cost savings of 0.01 x 10.78 million x $1166 = $125.7 million.

cigarettes (to compensate for ENDS-related declines in nicotine), reductions in binge drinking, reductions in marijuana use, and increased fruit and vegetable intake. These findings are consistent with recent studies suggesting non-tobacco-related health benefits of ENDS taxes arising from complementarities of ENDS with other unhealthy products.

We also conduct similar analyses for adults using the BRFSS. While we observe evidence that ENDS taxes reduce vaping among adults, the effects are smaller than among teens, consistent with adults' lower base rate of use. Accordingly, we find no clear evidence of an impact on weight for either adult females or males. Turning to mechanisms, the most robust evidence is for a decrease in alcohol use.

Impacts on body weight are only one of many considerations when evaluating the merits of ENDS taxes. Our work, combined with prior research on ENDS taxes, suggests that they improve health via reduced vaping as well as downstream effects on weight, use of non-tobacco substances, and dietary habits. However, ENDS taxes also appear to worsen health by increasing cigarette smoking, and the health harm from a one percentage point increase in the teen smoking rate may well be larger than the health gain from a reduction in the teen obesity rate of the same size. Further research is therefore necessary in order to determine whether the net effect on health is positive or negative after accounting for all these factors. Additionally, our work does not address the desirability of ENDS taxes from the standpoint of economic welfare. Externalities from secondhand smoke and internalities from time-inconsistent preferences provide potential justifications for cigarette taxes (Gruber & Köszegi, 2001). However, the applicability of these arguments to ENDS taxes is unclear, as vaping may carry fewer secondhand inhalation risks as well as fewer risks (and therefore fewer internalities) to the user. Also, obesity, alcohol, and marijuana are already the subject of several types of policies that aim to address their potential externalities and internalities.

While much therefore remains to be learned about ENDS taxes, our work provides one piece of the puzzle by showing that biologically plausible adverse effects on weight do not materialize. Instead, any weight-related impacts appear to be beneficial.

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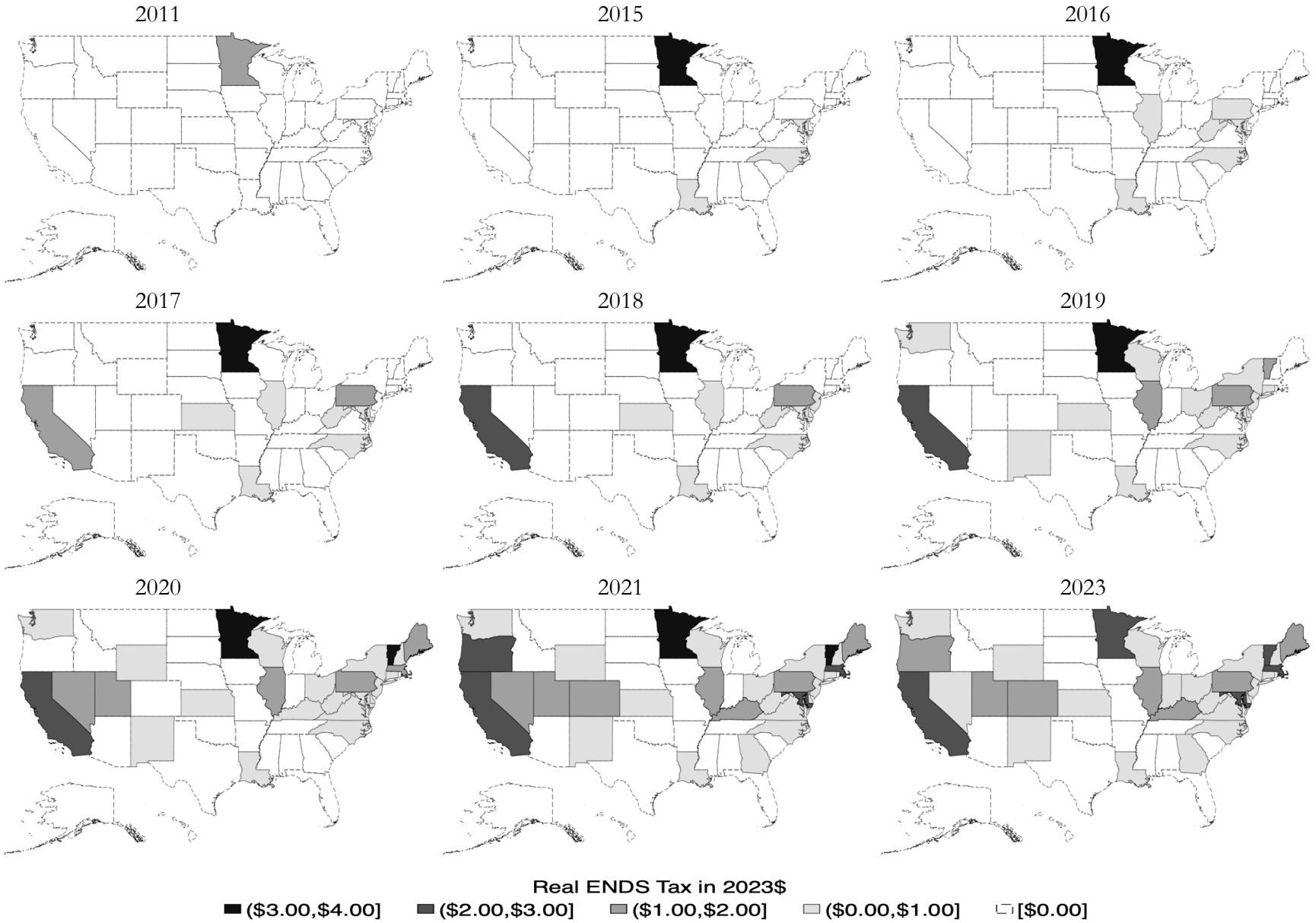
Figure 1. ENDS Tax Variation, 2011-2023

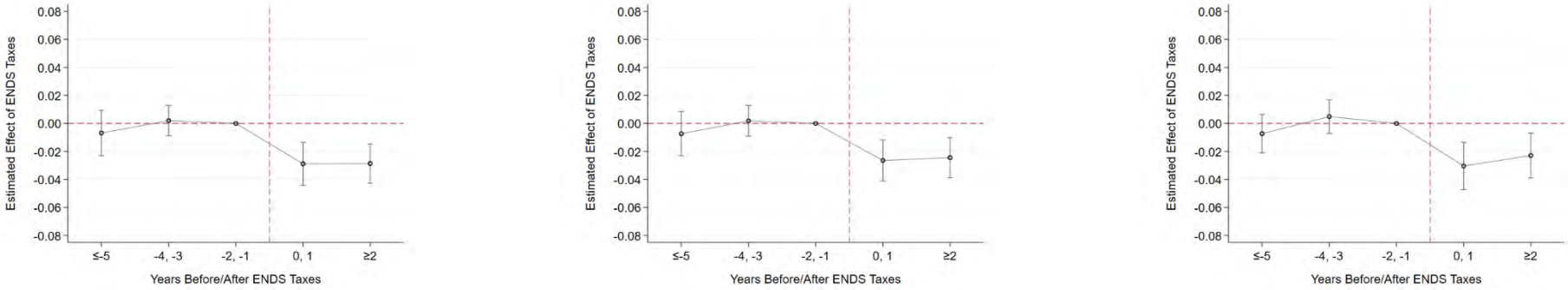


Notes: Data on ENDS taxes collected via Cotti et al. (2025), Dave et al. (2024b), and the authors' own searches.

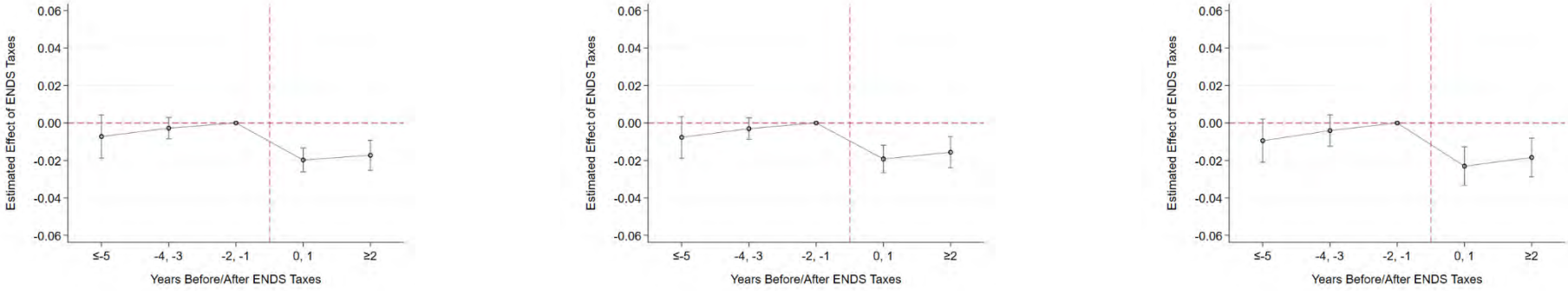
Figure 2. Event-Study Estimates of the Effect of ENDS Taxes on Youth ENDS Use

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

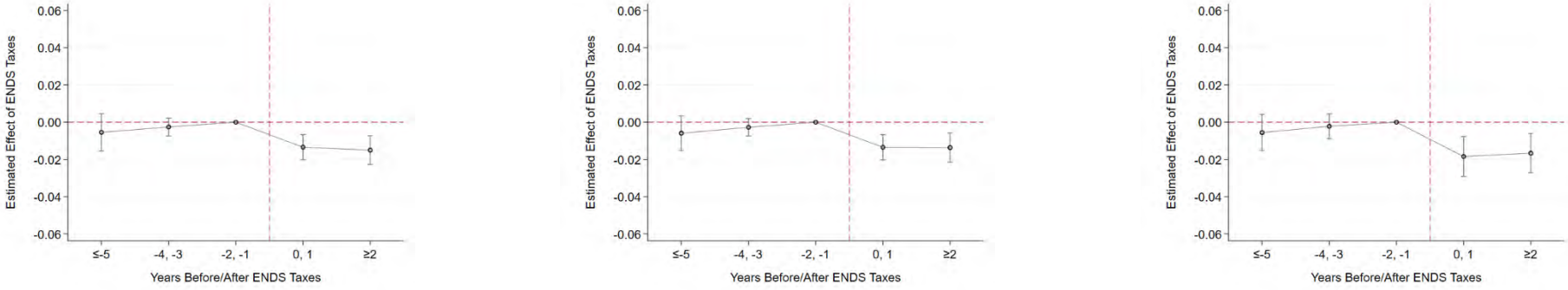
Panel (a): Current ENDS Use



Panel (b): Frequent ENDS Use



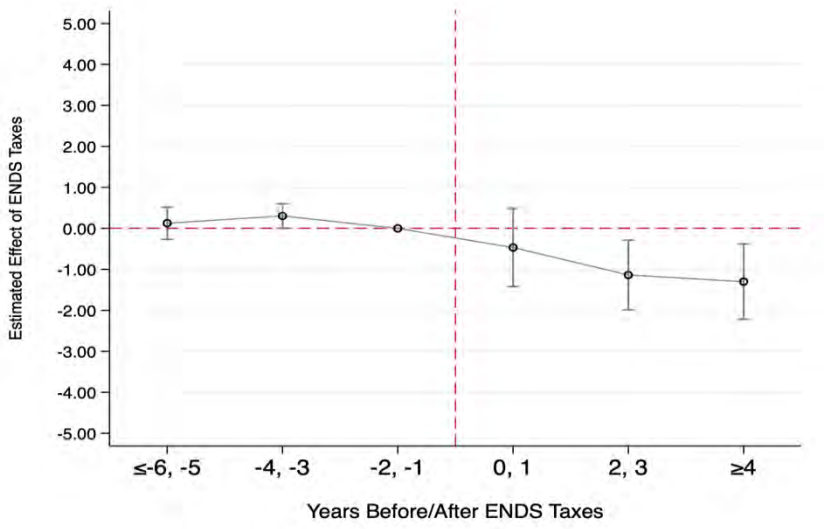
Panel (c): Everyday ENDS Use



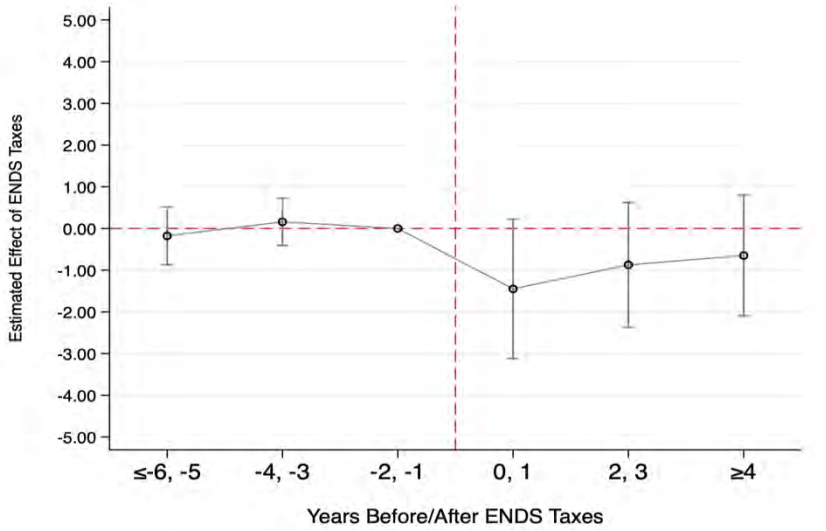
Notes: Data used for the above TWFE event-study regressions are from the 2015-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are current, frequent and everyday ENDS use respectively, in panels (a), (b), and (c). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; and demographics such as age, gender, race, and grade. Column (ii) additionally controls for macroeconomic controls (unemployment and poverty rates) and COVID-19 controls (cumulative case and death rates and the Oxford University government stringency index). Column (iii) additionally controls for combustible tobacco policies including cigarette taxes (in $2023) and indoor smoking bans; ENDS policies including MLSA and tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions; marijuana policies include recreational, medical, and decriminalization 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. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Figure 3. Event-Study Estimates of the Effect of ENDS Taxes on Weight, Using TWFE

Panel (a): Females



Panel (b): Males

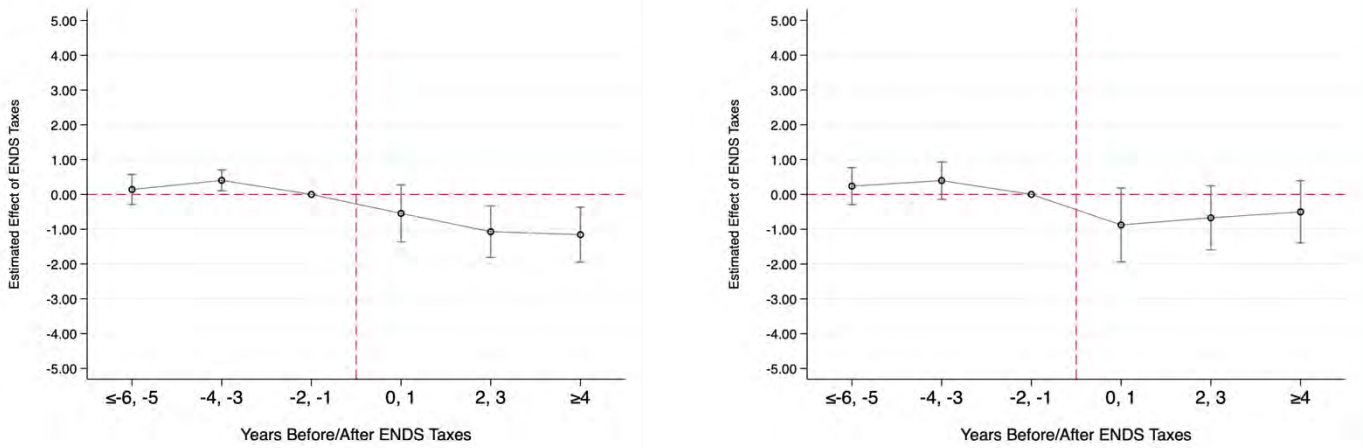


Notes: Data used for the above TWFE event-study regressions are from the 2011-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are female and male respondents' bodyweight measured in pounds respectively, in panels (a) and (b). Estimates are obtained from event study regressions using two-way fixed effects. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). 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.

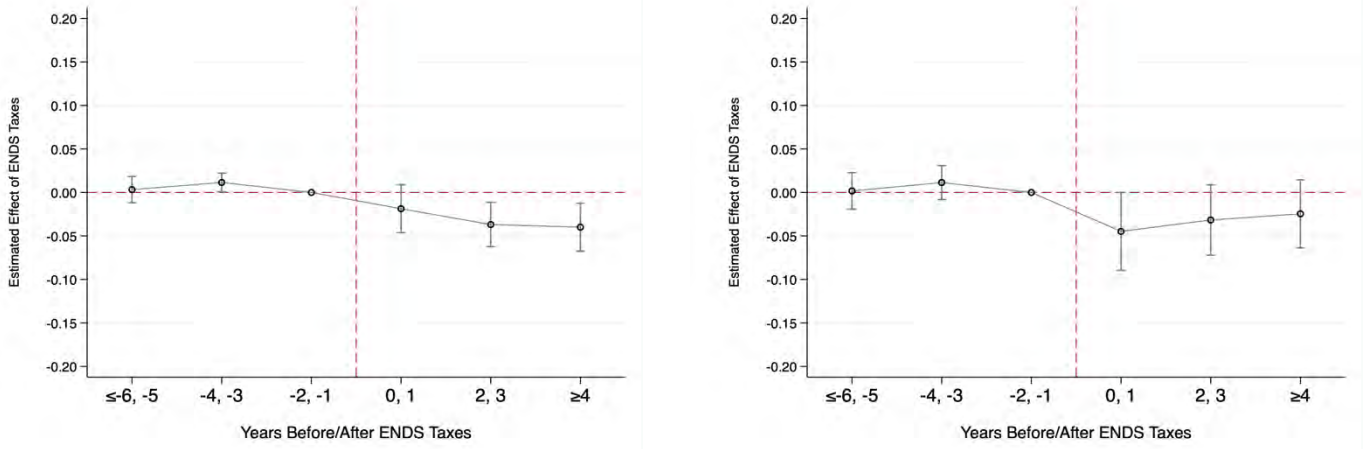
Figure 4. Event-Study Estimates of the Effect of ENDS Taxes on Alternate Body Weight Measures, Using TWFE

(i) Females (ii) Males

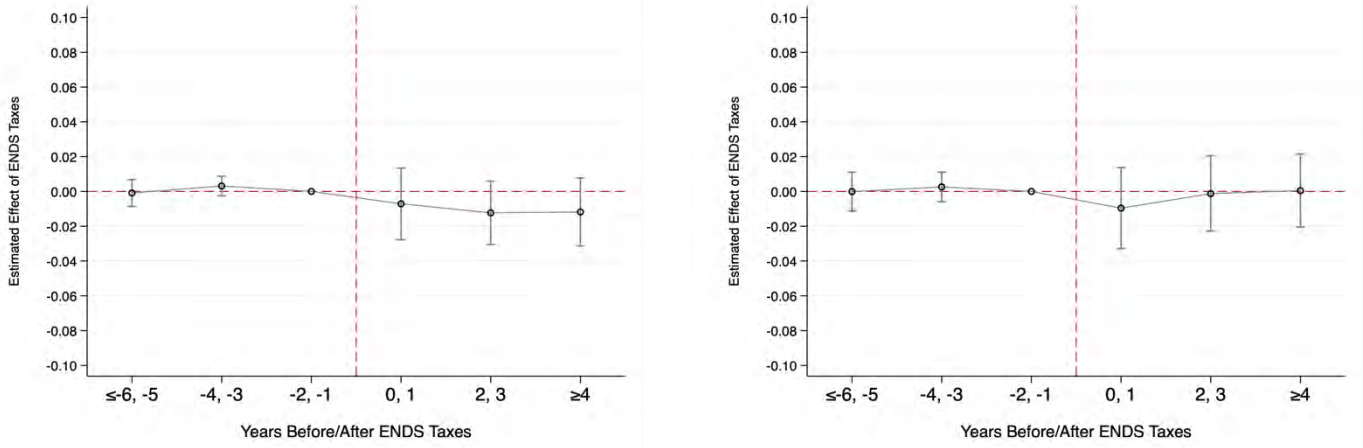
Panel (a): BMI Percentile



Panel (b): BMI Z-Score

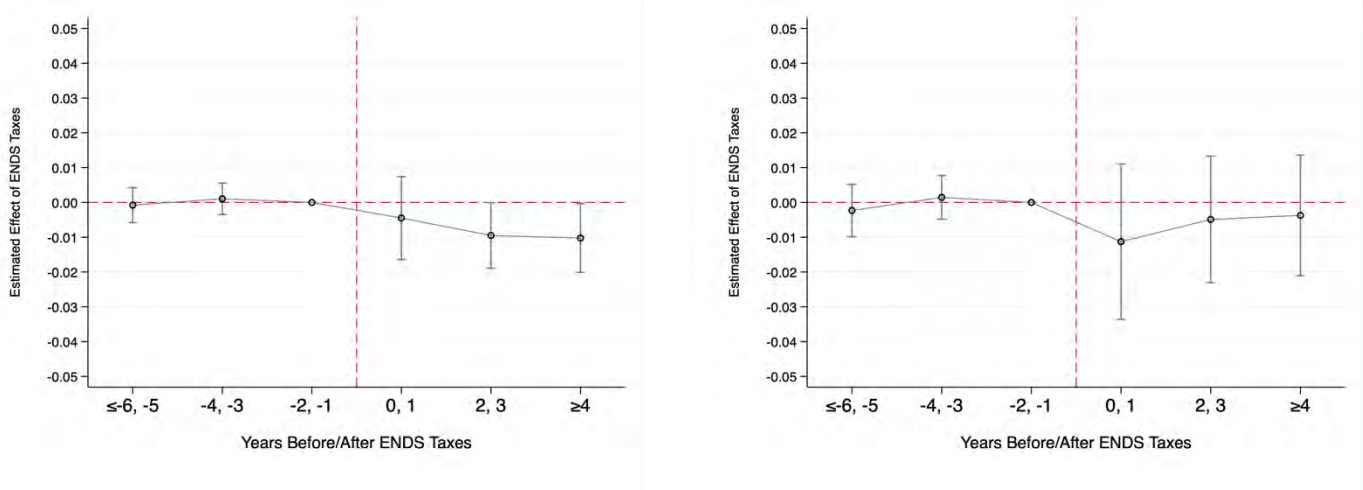


Panel (c): Overweight or Obese



(i) Females (ii) Males

Panel (d): Obese

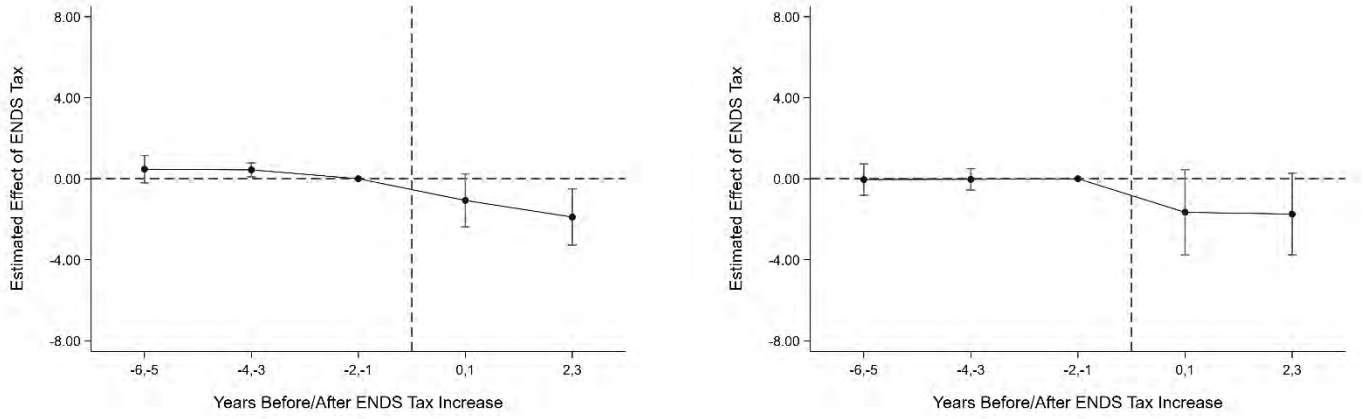


Notes: Data used for the above TWFE event-study regressions are from the 2011-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are female and male respondents' alternate body measures such as BMI percentile-for-age, BMI Z-score-for-age, probability of being overweight or obese and probability of being obese in panels (a), (b), (c) and (d) respectively. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). 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.

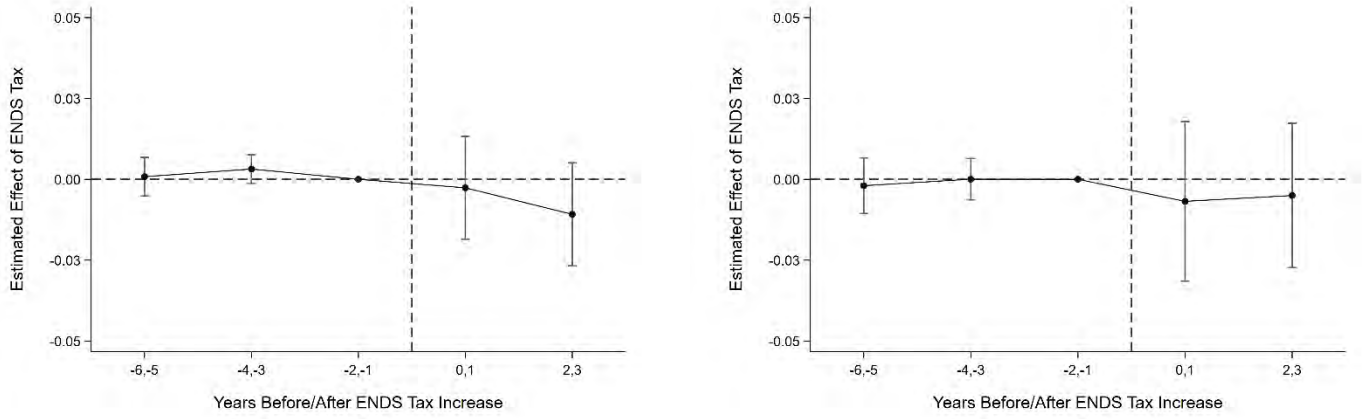
Figure 5A. Event Study Estimates of Prominent ENDS Tax Increase ($0.25 per mL) and Bodyweight, Using Stacked DD Estimates

(i) Females (ii) Males

Panel (a): Weight (Controlling for Height)



Panel (b): Obese

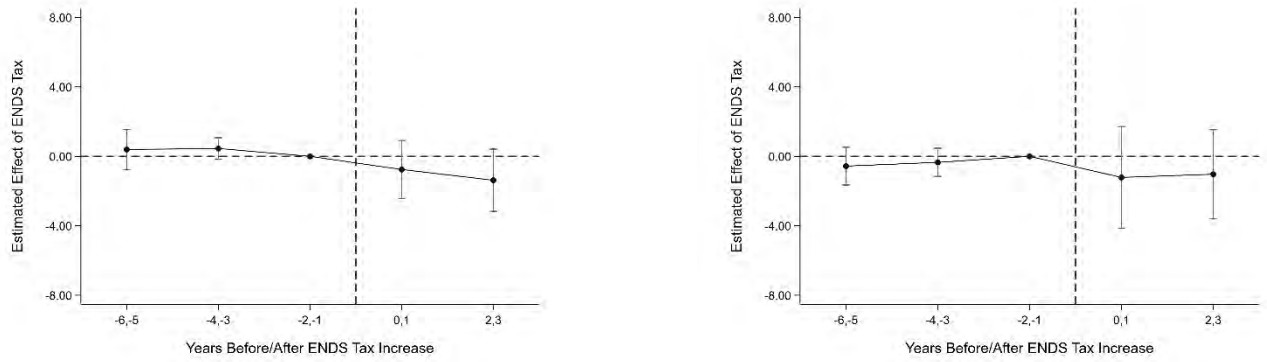


Notes: Data used for the above event-study regressions are obtained from the 2011-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are female and male respondents' body weight and probability of being obese in panels (a) and (b) respectively. Estimates are obtained from stacked DD regressions using data from the 2011-2023 State and National Youth Risk Behavior Surveys. A $0.25 (in nominal terms) increase in ENDS taxes is defined to be a prominent increase. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). 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.

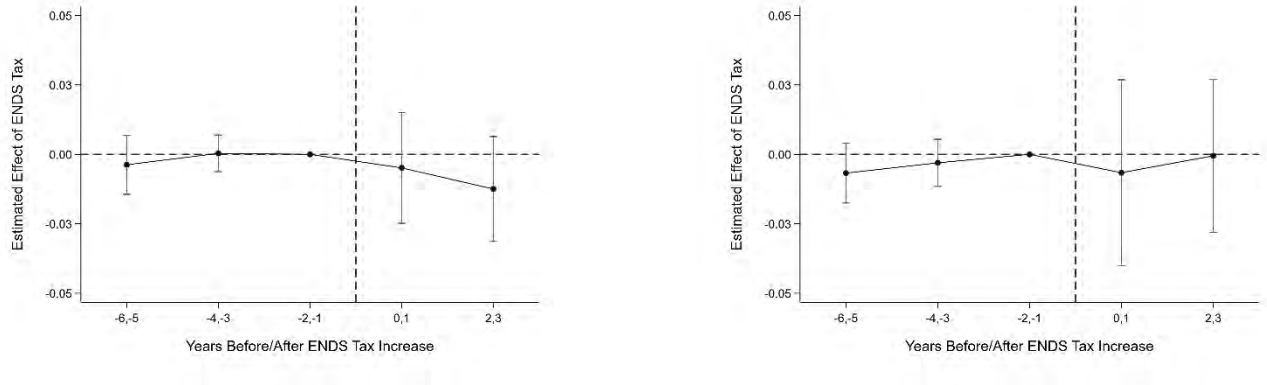
Figure 5B. Event Study Estimates of Prominent ENDS Tax Increase ($0.50 per mL) on Body Weight and Obesity, Using Stacked DD Estimates

(i) Females (ii) Males

Panel (a): Weight (Controlling for Height)



Panel (b): Obese

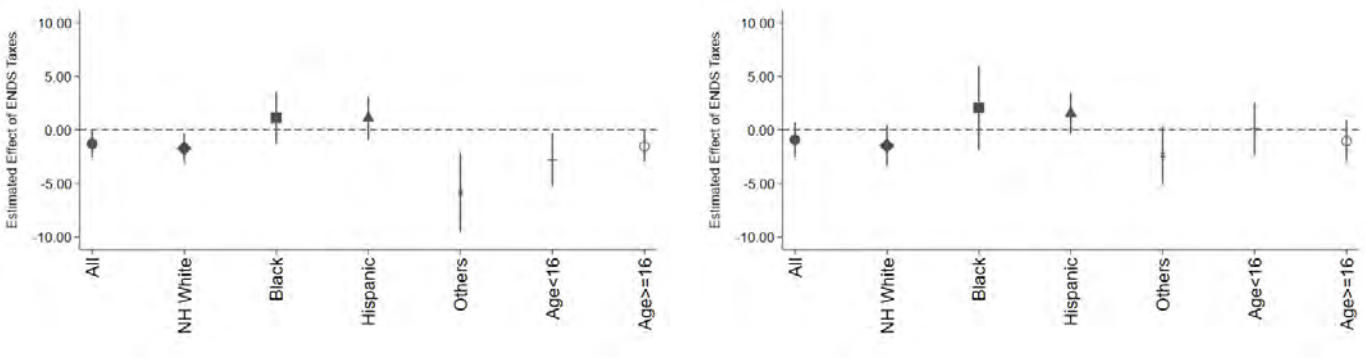


Notes: Data used for the above event-study regressions are obtained from the 2011-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are female and male respondents' body weight and probability of being obese in panels (a) and (b) respectively. Estimates are obtained from stacked DD regressions using data from the 2011-2023 State and National Youth Risk Behavior Surveys. A $0.50 (in nominal terms) increase in ENDS taxes is defined to be a prominent increase. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). 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.

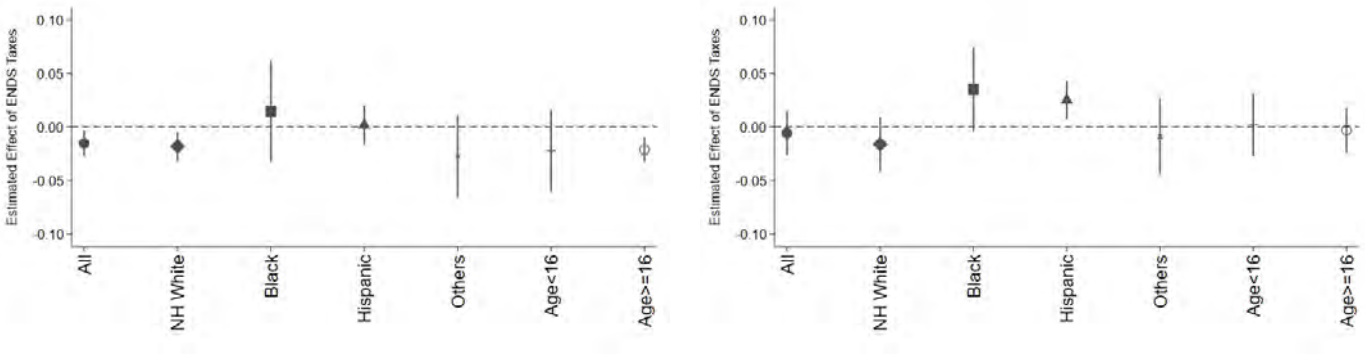
Figure 6. Heterogeneity in the Effect of ENDS Taxes on Body Weight, by Race/Ethnicity and Age

(i) Females (ii) Males

Panel (a): Weight (Controlling for Height)

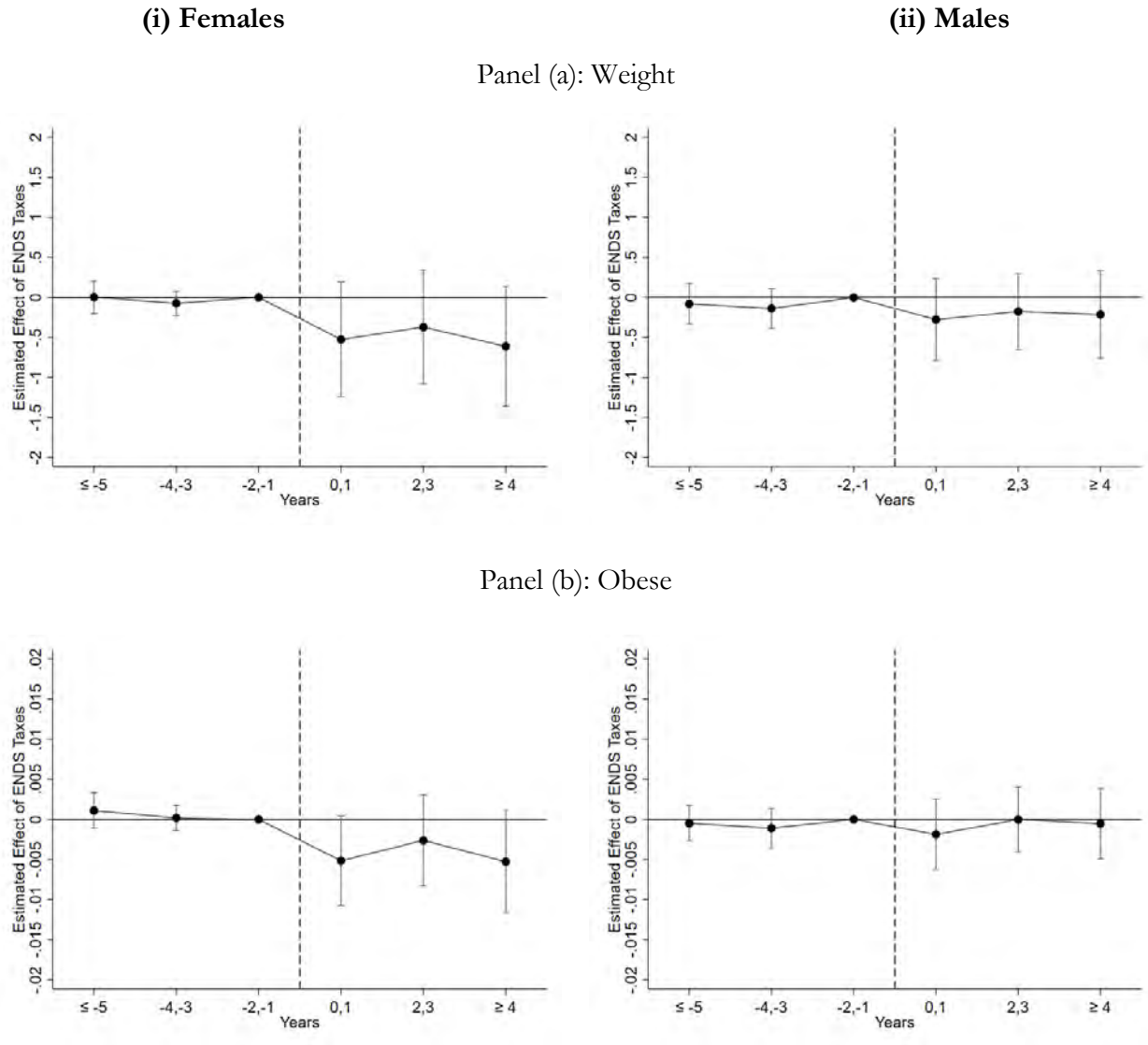


Panel (b): Obese



Notes: Data used for the above TWFE regressions are from the 2015-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are bodyweight (measured in pounds) and probability of being obese in panels (a) and (b), respectively. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). 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 7. Event Study of Effect of ENDS Taxes on Adult Body Weight, BRFSS



Notes: Data used for the above TWFE event-study regressions are from the 2011-2023 Behavioral Risk Factor Surveillance Surveys. Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, adjusted for clustering at the state level. All regressions control for state, year, and semester fixed effects; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, adjusted for clustering at the state level. Observations surveyed in January, February, and March of 2023 for the 2024 survey wave are assigned December 2023 control values. BRFSS sampling weights are used.

Table 1. Descriptive Statistics, YRBSS

Dataset: YRBSS	Pooled	Females	Males
Demographics			
Female	0.486		
White	0.556	0.554	0.557
Black	0.146	0.147	0.144
Hispanic	0.232	0.231	0.232
Others	0.067	0.068	0.066
Age-12 to 14 years old	0.192	0.192	0.192
Age-15 years old	0.199	0.198	0.199
Age-16 years old	0.201	0.200	0.202
Age-17 years old	0.204	0.204	0.204
Age-18 years old	0.204	0.205	0.203
Grade-9	0.300	0.292	0.307
Grade-10	0.206	0.204	0.207
Grade-11	0.207	0.205	0.208
Grade-12	0.288	0.299	0.278
Dependent Variables			
Current ENDS Use	0.200	0.206	0.195
Frequent ENDS Use	0.060	0.057	0.062
Everyday ENDS Use	0.043	0.041	0.044
Weight (Pounds)	149.473	136.711	161.538
	(38.555)	(32.341)	(40.043)
BMI Percentile	64.963	64.437	65.461
	(28.028)	(27.071)	(28.896)
BMI Z-score	0.540	0.500	0.577
	(1.060)	(0.977)	(1.131)
Obese	0.145	0.116	0.172
Overweight/Obese	0.302	0.280	0.323
Underweight	0.034	0.024	0.043
Exercised > 60 minutes last week	0.849	0.816	0.881
Had soda/sugary drink last week	0.732	0.702	0.761
Had fruits/fruit juices last week	0.936	0.944	0.929
Had vegetables last week	0.905	0.913	0.898
Cigarette Use	0.090	0.080	0.100
Binge Alcohol Use	0.154	0.155	0.152
MJ Use	0.194	0.191	0.197
Independent Variables			
Height (Inches)	66.669	64.048	69.147
	(4.060)	(2.916)	(3.375)
ENDS Tax, (2023 $)	0.306	0.302	0.309
	(0.714)	(0.709)	(0.718)
ENDS MLSA Law	0.735	0.734	0.737
Tobacco 21 Law	0.336	0.332	0.339

Dataset: YRBSS	Pooled	Females	Males
ENDS licensure law	0.283	0.280	0.285
Indoor vaping ban	0.212	0.211	0.213
Flavored ENDS Ban	0.065	0.064	0.066
Cigarette Tax, (2023 $)	2.072	2.070	2.073
	(1.322)	(1.324)	(1.320)
Indoor smoking ban	0.659	0.658	0.660
Beer Tax, (2023 $)	0.366	0.367	0.366
	(0.334)	(0.334)	(0.333)
Recreational Marijuana Law	0.196	0.193	0.199
Medical Marijuana Law	0.527	0.526	0.529
Unemployment Rate	5.667	5.677	5.657
	(2.235)	(2.238)	(2.232)
Poverty rate	12.761	12.774	12.750
	(2.954)	(2.953)	(2.954)
Oxford COVID Stringency Index	4.722	4.693	4.748
	(11.263)	(11.240)	(11.285)
Cumulative COVID-19 case rate	0.062	0.061	0.063
	(0.108)	(0.107)	(0.109)
Cumulative COVID-19 death rates	0.078	0.077	0.079
	(0.131)	(0.131)	(0.132)
Observations	1106828	558473	548355

Notes: Combined State and National Youth Risk Behavior Surveillance System Surveys data is used in each column. Weighted means are shown for dichotomous variables, while weighted means and standard deviations are shown for continuous variables. Summary statistics of vaping outcomes are using the primary years of analysis, i.e., 2015-2023, all other variables have summary statistics spanning the extended time period of 2011-2023. Cumulative Covid Death Rate variable is scaled up by a factor of 100 for display. Combined YRBS data is 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 1, Continued. Descriptive Statistics, BRFSS

Dataset: BRFSS	Pooled	Females	Males
Demographics			
Female	0.502	1.000	0.000
White	0.581	0.579	0.583
Black	0.123	0.131	0.115
Hispanic	0.182	0.180	0.185
Other Race	0.086	0.084	0.088
Age	40.737	41.058	40.413
	(13.649)	(13.627)	(13.664)
No High School Education	0.130	0.122	0.138
High School Education	0.277	0.251	0.303
Some College Education	0.310	0.326	0.294
College Education	0.283	0.300	0.265
Married	0.494	0.502	0.486
Dependent Variables			
Current ENDS Use	0.078	0.065	0.090
Everyday ENDS Use	0.034	0.028	0.039
Weight (Pounds)	180.886	164.477	196.636
	(47.864)	(44.280)	(45.834)
BMI	28.095	27.971	28.213
	(7.035)	(7.317)	(6.742)
Obese	0.307	0.312	0.303
Overweight/Obese	0.648	0.595	0.699
Current Cigarette Smoking	0.172	0.152	0.193
Everyday Cigarette Smoking	0.119	0.108	0.129
Alcohol Use	0.553	0.502	0.605
Binge Drinking	0.195	0.142	0.248
French Fry Consumption	0.852	0.830	0.875
Vegetable Consumption	0.993	0.995	0.991
Independent Variables			
Height (Inches)	67.196	64.373	70.004
	(4.292)	(3.093)	(3.379)
ENDS Tax, (2023 $)	0.342	0.340	0.343
	(0.778)	(0.776)	(0.780)
ENDS MLSA Law	0.770	0.770	0.770
Tobacco 21 Law	0.357	0.357	0.358
ENDS Licensure Law	0.257	0.256	0.257
Indoor Vaping Ban	0.225	0.224	0.225
Flavored ENDS Ban	0.065	0.066	0.065
Cigarette Tax, (2023 $)	2.144	2.144	2.143
	(1.356)	(1.360)	(1.352)
Indoor Smoking Ban	0.699	0.699	0.699
Beer Tax, (2023 $)	0.363	0.364	0.362
	(0.333)	(0.334)	(0.332)

Dataset: BRFSS	Pooled	Females	Males
Recreational Marijuana Law	0.201	0.200	0.202
Medical Marijuana Law	0.548	0.547	0.549
Marijuana Decriminalization Law	0.431	0.431	0.431
Unemployment Rate	5.652	5.654	5.650
	(2.376)	(2.378)	(2.375)
Poverty Rate	12.728	12.734	12.722
	(2.985)	(2.986)	(2.984)
Oxford COVID Stringency Index	10.716	10.734	10.703
	(18.798)	(18.829)	(18.771)
Cumulative COVID-19 Case Rate	5.650	5.658	5.644
	(10.757)	(10.766)	(10.749)
Cumulative COVID-19 Death Rate	0.070	0.070	0.069
	(0.126)	(0.126)	(0.126)
Observations	3748149	2037156	1710002

Notes: Behavioral Risk Factor Surveillance System Surveys data is used in each column. Weighted means are shown for dichotomous variables, while weighted means and standard deviations are shown for continuous variables. Summary statistics of current and everyday ENDS use are using 2016-2023, all other variables have summary statistics spanning the extended time period of 2011-2023. The Cumulative Covid Case Rate and Death Rate variables are scaled up by a factor of 100 for display. Weighting is performed using the BRFSS-provided individual sample weights.

Table 2. TWFE Estimates of Effect of ENDS Taxes on Youth ENDS Use, 2015-2023

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel I: Current ENDS Use							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	-0.026***	-0.021***	-0.017***	-0.016***	-0.019***	-0.019***	-0.013**
	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)	(0.007)	(0.005)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.028***	-0.023***	-0.017***	-0.016**	-0.013*	-0.013*	-0.007
	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)	(0.007)	(0.005)
Pre-Treat Mean DV	0.211	0.211	0.211	0.211	0.211	0.211	0.211
N	743,338	743,338	743,338	743,338	743,338	743,338	743,338
Panel II: Frequent ENDS Use							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	-0.013***	-0.011***	-0.012***	-0.011***	-0.016***	-0.015***	-0.013***
	(0.002)	(0.002)	(0. 003)	(0.003)	(0.005)	(0.004)	(0.004)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.014***	-0.013***	-0.012***	-0.012***	-0.014***	-0.012**	-0.010**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)
Pre-Treat Mean DV	0.055	0.055	0.055	0.055	0.055	0.055	0.055
N	743,338	743,338	743,338	743,338	743,338	743,338	743,338
Panel III: Everyday ENDS Use							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	-0.012***	-0.010***	-0.010***	-0.010***	-0.016***	-0.015***	-0.014***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.014***	-0.012***	-0.012***	-0.012***	-0.014***	-0.013***	-0.011**
	(0.003)	(0.002)	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)
Pre-Treat Mean DV	0.039	0.039	0.039	0.039	0.039	0.039	0.039
N	743,338	743,338	743,338	743,338	743,338	743,338	743,338
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 Combustible Tobacco Policies?	No	No	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	No	No	Yes	Yes	Yes
MJ 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 were obtained using data from the 2015-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables are current, frequent and everyday ENDS use in Panel I, II, and III respectively. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; and demographics such as age, gender, race, and grade. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 case and death rates and stringency index. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include MLSA and tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, medical and decriminalization laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are in parentheses and clustered at the state level. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Table 3. Gender-Specific Estimates of Effect of ENDS Taxes on Youth ENDS Use, 2015-2023

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Current ENDS Use			Frequent ENDS Use			Everyday ENDS Use		
Panel I: Females									
(a) Overall Contemporaneous Tax Effect									
ENDS Tax_{st} ($2023)	-0.025***	-0.031***	-0.024***	-0.012***	-0.018***	-0.017***	-0.011***	-0.017**	-0.015**
	(0.008)	(0.009)	(0.008)	(0.004)	(0.006)	(0.006)	(0.003)	(0.006)	(0.006)
(b) Three-Year Moving Average Tax Effect									
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.026***	-0.024**	-0.017**	-0.014***	-0.017**	-0.016**	-0.013***	-0.015**	-0.015**
	(0.010)	(0.010)	(0.008)	(0.004)	(0.007)	(0.007)	(0.004)	(0.006)	(0.006)
Pre-Treat Mean DV	0.207	0.207	0.207	0.049	0.049	0.049	0.034	0.034	0.034
N	374,496	374,496	374,496	374,496	374,496	374,496	374,496	374,496	374,496
Panel II: Males									
(a) Overall Contemporaneous Tax Effect									
ENDS Tax_{st} ($2023)	-0.009	-0.007	-0.003	-0.011**	-0.014***	-0.010**	-0.010***	-0.015***	-0.011***
	(0.006)	(0.007)	(0.006)	(0.004)	(0.005)	(0.004)	(0.003)	(0.005)	(0.004)
(b) Three-Year Moving Average Tax Effect									
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.008	-0.002	0.003	-0.010**	-0.010**	-0.005	-0.012***	-0.013***	-0.008**
	(0.006)	(0.007)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Pre-Treat Mean DV	0.215	0.215	0.215	0.060	0.060	0.060	0.043	0.043	0.043
N	368,842	368,842	368,842	368,842	368,842	368,842	368,842	368,842	368,842
Controls:									
Macro and COVID?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other Combustible Tobacco Policies?	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
ENDS Policies?	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
MJ Policies?	No	No	Yes	No	No	Yes	No	No	Yes
Beer Taxes?	No	No	Yes	No	No	Yes	No	No	Yes

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

Notes: Estimates were obtained using data from the 2015-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables are current, frequent and everyday ENDS use in columns (1)-(3), (4)-(6), (7)-(9) respectively. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; and demographics such as age, gender, race, and grade. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 case and death rates and stringency index. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include MLSA and tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, medical, and decriminalization laws. Standard errors are in parentheses and clustered at the state level. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Table 4A. TWFE Estimates of Effect of ENDS Taxes on Youth Body Weight, Controlling for Height, 2015-2023

	(1)	(2)	(3)	(4)	(5)
			Panel I: All		
	(a) Overall Contemporaneous Tax Effect				
ENDS Tax_{st} ($2023)	-1.105***	-1.009***	-1.032*	-0.991*	-1.087*
	(0.370)	(0.352)	(0.592)	(0.589)	(0.631)
	(b) Three-Year Moving Average Tax Effect				
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-1.009**	-0.790	-0.735	-0.639	-0.738
	(0.452)	(0.490)	(0.576)	(0.568)	(0.608)
Pre-Treat Mean DV	150.615	150.615	150.615	150.615	150.615
N	816,577	816,577	816,577	816,577	816,577
			Panel II: Females		
	(a) Overall Contemporaneous Tax Effect				
ENDS Tax_{st} ($2023)	-1.565***	-1.493***	-1.384**	-1.135**	-1.278**
	(0.466)	(0.440)	(0.566)	(0.516)	(0.633)
	(b) Three-Year Moving Average Tax Effect				
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-1.962***	-1.853***	-1.902***	-1.654**	-1.822**
	(0.545)	(0.570)	(0.687)	(0.644)	(0.754)
Pre-Treat Mean DV	138.260	138.260	138.260	138.260	138.260
N	410,400	410,400	410,400	410,400	410,400
			Panel III: Males		
	(a) Overall Contemporaneous Tax Effect				
ENDS Tax_{st} ($2023)	-0.708	-0.585	-0.718	-0.857	-0.899
	(0.567)	(0.558)	(0.774)	(0.818)	(0.808)
	(b) Three-Year Moving Average Tax Effect				
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.202	0.125	0.285	0.244	0.223
	(0.609)	(0.632)	(0.630)	(0.675)	(0.653)
Pre-Treat Mean DV	162.300	162.300	162.300	162.300	162.300
N	406,177	406,177	406,177	406,177	406,177
Controls:					
Macro and COVID?	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes
Other Combustible Tobacco Policies?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
MJ 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 were obtained using the 2015-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables is respondents' bodyweight (measured in pounds). Panel I shows results for the pooled sample, panel II shows the results for females and panel III shows the results for males. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; and demographics such as age, gender, race, and grade. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 case and death rates and stringency index. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include minimum legal sales age (MLSA) laws, tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational marijuana laws, medical marijuana laws, decriminalization of marijuana laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are in parentheses and clustered at the state level. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Table 4B. Robustness of Estimates in Table 4A to Extending Sample Period to 2011-2023

	(1)	(2)	(3)	(4)	(5)
			Panel I: Females		
	(a) Overall Contemporaneous Tax Effect				
ENDS Tax_{st} ($2023)	-1.299***	-1.237***	-1.100**	-1.103**	-1.076**
	(0.342)	(0.369)	(0.510)	(0.489)	(0.521)
	(b) Three-Year Moving Average Tax Effect				
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-1.615***	-1.578***	-1.536**	-1.497**	-1.515**
	(0.445)	(0.546)	(0.646)	(0.596)	(0.635)
Pre-Treat Mean DV	136.680	136.680	136.680	136.680	136.680
N	558,473	558,473	558,473	558,473	558,473
			Panel II: Males		
	(a) Overall Contemporaneous Tax Effect				
ENDS Tax_{st} ($2023)	-0.554	-0.425	-0.476	-0.519	-0.509
	(0.403)	(0.432)	(0.582)	(0.561)	(0.581)
	(b) Three-Year Moving Average Tax Effect				
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.181	0.074	0.208	0.224	0.241
	(0.448)	(0.497)	(0.492)	(0.471)	(0.499)
Pre-Treat Mean DV	161.615	161.615	161.615	161.615	161.615
N	548,355	548,355	548,355	548,355	548,355
Controls:					
Macro and COVID?	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes
Other Combustible Tobacco Policies?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
MJ 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 were obtained using data from the 2011-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables is respondents' bodyweight (measured in pounds). Panel I shows results for females and panel II shows results for males. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; and demographics such as age, gender, race, and grade. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 case and death rates and stringency index. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include MLSA and tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, medical, and decriminalization laws. Beer tax is scaled to the 2023 equivalent value. Standard errors are in parentheses and clustered at the state level. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Table 5. Effects of ENDS Taxes on BMI Percentile-for-Age, BMI Z-Score-for-Age, and Overweight or Obese, 2011-2023

	(1)	(2)	(3)	(4)	(5)	(6)
	BMI-percentile	BMI- Z Score	Overweight/ Obese	Obese	Overweight or Obese; Drop Underweight	Obese; Drop Underweight
Panel I: Females						
(a) Overall Contemporaneous Tax Effect						
ENDS Tax_{st} ($2023)	-0.944*	-0.033*	-0.009	-0.008*	-0.009	-0.009
	(0.491)	(0.016)	(0.010)	(0.005)	(0.011)	(0.006)
(b) Three-Year Moving Average Tax Effect						
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-1.270**	-0.043**	-0.012	-0.010**	-0.011	-0.011*
	(0.591)	(0.020)	(0.012)	(0.005)	(0.012)	(0.006)
Pre-Treat Mean DV	64.457	0.499	0.278	0.114	0.285	0.117
N	558,473	558,473	558,473	558,473	545,154	456,161
Panel II: Males						
(a) Overall Contemporaneous Tax Effect						
ENDS Tax_{st} ($2023)	-0.643	-0.024	0.001	-0.001	0.003	0.0001
	(0.444)	(0.017)	(0.008)	(0.007)	(0.009)	(0.009)
(b) Three-Year Moving Average Tax Effect						
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.277	-0.005	0.011	0.007	0.012	0.011
	(0.451)	(0.017)	(0.008)	(0.005)	(0.008)	(0.007)
Pre-Treat Mean DV	65.637	0.582	0.323	0.170	0.336	0.177
N	548,355	548,355	548,355	548,355	525,862	445,141

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

Notes: TWFE estimates were obtained using the 2011-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables are respondents' alternate body measures such as BMI percentile-for-age, BMI Z-score-for-age, probability of being overweight or obese and probability of being obese. Panel I shows results for females and panel II shows results for males. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). Standard errors are in parentheses and clustered at the state level. Columns (5) and (6) drop underweight individuals so that the comparisons are to healthy weight. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Table 6. Sensitivity of Estimates in Table 5 to State-Specific Linear Time Trends and Census Region-Specific Year FE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Weight (lbs)	BMI-percentile	BMI- Z Score	Over-weight/ Obese	Obese	Over-weight/ Obese; Drop Under-weight	Obese; Drop Under-weight
				Panel I: Females			
				(a) State-specific linear time trends			
ENDS Tax_{st} ($2023)	-0.856*	-0.829*	-0.028*	-0.007	-0.009*	-0.009	-0.011*
	(0.479)	(0.479)	(0.016)	(0.009)	(0.005)	(0.010)	(0.006)
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-1.405**	-1.507**	-0.048**	-0.013	-0.013**	-0.014	-0.016**
	(0.680)	(0.644)	(0.022)	(0.011)	(0.005)	(0.012)	(0.007)
				(b) Region-specific year fixed effects			
ENDS Tax_{st} ($2023)	-0.756	-0.837	-0.026	-0.009	-0.005	-0.009	-0.006
	(0.627)	(0.527)	(0.018)	(0.012)	(0.006)	(0.012)	(0.008)
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-1.276*	-1.265*	-0.040*	-0.010	-0.008	-0.010	-0.008
	(0.736)	(0.664)	(0.023)	(0.013)	(0.006)	(0.013)	(0.008)
Pre-Treat Mean DV	136.680	64.457	0.499	0.278	0.114	0.285	0.117
N	558473	558473	558473	558473	558473	545154	456161
				Panel II: Males			
				(a) State-specific linear time trends			
ENDS Tax_{st} ($2023)	-1.324	-1.055	-0.043	-0.007	-0.009	-0.007	-0.011
	(1.035)	(0.694)	(0.029)	(0.015)	(0.013)	(0.016)	(0.016)
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.812	-0.876	-0.033	0.002	-0.0002	0.005	0.002
	(1.020)	(0.735)	(0.030)	(0.015)	(0.011)	(0.015)	(0.014)
				(b) Region-specific year fixed effects			
ENDS Tax_{st} ($2023)	-0.321	-0.345	-0.014	0.0002	-0.002	0.001	-0.002
	(0.718)	(0.561)	(0.022)	(0.009)	(0.008)	(0.009)	(0.011)
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.371	-0.092	0.003	0.012	0.006	0.013	0.009
	(0.703)	(0.604)	(0.023)	(0.009)	(0.007)	(0.010)	(0.009)
Pre-Treat Mean DV	161.615	65.637	0.582	0.323	0.170	0.336	0.177
N	548355	548355	548355	548355	548355	525862	445141

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

Notes: TWFE estimates were obtained using the 2011-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables are respondents' bodyweight, BMI percentile-for-age, BMI Z-score-for-age, probability of being overweight or obese and probability of being obese. Panel I shows results for females and panel II shows results for males. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans, ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (2023$). Standard errors are in parentheses and clustered at the state level. Column (6) and (7) drop underweight individuals so that the comparisons are to healthy weight. Subpanel (a) controls for state-specific linear time trends and (b) controls for region-specific year fixed effects. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Table 7. Effect of ENDS Taxes on ENDS Use Among Adults Aged 18-64 Years, BRFSS

	(1)	(2)	(3)	(4)	(5)	(6)
	Current ENDS Use			Everyday ENDS Use		
			Panel I: All Adults			
			(a) Overall Contemporaneous Tax Effect			
ENDS Tax_{st} ($2023)	-0.0027*	-0.0027*	-0.0012	-0.0028***	-0.0028***	-0.0008
	(0.0015)	(0.0015)	(0.0019)	(0.0009)	(0.0009)	(0.0012)
			(b) Three-Year Moving Average Tax Effect			
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.0012	-0.0011	-0.0015	-0.0043***	-0.0042***	-0.0028**
	(0.0023)	(0.0023)	(0.0019)	(0.0010)	(0.0010)	(0.0012)
Pre-Treat Mean DV	0.060	0.060	0.060	0.021	0.021	0.021
N	1462179	1462179	1462179	1462179	1462179	1462179
			Panel II: Females			
			(a) Overall Contemporaneous Tax Effect			
ENDS Tax_{st} ($2023)	-0.0029**	-0.0028**	-0.0022	-0.0033***	-0.0033***	-0.0012
	(0.0013)	(0.0013)	(0.0026)	(0.0009)	(0.0009)	(0.0016)
			(b) Three-Year Moving Average Tax Effect			
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.0027*	-0.0026*	-0.0025	-0.0049***	-0.0049***	-0.0027**
	(0.0015)	(0.0015)	(0.0017)	(0.0010)	(0.0011)	(0.0011)
Pre-Treat Mean DV	0.047	0.047	0.047	0.015	0.015	0.015
N	768183	768183	768183	768183	768183	768183
			Panel III: Males			
			(a) Overall Contemporaneous Tax Effect			
ENDS Tax_{st} ($2023)	-0.0027	-0.0027	-0.0003	-0.0023*	-0.0023*	-0.0005
	(0.0023)	(0.0022)	(0.0018)	(0.0013)	(0.0013)	(0.0014)
			(b) Three-Year Moving Average Tax Effect			
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.0002	0.0003	-0.0007	-0.0036***	-0.0036***	-0.0030*
	(0.0034)	(0.0033)	(0.0023)	(0.0013)	(0.0013)	(0.0017)
Pre-Treat Mean DV	0.073	0.073	0.073	0.027	0.027	0.027
N	693996	693996	693996	693996	693996	693996
Controls:						
Macro and COVID?	Yes	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes	Yes
Other Combustible Tobacco 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 adults aged 18-64 in the Behavioral Risk Factor Surveillance System Surveys collected over the 2016-2023. Standard errors are in parentheses and clustered at the state level. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also in $2023). All regressions control for state, year and semester fixed effects and demographics such as age, gender, education, marital status, and race. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 case and death rates and stringency index. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include MLSA and tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, medical, and decriminalization laws. Beer tax is scaled to the 2023 equivalent value. Observations surveyed in January, February, and March of 2023 for the 2024 survey wave are assigned December 2023 control values. BRFSS sampling weights are used.

Table 8. Gender-Specific Estimates of the Effects of ENDS Taxes on Body Weight of Adults Aged 18-64 Years, BRFSS

	(1)	(2)	(3)	(4)	(5)	(6)
	Weight	BMI	Overweight/ Obese	Obese	Overweight/ Obese	Obese
			Panel I: All Adults			
			(a) Overall Contemporaneous Tax Effect			
ENDS Tax_{st} ($2023)	-0.2625	-0.0528	-0.0009	-0.0019	0.0005	-0.0021
	(0.2325)	(0.0377)	(0.0020)	(0.0019)	(0.0026)	(0.0033)
			(b) Three-Year Moving Average Tax Effect			
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.0221	0.0001	0.0011	0.0013	0.0028	0.0034
	(0.1587)	(0.0268)	(0.0013)	(0.0021)	(0.0032)	(0.0041)
Pre-Treat Mean DV	178.323	27.702	0.626	0.282	0.618	0.274
N	3306918	3306918	3306918	3306918	27322914	27322914
			Panel II: Females			
			(a) Overall Contemporaneous Tax Effect			
ENDS Tax_{st} ($2023)	-0.3624	-0.0773	-0.0024	-0.0035	-0.0004	-0.0050
	(0.3713)	(0.0627)	(0.0037)	(0.0029)	(0.0040)	(0.0043)
			(b) Three-Year Moving Average Tax Effect			
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.1586	-0.0318	-0.0013	-0.0008	-0.0006	0.0016
	(0.2143)	(0.0379)	(0.0026)	(0.0029)	(0.0048)	(0.0049)
Pre-Treat Mean DV	161.419	27.453	0.563	0.282	0.553	0.271
N	1759573	1759573	1759573	1759573	11035870	11035870
			Panel III: Males			
			(a) Overall Contemporaneous Tax Effect			
ENDS Tax_{st} ($2023)	-0.1624	-0.0296	0.0006	-0.0003	0.0011	0.0005
	(0.2386)	(0.0342)	(0.0031)	(0.0019)	(0.0028)	(0.0032)
			(b) Three-Year Moving Average Tax Effect			
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.2059	0.0330	0.0037*	0.0035	0.0062	0.0052
	(0.2211)	(0.0339)	(0.0019)	(0.0023)	(0.0039)	(0.0042)
Pre-Treat Mean DV	194.582	27.939	0.687	0.282	0.674	0.270
N	1547345	1547345	1547345	1547345	10399322	10399322
Estimation Strategy	TWFE	TWFE	TWFE	TWFE	Stacked DD	Stacked DD

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

Notes: TWFE estimates are obtained using adults aged 18-64 in the Behavioral Risk Factor Surveillance System Surveys collected over 2011-2023. Standard errors are in parentheses and clustered at the state level. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). We control for state, year, and quarter fixed effects; race; age; education; marital status; unemployment and poverty rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws and beer taxes (in $2023). Observations surveyed in January, February, and March of 2023 for the 2024 survey wave are assigned December 2023 control values. In columns (5) and (6), we employ a stacked differences-in-differences approach which estimates the effect of "prominent" $0.25 increases in the nominal ENDS tax. BRFSS sampling weights are used.

Table 9. Exploration of Mechanisms through which ENDS Taxes May Affect Youth Body Weight, YRBS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Cigarette	Binge Alc.	Marijuana	Exercise	Soda	Fruits	Vegetables
Panel I: All, 2015-2023							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	0.012**	-0.008*	-0.018***	-0.000	-0.002	0.010	0.019***
	(0.005)	(0.004)	(0.006)	(0.009)	(0.008)	(0.007)	(0.007)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.012***	-0.010**	-0.012**	-0.003	-0.005	0.007	0.019***
	(0.004)	(0.004)	(0.006)	(0.010)	(0.007)	(0.007)	(0.005)
Pre-Treat Mean DV	0.073	0.139	0.187	0.843	0.730	0.927	0.895
N	782,372	721,290	790,164	771,419	672,446	737,795	625,763
Panel II: All, 2011-2023							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	0.006	-0.017***	-0.016***	0.002	0.001	0.007	0.014**
	(0.005)	(0.006)	(0.005)	(0.010)	(0.006)	(0.006)	(0.006)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.006	-0.020***	-0.014**	0.000	-0.003	0.004	0.013***
	(0.004)	(0.005)	(0.005)	(0.012)	(0.005)	(0.006)	(0.004)
Pre-Treat Mean DV	0.105	0.168	0.199	0.849	0.748	0.935	0.904
N	1,059,113	992,417	1,071,173	1,035,795	930,349	1,013,789	857,947
Panel III: Females, 2011-2023							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	0.005	-0.015	-0.014***	-0.003	-0.006	0.004	0.012*
	(0.004)	(0.009)	(0.005)	(0.010)	(0.008)	(0.005)	(0.007)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.006	-0.018***	-0.012***	-0.001	-0.007	0.002	0.010*
	(0.004)	(0.007)	(0.004)	(0.012)	(0.007)	(0.005)	(0.006)
Pre-Treat Mean DV	0.093	0.165	0.190	0.816	0.718	0.943	0.912
N	538,327	504,926	544,702	526,946	474,494	515,608	435,812
Panel IV: Males, 2011-2023							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	0.007	-0.020***	-0.019*	0.007	0.007	0.010	0.016***
	(0.007)	(0.007)	(0.010)	(0.012)	(0.008)	(0.007)	(0.006)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.006	-0.022***	-0.017*	0.002	-0.000	0.006	0.017***
	(0.006)	(0.007)	(0.009)	(0.012)	(0.008)	(0.009)	(0.005)
Pre-Treat Mean DV	0.117	0.170	0.208	0.881	0.776	0.926	0.895
N	520,786	487,491	526,471	508,849	455,855	498,181	422,135

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

Notes: TWFE estimates are obtained using the Combined State and National Youth Risk Behavior Surveillance System Surveys. Standard errors are in parentheses and clustered at the state level. The dependent variables are any cigarette use, binge drinking and marijuana use in the past month, as well as any exercise, soda intake, fruits/fruit juices and vegetables intake in the prior week. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA laws; tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer taxes (in $2023). Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Table 10. Exploration of Mechanisms through which ENDS Taxes May Affect Body Weight of Adults Aged 18-64, BRFSS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Current Cig.	Everyday Cig.	Alcohol Use	Binge Drinking	Fries	Any Veggies	Exercise
Panel I: All Adults							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	0.0006	0.0005	-0.0077**	-0.0029	-0.0060*	-0.0001	-0.0021
	(0.0017)	(0.0016)	(0.0031)	(0.0019)	(0.0032)	(0.0007)	(0.0026)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.0009	0.0032**	-0.0096***	-0.0053***	-0.0104**	0.0002	-0.0071**
	(0.0016)	(0.0013)	(0.0033)	(0.0016)	(0.0042)	(0.0006)	(0.0027)
Pre-Treat Mean DV	0.181	0.126	0.567	0.198	0.842	0.994	0.777
N	3503475	3503475	3324714	3325393	698123	1588269	3467592
Panel II: Females							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	-0.0013	-0.0008	-0.0078**	-0.0039**	-0.0084	0.0003	-0.0014
	(0.0019)	(0.0020)	(0.0032)	(0.0016)	(0.0052)	(0.0004)	(0.0031)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.0019	0.0031*	-0.0108***	-0.0050***	-0.0166***	0.0003	-0.0065**
	(0.0017)	(0.0016)	(0.0034)	(0.0016)	(0.0061)	(0.0006)	(0.0028)
Pre-Treat Mean DV	0.160	0.115	0.514	0.143	0.816	0.996	0.766
N	1914813	1914813	1824561	1824542	369479	883683	1895176
Panel III: Males							
(a) Overall Contemporaneous Tax Effect							
ENDS Tax_{st} ($2023)	0.0023	0.0018	-0.0075**	-0.0017	-0.0034	-0.0005	-0.0028
	(0.0020)	(0.0021)	(0.0035)	(0.0026)	(0.0023)	(0.0010)	(0.0027)
(b) Three-Year Moving Average Tax Effect							
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.0000	0.0034	-0.0082*	-0.0056**	-0.0040	0.0001	-0.0078**
	(0.0022)	(0.0021)	(0.0047)	(0.0023)	(0.0036)	(0.0007)	(0.0030)
Pre-Treat Mean DV	0.202	0.137	0.620	0.254	0.869	0.993	0.789
N	1588662	1588662	1500153	1500851	328644	704586	1572416

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

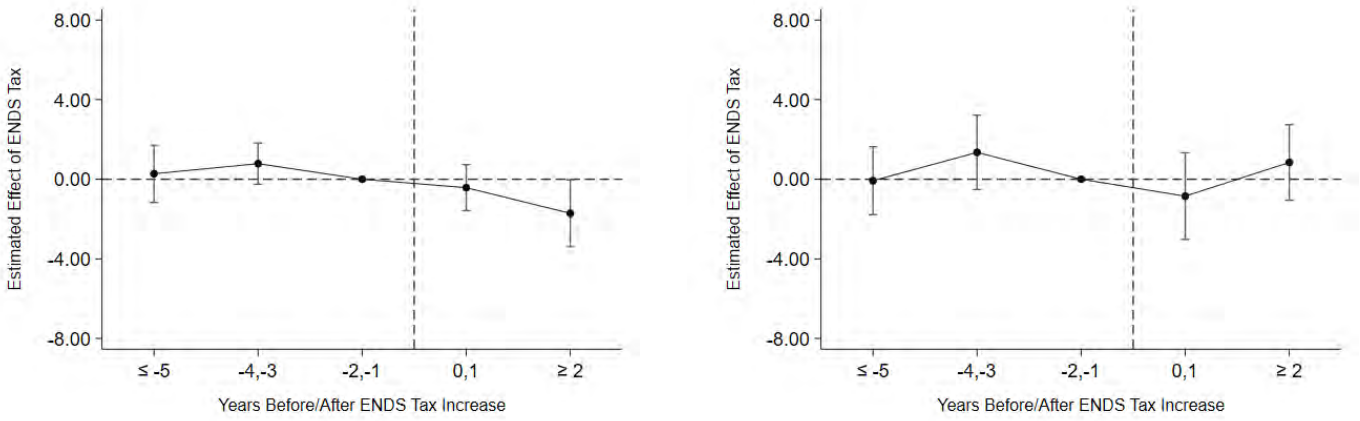
Notes: TWFE estimates are obtained using Behavioral Risk Factor Surveillance System Surveys collected over 2011-2023. Standard errors are in parentheses and clustered at the state level. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also in $2023). We control for state, year, and quarter fixed effects; race; age; education; marital status; unemployment and poverty rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer taxes (in $2023). Observations surveyed in January, February, and March of 2023 for the 2024 survey wave are assigned December 2023 control values. "Cig." refers to cigarette smoking. BRFSS sampling weights are used.

ONLINE APPENDIX

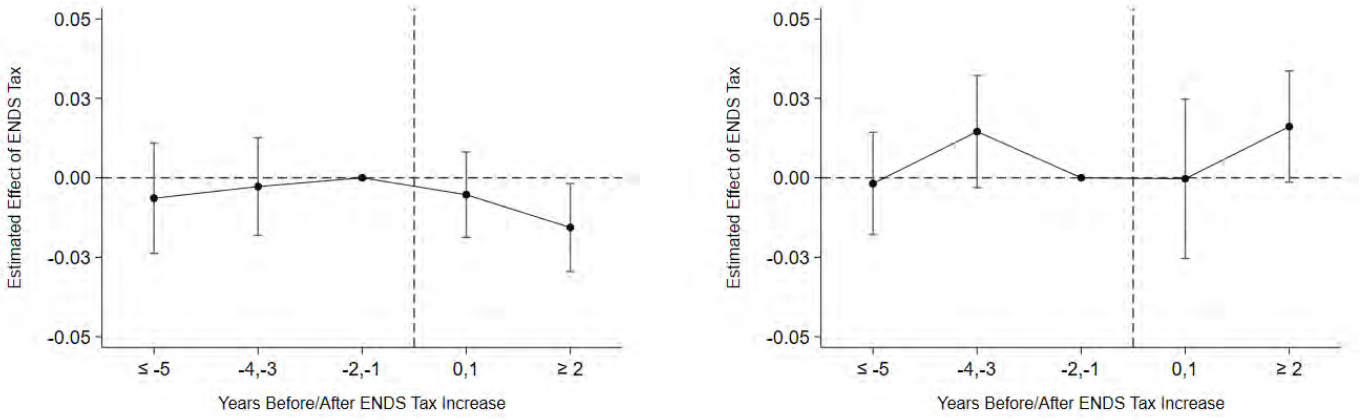
Appendix Figure 1. Event Study Estimates of First Prominent ENDS Tax Increase ($0.50 per mL) and Bodyweight, Using TWFE Estimates

(i) Females (ii) Males

Panel (a): Weight (Controlling for Height)



Panel (b): Obesity

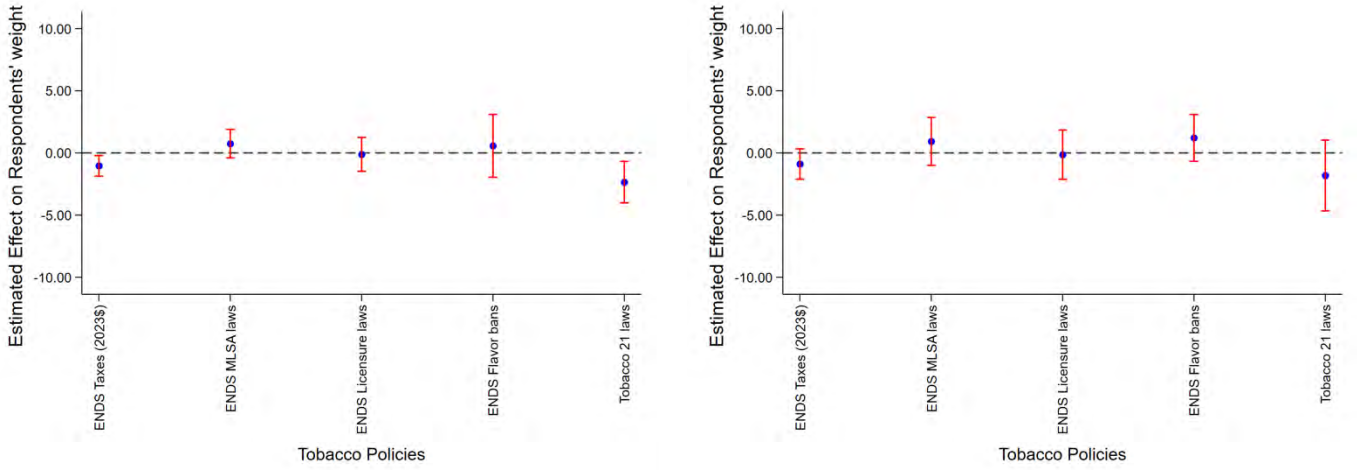


Notes: Data used for the above event study regressions are obtained from the 2011-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are female and male respondents' body weight and probability of being obese in panels (a) and (b) respectively. Estimates are obtained from stacked DD regressions using data from the 2011-2023 State and National Youth Risk Behavior Surveys. A $0.25 (in nominal terms) increase in ENDS taxes is defined to be a prominent increase. All regressions control for state fixed effects, year and semester fixed effects and utilize the following set of controls: Demographic controls include gender, race, age, and grade. Macro controls include unemployment and poverty rate, COVID controls include the cumulative COVID-19 case and death rate and the Oxford University government stringency index. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans, ENDS policies include minimum legal sales age (MLSA) laws, tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions, marijuana policies include recreational marijuana laws, medical marijuana laws, decriminalization marijuana 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.

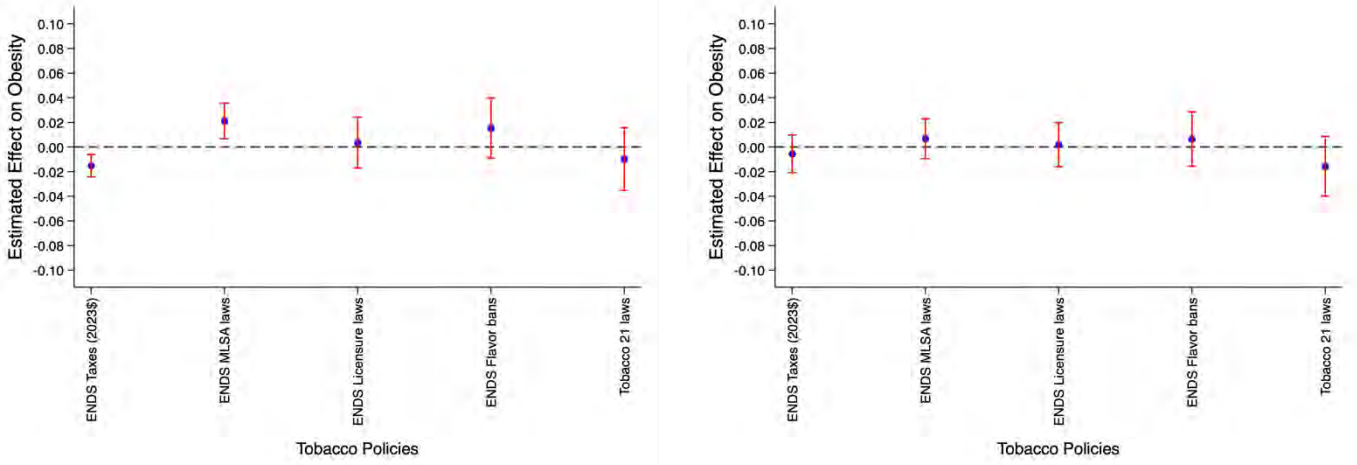
Appendix Figure 2. Comparing Effect of ENDS Taxes to Other ENDS Access Policies

(i) Females (ii) Males

Panel (a): Weight (Controlling for Height)



Panel (b): Obese

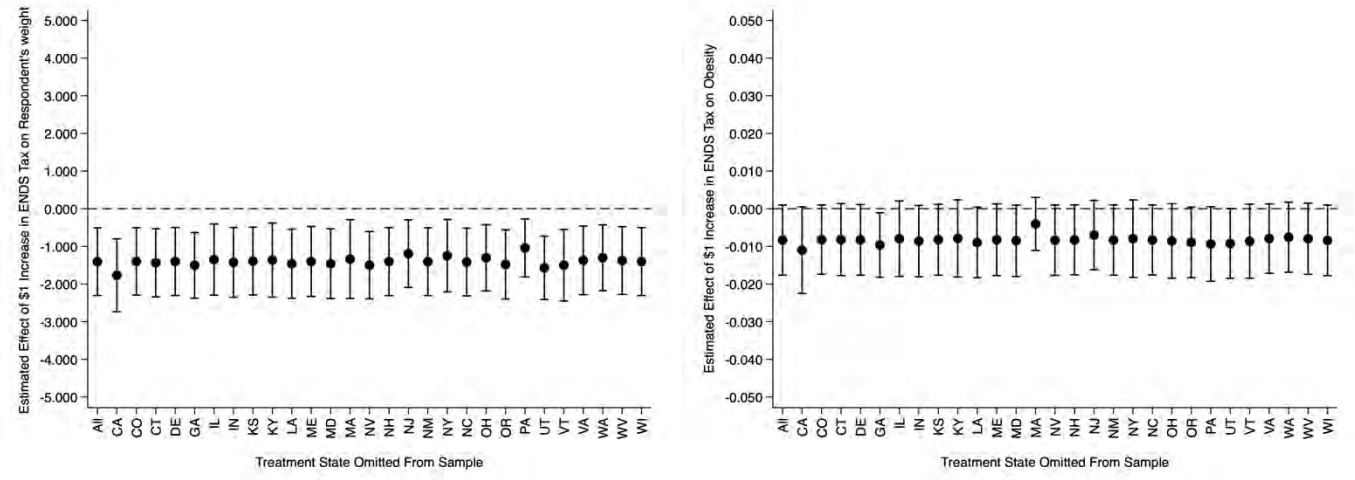


Notes: Data used for the above TWFE regressions are from the 2015-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are bodyweight (measured in pounds) and probability of being obese in panels (a) and (b) respectively. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). Coefficients are represented with dots, and vertical lines indicate 95% confidence intervals, adjusted for clustering at the state level. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

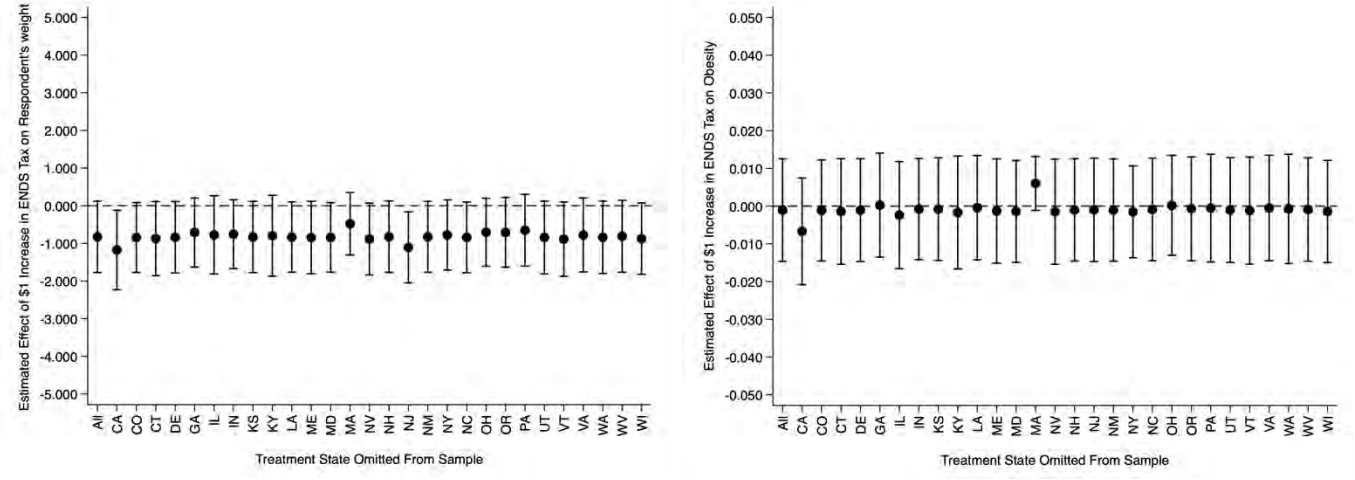
Appendix Figure 3. Sensitivity of ENDS Tax Effect to Leave-One-Treatment-State-Out-at-a-Time

(i) Weight (ii) Obese

Panel (a): Females



Panel (b): Males



Notes: Data used for the above TWFE regressions are from the 2011-2023 Combined State and National Youth Risk Behavior Surveys. The dependent variables are female and male respondents' bodyweight and probability of being obese. Panels (a), (b), and (c) show the results for the pooled sample, females and males respectively. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans; ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (in 2023$). 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 Table 1. 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. (2025). Reprinted from Dave et al. (2024b).

Appendix Table 2. Effects of ENDS Taxes on ENDS Use, by YRBSS Dataset

	(1)	(2)	(3)
	Panel I: State YRBSS		
	(a) Current ENDS Use		
ENDS Tax_{st} ($2023)	-0.020***	-0.017***	-0.030**
	(0.005)	(0.006)	(0.013)
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.020***	-0.019***	-0.023
	(0.006)	(0.007)	(0.014)
Pre-Treat Mean DV	0.191	0.191	0.191
N	677,376	677,376	677,376
	(b) Everyday ENDS Use		
ENDS Tax_{st} ($2023)	-0.013***	-0.012***	-0.011**
	(0.002)	(0.003)	(0.005)
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.014***	-0.014***	-0.010*
	(0.003)	(0.003)	(0.006)
Pre-Treat Mean DV	0.037	0.037	0.037
N	677,376	677,376	677,376
	Panel II: National YRBSS		
	(a) Current ENDS Use		
ENDS Tax_{st} ($2023)	-0.023**	-0.022**	-0.0002
	(0.010)	(0.009)	(0.016)
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.024*	-0.024**	0.003
	(0.012)	(0.010)	(0.013)
Pre-Treat Mean DV	0.241	0.241	0.241
N	65,962	65,962	65,962
	(b) Everyday ENDS Use		
ENDS Tax_{st} ($2023)	-0.009**	-0.008**	-0.006
	(0.004)	(0.004)	(0.007)
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.010**	-0.010**	-0.004
	(0.005)	(0.004)	(0.006)
Pre-Treat Mean DV	0.041	0.041	0.041
N	65,962	65,962	65,962
Controls:			
Demographic?	Yes	Yes	Yes
Macroeconomic and COVID-19?	No	Yes	Yes
Cigarette Taxes ($2023)?	No	No	Yes
Other Combustible Tobacco Policies?	No	No	Yes
ENDS Policies?	No	No	Yes
MJ Policies?	No	No	Yes
Beer Tax?	No	No	Yes

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

Notes: Estimates were obtained from weighted ordinary least squares regressions using data from the 2011-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. Panel I shows results for the state YRBS and Panel II for the national YRBS. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade. Macroeconomic controls include the poverty and unemployment rate, and COVID controls include the cumulative COVID-19 case and death rates and stringency index. Combustible tobacco policies include cigarette taxes (in $2023) and indoor smoking bans. ENDS policies include MLSA and tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational, medical, and decriminalization laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are in parentheses and clustered at the state level. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Table 3A. Stacked DD Estimates of Effect of a Prominent ENDS Tax Increase on Youth ENDS Use

	(1) Current ENDS Use	(2) Frequent ENDS Use	(3) Everyday ENDS Use
	Panel I: $0.50 per mL of E-Liquid		
	(a) Overall Contemporaneous Tax Effect		
ENDS Tax_{st} ($2023)	-0.023*	-0.011	-0.010
	(0.014)	(0.007)	(0.008)
Pre-Treat Mean DV	0.201	0.060	0.043
N	356,218	356,218	356,218
	(b) Three-Year Moving Average Tax Effect		
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.011	-0.020***	-0.019***
	(0.012)	(0.006)	(0.007)
Pre-Treat Mean DV	0.197	0.063	0.046
N	357,102	357,102	357,102
	Panel II: $0.25 per mL of E-Liquid		
	(a) Overall Contemporaneous Tax Effect		
ENDS Tax_{st} ($2023)	-0.010	-0.009	-0.009
	(0.015)	(0.008)	(0.007)
Pre-Treat Mean DV	0.202	0.061	0.045
N	431,656	431,656	431,656
	(b) Three-Year Moving Average Tax Effect		
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.015	-0.008	-0.009
	(0.013)	(0.007)	(0.006)
Pre-Treat Mean DV	0.197	0.063	0.046
N	726,995	726,995	726,995

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

Notes: Stacked DD estimates are from individual-level State and National Youth Risk Behavior Surveillance System Surveys from 2015-2023. Panel I uses a $0.50 (nominal) increase in ENDS taxes to define a prominent tax increase, and Panel II uses a $0.25 (nominal) increase. In each panel, (a) reports the contemporaneous effect of ENDS taxes and (b) reports the effect of the three-year moving average of ENDS taxes for the current year and the prior two years. All regressions control for state, year and semester fixed effects, an indicator for whether the observation comes from the state or national YRBS, demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans, ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (2023$). Standard errors are in parentheses and clustered at the state level. Column (6) and (7) drop underweight individuals so that the comparisons are to healthy weight. Subpanel (a) controls for state-specific linear time trends and (b) controls for region-specific year fixed effects. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Table 3B. TWFE Estimates of Effect of First Prominent ENDS Tax Increase on Youth ENDS Use

	(1) Current ENDS Use	(2) Frequent ENDS Use	(3) Everyday ENDS Use
	Panel I: $0.25 per mL of E-Liquid		
ENDS Tax_{st} ($2023)	-0.0150	-0.0196*	-0.0229**
	(0.0148)	(0.0109)	(0.0112)
Pre-Treat Mean DV	0.234	0.050	0.036
N	752481	752481	752481
	Panel II: $0.50 per mL of E-Liquid		
ENDS Tax_{st} ($2023)	-0.0188**	-0.0227***	-0.0228***
	(0.0087)	(0.0081)	(0.0083)
Pre-Treat Mean DV	0.215	0.045	0.033
N	752481	752481	752481
Controls:			
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 Policies?	Yes	Yes	Yes
Beer Tax?	Yes	Yes	Yes

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

Notes: Stacked DD 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 uses a $0.50 (nominal) increase in ENDS taxes to define a prominent tax increase, and Panel II uses a $0.25 (nominal) increase. In each panel, subpanel (a) reports the contemporaneous effect of ENDS taxes, and subpanel (b) reports the effect of the three-year moving average of ENDS taxes for the current year and the prior two years. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade. Macroeconomic controls include the unemployment rate, and COVID controls include the cumulative COVID-19 case and death rates and stringency index. 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, tobacco 21 laws, indoor vaping bans, ENDS licensure laws, and flavored ENDS restrictions. Marijuana policies include recreational marijuana laws and medical marijuana laws, and beer tax is scaled to the 2023 equivalent value. Standard errors are in parentheses and clustered 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 Table 4. TWFE Estimates of Effect of ENDS Taxes on Youth Weight, Controlling for Height, Using 2011-2023 Period, Pooled Sample

	(1)	(2)	(3)	(4)	(5)
	Panel I: Overall Contemporaneous Tax Effect				
ENDS Tax_{st} ($2023)	-0.900***	-0.803**	-0.764	-0.789*	-0.771
	(0.281)	(0.309)	(0.487)	(0.455)	(0.490)
	Panel II: Three-Year Moving Average Tax Effect				
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.842**	-0.688	-0.596	-0.563	-0.565
	(0.360)	(0.437)	(0.505)	(0.466)	(0.502)
Pre-Treat Mean DV	149.458	149.458	149.458	149.458	149.458
N	1,106,828	1,106,828	1,106,828	1,106,828	1,106,828
Controls:					
Macro and COVID?	Yes	Yes	Yes	Yes	Yes
Cigarette Taxes ($2023)?	Yes	Yes	Yes	Yes	Yes
Other Combustible Tobacco Policies?	No	Yes	Yes	Yes	Yes
ENDS Policies?	No	No	Yes	Yes	Yes
MJ Policies?	No	No	No	Yes	Yes
Beer Tax?	No	No	No	No	Yes

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

Notes: Estimates were obtained using data from the 2011-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables is respondents' bodyweight (measured in pounds). Panel I shows results for the pooled sample. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans, ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (2023$). Standard errors are in parentheses and clustered at the state level. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Table 5. Sensitivity of Estimates in Table 5 to Use of 2015-2023 Period

	(1)	(2)	(3)	(4)	(5)	(6)
	BMI-percentile	BMI- Z Score	Overweight or Obese	Obese	Overweight or Obese vs Normal BMI	Obese vs Normal BMI
Panel I: Females						
(a) Overall Contemporaneous Tax Effect						
ENDS Tax_{st} ($2023)	-0.600	-0.025	-0.013	-0.015**	-0.015	-0.019**
	(0.520)	(0.019)	(0.012)	(0.006)	(0.013)	(0.008)
(b) Three-Year Moving Average Tax Effect						
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-1.153*	-0.044*	-0.016	-0.019***	-0.017	-0.022**
	(0.622)	(0.023)	(0.013)	(0.006)	(0.013)	(0.008)
Pre-Treat Mean DV	65.689	0.547	0.299	0.127	0.306	0.130
N	410,400	410,400	410,400	410,400	400,958	334,111
Panel II: Males						
(a) Overall Contemporaneous Tax Effect						
ENDS Tax_{st} ($2023)	-0.705	-0.031	0.003	-0.006	0.005	-0.003
	(0.548)	(0.022)	(0.011)	(0.010)	(0.013)	(0.013)
(b) Three-Year Moving Average Tax Effect						
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.006	0.001	0.016	0.005	0.018*	0.011
	(0.527)	(0.020)	(0.010)	(0.007)	(0.010)	(0.009)
Pre-Treat Mean DV	65.561	0.586	0.331	0.178	0.346	0.186
N	406,177	406,177	406,177	406,177	389,053	329,432

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

Notes: Estimates were obtained using data from the 2015-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables are respondents' alternate body measures such as BMI percentile-for-age, BMI Z-score-for-age, probability of being overweight or obese and probability of being obese. Panel I shows results for females and panel II shows results for males. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans, ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (2023$). Standard errors are in parentheses and clustered at the state level. Column (5) and (6) use normal BMI as reference point. Rest of the columns contain the full sample based on gender. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Table 6. TWFE Estimates of Effect of ENDS Taxes on Youths' Probability of Being Underweight, YRBS, 2011-2023

	(1)	(2)
	Female	**Male**
	Panel I: Overall Contemporaneous Tax Effect	
ENDS Tax_{st} ($2023)	0.001	0.003
	(0.002)	(0.002)
	Panel II: Three-Year Moving Average Tax Effect	
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.002	0.005**
	(0.002)	(0.002)
Pre-Treat Mean DV	0.024	0.041
N	558,473	548,355

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

Notes: Estimates were obtained using data from the 2011-2023 Combined State and National Youth Risk Behavior Surveillance System Surveys. The dependent variables is respondents' probability of being underweight. Column (1) shows results for the pooled sample, column (2) for females and column (3) for males respectively. The independent variable of interest in (a) is contemporaneous ENDS tax (in $2023) and in (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans, ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (2023$). Standard errors are in parentheses and clustered at the state level. Age-by-gender-by-race/ethnicity-specific sample weights generated from the Surveillance, Epidemiology, and End Results (SEER) program are used to make observations representative of the youth population aged 14-18 years at the state and national levels.

Appendix Table 7. Stacked DD Estimates of Effect of a Prominent Increase in ENDS Taxes on Youth Body Weight and Obese

	(1)	(2)	(3)	(4)
	Bodyweight		Obese	
	Females	Males	Females	Males
Panel I: $0.50 per mL of E-Liquid				
(a) Overall Contemporaneous Tax Effect				
ENDS Tax_{st} ($2023)	-1.668	-0.470	-0.007	0.006
	(1.186)	(1.223)	(0.010)	(0.012)
Pre-Treat Mean DV	137.829	162.428	0.126	0.177
N	236,007	250,613	235,959	250,511
(b) Three-Year Moving Average Tax Effect				
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.142	-0.163	-0.005	0.009
	(1.009)	(1.371)	(0.0098)	(0.0117)
Pre-Treat Mean DV	137.744	162.214	0.126	0.177
N	230,525	244,990	230,470	244,904
Panel II: 25 Cents Prominent Increase				
(a) Overall Contemporaneous Tax Effect				
ENDS Tax_{st} ($2023)	-2.218**	-1.644*	-0.008	-0.003
	(0.908)	(0.929)	(0.009)	(0.009)
Pre-Treat Mean DV	137.980	162.506	0.127	0.178
N	296,038	313,940	295,972	313,812
(b) Three-Year Moving Average Tax Effect				
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-1.642	0.095	-0.009	0.012
	(1.122)	(1.248)	(0.009)	(0.011)
Pre-Treat Mean DV	138.155	162.516	0.129	0.179
N	461,298	489,896	461,196	489,701

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

Notes: Stacked DD 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 2011-2023. A $0.25 (in nominal terms) increase in ENDS taxes is defined to be a prominent increase. The independent variable of interest in subpanel (a) is contemporaneous ENDS tax and in subpanel (b) is the average of the ENDS taxes for the current year and the prior two years. All regressions control for state, year and semester fixed effects; an indicator for whether the observation comes from the state or national YRBS; demographics such as age, gender, race, and grade; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans, ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (2023$). Standard errors are in parentheses and clustered 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 Table 8. Estimates of the Effects of ENDS Taxes on Alternative Measures of Adult Body Weight, BRFSS

	(1)	(2)
	Overweight/Obese; Drop Underweight	Obese; Drop Underweight and Overweight
	Panel I: All Adults	
	(a) Overall Contemporaneous Tax Effect	
ENDS Tax_{st} ($2023)	-0.0014	-0.0020
	(0.0022)	(0.0029)
	(b) Three-Year Moving Average Tax Effect	
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.0013	0.0023
	(0.0014)	(0.0023)
Pre-Treat Mean DV	0.639	0.443
N	3254092	2112185
	Panel II: Females	
	(a) Overall Contemporaneous Tax Effect	
ENDS Tax_{st} ($2023)	-0.0030	-0.0050
	(0.0039)	(0.0044)
	(b) Three-Year Moving Average Tax Effect	
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	-0.0014	-0.0014
	(0.0027)	(0.0031)
Pre-Treat Mean DV	0.578	0.407
N	1724095	1212950
	Panel III: Males	
	(a) Overall Contemporaneous Tax Effect	
ENDS Tax_{st} ($2023)	0.0004	0.0014
	(0.0030)	(0.0035)
	(b) Three-Year Moving Average Tax Effect	
ENDS $Tax_{s(\overline{t,t-1,t-2})}$	0.0041**	0.0062**
	(0.0020)	(0.0030)
Pre-Treat Mean DV	0.696	0.485
N	1529997	899235

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

Notes: TWFE estimates are obtained using weighted least squares and generated from adults aged 18-64 in the Behavioral Risk Factor Surveillance System Surveys collected over the period 2011-2023. Standard errors are in parentheses and clustered at the state level. The independent variable of interest in subpanel (a) is contemporaneous ENDS tax (in $2023) and in subpanel (b) is the average of the ENDS taxes for the current year and the prior two years (also measured in $2023). All regressions control for state, year and semester fixed effects; age; gender; race; education; marital status; poverty and unemployment rates; cumulative COVID-19 case and death rates and stringency index; cigarette taxes (in $2023); indoor smoking bans; MLSA and tobacco 21 laws; indoor vaping bans, ENDS licensure laws; flavored ENDS restrictions; recreational and medical marijuana laws; marijuana decriminalization laws; and beer tax (2023$). Observations surveyed in January, February, and March of 2023 for the 2024 survey wave are assigned December 2023 control values. In column (1), we exclude individuals that are underweight (BMI less than 18.5), and in column (2), we exclude both underweight and overweight (BMI between 25 and 30) individuals. Regressions are weighted using the BRFSS-provided individual sample weights.