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Abstract

This paper examines the effects of tobacco restrictions policy on respiratory health. We leverage the heterogeneous timing across states in the adoption of the policy from a sample of 8,175 individuals between the ages of 18 and 21. Using the 2011 to 2019 Behavioral Risk Factor Surveillance System (BRFSS), we estimate the impact of the Tobacco 21 MLSA policy on the prevalence of chronic obstructive pulmonary disease (COPD), a progressive lung condition marked by airflow obstruction due to prolonged exposure to irritants like cigarette smoke and air pollution. We find that the T21 MLSA policy lowered the risk of COPD by 11.4 percentage points, or approximately 6.7%, among young adults between the ages of 18 and 21. In addition, we find that the policy had a greater effect on male, black, and Hispanic populations. We also find the policy to be more effective among 20-year-old unemployed young adults with some college education. These findings suggest that the T21 MLSA policy has effectively reduced respiratory health problems among teenagers and young adults, supporting its public health benefits to society. Therefore, states that are yet to adopt the T21 MLSA policy should consider its potential to decrease the risk of COPD and, ultimately, tobacco-related mortality as a valuable component of their health policy.

JEL codes: I12, I18

Keywords: Tobacco 21 MLSA policy, respiratory health, copd,

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1 Introduction

Tobacco consumption is the number one leading cause of preventable death in the United States, contributing to more than 480,000 deaths per year (Center for Disease Control and Prevention, 2023). Of these deaths, about 29% are linked to respiratory causes, while 9% are due to exposure to secondhand smoke (Center for Disease Control and Prevention, 2020). Tobacco use is also associated with an increased risk of heart disease, liver, stroke, and colon cancer (U.S. Department of Health and Human services, 2014). The cost of medical care for smoking is also substantial in the United States. Its use has been linked to a significant healthcare cost, amounting to approximately $170 billion annually (Xu et al., 2015), and lifetime healthcare expenditure of around $86,000 for women and $183,000 for men who started smoking before the age of 24 (Sloan et al., 2006).

Despite the well-known costs of tobacco use, the smoking rate among young adults in the United States has continued to rise. This increase has been attributed to smoking habits developed during adolescence. In 2012, the US Surgeon General reported that approximately 96% of current smokers began smoking before the age of 21, and only a few adults initiate smoking or transition to daily smoking after the age of 25 (U.S. Department of Health and Human services, 2018). According to the Center for Disease Control and Prevention (2023) report, current smokers are nearly five times more likely to be diagnosed with chronic obstructive pulmonary disease (COPD) than never smokers and are twice as likely to have COPD than former smokers (see Figure 2).[1]

In an effort to reduce the growing number of teenage smokers, several anti-smoking policies such as tax hikes, warning labels and minimum legal sales age (MLSA) were introduced in the 1990s and 2000s as a measure to restrict teenagers from accessing tobacco products (Bryan et al., 2020). Although, Tobacco MLSA law history in the United States began in the 19th century, and by 1993, all 50 states and Washington D.C. had established a tobacco MLSA of either 18 or 19 years (Apollonio and Glantz, 2016; Mtenga and Pesko, 2024). The most recent tobacco MLSA law is the Tobacco 21 MLSA policy, which prohibits the sale of tobacco products to individuals below the age of 21. Between 2016 and 2019, 16 states and Washington D.C. raised the MLSA of tobacco from 18 to 21 before a federal law came into place by December 2019.[2] Following the implementation of the law, tobacco retailers who violated its provision were subject to a civil penalty of up to $500, and in some cases, their licenses were withdrawn (Abouk et al., 2024).

[1] Additionally, extensive research on tobacco use has also confirmed that most adults who began smoking between the ages of 18 and 20 developed stronger addiction and had a lower likelihood of quitting compared to those who started smoking at 21 or later (Kwan et al., 2015; Abouk et al., 2024).

[2] Hawaii was the first state to raise its tobacco minimum legal sales age (MLSA) to 21 in January 2016, followed by California in June 2016. Subsequently, Washington, D.C. (February 2017), New Jersey (November 2017), Oregon (January 2018), Maine (July 2018), and Massachusetts (December 2018) implemented similar changes. In 2019, Virginia, Illinois, and Delaware adopted the policy in July, followed by Arkansas, Vermont, and Texas in September, Connecticut, Ohio, and Maryland in October, and New York in November.

The T21 MLSA law may lower the prevalence of COPD among teenagers and young adults by restricting their access to and exposure to cigarette smoking. However, the law may not be effective for several reasons. First, a significant number of retailers do not comply with the MLSA regulations. Evidence from the literature suggests that about 62% of teenagers and young adults reported that it is "easy" or "somewhat easy" to purchase tobacco products in stores (Feng and Pesko, 2019; Mtenga and Pesko, 2024).[3] Second, some sizable number of teenagers and young adults below the age of 21 rely on older peers for access to tobacco products or via third-party purchases (Abouk and Adams, 2017; Bryan et al., 2020). Third, some teenagers and young adults may be exposed regularly to secondhand smoke from older adults, which could be detrimental to their respiratory health outcome. As a result, the policy may not have an effect on their respiratory health outcome.

In this paper, we examine the effect of the Tobacco 21 MLSA on the prevalence of chronic obstructive pulmonary disease (COPD hereafter) by leveraging the staggered adoption of the MLSA across states.[4]. Our analysis focuses on states that increased tobacco MLSA from 18 to 21 between January 2017 and December 2019. States with a local Tobacco 21 MLSA policy prior to the state-wide implementation were excluded from the main analysis to avoid confounding our estimate. We examined whether the policy has significantly reduced the prevalence of COPD among teenagers and young American adults in the United States.

Prior studies have established evidence of a marginal reduction in tobacco sales and smoking rates among teenagers and young adults following the implementation of the Tobacco 21 minimum legal sales age (MLSA) law (Abouk et al., 2024; Friedman and Pesko, 2024). With respect to COPD outcome, Bircan et al. (2021) examined the effect of e-cigarette use and found that it increases the probability of being diagnosed with COPD. Although these separate studies exist in the literature, no study, at least to the best of our knowledge, has looked at the causal effect of a regulatory policy such as the Tobacco 21 MLSA policy on the incidence of COPD among young American adults. This paper fills this gap.

In this paper, we use a quasi-experimental difference-in-difference regression design to study the gradual roll-out of the Tobacco 21 MLSA policy at the state level between 2016 and 2019 using the 2011-2019 Behavioral Risk Factor Surveillance System (BRFSS) data. We estimate the staggered difference-in-difference (Staggered DiD hereafter) model proposed by (Callaway and Sant'Anna, 2021) to account for the heterogeneity in treatment effects. We find evidence that the T21 MLSA policy reduced the prevalence of COPD by 11.4% points, approximately 6.71% among teenagers and young adults between the ages of 18 and 21.[5] These

[3]From a profit-maximization standpoint, selling to minors may appear advantageous for firms, as fines are typically smaller compared to the potential revenue from such sales. Additionally, sting operations intended to prevent underage sales are often ineffective, as underage decoys are usually prohibited from employing common strategies used by actual underage buyers, such as presenting fake identification or misrepresenting their age (Mtenga and Pesko, 2024).

[4]COPD consists of emphysema and chronic bronchitis conditions that cause airflow blockage and breathing difficulties due to long-term exposure to cigarette smoke and air pollution.

[5]Additionally, we show that the policy had a greater effect in reducing respiratory issues among males than females. While

results are robust to several robustness checks, including controlling for individual demographic characteristics. [6] These findings provide policy-relevant guidance for states that are yet to implement the Tobacco 21 MLSA policy.

The rest of the paper is organized as follows: In Section 2, We describe the data. Section 3 discusses the empirical strategy, section 4 presents and analyzes the results and section 5 concludes the paper.

2 Data Description

We employ the 2011-2019 Behavioral Risk Factor Surveillance System (BRFSS) dataset to provide a causal estimate. The BRFSS is a repeated cross-section state representative annual telephone survey administered to individuals who are 18 years and above. The survey is jointly conducted by the Center for Disease Control and Prevention (CDC) and state authorities, covering a wide range of factors, including tobacco use and respiratory health outcomes. It is administered every month across all the 50 states and the District of Columbia through random-digit dialling. The BRFSS survey is designed to represent the non-institutionalized adult population of the United States.

The advantage of BRFSS in this study is that it covers a wide range of outcomes of interest, including COPD, smoking patterns, and other self-reported health indicators. Additionally, it contains state-specific identifiers and demographic information. With a large sample size of nearly 500,000 individuals each year, the BRFSS significantly represents young adults from 18 to 20 years old affected by the T21 MLSA law. In comparison, the Youth Risk Behavioral Risk Surveillance System (YRBSS) and the National Youth Tobacco Survey (NYTS) have an annual sample size of nearly 50,000 and 30,000 individuals, respectively, which is less than one-tenth of the BRFSS sample size.[7] To estimate the effect of the T21 MLSA policy on the prevalence of COPD, we constructed a binary indicator for the outcome using the BRFSS metric. Individuals who responded "Yes" to have ever been diagnosed with COPD were assigned 1, whereas those who responded "No" were assigned 0. Those who responded as" don't know/not sure" or" refused" were coded as missing.

In this paper, we utilize the BRFSS data from 2011 to 2019.[8] This time frame provides a plausible estimate of the effect of the T21 MLSA on the prevalence of COPD without the influence of confounding

there was no significant effect on respiratory health problems among white individuals, the policy effectively decreased respiratory health issues among Black and Hispanic populations. Moreover, the T21 MLSA policy also had a greater impact on unemployed young adults than on those employed and was particularly effective among 20-year-olds compared to those aged 18 and 19. Furthermore, the policy also showed a stronger effect on respiratory health outcomes among young adults with some college education compared to those with a high school diploma or less.

[6] Additionally, tests for pre-policy parallel trends, as well as placebo and falsification tests, provide support for a causal interpretation of the results.

[7] In addition, the YRBSS and NYTS have fewer samples of respondents aged 18 and above, which may be inadequate to provide a plausible estimate of the effect of T21 MLSA on the prevalence of COPD.

[8] excluding data prior to 2011 and after 2019 from our analysis due to a methodological change in the BRFSS survey starting in 2011 and the impact of the COVID-19 pandemic in 2020, which significantly affected respiratory health outcomes.

factors. We restrict the BRFSS sample to the demography targeted by the T21 MLSA policy: adults under 21. The condition to be included in the main analysis is that a respondent must be aged 18 to 20. We defined treatment states as those that have adopted the T21 MLSA by 2019 but without prior local Tobacco 21 MLSA policy, while states that have not adopted the Tobacco 21 MLSA law are classified as the control group. We excluded states with local Tobacco 21 MLSA policy prior to state-wide implementation.[9] Table 1 presents the demographic characteristics of the sample used in the main analysis.

3 Empirical Strategy

3.1 Callaway and Sant'Anna (2021) Difference-in-Difference

This paper seeks to identify the causal impact of the Tobacco 21 Minimum Legal Sales Age (T21 MLSA) on the prevalence of COPD using data from the Behavioral Risk Factor Surveillance System (BRFSS) spanning from 2011 to 2019. However, our research faces the issue of the gradual roll-out of the T21 MLSA policy by different states across the United States as shown in Table A6.[10] To address this problem, we utilized a recent difference-in-difference method proposed by Callaway and Sant'Anna (2021) to account for the staggered implementation of the T21 MLSA policy across the treated states. The Callaway and Sant'Anna (2021) approach is based on two key assumptions. First, it assumed that in the absence of treatment, outcomes for all cohorts follow parallel trends during the post-treatment period. This assumption is less stringent, unlike the imputation estimator, which is also robust to heterogeneous treatment but requires parallel trends across groups and all periods (Borusyak et al., 2021). The second identification assumption is that the treatment has no anticipation effect on the outcome variable. Thus, in the absence of the anticipation effect, the estimator assumed that the treatment had no causal effect on outcomes before implementation.

The Callaway and Sant'Anna (2021) DiD estimator also allows for separate identification of average treatment effects on the treated for each treatment cohort g and calendar year t, denoted as ATT(g, t).[11] Using never-treated states as the control group in one case, along with both never-treated and not-yet-treated states in another case, we estimate the effect of the T21 MLSA policy on the prevalence of COPD using equation 1 and the event study using equation 2 below.

$$ATT(g, t) = \mathbb{E}[Y_t(g) - Y_t(0)|G_g = 1] \tag{1}$$

[9] These states include CA, HI, IL, KS, MA, ME, MI, MO, MS, NJ, NY, OH and TX.

[10] In such a setting with treatment effect heterogeneity, the existing econometric literature argued that the estimates from the canonical difference-in-differences (static two-way fixed effects) and event-study (dynamic two-way fixed effects) methods may be biased (de Chaisemartin and d'Haultfoeuille, 2020; Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021; Sun and Abraham, 2021).

[11] The ATT(g, t) is derived by comparing the average change in outcome between periods $g - 1$ and t for cohort g with the average change over the same period for the control group.

Where ATT(g,t) is the difference between the potential outcomes before and after the units in that group are treated. After the estimation, we aggregated the individual estimates ATT(g,t) values to derive an economically relevant parameter through their weighted average as displayed in Table 2.[12]

$$ATT_n^{ES} = \sum_g w(g,n)\text{ATT}(g,g+n). \tag{2}$$

Where $w(g,n)$ is the weight determined based on the relative size of the group g among the groups that have participated in the treatment for n periods, which enables an aggregation that facilitates the examination of dynamic policy effects. While the ATT_n^{ES} is the average treatment on treated given the event study (ES) at n years.

To validate our estimate, we perform a falsification test on individuals aged 21–28 years who were eligible to purchase tobacco products both before and after the implementation of the T21 MLSA law and are therefore unlikely to be influenced by its enforcement.[13] Additionally, we conduct a placebo test with outcome variables that should be theoretically unaffected by the implementation of the T21 MLSA law—respondents' unemployment and household income.[14] We conduct a heterogeneous test by estimating the regression model separately for different subgroups of respondents by sex, race, education, employment, and age.

3.2 Two Way Fixed Effects (TWFE)

We test the validity of the Callaway and Sant'Anna (2021) estimator using the standard two-way fixed effects (TWFE) model and event study. we specify the baseline event study models as follows:

$$y_{st} = \alpha_0 + \sum_{n \in N} \alpha_1^n \text{T21Policy}_{st}^n + \alpha_2 X_{st} + \lambda_s + \tau_t + \epsilon_{st} \tag{3}$$

Where y_{st} is the COPD outcome of interest in state s in year t. The variable of interest T21Policy_{st}^n is a vector that takes a value of 1 if a state is treated for n years where $n = \{\leq -6, \ldots, -2, 0, \ldots, 1, \leq 2\}$ and 0 otherwise. The coefficient α_1^n measures the effect of the T21 policy for each n year with $n = -1$ serving as the omitted year. The variable X_{st} is a vector of individual demographic characteristics which may potentially affect the COPD outcome. λ_s and τ_t represent state-fixed effect and year-fixed effect, respectively.

[12]Following Callaway and Sant'Anna (2021), we present the standard errors using a multiplicative bootstrap procedure with clustering at the state level. We also reported the group-specific estimates and partially aggregated estimates weighted for all the cohorts and the event study estimates using equation 2 for n years relative to the T21 MLSA policy adoption for $n = \{-6, \ldots, -2, 0, \ldots, 1, 2\}$, in Table A1 and Table A2.

[13]A significant effect of T21 MLSA on COPD for this group would suggest the presence of simultaneous changes in other policies, which could bias our main results.

[14]Also, finding a strong effect of the T21 MLSA law on these outcomes would also indicate that other policy changes occurring either in the treatment or control group could bias the main estimate.

4 Results Interpretation and Discussion

We begin our analysis with the descriptive statistics of the outcome variable and the demographic characteristics of the sample used in this paper as presented in Table 1. We examined the sample mean of the outcome variable (COPD) from 2011 to 2019 and observed a substantial difference between the treated and control states. In particular, we find that teenagers and young adults between the ages of 18 and 21 experienced a significant decrease in the prevalence of COPD in the treated states compared to those in the control states. Interestingly, with regard to the demographic characteristics, we observed that the sample means for most variables are quantitatively similar between the treated and control states, with the exception of the proportions for Black, Hispanic, and Other racial groups. Additionally, there is a significant difference between the treated and control states in the proportions of individuals with less than a high school education and those with some college education.

Table 2 presents the main results for the effect of the Tobacco 21 MLSA law on the prevalence of COPD. Columns 1 and 2 show the estimates from the TWFE model whereas columns 3, 4, 5 and 6 present the estimates for the Callaway and Sant'Anna (2021) estimator. In columns 3 and 4, we consider the case where never-treated states are the comparison group and where we do not allow for any anticipation effects. We also provide results using the not-yet-treated states as the comparison group and allowing for one-year anticipation as presented in columns 4 and 5. State and year-fixed effects are included in all the regression models. We also control for individual characteristics in the specification displayed in columns 2, 4 and 6. Our preferred specification in column 4 uses the Callaway and Sant'Anna (2021) estimator with never-treated control group, individual characteristics, state, and year fixed effects.

Our findings suggest that the Tobacco 21 MLSA law significantly reduces the risk of COPD among teenagers and young adults between the ages of 18 and 21. Starting from the TWFE model, the results in Columns 1 and 2 show that the Tobacco 21 MLSA law is associated with a 2.1% point (approximately 1.24%) significant ($p < 0.05$) decrease in the prevalence of COPD among teenagers and young adults between the ages of 18 and 21.

Using our preferred Callaway and Sant'Anna (2021) specification, we find that the Tobacco 21 MLSA policy has a greater significant effect in reducing the prevalence of COPD in the treated states. Specifically, the results in Columns 3 for never-treated controls without covariates show that the Tobacco 21 MLSA policy was associated with a 6.7% point or approximately 4% significant ($p < 0.01$)decrease in the prevalence of COPD among teenagers and young adults between the ages of 18 and 21. Further, adding individual controls in Columns 4, we find that the Tobacco 21 MLSA significantly decreased the prevalence of COPD by 11.4% point among teenagers and young adults within the sample, which reflects a 6.71% ($p < 0.01$) decrease relative to the pre-treatment mean. Similarly, we estimate the Callaway and Sant'Anna (2021) model for not yet treated controls without covariates in Columns 5, we observed a 6.8% point (approximately 4%) significant ($p < 0.05$) reduction in the prevalence of COPD among teenagers and young adults between the ages of 18 and 21 across states that adopted the Tobacco 21 MLSA law. Adding individual characteristics in Columns 6, we find a greater decrease in the prevalence of COPD by 11.5% point, which reflects a 6.8% significant ($p < 0.01$) decrease relative to the pre-treatment mean. These findings complement Bircan et al. (2021) where they find that unregulated use of e-cigarettes increases the risk of COPD among current smokers.

Table 3 presents the results from the heterogeneity tests. The results show that the Tobacco 21 MLSA policy had a greater effect in decreasing the prevalence of COPD among males than females. While we find no significant effect of the policy on decreasing the prevalence of COPD among the white population, we observed that the policy effectively decreased the prevalence of COPD among Black and Hispanic populations. In addition, we find that the T21 MLSA policy had a greater significant impact on unemployed young adults compared to those employed and was particularly effective among 20-year-old young adults compared to individuals who are aged 18 and 19. Furthermore, the policy also showed a stronger effect on COPD outcomes among young adults with some college education compared to those with a high school diploma or less. These findings suggest that older young adults in the sample who were eligible to buy tobacco products before the implementation of the T21 MLSA law had better respiratory health outcomes.

The event study results presented in Figure 3 signal that the treatment and control states followed parallel trends in the pre-2017 period, which lends credence to the causal interpretation of the average treatment effects estimated in Table 2. Table 3A and Table 4A in the appendix present the results for the placebo test and falsification test, respectively. We conducted a placebo test for outcome variables such as unemployment and household income, which should be theoretically uncorrelated with the Tobacco 21 MLSA law. As expected, the average treatment effects for both placebo outcomes are statistically insignificant (see Appendix Table A3). Similarly, the falsification tests for young adults aged 21–28 years, a group unaffected by the implementation of the Tobacco 21 MLSA policy. For this cohort, the average treatment effect is close to zero and statistically insignificant, which increases our confidence that no other differential policy changes occurred in the treatment and control states concurrently with the implementation of the Tobacco 21 MLSA policy.

A significant limitation of this paper is the inability to estimate the long-term effects of the Tobacco 21 MLSA policy on COPD. The main analysis was restricted to three years post-implementation for the first treated group due to the COVID-19 pandemic in 2020, which significantly affected respiratory health outcomes. The inability to account for the pandemic's effects posed a slight challenge in extending the analysis beyond 2019.

5 Concluding Remarks

This study investigates the effect of the Staggered implementation of the Tobacco 21 MLSA law on the prevalence of chronic obstructive pulmonary disease (COPD) in the United States. Our paper is the first to look at this causal relationship. Using the Callaway and Sant'Anna (2021) difference-in-difference estimator, which accounts for the heterogeneous timing across states in the adoption of the Tobacco 21 MLSA policy. We find that the policy was associated with an 11.4% points or approximately 6.71% decrease in the risk of COPD among teenagers and young adults between the ages of 18 and 21. Further findings show that the policy had a greater effect among males than females. While there was no significant effect on the white population, the policy effectively decreased the risk of being diagnosed with COPD among Black and Hispanic populations. The T21 MLSA policy also had a greater impact on unemployed young adults than on those employed and was particularly effective among 20-year-olds compared to other ages within the sample. Furthermore, the policy also showed a stronger effect for individuals with some college education than those with a high school diploma or less. Our findings complement Bircan et al. (2021), where they find that e-cigarette use increases the risk of being diagnosed with COPD among current smokers. These findings provide policy-relevant guidance for states that are yet to adopt the Tobacco 21 MLSA policy; and for other countries.

Table 1: Summary Statistics (BRFSS, 2011 to 2019)

	(1) Treated States	(2) Untreated States	(3) T-test Difference
Outcome			
COPD	0.00	0.02	-0.02
	(0.00)	(0.13)	(0.02)
Demographic Characteristics			
Income ($)	72534.25	56029.38	16504.87
	(35070.6)	(34429.06)	(4048.32)
Unmarried	1.00	0.96	0.04
	(0.00)	(0.19)	(0.02)
Age	19.00	18.90	0.10
	(0.80)	(0.83)	(0.10)
Male	0.53	0.54	-0.01
	(0.50)	(0.50)	(0.06)
Female	0.47	0.46	0.01
	(0.50)	(0.50)	(0.06)
Less than High School	0.07	0.15	-0.09
	(0.25)	(0.36)	(0.04)
High School	0.45	0.50	-0.05
	(0.50)	(0.50)	(0.06)
Some College	0.48	0.33	0.15
	(0.50)	(0.47)	(0.06)
College and advance	0.00	0.01	-0.01
	(0.00)	(0.11)	(0.01)
Asian	0.01	0.04	-0.03
	(0.12)	(0.19)	(0.02)
White	0.73	0.68	0.05
	(0.45)	(0.47)	(0.05)
Black	0.15	0.10	0.05
	(0.36)	(0.29)	(0.03)
Hispanic	0.08	0.11	-0.03
	(0.28)	(0.31)	(0.04)
Other race	0.03	0.07	-0.04
	(0.16)	(0.25)	(0.03)
Unemployed	0.61	0.59	0.03
	(0.49)	(0.49)	(0.06)
Self-employed	0.03	0.04	-0.01
	(0.16)	(0.19)	(0.02)
Working	0.36	0.36	-0.01
	(0.48)	(0.48)	(0.06)

Note: Table displays the summary statistics of the outcomes and demographic characteristics for the treated and untreated states.Young adults are observed at ages 18-20 years between 2011 and 2019. Each cell reports weighted mean with standard deviation in parenthesis

Table 2: Main Results for the Effect of T21 MLSA Policy on COPD

	(1)	(2)	(3) Never Treated	(4)	(5) Not yet Treated	(6)
	TWFE	TWFE	C & S	C & S	C & S	C & S
T21Policy	-0.021**	-0.021**	-0.067***	-0.114***	-0.068**	-0.115***
	(0.008)	(0.009)	(0.026)	(0.042)	(0.025)	(0.043)
Pre-2017 Mean	1.70	1.70	1.70	1.70	1.70	1.70
Sample Size	8180	8180	8175	8175	8175	8175
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	No	Yes	No	Yes	No	Yes

Note: The first-two columns presents the simple average of the event-time effects obtained using the Two-way Fixed effect estimator. While Column 3-6 presents the average treatment effect for the Callaway and Sant'Anna (2021) estimator for not yet treated and never treated controls. Young adults are observed at ages 18-20 years between 2011 and 2019 for COPD outcomes. Unless otherwise stated all regressions control for state, and year fixed effects. ***p<0.01, **p<0.05, *p<0.10. Standard errors are in parentheses.

Table 3: Heterogeneity Tests (Source: BRFSS, 2011 to 2019)

	(1) T21 Policy	(2) Sample Size	(3) Pre-2017 Mean
Full Sample	-0.067***	8175	1.70
	(0.026)		
By Sex			
Male	-0.094**	4429	1.59
	(0.042)		
Female	-0.015	3730	1.74
	(0.019)		
By Race			
White	-0.031	5556	1.36
	(0.023)		
Black	-0.270**	789	2.84
	(0.112)		
Hispanic	-0.333	878	2.51
	(0.314)		
By Educational Status			
Less than High School	0.027	1,247	2.06
	(0.047)		
High School	-0.033	4098	1.83
	(0.031)		
Some College	-0.122***	2711	1.24
	(0.039)		
By Employment Status			
Working but not Self-employed	-0.040	2976	1.50
	(0.032)		
Not Working	-0.085**	4823	1.71
	(0.035)		
By Age			
18	0.005	3241	1.51
	(0.020)		
19	-0.050	2492	1.76
	(0.037)		
20	-0.157***	2411	1.76
	(0.051)		

Note: Table 3 presents the heterogeneous test estimates for the individual demographic characteristics using the Callaway and Sant'Anna (2021) DiD estimator with never treated controls. Young adults are observed at ages 18-20 years between 2011 and 2019 for COPD outcomes. Unless otherwise stated, all regressions control for state and year-fixed effects. ***p<0.01, **p<0.05, *p<0.10. Standard errors are in parentheses.

Table A1: Effect of T21 MLSA Policy on COPD for Never Treated Controls

(a) Unconditional Parallel Trends				
	Partially aggregated			Single parameters
TWFE				-0.021**
				(0.008)
Simple Weighted Average				-0.067***
				(0.026)
Group Specific effects	g=2017	g=2018	g=2019	
	-0.171***	0.004	-0.053*	-0.057**
	(0.005)	(0.009)	(0.028)	(0.025)
Event study	e=0	e=1	e=2	
	-0.059**	-0.089	-0.166***	-0.104***
	(0.024)	(0.064)	(0.008)	(0.026)
Calendar time effects	t=2017	t=2018	t=2019	
	-0.174***	-0.099	-0.056**	-0.110***
	(0.009)	(0.061)	(0.026)	(0.024)
(b) Conditional Parallel Trends				
	Partially aggregated			Single parameters
TWFE				-0.021**
				(0.008)
Simple Weighted Average				-0.114***
				(0.042)
Group Specific effects	g=2017	g=2018	g=2019	
	-0.338***	0.002	-0.080***	-0.092***
	(0.018)	(0.027)	(0.025)	(0.023)
Event study	e=0	e=1	e=2	
	-0.099***	-0.136*	-0.345***	-0.193***
	(0.030)	(0.083)	(0.058)	(0.042)
Calendar time effects	t=2017	t=2018	t=2019	
	-0.410***	-0.129	-0.092***	-0.210***
	(0.013)	(0.091)	(0.028)	(0.036)

Note: Panel (a) presents the unconditional parallel trends average treatment effect for the two-way fixed effects and Callaway and Sant'Anna (2021) DiD for never-treated controls. Panel (b) presents the conditional parallel trends average treatment effects for the two-way fixed effects and Callaway and Sant'Anna (2021) DiD for never-treated controls. Young adults are observed at ages 18-20 years between 2011 and 2019 for COPD outcomes. Unless otherwise stated, all regressions control for state and year-fixed effects. ***p<0.01, **p<0.05, *p<0.10. Standard errors are in parentheses.

Table A2: Effect of T21 MLSA Policy on COPD for Not Yet Treated Controls

(a) Unconditional Parallel Trends				
	Partially aggregated			Single parameters
TWFE				-0.021**
				(0.008)
Simple Weighted Average				-0.068**
				(0.027)
Group Specific effects	g=2017	g=2018	g=2019	
	-0.176***	0.003	-0.053*	-0.058**
	(0.006)	(0.009)	(0.028)	(0.025)
Event study	e=0	e=1	e=2	
	-0.060**	-0.094	-0.166***	-0.107***
	(0.025)	(0.067)	(0.008)	(0.027)
Calendar time effects	t=2017	t=2018	t=2019	
	-0.179***	-0.105*	-0.056**	-0.114***
	(0.009)	(0.063)	(0.026)	(0.026)
(b) Conditional Parallel Trends				
	Partially aggregated			Single parameters
TWFE				-0.021**
				(0.009)
Simple Weighted Average				-0.115***
				(0.043)
Group Specific effects	g=2017	g=2018	g=2019	
	-0.345***	0.003	-0.080***	-0.092***
	(0.018)	(0.027)	(0.025)	(0.024)
Event study	e=0	e=1	e=2	
	-0.099***	-0.146	-0.345***	-0.197***
	(0.031)	(0.090)	(0.058)	(0.045)
Calendar time effects	t=2017	t=2018	t=2019	
	-0.411***	-0.139	-0.092***	-0.214***
	(0.010)	(0.099)	(0.028)	(0.039)

Note: Panel (a) presents the unconditional parallel trends average treatment effect for the two-way fixed effects and Callaway and Sant'Anna (2021) DiD for not yet-treated controls. Panel (b) presents the conditional parallel trends average treatment effects for the two-way fixed effects and Callaway and Sant'Anna (2021) DiD for not yet-treated controls. Young adults are observed at ages 18-20 years between 2011 and 2019 for COPD outcomes. Unless otherwise stated, all regressions control for state and year-fixed effects. ***p<0.01, **p<0.05, *p<0.10. Standard errors are in parentheses.

Table A3: Placebo Test for Alternate Outcomes(Source: BRFSS 2011 to 2019)

	(1) TWFE	(2) TWFE	(3) C & S Never Treated	(4) C & S Not Yet Treated
	Unemployed	Household Income	Unemployed	Household Income
T21Policy	0.025	4089.069	0.040	-5404.519
	(0.057)	(5000.40)	(0.060)	(8269.235)
Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Individual Controls	No	No	No	No

Note: Table 4 presents the placebo test estimates for alternate outcomes using the two-way fixed effects and Callaway and Sant'Anna (2021) DiD estimator with never treated controls. Young adults are observed at ages 18-20 years between 2011 and 2019 for all the outcomes. Unless otherwise stated, all regressions control for state and year-fixed effects. ***p<0.01, **p<0.05, *p<0.10. Standard errors are in parentheses.

Table A4: Falsification Test for Age group 21-28 (Source:BRFSS 2011 to 2019)

	(1)	(2)	(3) Never Treated	(4)	(5) Not yet Treated	(6)
	TWFE	TWFE	C & S	C & S	C & S	C & S
T21Policy	0.015	0.014	0.009	0.016	0.009	0.015
	(0.013)	(0.013)	(0.026)	(0.022)	(0.026)	(0.023)
Sample size	29,432	29,432	29,431	29,431	29,431	29,431
Pre 2017 Mean	2.52	2.52	2.52	2.52	2.52	2.52
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	No	Yes	No	Yes	No	Yes

Note: The first-two columns presents the simple average of the event-time effects obtained using the Two-way Fixed effect estimator. While Column 3-6 presents the average treatment effect for the Callaway and Sant'Anna (2021) estimator for not yet treated and never treated controls. Young adults are observed at ages 18-20 years between 2011 and 2019 for COPD outcomes. All regressions exclude states with local T21 MLSA law and control for state, and year fixed effects. ***p<0.01, **p<0.05, *p<0.10. Standard errors are in parentheses.

Table A5: Sensitivity Analysis (Source: BRFSS 2011 to 2019)

	(1)	(2)	(3)	(4)	(5)	(6)
			Never Treated		Not yet Treated	
	TWFE	TWFE	C & S	C & S	C & S	C & S
T21Policy	-0.013*	-0.014*	-0.023	-0.024	-0.024	-0.032
	(0.008)	(0.008)	(0.016)	(0.014)	(0.016)	(0.021)
Sample size	9,387	9,387	9,377	9,377	9,377	9,377
Pre 2016 Mean	1.60	1.60	1.60	1.60	1.60	1.60
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	No	Yes	No	Yes	No	Yes

Note: The first-two columns presents the simple average of the event-time effects obtained using the Two-way Fixed effect estimator. While Column 3-6 presents the average treatment effect for the Callaway and Sant'Anna (2021) estimator for not yet treated and never treated controls. Young adults are observed at ages 18-20 years between 2011 and 2019 for COPD outcomes. The analysis also includes states like CA, HI, IL, KS, ME, MA, MI, MN, MS, MO, NJ, NY, OH, and TX, which had local Tobacco 21 MLSA laws in place prior to the implementation of statewide policies. Unless otherwise stated all regressions control for state, and year fixed effects. ***p<0.01, **p<0.05, *p<0.10. Standard errors are in parentheses.

Table A6: T21 State Laws and their Effective dates as of December, 2024

States	**Effective Date of Tobacco 21 MLSA**
Hawaii	1/1/2016
California	6/9/2016
Washington D.C.	2/18/2017
New Jersey	11/1/2017
Oregon	1/1/2018
Maine	7/1/2018
Massachusetts	12/31/2018
Illinois, Virginia	7/1/2019
Delaware	7/16/2019
Arkansas, Vermont, Texas	9/1/2019
Maryland, Connecticut	10/1/2019
New York	11/13/2019
Ohio	10/16/2019
Washington	1/1/2020
Oklahoma	5/19/2020
Iowa	6/29/2020
Utah, Pennsylvania, South Dakota, Wyoming, Indiana	7/1/2020
Mississippi	7/8/2020
Colorado	7/14/2020
New Hampshire	7/29/2020
Minnesota	8/17/2020
Nebraska	10/1/2020
Kentucky, New Mexico, Tennessee, Georgia	1/1/2021
Nevada	5/27/2021
Rhode Island, Louisiana, Alabama, North Dakota	7/1/2021
Florida	10/1/2021
Idaho	7/1/2022
Michigan	7/21/2022
Kansas	7/1/2023
West Virginia	6/7/2024

Note: The table displays only states that have implemented the Tobacco 21 MLSA law as of December 2024. However, in the main analysis, we excluded states with local Tobacco 21 policies in place prior to the statewide implementation. Additionally, since this study covers the period between 2011 and 2019, we classified states that adopted the Tobacco 21 MLSA policy after 2019 as control states, along with those that have not yet adopted the policy as of December 2024. Source: https://tobacco21.org

Timing of Adoption of State Tobacco 21 MLSA Policy

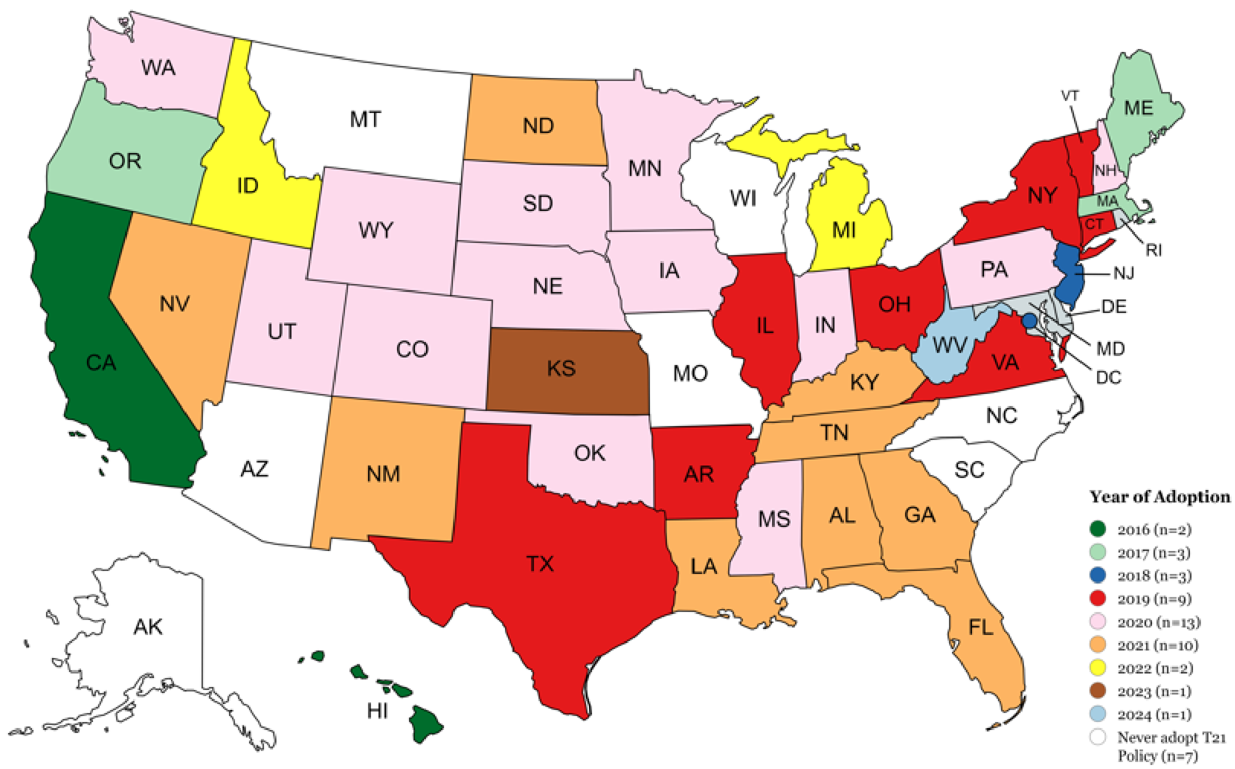

Figure 1: Shows the timing of the adoption of the state-level T21 MLSA policy as of December 2024. However, in the main analysis, we excluded states with local Tobacco 21 policies in place prior to the statewide implementation. Additionally, since our study covers the period between 2011 and 2019, we classified states that adopted the Tobacco 21 MLSA policy after 2019 as control states, along with those that have not yet adopted the policy as of December 2024. We considered a state to have an effective Tobacco 21 MLSA policy in a given calendar year if it adopted the policy by December of that year. For example, Massachusetts's effective year is coded as 2018, even though the policy took effect on December 31, 2018. See Appendix Table A6 for the exact month and year of adoption

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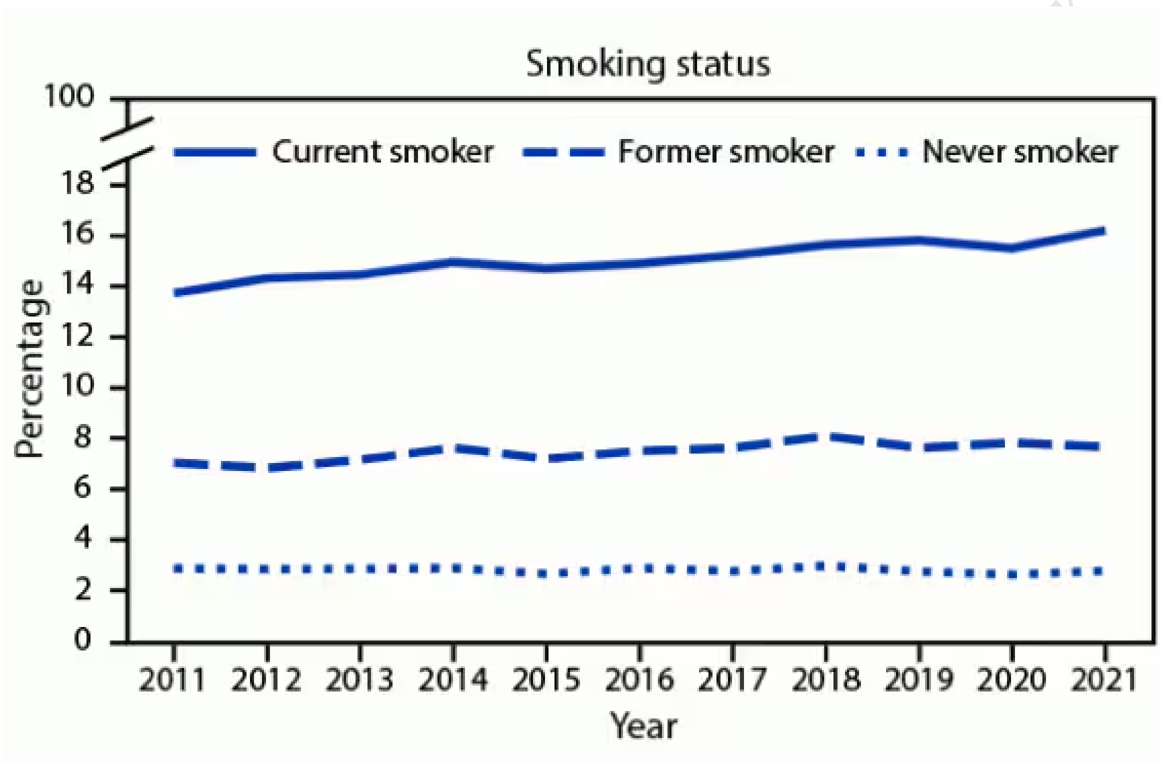

Figure 2: Presents the Trends in the prevalence of chronic obstructive pulmonary disease among adults aged ≥18 years, by smoking status in the United States from Behavioral Risk Factor Surveillance System. Between 2011 and 2021, current smokers consistently exhibited a higher risk of being diagnosed with COPD in the United States compared to former smokers and individuals who have never smoked.

Callaway and Sant'Anna (2021) Event Study Estimates

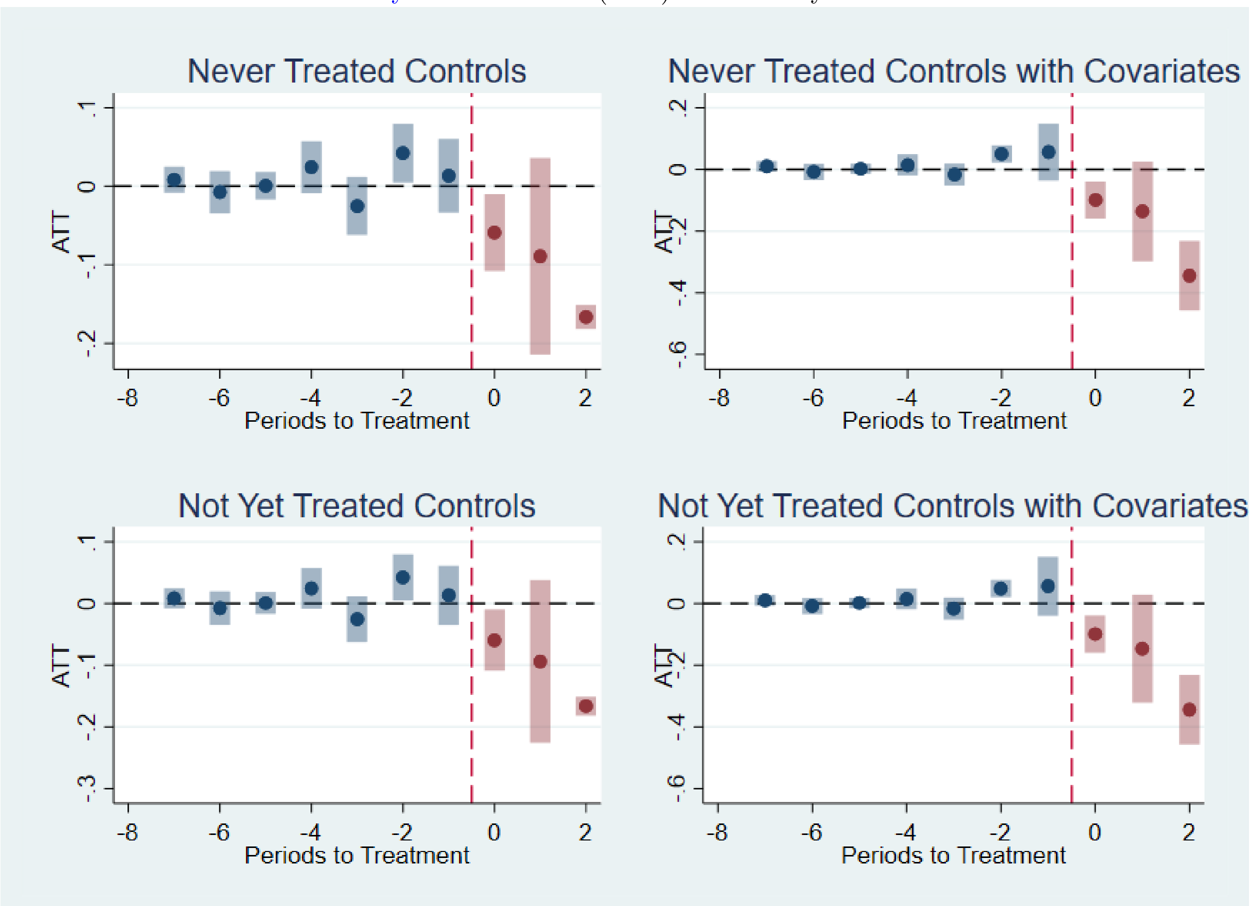

Figure 3: Presents the event study estimates showing the effect of Tobacco 21 MLSA policy on the prevalence of COPD among teenagers and young adults between the ages of 18 and 21 using the Callaway and Sant'Anna (2021) difference-in-difference estimator. We control for state and year fixed effects for all estimates. Additionally, for individual covariates for the second column estimates

Main Regression Estimates

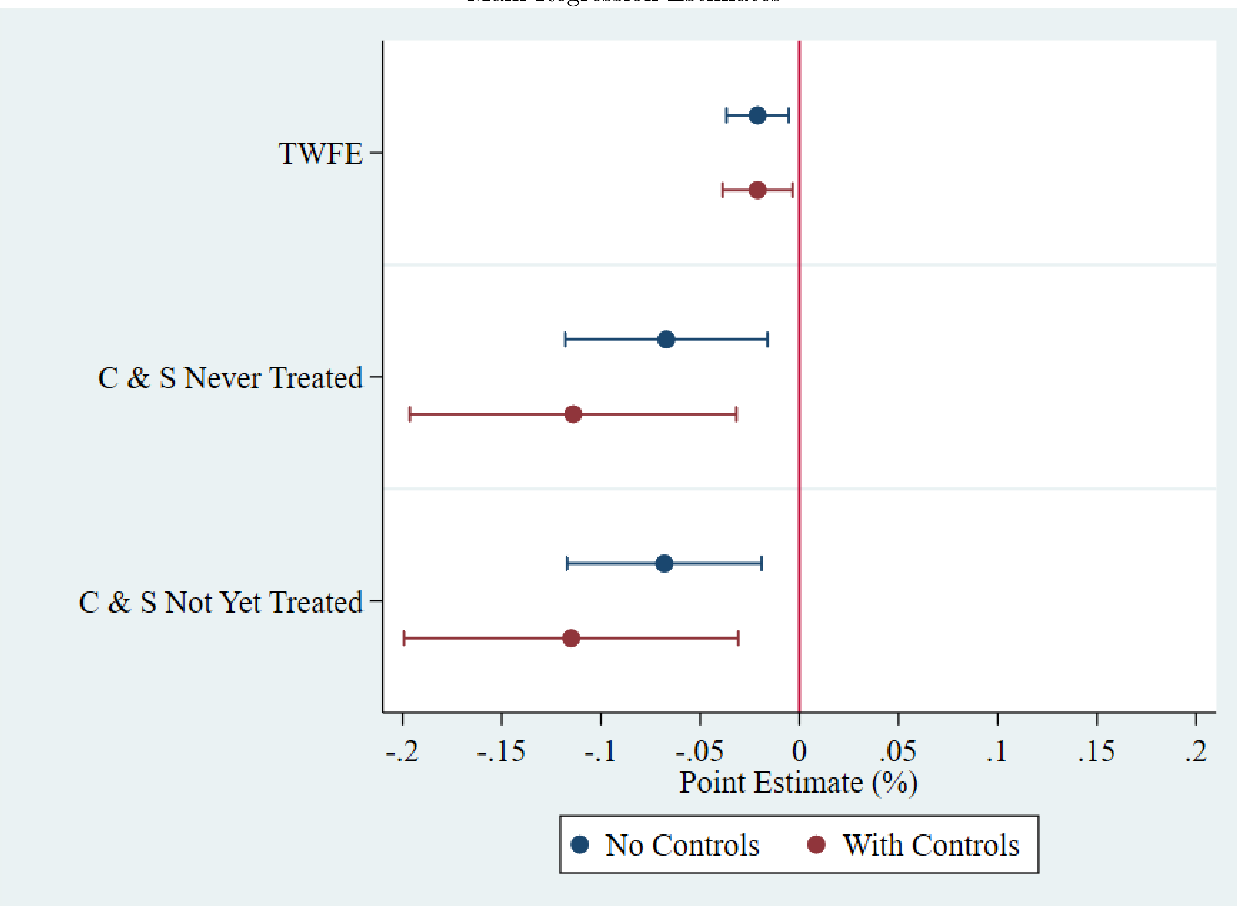

Figure 4: Callaway and Sant'Anna (2021) Two-Way Fixed Effect Estimates evaluating the impact of Tobacco 21 MLSA policy on the prevalence of COPD among teenagers and young adults aged 18 to 21. The red confidence interval represents estimates with controls, while the blue confidence interval represents estimates without controls.

Heterogeneous Test Estimates

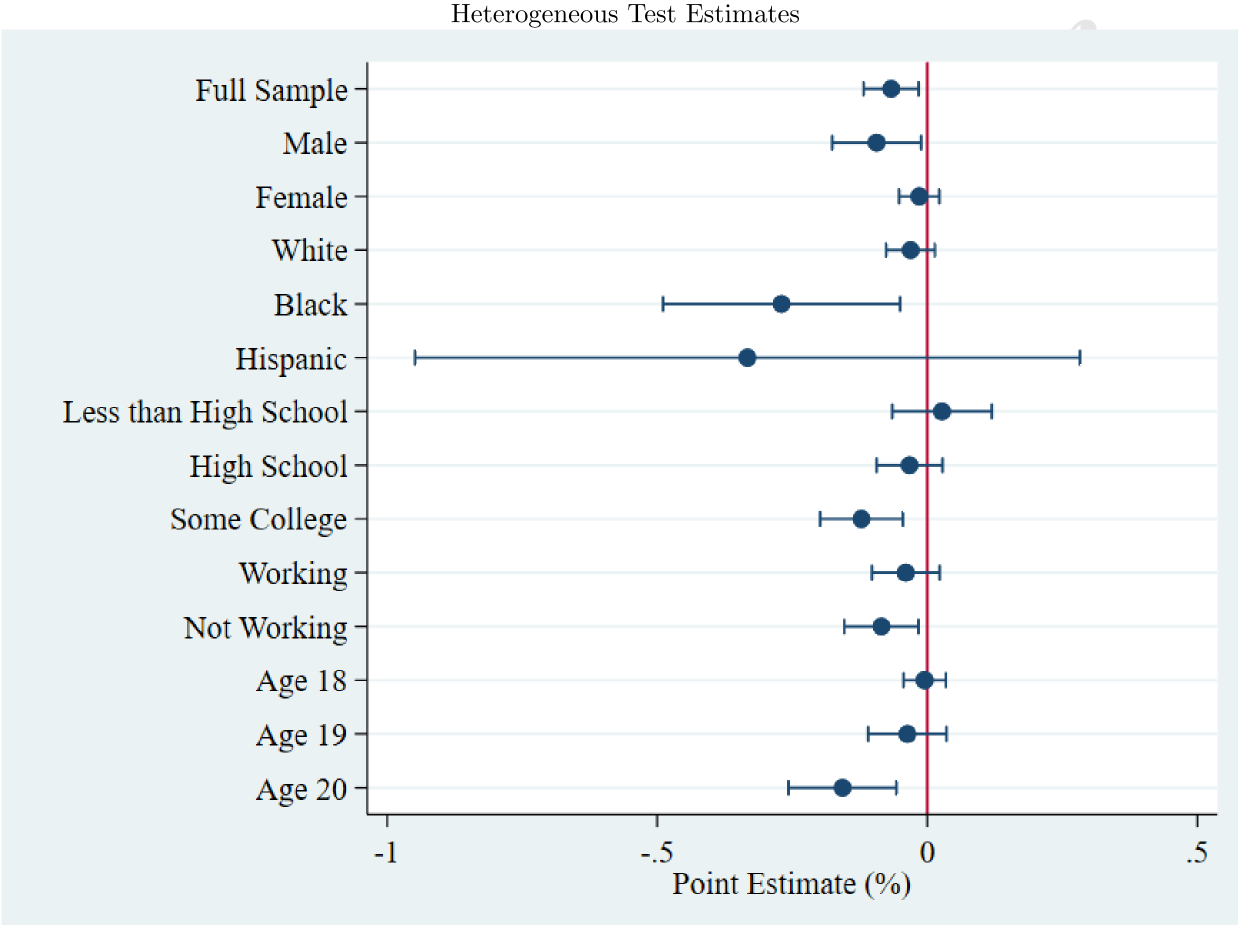

Figure 5: Presents the heterogeneous test estimates for individuals in the sample using the Callaway and Sant'Anna (2021) difference-in-difference estimator. The regression control for state and year fixed effects

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