The Effects of Tobacco 21 Policies on Smoking and Vaping: Evidence from Panel Data and Biomarkers

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T21 Laws

- **T21 Laws:** raise the minimum age of sale of all tobacco and nicotine products to 21 years old
- The general concept of T21 laws is that restricting the legal purchasing age will:
  - reduce access to all tobacco products during the critical youth initiation phase
  - reduce downstream adult smoking and vaping
- Understanding how well these policies work is important to having well-formulated tobacco product regulation
- In December 2019, a national T21 law was implemented
  - *Earlier T21 laws passed by 16 states and the District of Columbia*

State	*Effective Date*
Hawaii*	1/1/2016
California*	6/9/2016
District of Columbia*	2/18/2017
New Jersey	11/1/2017
Oregon*	1/1/2018
Maine*	7/1/2018
Massachusetts	12/31/2018
Illinois	7/1/2019
Virginia*	7/1/2019
Delaware	7/16/2019
Arkansas*	9/1/2019
Texas*	9/1/2019
Vermont	9/1/2019
Connecticut*	10/1/2019
Maryland*	10/1/2019
Ohio	10/16/2019
New York	11/13/2019

Specific Research Questions:

1. How do T21 laws impact those explicitly treated?
2. Are there spillovers onto adolescents via social networks?
3. How is the behavior of those formerly treated affected?
4. How is avoidance (shopping) behavior affected?
5. What are the net effects on overall tobacco/nicotine consumption?

Past Work – T21 laws

- Bryan, Hansen, McNichols, and Sabia (2021)
  - Using BRFSS: find T-21 laws are associated with decline in smoking participation among 18-to-20-year-olds
  - Using YBRSS: find that T-21 laws reduce
    - cigarette consumption among 16-to-18-year-olds
    - reduction in e-cigarette use among 18-year-olds
- Abouk, De, and Pesko (2021)
  - Using Monitoring the Future:
    - find that T21 laws reduce cigarette use among 8^{th}, 10^{th}, and 12^{th} graders
    - Also find some evidence that T21 laws reduce e-cigarette use across all grades

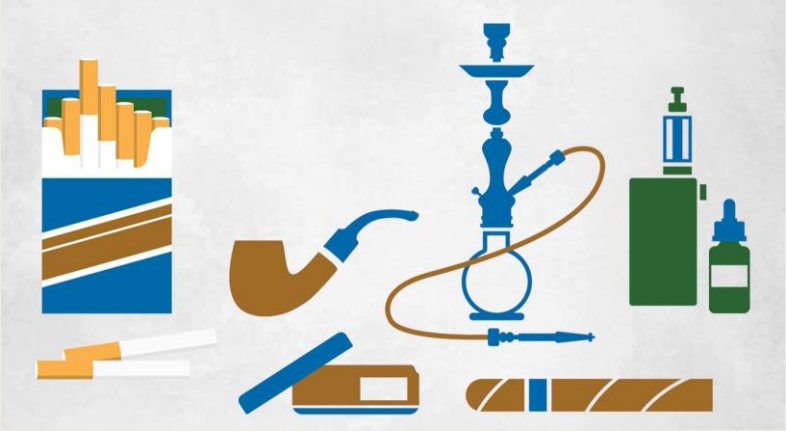
Limitations

- Prior work faces constraints imposed by the nature of the data available & employed

- For example:
  - *Cross-sectional data structures*
    - prevent explicitly gauging how T21 laws impact **within-person behaviors**
    - are unable to rule out that estimated behavioral changes are an **artifact of changes in sample composition**
    - Make it difficult to investigate the effects of T21 policies on **formerly treated individuals**
  - *Measurement error may not be classical*
    - self–reported data
  - *Understanding **"net behavioral" effects** can be challenging*

PATH Population Assessment of Tobacco and Health

A collaboration between the NIH and FDA

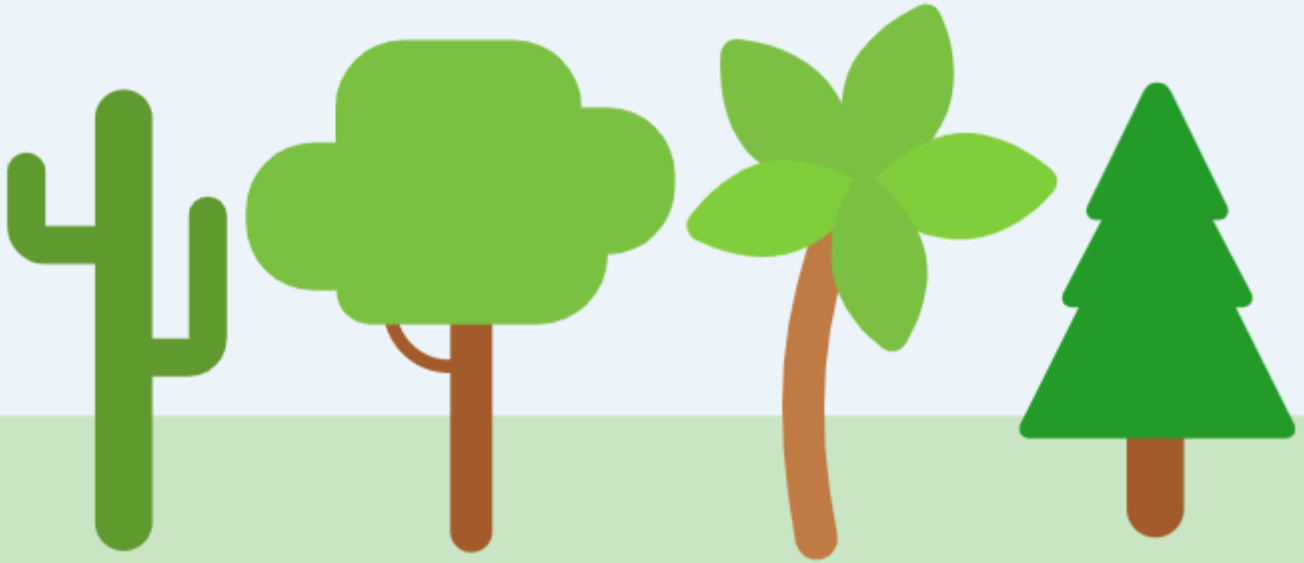


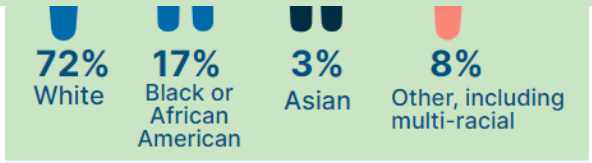
- **PATH** is a longitudinal study of tobacco use and health (accessed through the ICPSR VDE):
  - We observe 5 adult waves, 6 youth waves from 2013-2019
  - Over 234,000 observations of ~65,000 unique individuals
  - Includes adults aged 18-90 and youths aged 12-17; matched over time
  - Individuals from all 50 states and the District of Columbia
    - *although coverage in some states is exceedingly low*
- The average participant appears in the data set 4.3 times and approximately 60% of participants appear 5 times or more
- PATH includes detailed demographic data: sex, race, ethnicity, household income categories, educational attainment categories, and individual's age

PATH Population A of Tobacco

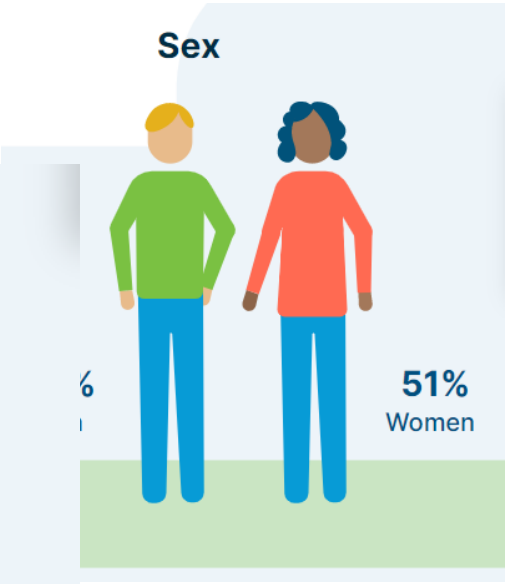
A collaboration between the NIH and FDA

Geography

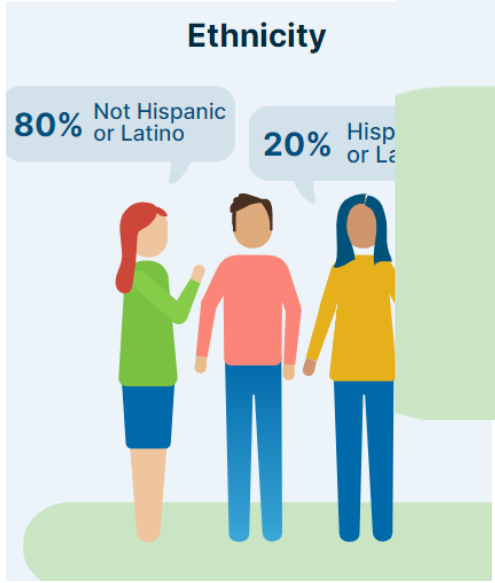




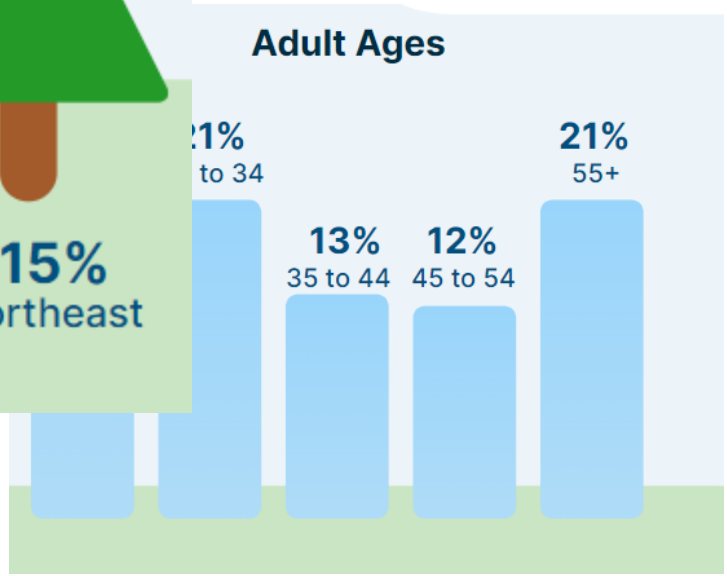
Sex

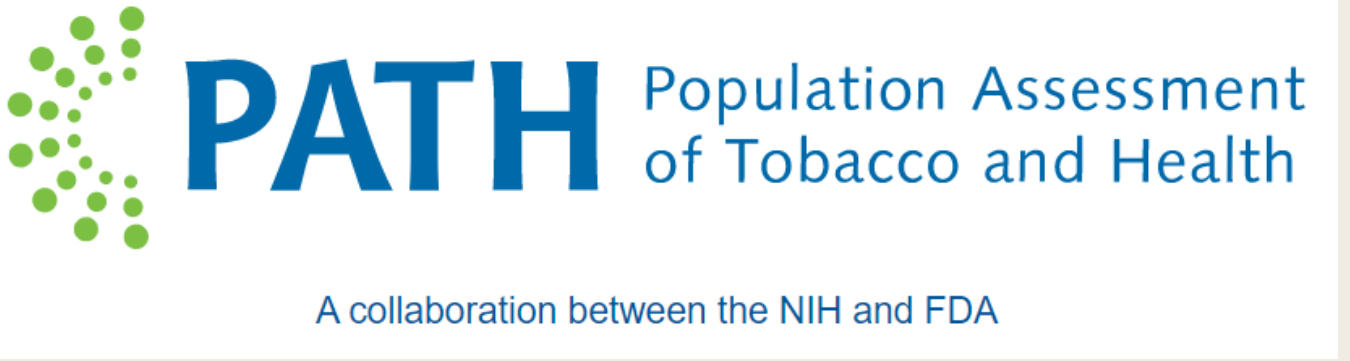


Ethnicity



Adult Ages





- <u>PATH contains:</u>
  - ***self-reported information about tobacco use***
    - This includes measures of whether individuals currently use cigarettes and e-cigarettes, other products, shopping behaviors, etc.
  - *urine samples from a subset of individuals and measures a wide variety of* ***biomarker compounds.***
    - **Cotinine**, a major metabolite of nicotine
    - **NNAL**, which belongs to family of chemicals found only in tobacco and tobacco products.
      - *NNAL provides comprehensive measures of total recent tobacco exposure*
      - *Urinary levels of NNAL among exclusive vapers are very similar to non-smokers (Bustamante 2018)*

Contribution

- Use longitudinal data set of tobacco use and related outcomes to measure:
  - Within-person behavioral response to T21
    - Young adults 18-20
    - Adolescents 12-17
  - Able to observe tobacco use behaviors of those formerly treated after they “age out”
  - Able to observe changes in avoidance (shopping) behaviors
  - Use biomarker data to:
    - Attempt to gauge “overall” effects more comprehensively
    - Compare results to self-reported outcomes; help alleviate/investigate non-classical measurement error

Analytical Sample

- In constructing our analytical sample, we begin by restricting the data to those 12-to-25 years of age
  - *This reduces the sample to 131,455 observations of 39,211 individuals of interest.*

Analytical Sample

PATH Limitations

- First, state representation:
  - *Seven low-population/rural states have very low representation in the survey (AK, DE, ND, RI, SD, VT, and WY) had collectively only 99 total observations, and were dropped.*
- Second, PATH does not provide sub-state geographical identifiers:
  - *Seven treated states (IL, KS, MA, MO, NJ, NY, and OH) had prior sub-state T21 laws; those residing in these states were dropped.*

Analytical Sample

- This leaves us with a **baseline analytical sample** of:
  - *approximately 107,000 observations across 36 states (plus D.C.)*
  - *10 treatment states*

Other Tobacco Control Policies

- **Cigarette excise taxes** (federal + state)
- **Indicator for an e-cigarette tax**
- **Indicator legal recreational marijuana**
- **Minimum legal purchasing age for e-cigarettes lower than 21**
- **State unemployment rates** (to account for variation in economic activities)

DDD models w/ Individual FEs

$$Y_{i,s,yq} = \alpha + \delta T21_{s,yq} + \sigma_{i,yq} + \boldsymbol{\delta_{u18} T21_{s,yq} \times ageu18_{i,yq}} + \boldsymbol{\delta_{1820} T21_{s,yq} \times age1820_{i,yq}} + \beta X_{s,yq} + \gamma Z_{c,yq} + u_i + \tau_{yq} + \epsilon_{i,s,yq}$$

- Y is individual's smoking or vaping participation (last 30 days), or biomarker measure
- All models include individual fixed effects and time period (year-quarter) fixed effects
- **Vector X** is public policies and state controls that may affect smoking or vaping:
  - *Cigarettes taxes, minimum legal purchasing age for e-cigarettes, the presence of an e-cigarette tax, an indicator legal recreational marijuana, and state UR*
- **Vector Z** contains time varying individual-level demographic characteristics:
  - *This reduces to only age measures and an indicator variable if a 21+ year old survey participant was formerly treatment by a T21 law*
- All standard errors are clustered at the state-level

Results

Self-Reported Behaviors

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	(1)	(2)
	Smoking Participation	*Vaping Participation*
T21 Law * 18-to-20 yr old T21 Law * 12-to-17 yr old Tobacco 21 Law Formerly Treated		
Pre-Treat DV Mean (18 - 20) Pre-Treat DV Mean (12 - 17)		
Observations		
Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Additionally, all models include individual, year-by-quarter fixed-effects, and utilize sample weights.		

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	(1)	(2)
	Smoking Participation	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.028**	
	(0.011)	
T21 Law * 12-to-17 yr old	-0.001	
	(0.008)	
Tobacco 21 Law	-0.001	
	(0.006)	
Formerly Treated	-0.011	
	(0.015)	
Pre-Treat DV Mean (18 - 20)	0.192	
Pre-Treat DV Mean (12 - 17)	0.026	
Observations	107,410	

Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Additionally, all models include individual, year-by-quarter fixed-effects, and utilize sample weights.

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	(1)	(2)
	Smoking Participation	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.028**	-0.029
	(0.011)	(0.024)
T21 Law * 12-to-17 yr old	-0.001	-0.017
	(0.008)	(0.013)
Tobacco 21 Law	-0.001	0.015
	(0.006)	(0.014)
Formerly Treated	-0.011	-0.017
	(0.015)	(0.014)
Pre-Treat DV Mean (18 - 20)	0.192	0.151
Pre-Treat DV Mean (12 - 17)	0.026	0.040
Observations	107,410	107,052

Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Additionally, all models include individual, year-by-quarter fixed-effects, and utilize sample weights.

Self-Reported Behaviors (Sub-Groups)

1. Are there heterogeneous effects across sub-groups?
2. Any evidence this is about initiation or cessation?

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	Wave 1 Non-Users Sample		***Wave 1 Users Sample***	
	Smoking Participation	*Vaping Participation*	*Smoking Participation*	*Vaping Participation*
T21 Law * 18-to-20 yr old T21 Law * 12-to-17 yr old Tobacco 21 Law Formerly Treated				
Pre-Treat DV Mean (18 - 20) Pre-Treat DV Mean (12 - 17)				
Observations				

Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Additionally, all models include individual, year-by-quarter fixed-effects, and utilize sample weights.

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

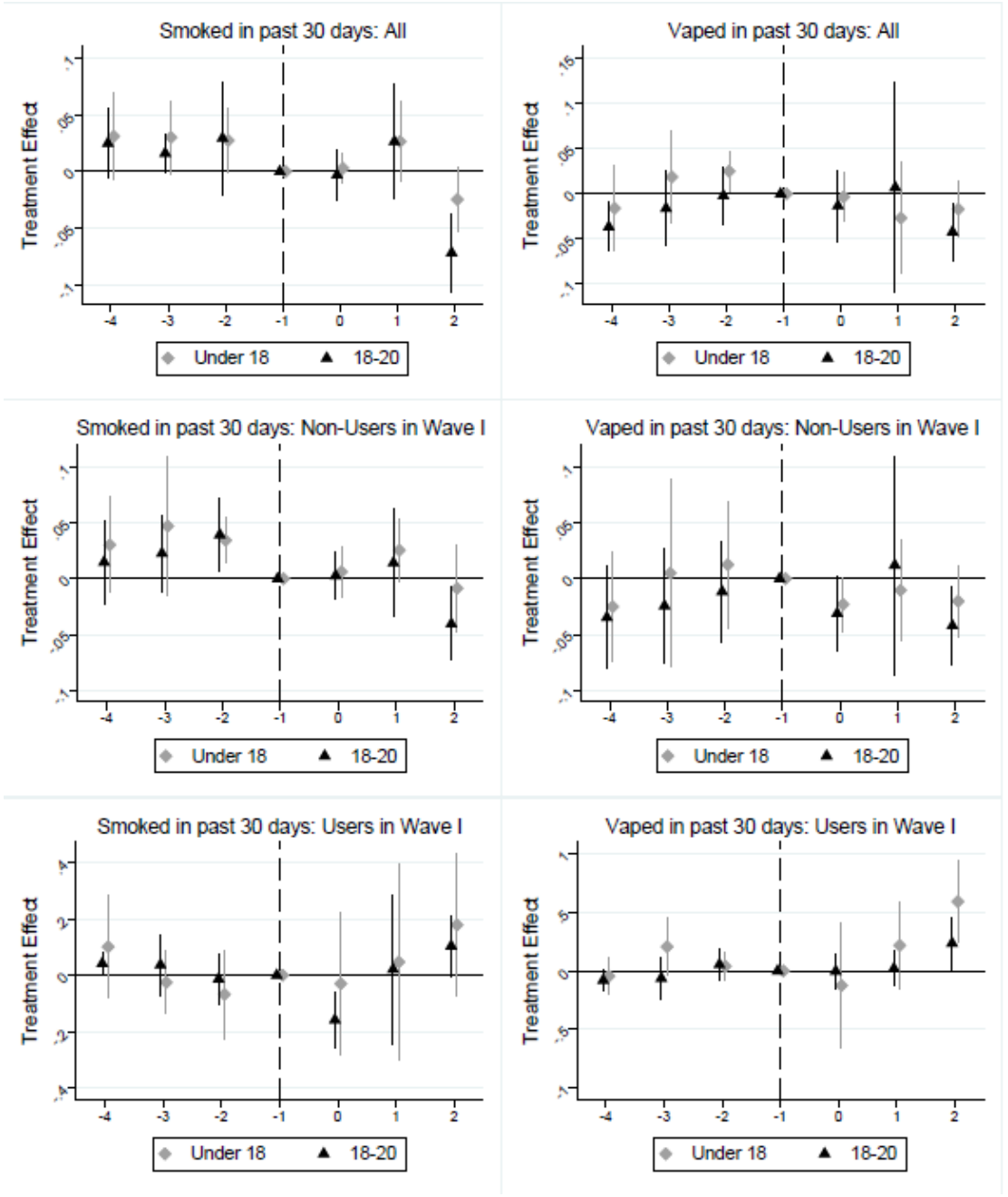
	Wave 1 Non-Users Sample		***Wave 1 Users Sample***	
	Smoking Participation	*Vaping Participation*	*Smoking Participation*	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.018**	-0.036		
	(0.009)	(0.026)		
T21 Law * 12-to-17 yr old	-0.001	-0.023		
	(0.009)	(0.015)		
Tobacco 21 Law	-0.006	0.017		
	(0.007)	(0.014)		
Formerly Treated	-0.032**	-0.039***		
	(0.013)	(0.011)		
Pre-Treat DV Mean (18 - 20)	0.087	0.097		
Pre-Treat DV Mean (12 - 17)	0.018	0.030		
Observations	60,860	60,730		

Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Additionally, all models include individual, year-by-quarter fixed-effects, and utilize sample weights.

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	Wave 1 Non-Users Sample		***Wave 1 Users Sample***	
	Smoking Participation	*Vaping Participation*	*Smoking Participation*	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.018**	-0.036	-0.074	-0.001
	(0.009)	(0.026)	(0.057)	(0.054)
T21 Law * 12-to-17 yr old	-0.001	-0.023	0.051	-0.131
	(0.009)	(0.015)	(0.114)	(0.169)
Tobacco 21 Law	-0.006	0.017	-0.030	0.125***
	(0.007)	(0.014)	(0.028)	(0.043)
Formerly Treated	-0.032**	-0.039***	-0.021	0.016
	(0.013)	(0.011)	(0.038)	(0.067)
Pre-Treat DV Mean (18 - 20)	0.087	0.097	0.823	0.641
Pre-Treat DV Mean (12 - 17)	0.018	0.030	0.781	0.663
Observations	60,860	60,730	11,060	5,336

Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Additionally, all models include individual, year-by-quarter fixed-effects, and utilize sample weights.


Smoked in past 30 days: All
Vaped in past 30 days: All
Smoked in past 30 days: Non-Users in Wave I
Vaped in past 30 days: Non-Users in Wave I
Smoked in past 30 days: Users in Wave I
Vaped in past 30 days: Users in Wave I
Treatment Effect
Under 18
18-20

Differences by Sex?

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	(1)	(2)	(3)	(4)
	Smoking Participation		***Vaping Participation***	
	Males	*Females*	*Males*	*Females*
T21 Law * 18-to-20 yr old T21 Law * 12-to-17 yr old Tobacco 21 Law Formerly Treated				
Pre-Treat DV Mean (18 - 20) Pre-Treat DV Mean (12 - 17)				
Observations				
Note: Same model specification as prior estimates				

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	(1)	(2)	(3)	(4)
	Smoking Participation		***Vaping Participation***	
	Males	*Females*	*Males*	*Females*
T21 Law * 18-to-20 yr old	-0.056***	0.003	-0.042*	-0.021
	(0.016)	(0.019)	(0.025)	(0.030)
T21 Law * 12-to-17 yr old	-0.014	0.014	-0.011	-0.025
	(0.012)	(0.016)	(0.013)	(0.019)
Tobacco 21 Law	0.009	-0.011	0.013	0.018
	(0.010)	(0.011)	(0.014)	(0.018)
Formerly Treated	0.011	-0.033	-0.049*	0.009
	(0.016)	(0.027)	(0.026)	(0.028)
Pre-Treat DV Mean (18 - 20)	0.228	0.155	0.181	0.120
Pre-Treat DV Mean (12 - 17)	0.028	0.025	0.043	0.037
Observations	54,557	52,601	54,375	52,425
Note: Same model specification as prior estimates				

PATH: Shopping Measures

- PATH asks self-reported smokers whether they purchase their own cigarettes
- PATH asks people who purchase their own cigarettes about where they are purchased
  - *i.e., in the state they reside or another state*
- Use this information to examine the effects of T21 laws on how individuals buy their cigarettes

Estimates of the Effect of Tobacco 21 Laws on Shopping Behaviors

	(1)	(2)
	Purchasing Own Cigarettes	
T21 Law * 18-to-20 yr old T21 Law * 12-to-17 yr old Tobacco 21 Law		
Pre-Treat DV Mean (18 - 20) Pre-Treat DV Mean (12 - 17)		
Observations		

Notes: Sample in column (1) includes only individuals who were reported as smokers, and the sample in column (2) is made up of individuals who reported they bought their own cigarettes. All models include age, individual, and year-by-quarter fixed-effects, measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. All models use sample weights. Additionally, the sample includes 36 states and the District of Columbia, among which 10 states (see Appendix Table 1) implemented a Tobacco 21 law during the estimation period. Robust standard errors clustered by state are in parentheses.

Estimates of the Effect of Tobacco 21 Laws on Shopping Behaviors

	(1)	(2)
	Purchasing Own Cigarettes	
T21 Law * 18-to-20 yr old		
T21 Law * 12-to-17 yr old		
Tobacco 21 Law		
Pre-Treat DV Mean (18 - 20)	0.839	
Pre-Treat DV Mean (12 - 17)	0.227	
Observations	13,008	

Notes: Sample in column (1) includes only individuals who were reported as smokers, and the sample in column (2) is made up of individuals who reported they bought their own cigarettes. All models include age, individual, and year-by-quarter fixed-effects, measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. All models use sample weights. Additionally, the sample includes 36 states and the District of Columbia, among which 10 states (see Appendix Table 1) implemented a Tobacco 21 law during the estimation period. Robust standard errors clustered by state are in parentheses.

Estimates of the Effect of Tobacco 21 Laws on Shopping Behaviors

	(1)	(2)
	Purchasing Own Cigarettes	
T21 Law * 18-to-20 yr old	-0.328***	
	(0.123)	
T21 Law * 12-to-17 yr old	-0.119	
	(0.125)	
Tobacco 21 Law	0.001	
	(0.034)	
Pre-Treat DV Mean (18 - 20)	0.839	
Pre-Treat DV Mean (12 - 17)	0.227	
Observations	13,008	

Notes: Sample in column (1) includes only individuals who were reported as smokers, and the sample in column (2) is made up of individuals who reported they bought their own cigarettes. All models include age, individual, and year-by-quarter fixed-effects, measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. All models use sample weights. Additionally, the sample includes 36 states and the District of Columbia, among which 10 states (see Appendix Table 1) implemented a Tobacco 21 law during the estimation period. Robust standard errors clustered by state are in parentheses.

Estimates of the Effect of Tobacco 21 Laws on Shopping Behaviors

	(1)	(2)
	Purchasing Own Cigarettes	*Among those who buy their own Cigarettes, buy in Own State*
T21 Law * 18-to-20 yr old	-0.328***	
	(0.123)	
T21 Law * 12-to-17 yr old	-0.119	
	(0.125)	
Tobacco 21 Law	0.001	
	(0.034)	
Pre-Treat DV Mean (18 - 20)	0.839	0.966
Pre-Treat DV Mean (12 - 17)	0.227	0.944
Observations	13,008	10,222

Notes: Sample in column (1) includes only individuals who were reported as smokers, and the sample in column (2) is made up of individuals who reported they bought their own cigarettes. All models include age, individual, and year-by-quarter fixed-effects, measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. All models use sample weights. Additionally, the sample includes 36 states and the District of Columbia, among which 10 states (see Appendix Table 1) implemented a Tobacco 21 law during the estimation period. Robust standard errors clustered by state are in parentheses.

Estimates of the Effect of Tobacco 21 Laws on Shopping Behaviors

	(1)	(2)
	Purchasing Own Cigarettes	*Among those who buy their own Cigarettes, buy in Own State*
T21 Law * 18-to-20 yr old	-0.328***	-0.255***
	(0.123)	(0.103)
T21 Law * 12-to-17 yr old	-0.119	0.029
	(0.125)	(0.123)
Tobacco 21 Law	0.001	-0.020
	(0.034)	(0.014)
Pre-Treat DV Mean (18 - 20)	0.839	0.966
Pre-Treat DV Mean (12 - 17)	0.227	0.944
Observations	13,008	10,222

Notes: Sample in column (1) includes only individuals who were reported as smokers, and the sample in column (2) is made up of individuals who reported they bought their own cigarettes. All models include age, individual, and year-by-quarter fixed-effects, measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. All models use sample weights. Additionally, the sample includes 36 states and the District of Columbia, among which 10 states (see Appendix Table 1) implemented a Tobacco 21 law during the estimation period. Robust standard errors clustered by state are in parentheses.

Biomarkers

- PATH also collects urine, and the corresponding biomarker data, from a sub-sample of survey participants
- Included in this data are individual measures of several tobacco and nicotine-derived metabolites
- We focus on two:
  - ***Cotinine**, a biomarker of recent nicotine exposure*
  - ***NNAL**, a biomarker of recent exposure to tobacco*

Biomarkers - Limitations

- PATH only collected biomarker data on youth (12-to-17) during Wave 1, so **the youth sample is not included** in the biomarker sample
- PATH only collected biomarker data from a sub-sample of approximately 11,500 adults, of which only **~4,000 are 18-to-25 years old**
  - *These adults were selected from a diverse mix of six tobacco product use groups representing never, current, and recent former (within 12 months) users of tobacco products.*
- Lastly, owning to **sub-state implementation** of T21 laws, survey participants residing in these states once again are excluded
- This leaves us with a relatively small analytical sample of approximately **3,200 unique individuals** with whom to study over time

Estimates of the Effect of Tobacco 21 Laws on Biomarker Measures

	(1)	(2)	(3)
PANEL A: Cotinine	*All Participants*	*Wave 1 Non-Users*	*Wave 1 Users*
T21 Law * 18-to-20 yr old Tobacco 21 Law			
Pre-Treat DV Mean (18 - 20)			
Observations			
PANEL B: NNAL	*All Participants*	*Wave 1 Non-Users*	*Wave 1 Users*
T21 Law * 18-to-20 yr old Tobacco 21 Law			
Pre-Treat DV Mean (18 - 20)			
Observations			

Estimates of the Effect of Tobacco 21 Laws on Biomarker Measures

	(1)	(2)	(3)
PANEL A: Cotinine	*All Participants*	*Wave 1 Non-Users*	*Wave 1 Users*
T21 Law * 18-to-20 yr old	-275.9*	-138.1**	-436.3
	(155.6)	(67.0)	(346.4)
Tobacco 21 Law	-60.9	-9.8	-97.5
	(53.4)	(41.2)	(141.1)
Pre-Treat DV Mean (18 - 20)	410.5	87.6	1185.1
Observations	9,005	3,697	5,303
PANEL B: NNAL	*All Participants*	*Wave 1 Non-Users*	*Wave 1 Users*
T21 Law * 18-to-20 yr old			
Tobacco 21 Law			
Pre-Treat DV Mean (18 - 20)			
Observations			

Estimates of the Effect of Tobacco 21 Laws on Biomarker Measures

	(1)	(2)	(3)
PANEL A: Cotinine	*All Participants*	*Wave 1 Non-Users*	*Wave 1 Users*
T21 Law * 18-to-20 yr old	-275.9*	-138.1**	-436.3
	(155.6)	(67.0)	(346.4)
Tobacco 21 Law	-60.9	-9.8	-97.5
	(53.4)	(41.2)	(141.1)
Pre-Treat DV Mean (18 - 20)	410.5	87.6	1185.1
Observations	9,005	3,697	5,303
PANEL B: NNAL	*All Participants*	*Wave 1 Non-Users*	*Wave 1 Users*
T21 Law * 18-to-20 yr old	-0.009	-0.01	-0.005
	(0.018)	(0.007)	(0.045)
Tobacco 21 Law	-0.019***	-0.015**	-0.029**
	(0.006)	(0.005)	(0.012)
Pre-Treat DV Mean (18 - 20)	0.034	0.014	0.084
Observations	8,178	3,294	4,880

Why isn’t there a tobacco effect?

- Could it be because of substitution toward other tobacco products?
  - *smokeless tobacco, pipes, cigars, etc.*
- T21 law affects access to **all** tobacco products, so meaningful substitution to these alternative products seems unlikely
- Nevertheless, if other tobacco containing products affect our results, we rerun our models including a measure for whether individuals self-report use of any of these other products in the last 30 days
- Results are unchanged

Why isn’t there a tobacco effect?

- Could it be because the Biomarkers sample is a small sub-sample?

- In order to investigate, we re-estimate the overall self-reported specifications with the sample used in the analysis of biomarkers

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	Wave 1 Non-Users Sample			
	Full Sample (presented earlier)		***Biomarkers Sample***	
	Smoking Participation	*Vaping Participation*	*Smoking Participation*	*Vaping Participation*
T21 Law * 18-to-20 yr old Tobacco 21 Law				
Pre-Treat DV Mean (18 - 20)				
Observations				
Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Robust standard errors clustered by state are in parentheses.				

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	Wave 1 Non-Users Sample			
	Full Sample (presented earlier)		***Biomarkers Sample***	
	Smoking Participation	*Vaping Participation*	*Smoking Participation*	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.018** (0.009)	-0.036 (0.026)		
Tobacco 21 Law	-0.006 (0.007)	0.017 (0.014)		
Pre-Treat DV Mean (18 - 20)	0.087	0.097		
Observations	60,860	60,730		

Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Robust standard errors clustered by state are in parentheses.

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use

	Wave 1 Non-Users Sample			
	Full Sample (presented earlier)		***Biomarkers Sample***	
	Smoking Participation	*Vaping Participation*	*Smoking Participation*	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.018** (0.009)	-0.036 (0.026)	-0.054** (0.025)	-0.087* (0.049)
Tobacco 21 Law	-0.006 (0.007)	0.017 (0.014)	0.029* (0.017)	0.030 (0.031)
Pre-Treat DV Mean (18 - 20)	0.087	0.097	0.044	0.026
Observations	60,860	60,730	3702	3693

Notes: All models include an indicator variable for the presence of a Tobacco 21 law, an indicator if the PATH survey participant was 12-to-17 years old or 18-to-20 years old, and the corresponding policy/age interactions (as shown above). All models also include controls for participant age, and also include measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. Robust standard errors clustered by state are in parentheses.

Why isn't there a tobacco effect?

- Could it be because self-reporting smoking status is related T21 policy treatment?
  - *This would lead one to estimate a reduction in self-reported smoking participation but observe no reduction in NNAL levels.*
- We re-estimate self-reported outcomes, but only for individuals where the biomarkers themselves clearly indicate that the survey participant is a smoker or vaper (but not smoker).
- We measure the effect of T21 laws on self-reported cigarette or e-cigarette use among a sample of clinically defined users.

Why isn’t there a tobacco effect?

- Using the clinical literature as a guide (Goniewicz et al. 2011, Benowitz et al. 2018):
  - We define smokers as individuals with a measured NNAL level **over** 0.030 ng/ml (30 pg/ml)
  - We define non-smoker vapers as individuals with an NNAL **under** 0.025 ng/ml but with a cotinine level **above** 25 ng/ml.

Estimates of the Effect of Tobacco 21 Laws on the Likelihood of Self-Reporting

	(1)	(2)
	Smoking Participation	*Vaping Participation*
T21 Law * 18-to-20 yr old Tobacco 21 Law		
Pre-Treat DV Mean (18 - 20)		
Observations		

Notes: Sample in column (1)includes only participants who had a urine NNAL level of greater than or equal to 0.030 ng/ml. Sample in column (2) includes only participants who had a urine cotinine level of greater than or equal to 25 ng/ml but NNAL levels below 0.025 ng/ml. All models include age, individual, and year-by-quarter fixed-effects, measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. All models use sample weights.

Estimates of the Effect of Tobacco 21 Laws on the Likelihood of Self-Reporting

	(1)	(2)
	Smoking Participation	*Vaping Participation*
T21 Law * 18-to-20 yr old		0.152
		(0.386)
Tobacco 21 Law		0.035
		(0.035)
Pre-Treat DV Mean (18 - 20)		0.442
Observations		221

Notes: Sample in column (1)includes only participants who had a urine NNAL level of greater than or equal to 0.030 ng/ml. Sample in column (2) includes only participants who had a urine cotinine level of greater than or equal to 25 ng/ml but NNAL levels below 0.025 ng/ml. All models include age, individual, and year-by-quarter fixed-effects, measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. All models use sample weights.

Estimates of the Effect of Tobacco 21 Laws on the Likelihood of Self-Reporting

	(1)	(2)
	Smoking Participation	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.515*	0.152
	(0.263)	(0.386)
Tobacco 21 Law	-0.108	0.035
	(0.065)	(0.035)
Pre-Treat DV Mean (18 - 20)	0.795	0.442
Observations	748	221

Notes: Sample in column (1)includes only participants who had a urine NNAL level of greater than or equal to 0.030 ng/ml. Sample in column (2) includes only participants who had a urine cotinine level of greater than or equal to 25 ng/ml but NNAL levels below 0.025 ng/ml. All models include age, individual, and year-by-quarter fixed-effects, measures of per pack excise tax on cigarettes, the minimum legal purchasing age for e-cigarettes (if below 21 years old), the presence of an e-cigarette tax, an indicator for the legalization of recreational marijuana, and state unemployment rates. All models use sample weights.

Given negative T21 effects on self-reported smoking status are largely driven by those who were initially not users, suggests those who were not smokers when first interviewed are less likely to honestly admit their smoking behaviors once tobacco purchases are made illegal

Summary Findings: Self-Reports

- Evidence suggests T21 laws associated with:
  1. ***Reduced smoking participation*** *among:*
     - 18-to-20-year-olds
       - *Wave I non-users*
       - *Males*
     - Those formerly treated
  2. ***Reduced vaping participation*** *among:*
     - Males
     - Those formerly treated

  3. ***Increase in Surrogate & Cross-Border shopping*** *to avoid T21 restrictions*

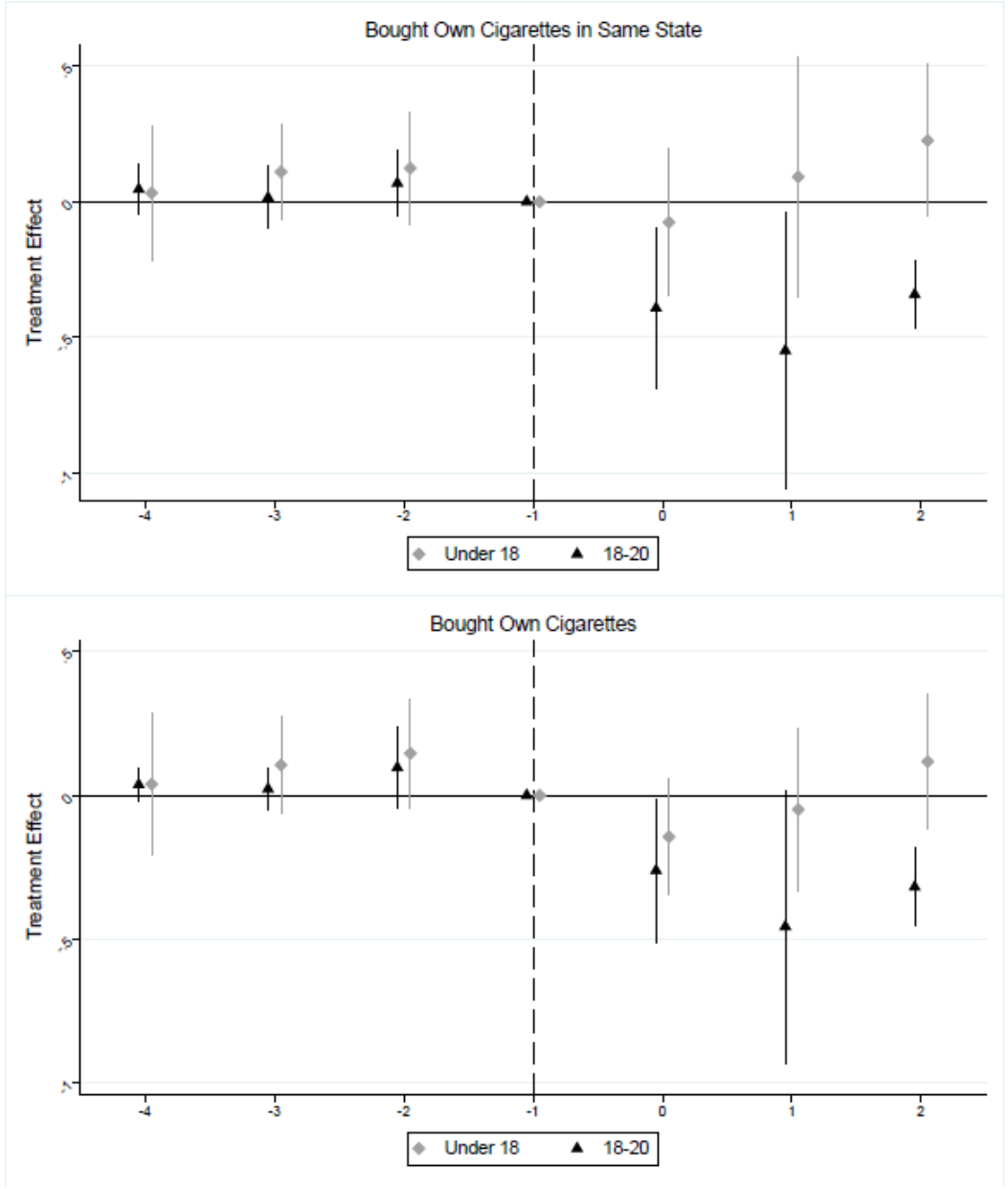
Summary Findings: Biomarkers

- Evidence suggests T21 laws associated with:

1. ***Reduced Nicotine consumption (cotinine)***
2. *But* ***no change in Tobacco consumption (NNAL)***
3. *Investigation reveals the inconsistency between the self-reports and biomarkers may be due to the* ***reduction in likelihood smokers are honest in reporting*** *after treated with T21 laws*

Thank you

- *Questions?*


Bought Own Cigarettes in Same State
Treatment Effect
.5
0
-.5
-1
-4
-3
-2
-1
0
1
2
Under 18
18-20
Bought Own Cigarettes
Treatment Effect
.5
0
-.5
-1
-4
-3
-2
-1
0
1
2
Under 18
18-20

Background and Motivation

- Economic theory suggests tobacco control policies should reduce smoking prevalence and/or the quantity of cigarettes smoked
- Empirically understanding the comprehensive effects of different tobacco control policies on the demand for different tobacco products is critically important to developing sound public policy that leads to the desired public health outcomes
- Particularly salient among adolescents and young adult
  - mean age of smoking initiation of approximately 15-16 years old (CDC 2014)
- Complexities of youth smoker access to tobacco:
  - Obtaining product via social networks (Hansen, Rees, and Sabia, 2013)
  - and having time-inconsistent preferences (Crettez and Deloche, 2020)
- Developing a comprehensive understanding into how adolescents and young adults respond to tobacco control policies is of utmost importance

Analytical Sample: California

- California dominates treatment observations
- Approximately 82 percent of all treated live in California

State	*Effective Date*
Hawaii*	1/1/2016
California*	6/9/2016
District of Columbia*	2/18/2017
New Jersey	11/1/2017
Oregon*	1/1/2018
Maine*	7/1/2018
Massachusetts	12/31/2018
Illinois	7/1/2019
Virginia*	7/1/2019
Delaware	7/16/2019
Arkansas*	9/1/2019
Texas*	9/1/2019
Vermont	9/1/2019
Connecticut*	10/1/2019
Maryland*	10/1/2019
Ohio	10/16/2019
New York	11/13/2019

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use: CA Treatment Only

	(1)	(2)
	All Participants Sample	
	Smoking Participation	*Vaping Participation*
T21 Law * 18-to-20 yr old T21 Law * 12-to-17 yr old Tobacco 21 Law Formerly Treated		
T21 Law * 18-to-20 yr old (Bootstrap p-value) T21 Law * 12-to-17 yr old (Bootstrap p-value)		
Pre-Treat DV Mean (18 - 20) Pre-Treat DV Mean (12 - 17)		
Observations		
Note: Same model specification as prior estimates		

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use: CA Treatment Only

	(1)	(2)
	All Participants Sample	
	Smoking Participation	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.036***	-0.051***
	(0.012)	(0.012)
T21 Law * 12-to-17 yr old	-0.007	-0.028***
	(0.010)	(0.010)
Tobacco 21 Law	-0.001	0.027***
	(0.007)	(0.007)
Formerly Treated	-0.023	-0.021
	(0.016)	(0.015)
T21 Law * 18-to-20 yr old (Bootstrap p-value)	0.200	0.082*
T21 Law * 12-to-17 yr old (Bootstrap p-value)	0.799	0.231
Pre-Treat DV Mean (18 - 20)	0.170	0.120
Pre-Treat DV Mean (12 - 17)	0.024	0.023
Observations	80,339	80,064
Note: Same model specification as prior estimates		

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use: CA Treatment Only

	(3)	(4)	(5)	(6)
	Wave 1 Non-Users Sample		***Wave 1 Users Sample***	
	Smoking Participation	*Vaping Participation*	*Smoking Participation*	*Vaping Participation*
T21 Law * 18-to-20 yr old T21 Law * 12-to-17 yr old Tobacco 21 Law Formerly Treated				
18-to-20 (Bootstrap p-value) 12-to-17 (Bootstrap p-value)				
Pre-Treat DV Mean (18 - 20)				
Pre-Treat DV Mean (12 - 17)				
Observations				
Note: Same model specification as prior estimates				

Estimates of the Effect of Tobacco 21 Laws on Cigarette and E-Cigarette Use: CA Treatment Only

	(3)	(4)	(5)	(6)
	Wave 1 Non-Users Sample		***Wave 1 Users Sample***	
	Smoking Participation	*Vaping Participation*	*Smoking Participation*	*Vaping Participation*
T21 Law * 18-to-20 yr old	-0.024**	-0.061***	-0.098***	0.001
	(0.010)	(0.012)	(0.031)	(0.039)
T21 Law * 12-to-17 yr old	-0.009	-0.037***	0.026	-0.271***
	(0.008)	(0.008)	(0.121)	(0.088)
Tobacco 21 Law	-0.008	0.033***	-0.067**	0.161***
	(0.010)	(0.008)	(0.030)	(0.036)
Formerly Treated	-0.038***	-0.041	-0.047	-0.003
	(0.012)	(0.012)	(0.040)	(0.042)
18-to-20 (Bootstrap p-value)	0.330	0.032**	0.315	0.988
12-to-17 (Bootstrap p-value)	0.666	0.066*	0.863	0.409
Pre-Treat DV Mean (18 - 20)	0.067	0.055	0.818	0.648
Pre-Treat DV Mean (12 - 17)	0.012	0.015	0.864	0.633
Observations	45,422	45,322	8,334	3,918

Note: Same model specification as prior estimates