Assessing the Public Health Effects of Tobacco 21 Laws on Maternal and Infant Outcomes

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Abstract

This paper evaluates the impact of raising the minimum legal purchasing age for tobacco products from 18 to 21 (T21 laws) on maternal smoking behaviors and associated birth outcomes, including low birth weight, premature birth, and Cesarean delivery. Using birth certificate data from the National Center for Health Statistics (2014-2019), the study employs a difference-in-differences and triple-difference framework to assess the effects of T21 laws on pregnant individuals aged 18-20 in states that enacted the policy before the federal implementation in December 2019. The analysis compares smoking behaviors and birth outcomes of mothers aged 18-20 to those aged 21-23 in these states. Results show no significant effect on smoking prevalence but a 7% reduction in the number of cigarettes smoked per month. Despite this reduction in smoking intensity, no significant improvements in adverse birth outcomes are observed, suggesting that while T21 laws may reduce smoking intensity, their effectiveness in improving maternal and infant health outcomes may be limited without additional interventions.

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1 Introduction

Smoking remains the leading preventable cause of death in the United States, accounting for over 480,000 deaths annually. Beyond its impact on adult mortality, secondhand smoke exposure contributes to over 400 infant deaths and 40,000 adult deaths each year (CDC, 2024; American Lung Association, 2024). Among pregnant individuals, smoking poses significant health risks, increasing the likelihood of adverse birth outcomes such as low birth weight, preterm birth, stillbirth, and congenital anomalies. Additionally, smoking during pregnancy elevates maternal health risks, including placenta previa and placental abruption, which often necessitate emergency Cesarean deliveries (CDC, 2024; ACS, 2020; Hamadneh et al., 2024). These health complications contribute to the substantial public health and economic burden of smoking, which in 2018 exceeded $600 billion, with $240 billion attributed to healthcare costs alone (CDC, 2022). The financial burden is particularly notable in hospital costs associated with smoking-related birth complications. Kowlessar et al. (2013) estimate that the average hospital cost of low birth weight, very low birth weight, and preterm birth is $14,000, $76,700, and $21,500, respectively, with total hospital expenditures reaching $13.1 billion in 2011. Furthermore, Cesarean deliveries linked to smoking-related complications cost an average of $5,300 per procedure, totaling $7.3 billion in 2009 (Stranges et al., 2012).

A comprehensive review by Gould et al. (2020) consolidates evidence on the adverse maternal and child health outcomes associated with tobacco exposure during pregnancy. Smoking during pregnancy is linked to an increased risk of complications, including placental abruption and spontaneous miscarriage. Prenatal tobacco exposure is also associated with adverse child health outcomes such as low birth weight, preterm birth, respiratory issues, and neurodevelopmental disorders. Smoking during pregnancy raises the likelihood of stillbirth by 47% and neonatal mortality by 22%, with long-term consequences extending into childhood, including heightened risks of asthma and wheezing. Although psychosocial interventions—such as counseling and incentive-based approaches—have shown promise in promoting smoking cessation, barriers such as social stressors, mental health issues, and limited healthcare provider training hinder their widespread effectiveness. Moreover, exposure to secondhand smoke, smokeless tobacco, and waterpipe smoking further exacerbates these risks, underscoring the need for comprehensive tobacco control measures.

To address these challenges, policymakers have implemented various tobacco control measures, including taxation, smoke-free air laws, and, more recently, Tobacco 21 (T21) laws, which raise the minimum legal purchasing age for tobacco products to 21. Some cities or counties enacted the policy before the implementation at the state level. While taxation is widely regarded as the most effective tool for reducing smoking prevalence (Warner et al., 1995), T21 laws have gained prominence as a targeted strategy to curb youth smoking. Enacted federally in December 2019, T21 laws were implemented at different times across states, creating a natural experiment to assess their effectiveness. Studies such as Been et al. (2015) and Hawkins and Baum (2014, 2019) find that taxation and smoke-free air laws contribute to reductions in maternal smoking and improvements in birth outcomes. In the context of T21 laws, Friedman and Pesko (2024) and Hansen et al. (2023) report significant declines in smoking prevalence among individuals aged 18 to 20, while Tennekoon (2023) finds reductions in adverse birth outcomes such as low birth weight and preterm birth in counties implementing T21 policies. Additionally, Hansen et al. (2023) identify spillover effects, including declines in smoking participation among 16- and 17-year-olds, as well as reductions in alcohol and marijuana consumption following T21 implementation.

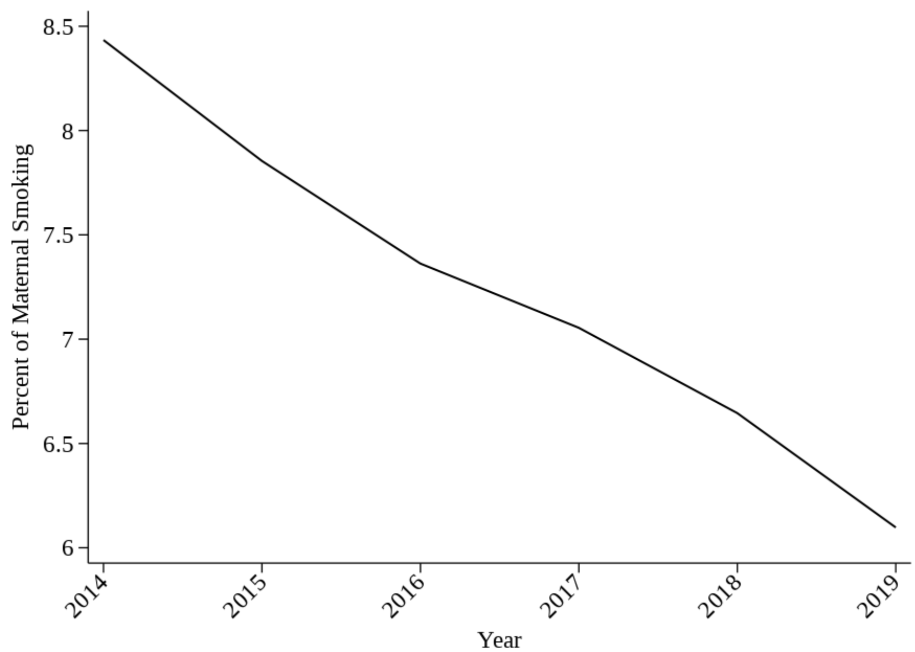
It appears that these policies had led to smoking prevalence among pregnant individuals declining over time. As shown in Figure 1, smoking during pregnancy decreased by approximately 29% from 2014 to 2019. Figure 3 indicates that the average age of pregnancy is around 28 years; however, younger mothers are more likely to smoke during pregnancy, as seen in Figure 4. The decline in smoking during pregnancy is likely attributed to existing tax rates and smoke-free air laws. Additionally, there is evidence suggesting that some individuals may be substituting traditional cigarettes with alternatives such as vaping or marijuana (McClure et al., 2019; Alshaarawy et al., 2021; Banerjee et al., 2022; Wen et al., 2023).

This paper examines the impact of state-level T21 laws on maternal smoking and associated adverse birth outcomes. The analysis utilizes birth certificate data from the National Center for Health Statistics, covering the years 2014 to 2019 across all 50 states and U.S. territories. However, due to inconsistencies in the collection of tobacco use information prior to 2015, the states of New Jersey, Connecticut, Rhode Island, and Hawaii are excluded from the analysis.

Focusing on younger mothers (ages 18-to-20) directly affected by the T21 law, and comparing them to older mothers (ages 21-to-23), this study investigates the policy's effects on maternal smoking at both the extensive (prevalence) and intensive (consumption) margins. Additionally, it explores whether changes in smoking behaviors translate into differences in the likelihood of adverse birth outcomes. The economic theory guiding this analysis follows Grossman (2005), which posits that increasing the minimum legal purchasing age raises the full price of cigarettes by imposing access barriers, potentially reducing smoking at both margins.

To estimate the causal effects of T21 laws, this paper employs a difference-in-difference framework alongside a triple difference approach, accounting for the staggered adoption of T21 laws and their targeted focus on youth tobacco consumption. This methodological approach leverages variation in the timing of state-level enactments to provide robust causal estimates. Nonlinear methods, including probit and logit probability models, generalized log-link linear models with

Figure 1. Smoking Prevalence During Pregnancy per Year



The data comes from NCHS (2019).

Figure 2. Distributions

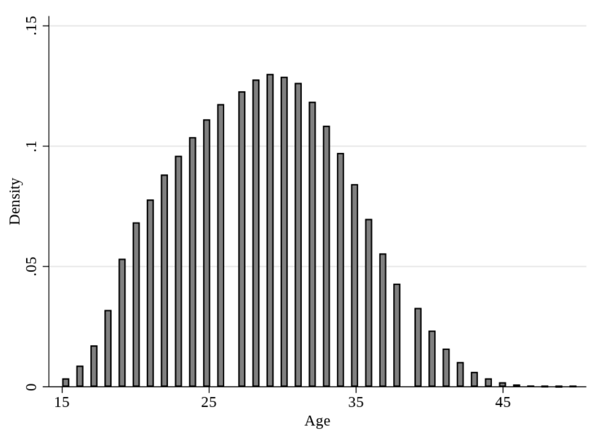


Figure 3. Pregnancy Distribution

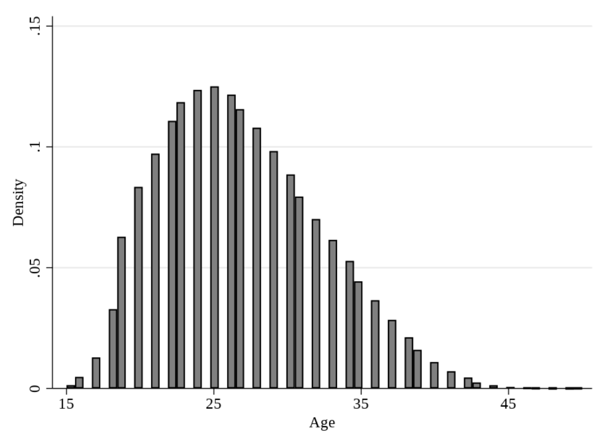


Figure 4. Smoking & Pregnancy Distribution

The data comes from NCHS (2019).

varying distributional assumptions on smoking intensity, and Callaway and Sant'Anna's estimator, are used to ensure the robustness of the findings.

The findings suggest that while T21 laws do not significantly influence the decision to smoke during pregnancy, they do result in an approximate 7% reduction in smoking intensity among individuals aged 18-to-20 in states that implemented the policy. However, the analysis finds no significant improvements in low birth weight outcomes. Premature birth rates increase by about 2 to 3 percentage points among the smoking population in states that adopted the policy early, whereas the prevalence of premature birth decreases slightly—by less than one percentage point—among those aged 18-to-20 compared to their older counterparts in T21 states. The impact on Cesarean delivery rates is minimal, with a reduction of about 1 to 2 percentage points, primarily driven by women aged 21-to-23. These findings suggest that existing tobacco control policies may have been more effective in reducing smoking, or that state-level T21 enactments were less impactful due to the prior implementation of similar policies at the local level before statewide mandates took effect.

This paper contributes to the literature in two key ways. First, it provides new evidence on the effectiveness of T21 laws in reducing maternal smoking and improving birth outcomes, particularly among younger mothers. Second, it underscores the value of staggered policy implementation as a tool for evaluating public health interventions, demonstrating the potential of regulatory measures to address the public health and economic burdens of smoking.

The remainder of the paper is structured as follows. Section 2 presents the theoretical framework, Section 3 describes the data and empirical strategy, Section 4 discusses the results and robustness checks, and Section 5 explores the economic implications and concludes the study.

2 Framework

Based on Grossman (2005), the full price of cigarettes can be described as:

$$P := P_{\text{E}} + P_{\text{I}}$$

where P_{E} is the explicit monetary price of cigarettes, and P_{I} is the implicit, or non-monetary, price associated with smoking, as outlined by Grossman (2005). Assume that the following conditions hold: $\partial_{P_{\text{E}}} P > 0$ and $\partial_{P_{\text{I}}} P > 0$. In other words, as the explicit or implicit price increases, the full price increases as well.

The explicit price of cigarettes comprises the base price and tax, represented as:

$$P_{\text{E}} = g(P_B, \tau, \rho)$$

where P_B is the base price of cigarettes, τ represents the excise tax, and ρ denotes penalties for illegally purchasing or consuming tobacco. The implicit price can be influenced by factors such as the effort required to purchase cigarettes and adverse health outcomes. This is modeled as:

$$P_{\mathrm{I}} = h(T, H, Z)$$

where T is the travel time or effort needed to purchase cigarettes, H represents adverse health outcomes, and Z includes other factors such as future earnings loss due to disability or death and social stigma. Combining these components, the full price of cigarettes can be expressed as:

$$P = g(P_B, \tau, \rho) + h(T, H, Z).$$

As Friedman and Pesko (2024) finds, T21 laws significantly reduce tobacco use among individuals aged 18 to 20. This suggests that pregnant individuals within this age range are likely impacted by the increase in the minimum legal purchase age (MLPA). The T21 laws raise the implicit price of tobacco through multiple channels. One clear channel is increased search costs (T). For individuals aged 18 to 20, the additional effort required to obtain cigarettes elevates both the implicit and full price of tobacco. Another channel is the heightened enforcement penalties (ρ). For example, under Illinois law, individuals under 21 caught using tobacco products may face fines, community service requirements, or participation in a non-residential youth program (ILGA, 2019). These increased costs contribute to the full price of tobacco, which can lead to smoking cessation or a reduction in cigarette consumption among individuals aged 18 to 20.

Additionally, T21 laws influence individuals under 18, who are further from the legal purchase threshold. For these individuals, the increase in the full price of tobacco products is even greater due to heightened access barriers and potential penalties.

As the increase in the MLPA impacts the entire population under the age of 21, these policies are expected to produce spillover effects, particularly for pregnant individuals. Reduced cigarette consumption among this group should lead to improved health outcomes during pregnancy and a decrease in adverse birth outcomes.

3 Methodology

3.1 Data

3.1.1 National Vital Statistics System

This paper utilizes restricted data from the NCHS (2019), maintained by the Centers for Disease Control and Prevention (CDC). The data, collected under the National Vital Statistics System (NVSS), encompass birth years 2014 to 2019, prior to the federal enactment of Tobacco 21 (T21) in December 2019. The dataset includes information from all 50 U.S. states and Washington, D.C., providing a comprehensive view of U.S. birth outcomes during this period. However, due to inconsistent data collection on tobacco use, I exclude data from New Jersey, Connecticut, Rhode Island, and Hawaii, as these states lack sufficient pre-period data for a reliable difference-in-difference analysis (CDC, 2024).

Each state, along with D.C., Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands, collects birth data using standardized forms developed and recommended by the CDC's National Center for Health Statistics (NCHS). These forms ensure consistency in data collection and capture details about the infant, such as birthweight, gestational age, APGAR scores, abnormal conditions, congenital anomalies, and live birth status. Maternal information, including health and risk factors, education, race, ethnicity, delivery method, previous births, and prenatal care, is also included. While paternal data is more limited, it includes education, race, ethnicity, and age. Notably, California ceased reporting marital status and paternal information starting in 2017, which introduces a limitation for these variables (CDC, 2024).

The NVSS data collection process is part of a long-standing collaboration between the CDC and jurisdictional vital registration systems, which are legally responsible for registering vital events (CDC, 2023). Although jurisdictions operate independently, they adhere to standardized practices and forms to maintain uniformity. The 2003 revisions to birth certificate forms enhanced data scope and quality by incorporating multiple-race and Hispanic origin data. The CDC also supports jurisdictions with tools such as the MedCoder automated system for efficient data coding and classification.

The outcome variables of interest include maternal smoking, the daily number of cigarettes consumed per trimester, low birth weight (LBW), very low birth weight (VLBW), preterm birth, and Cesarean delivery. These variables are constructed from NVSS data, but earlier years exhibit higher rates of missing values for maternal tobacco use and adverse health outcomes, requiring careful data handling.

Maternal smoking is defined as a dichotomous variable indicating whether a woman reported smoking at any point during pregnancy. This measure captures the extensive margin of tobacco use and supports the analysis of how T21 laws affect smoking prevalence among pregnant individuals. To address reporting variability, especially in earlier years, the sample is restricted to states and years with reliable reporting, with robustness checks ensuring consistency.

The average number of cigarettes smoked during pregnancy is calculated as the mean daily consumption across the three trimesters, conditional on smoking. Non-smokers are assigned a value of zero, capturing the intensive margin of tobacco use. The availability of trimester-level smoking data enhances the robustness of these measures, and missing values are carefully handled to avoid bias.

Adverse birth outcomes are measured using dichotomous indicators: LBW (infants weighing less than 2,500 grams), VLBW (less than 1,500 grams), preterm birth (delivery before 37 weeks gestation), and Cesarean delivery (surgical method).

Table 1 summarizes the mean and standard deviation for maternal and infant characteristics, including race and ethnicity, education, smoking behavior, number of prenatal visits, and birth-related outcomes. The dataset includes approximately 21.3 million observations, representing about 4 million births per year. The population consists of 74% White, 16% Black, 6% Asian, and 3% identifying as American Indian/Alaska Native (AIAN) or multiple races. Additionally, 24% of women identify as Hispanic. In terms of education, 86% of women have at least a high school diploma. Maternal smoking during pregnancy is reported by 7% of women, with smokers consuming an average of 8 cigarettes per day. Most women (72%) reported having between 9 and 16 prenatal visits during pregnancy. The average gestational age is 39 weeks, with 10% of births classified as premature. The mean birthweight is approximately 3300 grams (7.3 pounds), with 6% of births classified as LBW and 1% as VLBW. Cesarean deliveries account for 30% of all births. Table 2 presents the annual means for these outcome variables from 2014 to 2019. During this period, smoking prevalence declined significantly, from 8.43% in 2014 to 5.91% in 2019. The number of cigarettes smoked daily showed a modest incline, increasing from 8.36 to 8.56. Among infant health outcomes, the percentage of LBW infants increased slightly, from 6.24% in 2014 to 6.65% in 2019. VLBW and preterm births remained relatively stable, fluctuating around 1% and 9–10%, respectively. Cesarean delivery rates have been stable around 30%.

Table 1. Summary Statistics of Maternal and Infant Health Variables
($n = 21,300,000$)

Variable	Mean	SD
Maternal Characteristics		
Mother's Age (in Years)	28.63	5.82
White (=1 if White, =0 otherwise)	0.74	0.44
Black (=1 if Black, =0 otherwise)	0.16	0.36
AIAN (=1 if American Indian/Alaska Native, =0 otherwise)	0.01	0.10
Asian (=1 if Asian, =0 otherwise)	0.06	0.25
Multiple Races (=1 if Multiple Races, =0 otherwise)	0.02	0.15
Hispanic (=1 if Hispanic, =0 otherwise)	0.24	0.42
Education		
Grades K8 (=1 if Grades K-8, =0 otherwise)	0.03	0.18
Grades 9-12 (=1 if Grades 9-12, =0 otherwise)	0.10	0.31
High School Graduate (=1 if High School Graduate, =0 otherwise)	0.26	0.44
Some College (=1 if Some College, =0 otherwise)	0.29	0.45
College Graduate (=1 if College Graduate, =0 otherwise)	0.20	0.40
Graduate School (=1 if Graduate School, =0 otherwise)	0.11	0.32
Prenatal Visits		
No Prenatal Visits (=1 if No Visits, =0 otherwise)	0.02	0.13
At Most 8 Prenatal Visits (=1 if At Most 8 Visits, =0 otherwise)	0.17	0.38
Between 9 to 16 Visits (=1 if Between 9-16 Visits, =0 otherwise)	0.73	0.45
At Least 17 Visits (=1 if At Least 17 Visits, =0 otherwise)	0.09	0.28
Weight Gain During Pregnancy		
Less than 11 lbs (=1 if Less than 11 lbs, =0 otherwise)	0.09	0.29
11-20 lbs (=1 if 11-20 lbs, =0 otherwise)	0.17	0.37
21-30 lbs (=1 if 21-30 lbs, =0 otherwise)	0.27	0.45
31-40 lbs (=1 if 31-40 lbs, =0 otherwise)	0.24	0.42
41-98 lbs (=1 if 41-98 lbs, =0 otherwise)	0.19	0.40
Smoking Behavior		
Smoking Prevalence (if smoker = 1, = 0 otherwise)	0.073	0.26
Cigarettes Smoked Per Day (if smoker)	8.46	7.26
Birth-Related Outcomes		
Gestation Age (in Weeks)	38.73	2.35
Premature Birth (=1 if Gestation Age < 37 weeks, =0 otherwise)	0.10	0.30
Birthweight (in Grams)	3298.18	562.38
Low Birth Weight (=1 if Birthweight < 2500 g, =0 otherwise)	0.06	0.25
Very Low Birth Weight (=1 if Birthweight < 1500 g, =0 otherwise)	0.01	0.10
Cesarean Delivery (=1 if Cesarean, =0 otherwise)	0.30	0.46

Table 2. Outcome Variables Means by Year

Year	Smoker (%)	Avg. Cigarettes (#)	LBW (%)	Very LBW (%)	Preterm (%)	C-section (%)
2014	8.43	8.36	6.24	1.07	9.63	30.71
2015	7.77	8.37	6.34	1.08	9.62	30.51
2016	7.23	8.36	6.44	1.08	9.73	30.42
2017	6.92	8.46	6.56	1.09	9.98	30.50
2018	6.51	8.57	6.60	1.09	10.08	30.42
2019	5.96	8.56	6.65	1.09	10.53	30.21

Note: Average cigarettes are calculated for smokers only.

3.1.2 Tobacco Control Policies

The cigarette tax data come from Orzechowski and Walker (2024), with all monetary values deflated to 2019 dollars using CPI data. The T21 policy variable is constructed using effective dates from Campaign for Tobacco-Free Kids (2025), with implementation dates matched to each birth's conception month-year (calculated using gestational age and birth date). Figure 5 shows the state and year enactment of T21 laws.

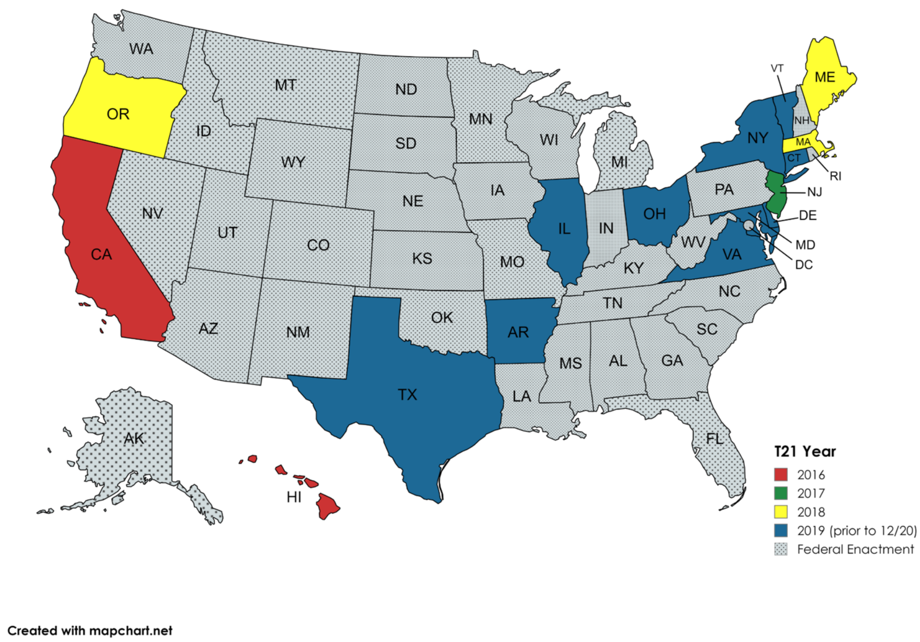
3.2 Empirical Strategy

T21 laws are designed to limit tobacco consumption among individuals under 21. These laws were enacted at different times across states. If there is an impact of T21 laws on smoking behaviors, I will evaluate the potential spillover onto adverse birth outcomes. Additionally, I interact T21 with the under-21 population, as the policy specifically targets youth smoking, as illustrated in Figure 6.

3.2.1 First Stage: Impact on Maternal Smoking

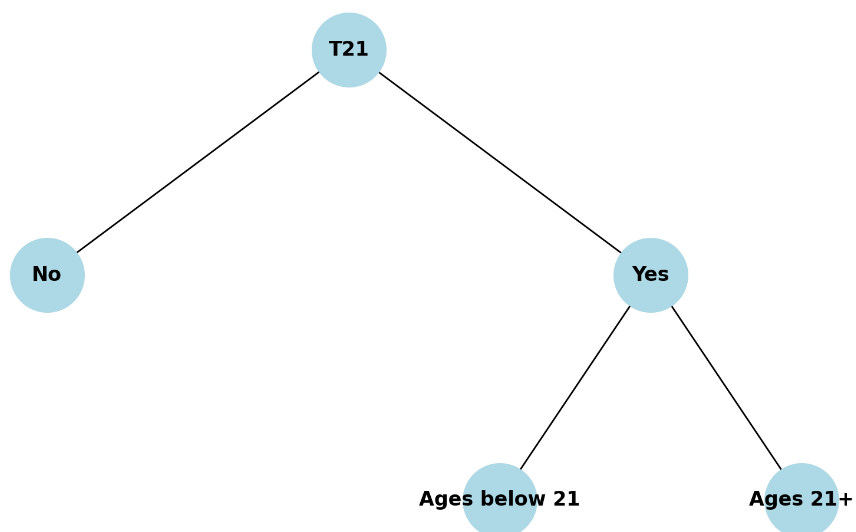
The first stage examines the impact of T21 laws on maternal smoking at both the extensive and intensive margins. I employ a difference-in-difference (DiD) and triple difference (TD) approach. The outcome variables are defined as (1) whether or not a pregnant woman smokes during pregnancy, and (2) for those who smoke, the average number of cigarettes smoked per month. In the DiD analysis, I compare individuals aged 18-20 in states where T21 was enacted before December 2019 to individuals in states that did not enact it by that time. In the TD analysis, I compare individuals aged 18-20 to those aged 21-23, as conducted in studies such as Hansen et al. (2023)

Figure 5. T21 Laws and State Implementation



Map displaying state-wide enactment of T21 laws.

Figure 6. Identification Strategy



Identification Strategy of TD Approach.

and Friedman and Pesko (2024). In Table 3, age groups 18-20 and 21-23 have pretty similar characteristics, education, smoking behaviors, and prevalence of adverse birth outcomes.

The rationale for focusing on these age groups is that individuals under 18 were already legally prohibited from purchasing tobacco products before the T21 laws and are not directly affected. It is also important to note that younger mothers are more likely to smoke. These groups exhibit similar rates of smoking during pregnancy, low birth weight, premature birth, and Cesarean delivery.

To improve the accuracy of the model and address potential biases, I use inverse probability weighting (IPW) in conjunction with the DiD and TD frameworks. My rationale for using IPW is that treatment assignment is not random. States implement T21 laws based on their political climate, which may reflect public health concerns. This non-randomness can be correlated with smoking patterns among pregnant women, potentially creating bias in the DiD estimates. Additionally, T21 laws are enacted at different times, and IPW helps account for staggered adoption by balancing pregnant women's characteristics across states and birth years. To construct the IPW, I regress the treatment variable (T21) onto the characteristics of the mother, i.e., education, race, Medicaid status, and WIC status. The collection of data on smoking behaviors among pregnant women may also be inconsistent, as individuals might be unwilling to disclose smoking behaviors, or they might not be asked about smoking at the time of delivery. IPW reweights the data to account for the probability of being included in the sample, thereby reducing potential bias.

To examine how smoking prevalence changes with respect to T21 laws for individuals aged 18-20 within a DiD framework, I estimate the model

$$\Pr(c > 0|\cdot)_{ist} = \alpha_0 + \alpha_1 \tau_{st} + \alpha_2 \text{T21}_{st} + \phi_s + \gamma_t + X'_{ist} b + \varepsilon_{ist}, \tag{1}$$

where c represents the average number of cigarettes smoked per day during pregnancy, τ is the real cigarette tax rate (in 2019 dollars), T21 is a binary indicator equal to 1 when a state enacts T21 at time t and beyond, and ϕ_s, γ_t, and α_a denote state, birth year, and maternal age fixed effects, respectively. X is a vector of maternal characteristics, including age, education, race, and ethnicity. The extensive margin analysis compares cases where $c = 0$ to $c > 0$, coding $c > 0$ as a smoking indicator equal to 1.

For the TD framework, I study the impact of T21 laws on individuals aged 18–20 relative to those aged 21–23 in states that enacted T21 laws versus states that did not by estimating:

$$\Pr(c > 0|\cdot)_{ist} = \alpha_0 + \alpha_1 \tau_{st} + \alpha_2 \text{T21}_{st} + \alpha_3 \left(\text{T21}_{st} \times \mathbb{1}[< 21]_i\right) + \phi_s + \gamma_t + \alpha_a + X'_{ist} b + \varepsilon_{ist}, \tag{2}$$

where $\mathbb{1}[< 21]$ is a binary indicator for pregnant individuals under the age of 21, and all other variables are as described for Equation 1. In this model, I use α_a for an age-fixed effect and do not include age in the X vector. The interaction term in Equation 6 is the triple difference estimator.

To measure the effect of T21 laws on the intensive margin (i.e., the average number of cigarettes smoked per month), I use a similar approach. For the DiD setting:

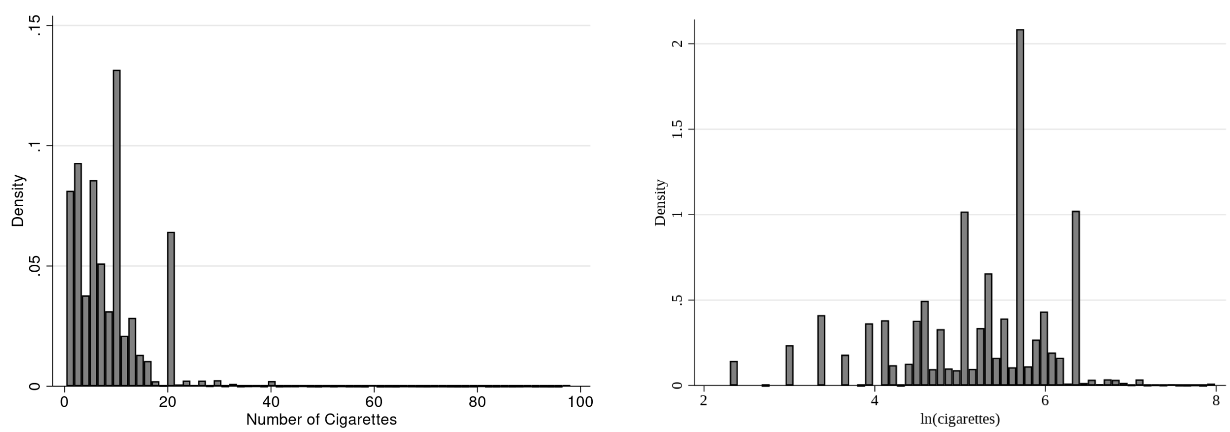
$$\ln(\bar{c}|\cdot, c > 0)_{ist} = \beta_0 + \beta_1 \tau_{st} + \beta_2 \text{T21}_{st} + \tilde{\phi}_s + \tilde{\gamma}_t + X'_{ist}d + \varepsilon_{ist}, \tag{3}$$

and for the TD setting:

$$\ln(\bar{c}|\cdot, c > 0)_{ist} = \beta_0 + \beta_1 \tau_{st} + \beta_2 \text{T21}_{st} + \beta_3 \left(\text{T21}_{st} \times \mathbb{1}[< 21]_i\right) + \tilde{\phi}_s + \tilde{\gamma}_t + \tilde{\alpha}_a + X'_{ist}d + \varepsilon_{ist}, \tag{4}$$

where $\ln(\bar{c}|\cdot, c > 0)_{ist}$ represents the log of the average number of cigarettes smoked per month during pregnancy, and other variables are defined as in the preceding equations. Figure 7 shows that the average number of cigarettes consumed per day is positively skewed. To be consistent with the assumption of OLS, I use a natural log transformation of the variable.

Figure 7. Distribution of Cigarette Consumption



This graphs is to show the how the distribution of number of cigarettes changes when a log transformation is implemented.

Table 3. Summary Statistics by Maternal Age Groups

	15-17	18-20	21-23	24-34	35-44	45-50
Maternal Characteristics						
Mother's Age	16.46	19.24	22.07	28.98	37.34	46.26
	(0.69)	(0.77)	(0.81)	(3.04)	(2.19)	(1.57)
White	0.68	0.71	0.72	0.75	0.73	0.69
	(0.47)	(0.46)	(0.45)	(0.43)	(0.44)	(0.46)
Black	0.24	0.22	0.21	0.14	0.13	0.16
	(0.43)	(0.41)	(0.41)	(0.35)	(0.34)	(0.37)
Hispanic	0.40	0.32	0.28	0.22	0.22	0.20
	(0.49)	(0.47)	(0.45)	(0.42)	(0.42)	(0.40)
Education						
Grades K-8	0.07	0.03	0.03	0.03	0.05	0.08
	(0.25)	(0.16)	(0.17)	(0.17)	(0.22)	(0.27)
Grades 9-12	0.80	0.26	0.14	0.07	0.06	0.06
	(0.40)	(0.44)	(0.35)	(0.26)	(0.24)	(0.24)
Some College	0.01	0.20	0.35	0.31	0.24	0.20
	(0.08)	(0.40)	(0.47)	(0.46)	(0.42)	(0.40)
Graduate School	0.00	0.00	0.00	0.12	0.23	0.26
	(0.00)	(0.01)	(0.05)	(0.33)	(0.42)	(0.44)
Smoking Behavior						
Smoking Prevalence	0.06	0.10	0.11	0.07	0.04	0.02
	(0.23)	(0.30)	(0.31)	(0.26)	(0.20)	(0.15)
Average Cigarettes/Day	6.73	7.42	8.02	8.69	9.17	9.65
	(6.85)	(6.86)	(7.08)	(7.30)	(7.71)	(8.47)
Birth Outcomes						
Low Birth Weight	0.09	0.08	0.07	0.06	0.07	0.11
	(0.29)	(0.28)	(0.26)	(0.24)	(0.25)	(0.32)
Preterm Birth	0.14	0.11	0.10	0.09	0.11	0.17
	(0.35)	(0.32)	(0.30)	(0.27)	(0.28)	(0.34)
Cesarean Delivery	0.17	0.21	0.25	0.30	0.40	0.55
	(0.37)	(0.41)	(0.43)	(0.46)	(0.49)	(0.50)
Observation	300,820	1,564,180	2,670,690	13,169,663	3,509,079	42,565

3.2.2 Second Stage: Adverse Health Outcomes

Smoking is strongly correlated with adverse health outcomes during pregnancy. Similar to the first stage, I examine whether the policy is correlated with adverse birth outcomes. I use a DiD and TD approach, but separately analyze the whole population and the population of pregnant women who smoke in each model. The models are specified as follows

$$\Pr(Y = 1|\cdot) = \gamma_0 + \gamma_1\tau + \gamma_2\text{T21} + \theta_s + \lambda_t + \chi_a + X'_{ist}\beta + H'_{ist}\delta + \eta_{ist} \quad (5)$$

$$\Pr(Y = 1|\cdot) = \gamma_0 + \gamma_1\tau + \gamma_2\text{T21} + \gamma_3\left(\text{T21}_{st} \times \mathbb{1}[< 21]_i\right) + \theta_s + \lambda_t + \chi_a + X'_{ist}\beta + H'_{ist}\delta + \eta_{ist} \quad (6)$$

where Y represents the adverse health outcomes, T21 is a binary indicator equal to 1 when a state enacts T21 at time t and beyond, and $\mathbb{1}[< 21]$ is a binary indicator for pregnant individuals under the age of 21. The terms θ_s, λ_t, and χ_a represent fixed effects for state, birth year, and maternal age, respectively. The model includes controls for maternal education, race, and ethnicity, captured in the vector X. H is a vector that includes prenatal visits, the BMI of the pregnant individual at the beginning of their pregnancy, and the weight gained during pregnancy. The error term, η_{ist}, accounts for unobserved factors affecting health outcomes. The interaction term in Equation 6 represents the triple difference estimator.

4 Results

4.1 Effects on Smoking During Pregnancy

4.1.1 Primary Results

Firstly, I compare the smoking behaviors of pregnant women aged 18–20 in states that enacted T21 laws before December 2019 to those in states that did not. I employ both Difference-in-Differences (DiD) and Triple Differences (TD) methods, incorporating inverse probability weighting (IPW) to account for potential selection bias. Table 4 presents the results across four specifications, with columns (1) and (2) showing the DiD estimates, and columns (3) and (4) reporting the TD results.

For the extensive margin (columns 1 and 3), the DiD estimates indicate no statistically significant impact of T21 laws on smoking prevalence among pregnant women aged 18–20 in treated states compared to non-treated states. Similarly, the TD results show that T21 laws alone do not significantly affect smoking prevalence. However, the interaction term between T21 and being under 21 in column (3) reveals a statistically significant 0.69 percentage point increase in smoking prevalence, significant at the 5% level. Despite this significance, the small magnitude suggests that T21 laws do not meaningfully influence the decision to initiate or continue smoking during pregnancy.

On the intensive margin (columns 2 and 4), the DiD results indicate that T21 laws are associated with a significant reduction in cigarette consumption among pregnant smokers. The coefficient of -0.1031 in column (2) implies that pregnant women aged 18–20 who smoked during pregnancy reduced their monthly cigarette consumption by approximately 9.82% compared to those in states without the policy, calculated using the formula $(\exp(\hat{\beta}) - 1) \times 100\%$. The TD results in column (4) further suggest that the implementation of T21 laws resulted in an overall 6.71% reduction in cigarette consumption for the entire 18–23 age group, with an additional 4.55% reduction among those aged 18–20 relative to those aged 21–23.

In terms of control variables, the DiD models (columns 1 and 2) include state and year fixed effects along with additional covariates. Age is included as a control variable in vector X, but age fixed effects are not used. In contrast, the TD models (columns 3 and 4) incorporate age fixed effects to account for potential age-specific trends in smoking behavior.

Overall, these results suggest that while T21 laws have a limited impact on smoking prevalence, they are effective in reducing the intensity of cigarette consumption among pregnant smokers, particularly younger individuals. This highlights the role of policy interventions in shaping smoking behavior during pregnancy.

Table 4. Impact of Tobacco 21 on Smoking Behavior

	(1) Cigarette User	(2) ln(Cigarettes)	(3) Cigarette User	(4) ln(Cigarettes)
T21 Policy	0.0038	-0.1031***	0.0037	-0.0695***
	(0.0060)	(0.0236)	(0.0076)	(0.0109)
T21 × Under 21			0.0069**	-0.0466***
			(0.0034)	(0.0166)
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Age FE	No	No	Yes	Yes
Covariates	Yes	Yes	Yes	Yes
Observations	1,116,159	105,113	4,056,613	432,468
R^2	0.1091	0.0864	0.1107	0.0905
Root MSE	0.2316	0.9297	0.2496	0.9141

Robust standard errors in parentheses, clustered by state.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Age is a control in DiD.

4.1.2 Parallel Trends Assumption

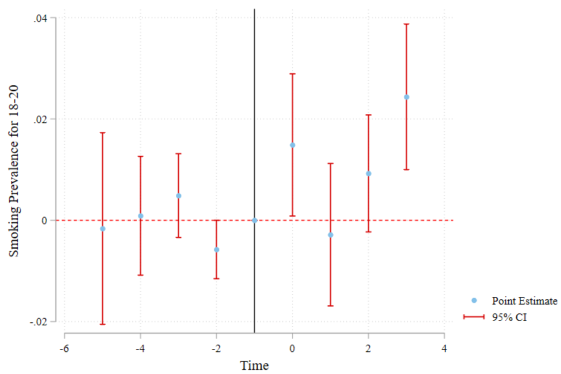
In DiD methodologies, the primary assumption is parallel trends. In other words, if T21 laws had not been enacted, the smoking behaviors of individuals in states that did enact T21 laws before the December 2019 federal enactment would have followed similar trends to those in states that did not enact such laws. The differences between states that enacted T21 laws and those that did not would be constant over time. This assumption is crucial in difference-in-difference designs; without it, estimates may be biased, and causal inference would be difficult to defend. To test this assumption, researchers often examine whether trends in the pre-T21 periods are parallel. Given the staggered nature of this research design, I use event study plots to assess this assumption for both the extensive and intensive margins.

The extensive margin, representing the decision to smoke during pregnancy, is illustrated in Figure 8. Panel 8a and Panel 8b depict smoking prevalence trends among pregnant women aged 18-20 and 21-23, respectively. In the pre-T21 periods, the 95% confidence intervals include zero, providing evidence that the parallel trends assumption holds for the decision to smoke during pregnancy. In the post-T21 periods, there are statistically significant decreases in smoking prevalence for individuals aged 18-20 in treated states. Among those aged 21-23, there is a slight decline in smoking prevalence in the first year after T21 implementation, but little change is observed in subsequent years.

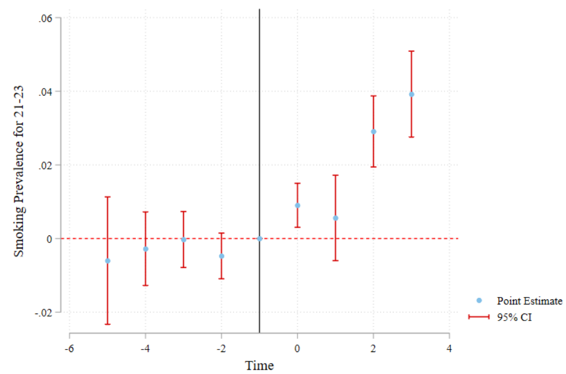
The intensive margin, representing the number of cigarettes smoked per month during pregnancy among smokers, is illustrated in Figure 8. Panels 8c and 8d show the log of the monthly average number of cigarettes consumed by individuals aged 18-20 and 21-23, respectively. Similar to the extensive margin, the 95% confidence intervals for pre-T21 estimates include zero, providing evidence that the parallel trends assumption holds. In the post-T21 periods, individuals aged 18-20 in treated states exhibit statistically significant reductions in cigarette consumption during pregnancy, particularly in the first few years after T21 implementation. Among those aged 21-23, there is an initial decline in cigarette consumption during the first year, but these reductions are not sustained, with subsequent estimates close to zero and confidence intervals overlapping zero.

Figure 8. Smoking Prevalence and ln(Cigarettes) Trends for Ages 18-20 and 21-23

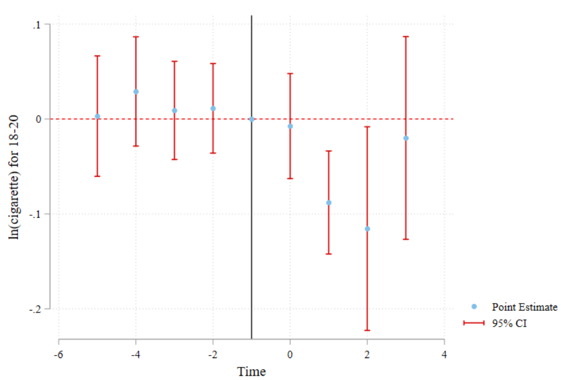
(a) Smoking Prevalence: Ages 18-20



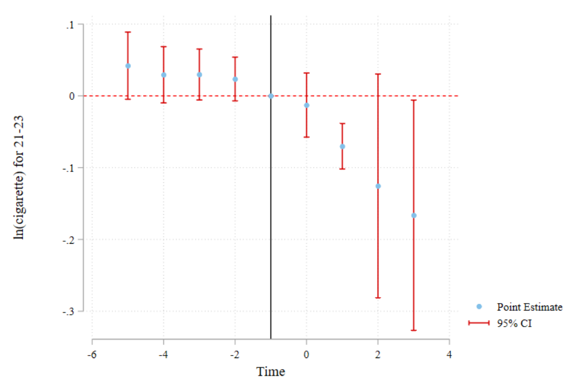
(b) Smoking Prevalence: Ages 21-23



(c) ln(Cigarettes): Ages 18-20



(d) ln(Cigarettes): Ages 21-23



4.1.3 Nonlinear Models

Due to the dichotomous nature of the choice to smoke, I also use probit and logit models to test the impact of T21 policies on the latent probability of smoking during pregnancy. These models have been used in other literature, such as Hawkins and Baum (2014) and Hawkins and Baum (2019), to assess how cigarette taxes and smoke-free air laws impact smoking among pregnant women and adverse birth outcomes. Tables 5 and 6 display the maximum likelihood estimates (MLE) for smoking prevalence and the GLM estimates for the average monthly number of cigarettes smoked.

An important methodological consideration when using fixed effects in probit models is the potential incidental parameter problem, first identified by Neyman and Scott (1948) and reviewed in detail by Lancaster (2000). However, this concern arises primarily in panel data settings where individual-specific effects are estimated with limited time periods. In this analysis, because I use pooled cross-sectional data with fixed effects for state, maternal age, and birth year, the incidental parameter problem is less of a concern. This is because these fixed effects represent group-level rather than individual-level heterogeneity, and each category of fixed effects contains many observations.

Table 5 presents the results from the probit and logit probability regressions, as well as the log-linked GLM models that assume Gamma and Gaussian distributions. The latent probability of smoking during pregnancy decreases by -0.0344 and -0.1161 in the probit and logit models, respectively. These estimates translate to a 0.47 and 0.85 percentage point decrease in the probability of smoking. For smoking intensity, the Gamma and Gaussian distribution log-linked GLMs show a 9.68% and 9.5% decrease in the average monthly number of cigarettes smoked, respectively. The results are not consistent with the prevalence of smoking, as the DiD analysis does not show a statistically significant impact on smoking prevalence for pregnant women aged 18-20, whereas the MLE estimates show a small negative effect (significant at the 5% level). In terms of smoking intensity, the results are consistent with a 9.5% decrease in the average monthly number of cigarettes smoked.

To explore the impact of T21 laws on individuals aged 18-20 compared to those aged 21-23, I use 3WFE MLE and GLM models, as shown in Table 6. In the probit and logit models, there appears to be no effect in states that enacted T21 laws, and the prevalence of smoking among individuals aged 18-20 does not differ from those aged 21-23. In the GLM models, T21 policies seem to spill over into the smoking intensity of individuals in states where T21 laws are enacted; however, there is no difference in the intensity between those aged 18-20 and those aged 21-23.

Table 5. 2WFE for Cigarette User and Cigarettes Smoked

	Cigarette User		Cigarettes Smoked	
	Probit	Logit	Gamma	Gauss
T21 Policy	-0.0344*	-0.1161**	-0.0968***	-0.0950***
	(0.0186)	(0.0532)	(0.0151)	(0.0183)
Marginal Effect T21	-0.0047	-0.0085		
(MLE Only)	(0.0026)	(0.0039)		
State Fixed Effects	Yes	Yes	Yes	Yes
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes
Additional Covariates	Yes	Yes	Yes	Yes
Pseudo R^2/AIC	0.1935	0.1948	12.754	13.391
Observations	1,118,318	1,118,318	105,138	105,138

Robust standard errors in parentheses, clustered by state.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Pseudo R^2 is reported for Probit and Logit models.
AIC is reported for Gamma and Gauss models.

Table 6. 3WFE Models for Cigarette User and Cigarettes Smoked

	Cigarette User		Cigarettes Smoked	
	Probit	Logit	Gamma	Gauss
T21 Policy	-0.0127	-0.0357	-0.103***	-0.1011***
	(0.0412)	(0.0471)	(0.0132)	(0.0201)
T21 $\times$ Under 21	0.0205	0.0449	-0.007	-0.004
	(0.0352)	(0.0777)	(0.0190)	(0.0171)
State Fixed Effects	Yes	Yes	Yes	Yes
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes
Age Fixed Effects	Yes	Yes	Yes	Yes
Additional Covariates	Yes	Yes	Yes	Yes
Pseudo R^2/AIC	0.2099	0.2116	17.471	18.376
Observations	4,056,613	4,056,613	301,891	301,891

Robust standard errors in parentheses, clustered by state.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Pseudo R^2 is reported for Probit and Logit models.
AIC is reported for Gamma and Gauss models.

4.1.4 Callaway and Sant'Anna DiD Estimate

Given the staggered timing of T21 law enactments, I employ the approach proposed by Callaway and Sant'Anna (2021) as a robustness check for the results discussed in the Results section. This method accounts for heterogeneous treatment effects by incorporating variation in treatment timing across states and birth years, using weights constructed for individual observations. These weights allow for a robust difference-in-differences estimate of the impact of T21 laws on maternal smoking behaviors. The CS estimate for the overall ATT, θ, is a weighted average of the ATT for each state g treated at time t, $ATT(g,t)$, mathematically expressed as:

$$\theta = \sum_{g} \sum_{t} w_{gt} \cdot \mathbb{1}[g \leq t] \cdot ATT(g,t), \tag{7}$$

where w_{gt} represents the weight for state g treated at time t, and $\mathbb{1}[g \leq t]$ ensures that only post-T21 enactment periods are included in the calculation. The CS approach provides a robust and unbiased estimate of the average treatment effect on the treated (ATT) by accounting for the staggered implementation of T21 laws, offering insight into their effects on smoking prevalence and the number of cigarettes smoked during pregnancy.

The CS estimates, as shown in Table 7, suggest that T21 laws do not significantly influence the decision to smoke during pregnancy. However, there is evidence of an effect on the intensity of cigarette smoking. Specifically, the calendar average indicates that the average yearly decrease in cigarette consumption is 4.66%. Additionally, the post-T21 enactment period shows a 6.8% decrease in monthly cigarette consumption. In Figure 9, the findings of the CS estimates are further validated by the event study plots. Generally, the 95% confidence intervals for the pre-T21 period estimates include zero, suggesting no pre-existing trends that would confound the results. In the post-T21 periods, while smoking prevalence does not show a statistically significant change due to the T21 policy, the intensity of smoking (i.e., the number of cigarettes smoked) is significantly impacted.

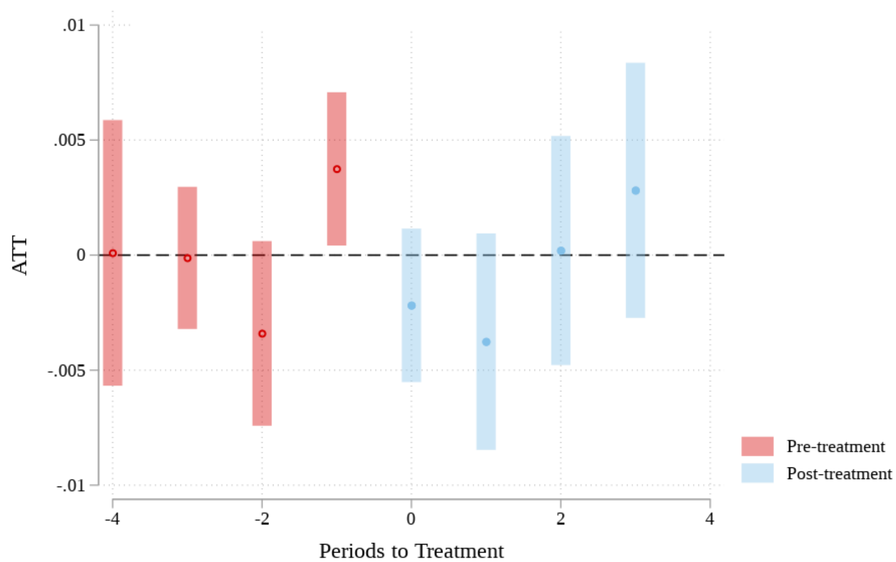
Table 7. Treatment Effect Estimates

	ATT	Group Avg.	Calendar Avg.	Pre-T21 Avg.	Post-T21 Avg.
Smoking Prevalence	-0.0014	-0.0022	-0.0013	0.0001	-0.0007
	(0.0019)	(0.0018)	(0.0019)	(0.0012)	(0.0021)
Ln(Cigarettes)	0.0135	0.0084	-0.0477**	-0.0077	-0.0705***
	(0.0297)	(0.0211)	(0.0265)	(0.00598)	(0.0126)

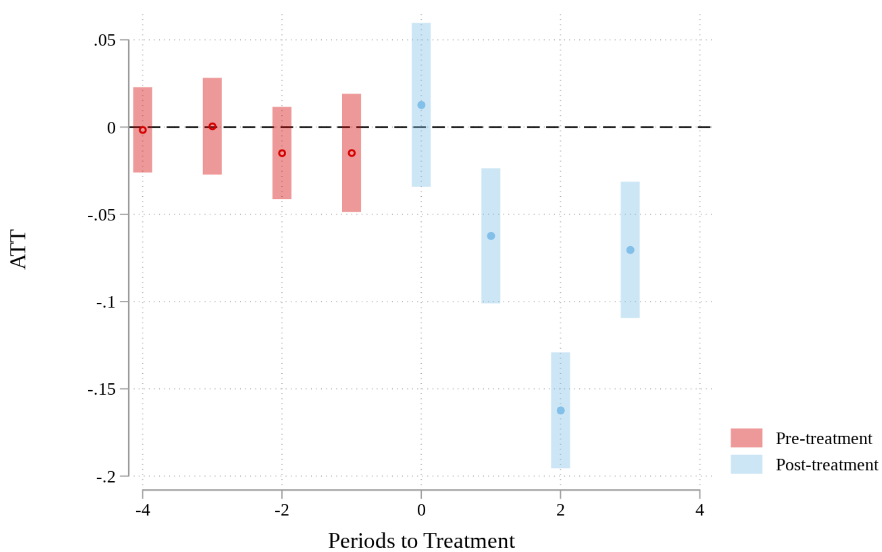
Robust standard errors in parentheses, clustered by state.

Figure 9. Callaway and Sant'Anna Event Study

(a) Cigarette Prevalence



(b) Ln(Cigarettes)



4.2 Smoking and Adverse Health Outcomes

In this section, I examine the spillover effects of T21 laws on adverse birth outcomes, focusing on four key indicators: (1) low birth weight, (2) very low birth weight, (3) premature birth, and (4) Cesarean delivery. Given the evidence suggesting that T21 laws primarily influence smoking through the intensive margin, I analyze both the overall population of pregnant women aged 18-23 and those who smoked during pregnancy.

The DiD analysis compares women aged 18-20 in states that enacted T21 laws to their counterparts in states that did not, while the TD approach evaluates differences between treated and non-treated states, as well as comparisons between women aged 18-20 and those aged 21-23 in states with T21 laws.

The findings suggest minimal effects of T21 laws on low birth weight and very low birth weight. In the overall population, low birth weight prevalence decreased by 0.19 percentage points for women aged 18-20 relative to those aged 21-23 in T21-enacted states, though the impact on very low birth weight was not statistically significant.

For premature birth, T21 laws were associated with a 2.4 percentage point increase among women aged 18-20 in states with T21 laws compared to those without. Including the 21-23 age group, states with T21 laws experienced a 3.1 percentage point rise in premature birth prevalence. However, when comparing age groups within T21 states, preterm birth prevalence declined by 0.35 percentage points in the overall population and by 0.89 percentage points among smokers.

Regarding Cesarean deliveries, T21 laws had no significant effect on rates among women aged 18-20 in treated states compared to those in non-treated states. However, in the broader 18-23 age group, C-section rates declined by 0.98 percentage points, with a larger decline of 2.3 percentage points observed in the smoking population. No significant differences were found between the 18-20 and 21-23 age groups.

Table 8. Effect of T21 Policy on Low Birth Weight

	Difference-in-Differences (DiD)		Triple-Differences (TD)	
	Whole Pop	Smoker Pop	Whole Pop	Smoker Pop
T21 Policy	-0.0022	0.0057	-0.0004	0.0104
	(0.0086)	(0.0060)	(0.0078)	(0.0073)
T21 × Under 21			-0.0019***	-0.0068
			(0.0005)	(0.0051)
State Fixed Effects	Yes	Yes	Yes	Yes
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes
Additional Covariates	Yes	Yes	Yes	Yes
R^2	0.0346	0.0576	0.0309	0.0502
Observations	1,447,019	147,900	3,933,001	417,877

Robust standard errors in parentheses, clustered by state.

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

Table 9. T21 Policy on Very Low Birth Weight

	Difference-in-Differences (DiD)		Triple-Differences (TD)	
	Whole Pop	Smoker Pop	Whole Pop	Smoker Pop
T21 Policy	0.00001	0.0049	0.0007	0.0002
	(0.0042)	(0.0032)	(0.0027)	(0.0020)
T21 × Under 21			-0.00007	0.0028
			(0.0003)	(0.0021)
State Fixed Effects	Yes	Yes	Yes	Yes
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes
Additional Covariates	Yes	Yes	Yes	Yes
R^2	0.0161	0.0339	0.0128	0.0170
Observations	1,447,019	147,900	3,933,001	417,877

Robust standard errors in parentheses, clustered by state.

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

Table 10. Effect of T21 Policy on Preterm Birth

	Difference-in-Differences (DiD)		Triple-Differences (TD)	
	Whole Pop	Smoker Pop	Whole Pop	Smoker Pop
T21 Policy	-0.00133	0.02411**	0.00111	0.03139**
	(0.01251)	(0.01010)	(0.01006)	(0.01402)
T21 × Under 21			-0.00354***	-0.00891***
			(0.00040)	(0.00192)
State Fixed Effects	Yes	Yes	Yes	Yes
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes
Additional Covariates	Yes	Yes	Yes	Yes
R^2	0.0228	0.0335	0.0208	0.0303
Observations	1,447,033	147,888	3,933,172	417,795

Robust standard errors in parentheses, clustered by state.

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

Table 11. Effect of Tax and T21 Policy on C-Section Rates

	Difference-in-Differences (DiD)		Triple-Differences (TD)	
	Whole Pop	Smoker Pop	Whole Pop	Smoker Pop
T21 Policy	-0.00809	-0.01237	-0.00980*	-0.02317*
	(0.00827)	(0.01990)	(0.00470)	(0.01263)
T21 × Under 21			0.00306	-0.00769
			(0.00235)	(0.01415)
State Fixed Effects	Yes	Yes	Yes	Yes
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes
Additional Covariates	Yes	Yes	Yes	Yes
R^2	0.0331	0.0295	0.0378	0.0356
Observations	1,447,379	147,934	3,934,035	417,995

Robust standard errors in parentheses, clustered by state.

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

5 Discussion and Conclusion

This paper explores the relationship between the enactment of T21 laws and maternal smoking behaviors. T21 (Tobacco 21) laws increase the minimum legal purchasing age of tobacco products from either 18 or 19 to 21. Existing literature generally finds that these laws reduce tobacco use (including traditional and electronic cigarettes), alcohol consumption, and marijuana consumption among individuals aged 18 to 20. Tennekoon (2023) found that city-level enactment of T21 laws lowers smoking prevalence, the number of cigarettes smoked, and the prevalence of adverse birth outcomes. This paper focuses on the state-wide enactment of T21 policies and hypothesizes that if T21 laws reduce maternal smoking, there might be spillover effects that lower the likelihood of adverse birth outcomes, such as low birth weight, very low birth weight, premature birth, and Cesarean delivery. This study employs DiD and TD methodologies to address this question. The DiD approach compares pregnant women aged 18 to 20 in states that enacted the policy before the federal enactment in December 2019 to those that did not. The TD approach adds another dimension by comparing pregnant women aged 18 to 20 to those aged 21 to 23.

In the first stage of the analysis, the variables of interest are smoking prevalence and the monthly average number of cigarettes consumed. The findings suggest that T21 laws do not influence the extensive margin, i.e., the decision to smoke; however, there is evidence that they lower the intensive margin, i.e., the amount smoked during pregnancy. The results indicate that the decrease in the monthly average number of cigarettes smoked ranges from 7% to 11%.

These results differ from those of Tennekoon (2023), who found a significant impact of these policies. In many cases, various localities enacted their own T21 laws before state-wide implementation. For example, Campaign for Tobacco-Free Kids (2025) reports that 540 localities enacted the T21 policy before the federal policy was introduced on December 20, 2019. This suggests that if enough localities implemented the policy before the state, its effectiveness may have diminished by the time it was enacted state-wide. Additional potential explanations include the significant decline in the prevalence of women smoking during pregnancy, particularly after the federal cigarette tax increase in April 2009 (from $0.62 per pack to $1.01 per pack). Furthermore, some states have increased their tax rates over time. Various states have also enacted stricter smoke-free air laws, such as California's prohibition of smoking in bars, restaurants, private workplaces, and multi-unit housing. These regulations apply to both traditional and electronic cigarettes. Declining trends in cigarette smoking are also correlated with the increasing use of electronic cigarettes (or vapes).

It is important to note that T21 laws prohibit individuals under 21 from purchasing tobacco products; however, they do not restrict the legality of tobacco consumption. This distinction likely explains why there is no significant impact on smoking prevalence among those aged 18 to 20.

However, the observed reduction in consumption suggests that the law makes it more difficult to smoke the same amount of cigarettes, even though consumption remains legal. Another effective alternative is increasing cigarette taxes. In another paper, I find that increasing excise cigarette taxes from $2 to $7 per pack can significantly benefit a state's GDP, employment, and income. This suggests that higher taxes could also improve health outcomes and lower healthcare costs (Esposito, 2024).

The results vary when exploring the spillover impact of T21 laws on low birth weight, very low birth weight, premature birth, and Cesarean delivery. Among pregnant individuals aged 18 to 20, there is a 0.2 percentage point decrease in low birth weight prevalence compared to those aged 21 to 23 in states that enacted T21 laws. However, no significant difference in low birth weight prevalence was observed when comparing states that enacted T21 laws to those that did not between 2014 and 2019. There was no impact on very low birth weight prevalence.

Premature birth rates increased by 1.2 percentage points among women aged 18 to 20 who smoked during pregnancy in states that enacted T21 policies. Among the smoking population of women aged 18 to 23, there was a 3 percentage point increase in premature birth rates in T21 law states. However, within the entire population, women aged 18 to 20 experienced a 0.4 percentage point decrease, and within the smoking population, they experienced a 0.9 percentage point decrease compared to those aged 21 to 23.

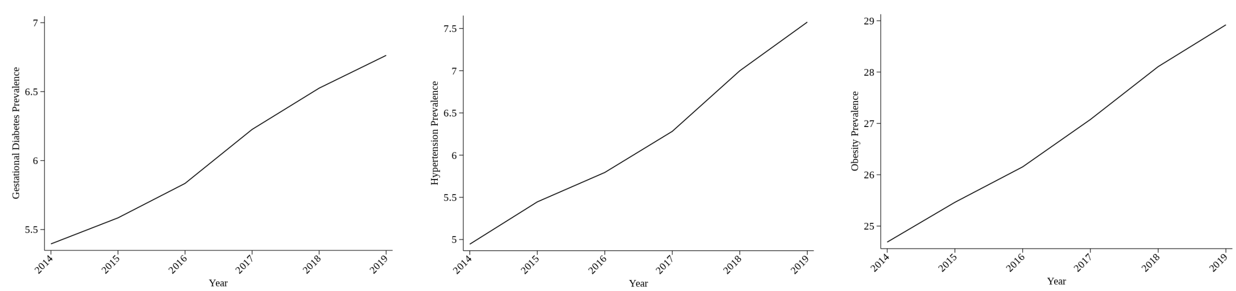
In states with T21 laws, there was a 0.1 percentage point decrease in Cesarean delivery rates in the entire population and a 2 percentage point decrease in the smoking population. In the DiD models, there appears to be no significant difference in C-section rates attributable to T21 laws, suggesting that any observed differences might be driven by individuals aged 21 to 23.

Because the state-wide enactment of T21 laws impacts the intensity of smoking during pregnancy rather than the decision to smoke, the overall impact on adverse birth outcomes is limited, except for Cesarean delivery. Given the declining trend in smoking prevalence over time, adverse health outcomes would also be expected to decline. However, as illustrated in Figures 10a, 10b, and 10c, gestational diabetes, gestational hypertension, and obesity rates have been increasing over the last several years, in contrast to the declining cigarette smoking prevalence among pregnant women. Recent medical literature suggests that gestational diabetes has increased the rate of premature birth (Preda et al., 2023). Chronic hypertension is correlated with adverse birth outcomes such as premature birth, Cesarean delivery, pre-eclampsia, maternal mortality, and small-for-gestational-age births (Al Khalaf et al., 2021; Leonard et al., 2024). Obesity is also associated with increased rates of gestational diabetes, gestational hypertension, and pregnancy complications (Paredes et al., 2021). These findings suggest that rising rates of premature birth may be driven by increasing prevalence rates of these adverse maternal health conditions.

While I strongly believe the results of this paper are valid, several limitations should be acknowledged. First, data collection for Vital Statistics was inconsistent before 2015, leading to the exclusion of New Jersey, Connecticut, Rhode Island, and Hawaii, as reported by CDC (2024). Additionally, due to the observational nature of the data, pregnant women may underreport their tobacco use, introducing potential measurement error. To address this concern, I applied inverse probability weighting (IPW) in the DiD and TD models and conducted robustness checks using maximum likelihood estimation (MLE), generalized linear models (GLM), and the Callaway and Sant'Anna (2021) method. Another limitation is that the dataset does not contain information on the use of alcohol, electronic cigarettes, marijuana, or other potential substitutes or complements to tobacco consumption, which could influence the observed effects. Despite these limitations, I firmly believe this paper provides a robust evaluation of the state-wide enactment of T21 laws on maternal smoking behaviors.

Future research should explore the federal enactment of T21 laws and their impact on maternal smoking and adverse birth outcomes. This study did not evaluate this aspect due to the lack of sufficient post-policy data without the confounding effects of the COVID-19 pandemic, which may have influenced smoking behaviors and access to prenatal care. Additionally, using datasets such as PRAMS could provide valuable insights into the impact of T21 laws on the use of vapes, marijuana, and alcohol.

Figure 10. Trends in Gestational Diabetes, Hypertension, and Obesity



(a) Gestational Diabetes (b) Gestational Hypertension (c) Obesity

References

ACS (2020, Oct). Health risks of smoking tobacco.

Al Khalaf, S. Y., J. O'Reilly, P. M. Barrett, D. F. B Leite, L. C. Pawley, F. P. McCarthy, and A. S. Khashan (2021, May). Impact of chronic hypertension and antihypertensive treatment on adverse perinatal outcomes: Systematic review and meta-analysis. *Journal of the American Heart Association 10*(9), e018494. Epub 2021 Apr 17.

Alshaarawy, O., S. E. Roskos, and C. I. Meghea (2021, Sep). Tobacco cigarette and cannabis use among new mothers. *Addiction 116*(9), 2572–2576.

American Lung Association (2024). State of tobacco control - facts. https://www.lung.org/research/sotc/facts#:~:text=Smoking%20is%20the%20number%20one,in%20the%20U.S.%20each%20year. Accessed: 2024-11-08.

Banerjee, S., A. Deacon, M. A. Suter, and K. M. Aagaard (2022, Jun). Understanding the placental biology of tobacco smoke, nicotine, and marijuana (thc) exposures during pregnancy. *Clinical Obstetrics and Gynecology 65*(2), 347–359.

Been, J. V., U. B. Nurmatov, B. Cox, T. S. Nawrot, C. P. van Schayck, and A. Sheikh (2015). Effect of smoke-free legislation on perinatal and child health: a systematic review and meta-analysis. *European journal of paediatric dentistry 16*(3), 210–211.

Callaway, B. and P. H. Sant'Anna (2021). Difference-in-differences with multiple time periods. *Journal of econometrics 225*(2), 200–230.

Campaign for Tobacco-Free Kids (2025). States and localities that have raised the minimum legal sales age for tobacco to 21. Accessed: 2025-01-21.

CDC (2022, Jul). Costs and expenditures.

CDC (2023). About the national vital statistics system. Accessed: 2024-11-17.

CDC (2024). About the office on smoking and health. https://www.cdc.gov/tobacco/about/index.html. Accessed: 2024-11-08.

CDC (2024). Cdc wonder natality: Birth data summary. Accessed: 2025-01-14.

CDC (2024). Cigarettes and reproductive health. https://www.cdc.gov/tobacco/about/cigarettes-and-reproductive-health.html#:~:text=345-,Pregnancy%20complications.,placental%20abruption%2C%20and%20ectopic%20pregnancy. Accessed: 2024-11-08.

Esposito, C. (2024, June 12). Optimal cigarette taxation and macroeconomic implications: A case study of indiana. *SSRN Electronic Journal*. Available at SSRN: https://ssrn.com/abstract=4945603 or http://dx.doi.org/10.2139/ssrn.4945603.

Friedman, A. S. and M. F. Pesko (2024). Tobacco 21 laws and youth tobacco use: The role of policy attributes. *American Journal of Public Health 114*(1), 90–97.

Gould, G. S., A. Havard, L. L. Lim, P. S. I. P. E. Group, and R. Kumar (2020). Exposure to tobacco, environmental tobacco smoke and nicotine in pregnancy: a pragmatic overview of reviews of maternal and child outcomes, effectiveness of interventions and barriers and facilitators to quitting. *International journal of environmental research and public health 17*(6), 2034.

Grossman, M. (2005). Individual behaviours and substance use: the role of price. In *Substance use: Individual behaviour, social interactions, markets and politics*, pp. 15–39. Emerald Group Publishing Limited.

Hamadneh, S., J. Hamadneh, E. Alhenawi, R. A. Khurma, and A. G. Hussien (2024). Predictive factors and adverse perinatal outcomes associated with maternal smoking status. *Scientific Reports 14*(1), 3436.

Hansen, B., J. J. Sabia, D. McNichols, and C. Bryan (2023). Do tobacco 21 laws work? *Journal of Health Economics 92*, 102818.

Hawkins, S. S. and C. F. Baum (2014). Impact of state cigarette taxes on disparities in maternal smoking during pregnancy. *American Journal of Public Health 104*(8), 1464–1470.

Hawkins, S. S. and C. F. Baum (2019). The downstream effects of state tobacco control policies on maternal smoking during pregnancy and birth outcomes. *Drug and Alcohol Dependence 205*, 107634.

ILGA (2019, Jul). Public act 101-0002.

Kowlessar, N. M., H. J. Jiang, and C. Steiner (2013, October). Hospital stays for newborns, 2011. Technical Report Statistical Brief #163, Agency for Healthcare Research and Quality (AHRQ).

Lancaster, T. (2000). The incidental parameter problem since 1948. *Journal of Econometrics 95*(2), 391–413.

Leonard, S., S. Siadat, E. Main, et al. (2024). Chronic hypertension during pregnancy: Prevalence and treatment in the united states, 2008-2021. *Hypertension*. [Online]. Available: https://doi.org/10.1161/HYPERTENSIONAHA.124.22731.

McClure, E. A., R. L. Tomko, C. A. Salazar, S. A. Akbar, L. M. Squeglia, E. Herrmann, M. J. Carpenter, and E. N. Peters (2019). Tobacco and cannabis co-use: Drug substitution, quit interest, and cessation preferences. *Experimental and clinical psychopharmacology 27*(3), 265.

NCHS (2006–2019). Vital statistics natality birth data, restricted use file. Accessed via restricted use agreement.

Neyman, J. and E. L. Scott (1948). Consistent estimates based on partially consistent observations. *Econometrica*, 1–32.

Orzechowski and Walker (2024). The tax burden on tobacco: historical compilation.

Paredes, C., R. C. Hsu, A. Tong, and J. R. Johnson (2021, Feb). Obesity and pregnancy. *Neoreviews 22*(2), e78–e87.

Preda, A., D. Iliescu, A. Comănescu, G. Zorilă, I. Vladu, M. Forțofoiu, T. Țenea Cojan, S. Preda, I. Diaconu, E. Moța, I. Gheorghe, and M. Moța (2023, July). Gestational diabetes and preterm birth: What do we know? our experience and mini-review of the literature. *Journal of Clinical Medicine 12*(14), 4572.

Stranges, E., L. M. Wier, and A. Elixhauser (2012, May). Complicating conditions of vaginal deliveries and cesarean sections, 2009. Technical Report Statistical Brief #131, Agency for Healthcare Research and Quality (AHRQ).

Tennekoon, V. S. (2023). Purchase restrictions as a tobacco control policy: An analysis of the effect on adverse birth outcomes. *Economic Analysis and Policy 78*, 967–974.

Warner, K. E., F. J. Chaloupka, P. J. Cook, W. G. Manning, J. P. Newhouse, T. E. Novotny, T. C. Schelling, and J. Townsend (1995). Criteria for determining an optimal cigarette tax: the economist's perspective. *Tobacco Control 4*(4), 380.

Wen, X., L. Liu, A. A. Moe, and et al. (2023). Use of e-cigarettes and cigarettes during late pregnancy among adolescents. *JAMA Network Open 6*(12), e2347407.