

# The Effect of ENDS Taxes on Substance Use

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## Disclaimer

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# ENDS

## • Electronic Nicotine Delivery System (ENDS), Vape, E-Cigarette

- Developed in China in 2003 as a harm reduction product.
- Battery-operated, vaporizes a liquid, most contain nicotine, many contain flavors, and there is no burning.
- Believed to be less harmful than tobacco cigarettes by many tobacco policy experts: 37% as harmful (Allcott & Rafkin, 2022).
- First sale in the U.S. in 2006.
- Extremely popular among American teens.
- 23-27% of youth vaped from 2015-2019, 10-15% after the pandemic.
- The U.S. Surgeon General has deemed high rates of teen E-cigarette use an “epidemic” (U.S. Surgeon General, 2018).

# Marijuana

- Marijuana

- Prohibited at the federal level since Marihuana Tax Act of 1937
- States have increasingly legalized marijuana:
  - By November 2023, 38 states and the DC had legalized the medical use of marijuana and 24 states and the DC had legalized recreational marijuana.
- 7–22% of youth used marijuana 2015–2019 (YRBS, NSDUH)
- 7% of adults used marijuana in 2015–2019 (NSDUH)

# ENDS & Marijuana

Both products potentially offer health benefits & harms

- Beneficial Effects

- Harm reduction: curb combustible cigarettes use
- Manage symptoms associated with chronic conditions (e.g., pain)
- Induce substitution away from other potentially more harmful health behaviors such as problem drinking and opioid misuse

- Concerning Effects

- Renormalize smoking (ENDS)
- Unintended gateway effects on other substance use (ENDS)
- Frequent/heavier marijuana use has been found to increase the risk of respiratory disease (MJ)
- Joint consumption of ENDS and MJ products during the 2019-2020 "e-cigarette, or vaping, product use associated lung injury" (EVALI) outbreak caused 68 deaths and nearly 3,000 hospitalizations for severe respiratory problems
- Gateway effects to harder drugs (MJ)

# ENDS & Marijuana Policies

Opposing regulatory approaches:

- ENDS: policies designed to ↓ use
  - MLSA, flavor bans, indoor bans, & taxes
- Marijuana: policies designed to ↑ use
  - Medical marijuana Laws and Recreational Marijuana Laws

# ENDS Regulations

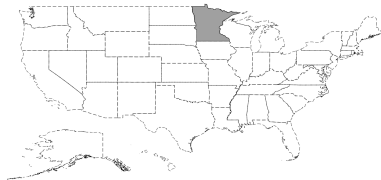
- By 2016, all U.S. states and the District of Columbia implemented a minimum legal sales age of 18 or higher
- In December 2019, a federal Tobacco-to-21 law raised the minimum legal purchasing of all tobacco products to age 21
- As of March 31, 2023:
  - 17 states and the District of Columbia had adopted clean indoor air laws that extended to ENDS
  - 5 states had adopted statewide ENDS flavor bans
  - 34 states and the District of Columbia had adopted ENDS licensure laws

# ENDS Taxes

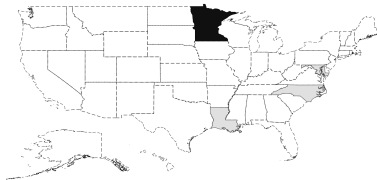
- States adopt ENDS taxes in different ways, hard to compare
  - Ad valorem tax on wholesale price
  - Excise tax per unit or fluid mL of liquid nicotine
  - Special sales tax
- Use of standardized measure of tax per fluid mL produced by Cotti et al. (2021) that allows comparability across states and over time
  - The magnitudes of ENDS taxes ranges from \$0.01 per ml of liquid nicotine (2019\$) in Wisconsin to over \$2.00 in Minnesota
- As of December 2023, 31 states and the District of Columbia had adopted an ENDS tax



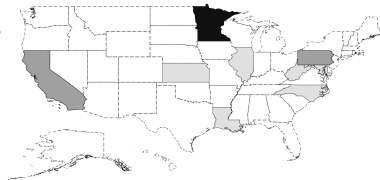
# Geographic and Temporal Variation in ENDS Taxes



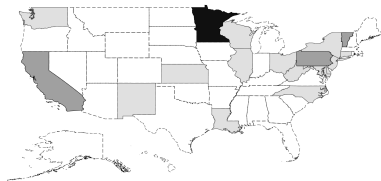
(a) 2010



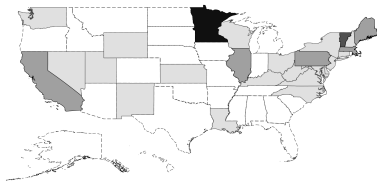
(b) 2015



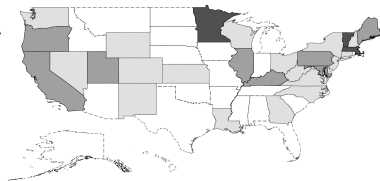
(c) 2017



(d) 2019



(e) 2020



(f) 2021

# What is the Effect of ENDS Taxes on Youth Marijuana Use?

- (1) ENDS taxes may increase marijuana consumption:
  - ENDS and marijuana as economic substitutes: competing ways to attain utility from a buzz or the act of vaping
- (2) ENDS taxes may reduce marijuana consumption:
  - Income effect : less disposable income
  - ENDS and marijuana as economic complements:
    - Vaping nicotine serves as a gateway to marijuana use
    - Shared fixed cost: investing in the fixed cost of a nicotine vaping device reduces the cost of vaping marijuana
    - Social network effects: reduced social utility
    - If the use of one product increases the high or euphoria associated with the use of the other product
  - ENDS taxes serve as signal about the relative risk of vaping specifically and substance use generally

# What is the Effect of ENDS Taxes on Youth Harder Drug Use?

- Increases in ENDS taxes could impact harder drug use through similar pathways as outlined above for marijuana
- Such relationships, if present, are likely weaker
  - Fewer youth and young adults consume harder drugs overall
  - Joint use of harder drugs and ENDS is much less common
    - 1.1 percent of youth aged 12-to-18 years report past-month ENDS use and ever use of cocaine or heroin
    - Much weaker associations between youth tobacco product use and harder drugs such as cocaine and heroin than with marijuana (Silveira et al., 2018).

# What we do?

- What is the effect of electronic nicotine delivery system (ENDS) taxes on substance use?
  - State & local taxes adopted between 2010 & 2019 in the US
  - Range from \$0.05 to > \$2.00 per ml of fluid nicotine
  - Five national databases
- Substances
  - ① ENDS
  - ② Marijuana
  - ③ Harder drugs (cocaine, heroin, & methamphetamine)
- Generalized difference-in-differences (DID) regression
  - Exploit variation within states over time
  - Tax introduction & later changes in the tax rate

## Previous Literature

- ENDS taxes have been found to reduce ENDS use (Abouk et al., 2023; Cotti et al., 2022)
- ENDS taxes induce substitution toward cigarette use (Abouk et al (2023a; 2023b); Cotti et al., 2022; Friedman & Pesko, 2022; Pesko et al. 2020; Pesko & Warman 2022)
- Spillover effects: a one-dollar increase in ENDS taxes leads to a 1-to-2 percentage-point decline in youth binge drinking and an approximately 0.4 to 0.6 percent decline in alcohol-related traffic fatalities (Dave et al. 2022)
- The evidence on the relationship between tobacco and marijuana is mixed (Pacula 1998; Chaloupka et al. 1999; Farrelly et al. 2001; Anderson et al., 2020; Hansen et al., 2021; Dave et al., 2023)

## Our Contribution to the Literature

- First study to examine the effects of ENDS taxes on marijuana and harder drug use
- Use data from five national datasets to study youth and adult substance use, including outcomes that measure heavier and more problematic use
- Descriptively explore mechanisms that could be at work
- Provide important new evidence on spillover effects of ENDS taxes, which will help to assess social welfare implications

# Datasets (1)

- State & National Youth Risk Behavior Surveys (**YRBS**)
  - School-based surveys
  - Fielded in spring
  - Centers for Disease Control & Prevention (CDC)
  - 2015–2019 & 2003–2019
  - Past 30-day ENDS & marijuana use
  - Youth (12–18 years)
- Behavioral Risk Factor Surveillance Survey (**BRFSS**)
  - CDC
  - 2016–2018
  - Current e-cigarette use
  - 18–20 years & 21 years+

## Datasets (2)

- National Survey on Drug Use and Health (**NSDUH**)
  - Substance Abuse & Mental Health Services Administration (SAMHSA)
  - Public use two-year averages
  - 2002–2019
  - Harder drugs (illicit drugs, cocaine, heroin, meth) use prevalence rates
  - 12–17 years & 18 years+
- Treatment Episode Dataset (**TEDS**)
  - SAMHSA
  - Specialized substance use disorder (SUD) treatment
  - 2000–2019
  - Marijuana- & harder drug-related admissions: ratio of total primary marijuana/harder drug-related admissions to the population (in thousands)
  - Primary substance
  - 12–17 years & 18 years+



# Methods (1)

- Generalized difference-in-differences model:
  - TWFE regression
  - Continuous event study (Schmidheiny and Siegloch, 2023)
  - Stacked DID:
    - accounts for differences in tax sizes
    - mitigates concerns related to differential treatment variance weights given to each treated unit in the standard DID estimation.
- OLS regression
- Cluster standard errors by state
- Weight by YRBS– & BRFSS–provided weights
- Weight by state–population for NSDUH & TEDS

## Methods (2)

$$Y_{ist} = \gamma_0 + \gamma_1 ENDS_{tax_{st}} + X_{ist}\beta + Z_{st}\delta + \alpha_s + \alpha_t + \epsilon_{ist} \quad (1)$$

- $Y_{ist}$ : Substance use (ENDS, marijuana, or harder drug) for individual  $i$  in state  $s$  in survey wave  $t$
- $ENDS_{tax_{st}}$ : ENDS tax per mL of nicotine measured in 2019 dollars
- $X_{imt}$ : Individual characteristics (gender, age, grade and race)
- $Z_{smt}$ : State characteristics
  - **Macroeconomic conditions:** Unemployment rate and poverty rate
  - **Substance use policies:** Tobacco 21 law, combustible cigarette excise tax, ENDS minimum legal sales age laws, indoor smoking restrictions, indoor ENDS restrictions, RML and MML, beer tax, Naloxone access laws, and prescription drug monitoring programs
- $\alpha_s$ : State fixed-effects
- $\alpha_t$ : Year fixed-effects

## First Stage: Youth ENDS use

**Table:** TWFE Estimates of Effect of ENDS Taxes on ENDS Use Among Youths, State YRBS 2015-2019

	(1)	(2)	(3)	(4)	(5)	(6)
ENDS Tax (\$)	-0.0345*** (0.0054)	-0.0363*** (0.0073)	-0.0675*** (0.0144)	-0.0659*** (0.0138)	-0.0642*** (0.0165)	-0.0761*** (0.0175)
N	499,839	499,839	499,839	499,839	499,839	499,839
Pre-Treat. Mean of MJ Use	0.2275	0.2275	0.2275	0.2275	0.2275	0.2275
State and Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls?	No	Yes	Yes	Yes	Yes	Yes
Macroeconomic Controls?	No	Yes	Yes	Yes	Yes	Yes
Tobacco Policy Control	No	No	Yes	Yes	Yes	Yes
Alcohol Policy Controls?	No	No	No	Yes	Yes	Yes
Marijuana Policy Controls?	No	No	No	No	Yes	Yes
Non-marijuana Drug Policy Controls?	No	No	No	No	No	Yes

*A one-dollar increase in e-cigarette taxes is associated with a 20 to 34% decline in ENDS use*

# Youth Marijuana Use, YRBS

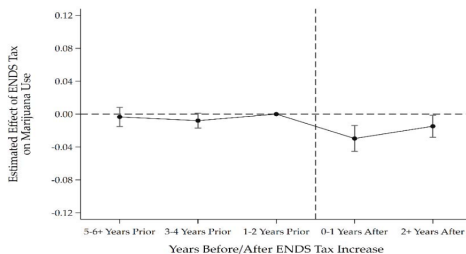
**Table:** Estimated Effects of ENDS Taxes on MJ Use Among Youths, State YRBS

	(1)	(2)	(3)	(4)	(5)	(6)
<b>Panel I: ENDS Use, 2015-2019</b>						
ENDS Tax (\$)	-0.0359*** (0.0057)	-0.0388*** (0.0075)	-0.0648*** (0.0142)	-0.0608*** (0.0137)	-0.0596*** (0.0164)	-0.0702*** (0.0177)
N	483,959	483,959	483,959	483,959	483,959	483,959
Pre-Treat. Mean of MJ Use	0.2275	0.2275	0.2275	0.2275	0.2275	0.2275
<b>Panel II: Marijuana Use, 2015-2019</b>						
ENDS Tax (\$)	-0.0225*** (0.0039)	-0.0206*** (0.0037)	-0.0115 (0.0071)	-0.0139** (0.0068)	-0.0154** (0.0075)	-0.0200*** (0.0067)
N	483,959	483,959	483,959	483,959	483,959	483,959
Pre-Treat. Mean of MJ Use	0.2092	0.2092	0.2092	0.2092	0.2092	0.2092
<b>Panel III: Marijuana Use, 2003-2019</b>						
ENDS Tax (\$)	-0.0216** (0.0094)	-0.0212** (0.0081)	-0.0241*** (0.0081)	-0.0243*** (0.0080)	-0.0239*** (0.0083)	-0.0238*** (0.0082)
N	1,194,048	1,194,048	1,194,048	1,194,048	1,194,048	1,194,048
Pre-Treat. Mean of MJ Use	0.2059	0.2059	0.2059	0.2059	0.2059	0.2059
State and Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls?	Yes	Yes	Yes	Yes	Yes	Yes
Macroeconomic Controls?	No	Yes	Yes	Yes	Yes	Yes
Tobacco Policy Control	No	No	Yes	Yes	Yes	Yes
Alcohol Policy Controls?	No	No	No	Yes	Yes	Yes
Marijuana Policy Controls?	No	No	No	No	Yes	Yes
Non-marijuana Drug Policy Controls?	No	No	No	No	No	Yes

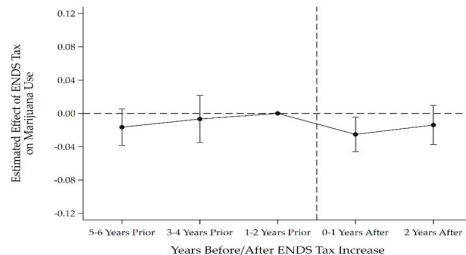
*A one-dollar increase in ENDS taxes leads to a  $\approx 10\%$  reduction in mj use*

# Youth Marijuana Use, YRBS

**Figure:** Dynamic Effects of ENDS Taxes on Marijuana Use Among Youths, 2003-2019



(a) TWFE Estimates



(b) Stacked DD Estimates

## Dual use of ENDS and Marijuana

**Table:** TWFE Estimates of the Effects of ENDS Taxes on Dual ENDS and Marijuana Use Among Youths, State YRBS 2015-2019

	(1)	(2)	(3)
ENDS Tax (\$)	-0.0219*** (0.0024)	-0.0183** (0.0078)	-0.0242*** (0.0064)
N	483,959	483,959	483,959
Pre-Treat. Mean of MJ Use	0.1166	0.1166	0.1166
State and Year FE?	Yes	Yes	Yes
Demographic Controls?	Yes	Yes	Yes
Macroeconomic Controls?	No	Yes	Yes
Tobacco Policy Control	No	Yes	Yes
Alcohol Policy Controls?	No	Yes	Yes
Marijuana Policy Controls?	No	Yes	Yes
Non-marijuana Drug Policy Controls?	No	No	Yes

*A one-dollar increase in ENDS taxes leads to a 20.8 percent reduction in the probability of ENDS use and marijuana use*

# Harder Drugs Use

**Table:** Effects of ENDS Taxes on Prevalence of Youth and Adult Substance Use, NSDUH 2002-2019 and State YRBS 2015-2019

	(1)	(2)	(3)	(4)
	Cocaine	Heroin	Meth	Cocaine or Heroin
	NSDUH	NSDUH	NSDUH	YRBS
<b>Panel I: Ages 12-to-17</b>				
ENDS Tax (\$)	-0.00006 (0.0004)	-0.00005 (0.0001)	-0.0004 (0.0004)	0.0016 (0.0056)
N	867	306	204	842,133
Pre-Treat. Mean DV	0.0107	0.0007	0.0017	0.0599
<b>Panel II: Ages 18-and-Older</b>				
ENDS Tax (\$)	0.0007 (0.0005)	-0.00001 (0.00068)	-0.00002 (0.00099)	-0.0311 (0.0186)
N	867	306	204	194,297
Pre-Treat. Mean DV	0.0211	0.00340	0.00663	0.1011

# Harder Drugs Use

**Table:** Effects of ENDS Taxes on Drug Treatment Admissions, TEDS 2000-2019

	(1)	(2)	(3)
	Non-Marijuana (Any)	Heroin (Primary)	Cocaine or Meth (Primary)
	TEDS	TEDS	TEDS
<b>Panel I: Ages 12-to-17</b>			
ENDS Tax (\$)	-0.141 (0.161)	-0.124 (0.320)	-0.165 (0.244)
N	996	996	996
Pre-Treat. Mean DV	0.800	0.0724	0.352
<b>Panel II: Ages 18-and-Older</b>			
ENDS Tax (\$)	-0.0712 (0.0542)	-0.0568 (0.112)	0.0317 (0.135)
N	996	996	996
Pre-Treat. Mean DV	4.722	1.55	1.65



# Heavier MJ Use

**Table:** Effects of ENDS Taxes on Drug Treatment Admissions and Marijuana Use, State YRBS 2003-2019 and TEDS 2000-2019

	(1) MJ Use < 3 Times vs No Use	(2) Ever MJ Use	(3) MJ Use 3+ Times	(4) MJ Use 10+ Times	(5) Marijuana (Primary)	(6) Marijuana (Any)
	YRBS	YRBS	YRBS	YRBS	TEDS	TEDS
<b>Panel I: Ages 12-to-17</b>						
ENDS Tax (\$)	-0.0160*** (0.0048)	-0.1023** (0.0512)	-0.0101* (0.0059)	-0.0014 (0.0028)	0.0149 (0.112)	-0.0361 (0.114)
N	939,937	864,649	1,072,980	1,072,980	996	996
Pre-Treat. Mean DV	0.124	0.353	0.073	0.080	3.996	4.865
<b>Panel II: Ages 18-and-Older</b>						
ENDS Tax (\$)	-0.0191* (0.0097)	-0.0884** (0.0439)	0.0007 (0.0071)	0.0151 (0.0136)	-0.0159 (0.0555)	-0.0531 (0.0681)
N	98,799	104,452	121,068	121,068	996	996
Pre-Treat. Mean DV	0.185	0.509	0.126	0.113	0.818	2.080

## Exploring the Income Effect

**Table:** Exploring an Income Effect of ENDS Taxes on Non-Alcoholic Drinks, Food, and Condom Use, BRFSS 2011-2019 and State YRBS 2003-2019

	(1)	(2)	(3)	(4)	(5)
<b>Panel I : BRFSS</b>					
	Any French Fries	Any Soda	Any Sugar Beverage	Any Juice	Any Fruit
ENDS Tax (\$)	-0.0148 (0.0126)	-0.1082 (0.0769)	-0.0134 (0.0519)	0.0242 (0.0187)	0.0088 (0.0064)
N	17507	7033	6982	43447	43344
Pre-Treat. Mean DV	0.924	0.798	0.782	0.697	0.692
<b>Panel II: State YRBS</b>					
	Soda Everyday	Milk Everyday	Veggie Everyday	No Condom Use	No Condom Use — Sex
ENDS Tax (\$)	0.00889 (0.01180)	0.01161 (0.00959)	0.01151 (0.00741)	0.00649 (0.00666)	-0.02105 (0.01517)
N	940,058	709,694	978,088	1,034,573	411,423
Pre-Treat. Mean DV	0.244	0.368	0.213	0.155	0.645

## Robustness and Sensitivity Tests

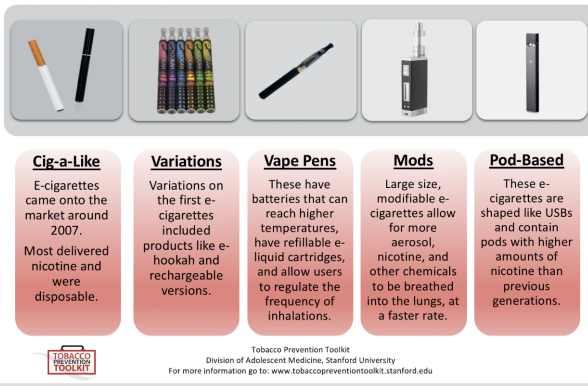
- The first stage is confirmed for young adults with BRFSS data: a one-dollar increase in ENDS taxes leads to a 2.2-3.1 percentage-point (16 to 23 percent) decline in prior-month ENDS use for individuals aged 18-to-20 and a 0.8-1.1 (9 to 13 percent) percentage-point decline for individuals aged 21-to-30.
- The negative effect on marijuana is confirmed when:
  - ① Use the National YRBS dataset
  - ② Control for border states taxes
  - ③ Control for state general sale tax
- Interactive Effects of Marijuana Policy Environment
- Heterogeneous analyses by gender, race, and age confirm the negative relationship for all demographic groups, except for Blacks.
- All main results are robust to the use of
  - ① Stacked DID estimators
  - ② Continuous event studies analysis

# Conclusion

- Evaluate spill-over effects of ENDS taxation on substance use
- First stage effects are in-line with earlier work
- Following a \$1.00  $\uparrow$ :
  - 1 20 to 34%  $\downarrow$  in teenage vaping and 13 to 23%  $\downarrow$  in young adults (18-to-30 years) vaping
  - 2 10%  $\downarrow$  in marijuana use among youth  $\rightarrow$  lighter margins of use
  - 3 No  $\Delta$  in harder drug use
- Evidence that marijuana is an economic complement to ENDS among youth & young adults
  - Income effects & risk signaling do not appear to drive relationship
  - Cannot fully rule out other channels
- No evidence that ENDS taxes affect more frequent MJ use, MJ-related drug treatment admissions, or use of harder drugs.

Thank you!  
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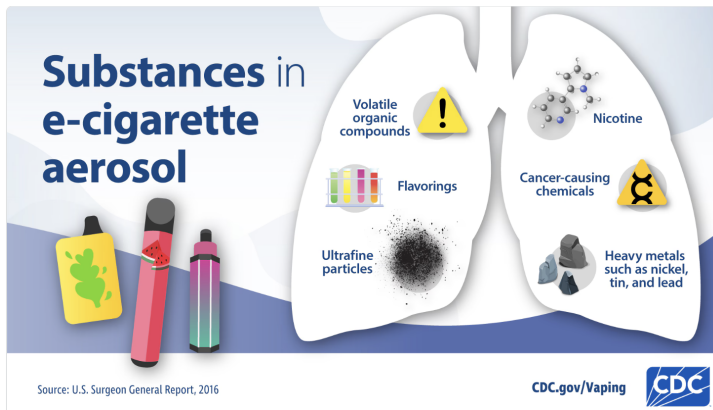
## E-Cigarettes & Vape Pens Generations



■ Source: Stanford Medicine, Stanford University

■ [Back](#)

# Substances found in e-cigarettes



■ Source: CDC

■ [Back](#)

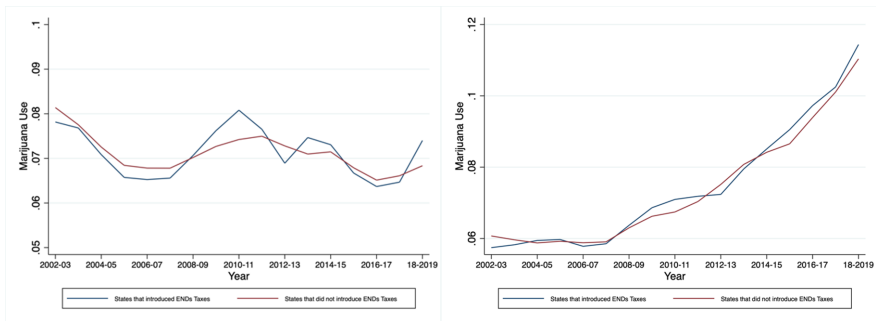
## First Stage: Youth ENDS use

**Table:** TWFE Estimates of Effect of ENDS Taxes on ENDS Use Among Youths, National YRBS 2015-2019

	(1)	(2)	(3)	(4)	(5)	(6)
ENDS Tax (\$)	-0.0701*** (0.0158)	-0.0689*** (0.0172)	-0.0846*** (0.0205)	-0.0612*** (0.0196)	-0.0712*** (0.0254)	-0.0535*** (0.0256)
N	39,153	39,153	39,153	39,153	39,153	39,153
Pre-Treat. Mean of MJ Use	0.2628	0.2628	0.2628	0.2628	0.2628	0.2628
State and Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls?	No	Yes	Yes	Yes	Yes	Yes
Macroeconomic Controls?	No	Yes	Yes	Yes	Yes	Yes
Tobacco Policy Control	No	No	Yes	Yes	Yes	Yes
Alcohol Policy Controls?	No	No	No	Yes	Yes	Yes
Marijuana Policy Controls?	No	No	No	No	Yes	Yes
Non-marijuana Drug Policy Controls?	No	No	No	No	No	Yes



# Trends in marijuana use among youth 12–17 & adults 18+



■ Data source: NSDUH 2002–2019

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# Heterogeneities

**Figure:** Heterogeneity in the Effects of ENDS Taxes on Marijuana Use Among Youths, State YRBS 2003-2019

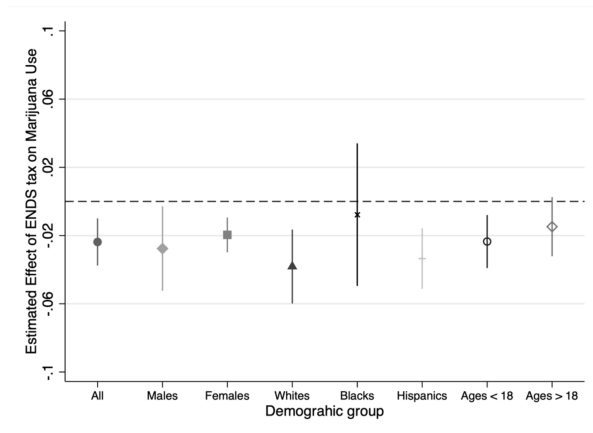


Table: Descriptive Statistics of Main Outcome Variables

	Mean	Standard Deviation	N
State YRBS			
E-cigarette use	0.211	0.408	499,839
Marijuana Use	0.199	0.399	1,194,048
BRFSS			
ENDS Use, 18-20	0.135	0.342	25,653
ENDS Use, 21-30	0.081	0.272	104,943
ENDS Use, 31+	0.027	0.161	1,011,642
TEDS			
Primary Marijuana-Related Admissions, 12-17	3.335	0.092	996
Primary Marijuana-Related Admissions, 18+	0.867	0.029	996