Assessing Public Health & Economic Impact of Tobacco Control Laws: Examining Health & Costs of Mothers and Infants

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Abstract

1 Introduction

Tobacco consumption is strongly correlated with major public health concerns worldwide. It significantly affects birth outcomes by increasing the likelihood of newborns being born with a low birth weight, small for gestational age, or prematurely. It also can negatively affect the mother's health. In 2018, it was reported that cigarette smoking financially impacts the United States by more than $600 billion, including $240 billion spent on healthcare (CDC, 2022), which accounts for about 40% of the total impact. Other contributors to the $600 billion include lost productivity from smoking-related illness, premature death, and secondhand smoke exposure.

Tobacco control policies have been introduced at the city, state, and federal levels to address these concerns. States have also increased the minimum legal purchasing age (MLPA) for tobacco products from 18 to 21, increased tobacco tax, prohibited smoking in public places, and banned flavored e-cigarettes. The implementation of these policies varies by state. Under the Trump administration, the federal MLPA was raised to 21 on December 20, 2019.

This paper explores the impact of the state's enactment of T21 laws on maternal smoking and the adverse health effects on both mothers and infants. Additionally, I estimate the average hospital cost savings from policy implementation. This paper contributes to the growing literature on the impact of tobacco control policies and their spillover effects by estimating the impact on both the extensive and intensive margins of maternal smoking, low birth weight, preterm birth, Cesarean birth, and hospital cost savings. The variation in policy enactment occurs at the state-by-year level, with the T21 policy targeting tobacco use for those younger than 21. Therefore, this

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paper implements a difference-in-difference-in-difference framework, otherwise known as a triple difference framework.

There is evidence that T21 laws lower the probability of smoking for those under 21 by [*result*]; however, there is no suggestive evidence that T21 laws have a differential effect on the number of cigarettes smoked compared to those over 21.

Friedman and Pesko (2024) find that T21 laws, in the general population of youths aged 18-20, reduced the odds of cigarette smoking by 40% in their TWFE model, suggesting that T21 laws significantly impact youth cigarette consumption. Tennekoon (2023) studied the effect of raising the minimum legal purchasing age (MLPA) from 18 to 21 on adverse birth outcomes at the county level, prior to the federal implementation on December 20, 2019, with laws varying by state and county. Using a TWFE model and restricted-use data from the NCHS, he finds that the probability of adverse birth outcomes (low birth weight, small for gestational age, and preterm birth) decreases by 9.5%. Specifically, incidences of low birth weight, preterm birth, and small-for-gestational-age infants decrease by 13.27%, 15.78%, and 3.32%, respectively, when T21 laws are introduced.

Tauras et al. (2017) estimate hospital cost savings if the United States enforced graphic warning labels (GWL) on cigarettes, as proposed by the 2009 Family Smoking Prevention and Tobacco Control Act. Using data from the National Center for Health Statistics (NCHS) and a two-stage logit regression, they estimate that GWL could result in annual savings of between $60 million and $100 million, with long-term savings of between $1.2 billion and $2 billion over 30 years. They argue that GWL improves birth health by reducing smoking prevalence among mothers.

Smoking during pregnancy harms infant health by increasing fetal heart rate, disrupting placental development, raising the rate of premature births, and increasing the risk of abnormal bleeding during pregnancy and delivery (Organization, 2013; HHS, 2014). Specifically, smoking is known to cause higher rates of low birth weight and preterm births (Pollack et al., 2000), and it is also associated with a higher likelihood of requiring a Cesarean delivery (Roos et al., 2010; Samuel Lurie and Sadan, 2014; Wallenborn and Masho, 2016; Song and Cai, 2023; Hamadneh et al., 2024).

2 Framework

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

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

where P_{E} is the explicit monetary price of cigarettes and P_{I} is the implicit, or non-monetary, price associated with smoking as described by Grossman (2005). Assume that the following conditions hold: $\partial_{P_E} P > 0$ and $\partial_{P_I} P > 0$. The explicit price of cigarettes is the base price and tax, i.e.,

$$P_E = g(P_B, \tau)$$

where P_B is the base price of cigarettes, and τ is the excise tax. Then, the implicit price can be a function of the travel needed to purchase cigarettes and adverse health outcomes. This can be modeled as

$$P_I = h(T, H, Z)$$

where T is amount of travel needed to purchase cigarettes, H represents adverse health outcomes, and Z can be things such as social stigma. So the full price of cigarettes can be represented by

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

As Friedman and Pesko (2024) finds, T21 laws reduce tobacco use among individuals ages 18 to 20. This indicates that pregnant individuals within this age range are also likely impacted by the increase in the minimum legal purchase age (MLPA). The implication is that MLPA raises the implicit price of tobacco through multiple channels. One clear channel is through increased search costs T for those 18 to 20, T rises, thereby elevating both the implicit and full price of tobacco. Additionally, these laws can raise the price through enforcement penalties Z. For instance, under Illinois law, individuals under 21 caught using tobacco products illicitly may face fines, be required to perform community service, or participate in a non-residential youth program (ILGA, 2019). This increase in the full price can lead to smoking cessation or a reduction in the number of cigarettes smoked for those ages 18 to 20. Moreover, T21 laws also affect individuals under 18, as they are further from the legal purchase threshold, experiencing an even greater increase in the full price of tobacco products.

Since the increase MLPA affects the whole population of those under the age of 21, then a spill over effect of these policies, especially for those that are pregnant, we would expect that adverse birth outcomes will lower and the health during pregnancy should improve from less cigarette smoking. For example, ACS (2020) finds that mothers who smoke during pregnancy face higher risks of placenta previa and placenta abruption, which requires an emergency C-section. Hamadneh et al. (2024) explore how smoking impacts pregnancy in Jordan and find the risk of requiring a C-section could be as high as ”nine-fold higher” in women who smoked during pregnancy.

3 Methodology

3.1 Data

3.1.1 National Vital Statistics System

This paper will use restricted data from the NCHS (2019) housed by the Centers for Disease Control and Prevention (CDC). The data used in this particular study by the NCHS are related to the National Vital Statistics System (NVSS). It contains information on birth-related health and deaths, as well as information about the parents.

The outcome variables of interest are maternal smoking, the number of cigarettes consumed per trimester, low birth weight, very low birth weight, preterm birth, and Cesarean section rates. The first stage of the analysis is to measure the impact of T21 laws on smoking during pregnancy. Tobacco use during pregnancy is defined as whether a person smoked during their pregnancy; it is a dichotomous variable. This provides how the T21 law impacts the extensive margin. Average number of cigarettes smoked during pregnancy is defined as the average number of cigarettes smoked over the three trimesters; this is an attempt to look at the intensive margin. The variables available in the NVSS are at the trimester level which will provide as a level of robustness. The second stage of the analysis is meant to measure the impact of the T21 laws on adverse birth outcomes and maternal health. These measures are dichotomous indicators for low birth weight, very low birth weight, preterm birth, and Cesarean birth.

3.1.2 Tobacco Control Policies

The cigarette price and tax data come from Orzechowski and Walker (2024). The T21 variable is constructed based on information provided by Campaign for Tobacco-Free Kids (2020). Smoke-free air law data comes from ANRF (2024). The variables are constructed by the month and year the laws are implemented, which is matched to the month-year of conception of birth, based on gestational age and month-year of birth.

3.1.3 Healthcare Cost and Utilization Project

This project also uses data from the Healthcare Cost and Utilization Project (HCUP) housed by the Agency for Healthcare Research and Quality (AHRQ). This data collected by AHRQ (2024) includes inpatient data on children and adults, emergency department services, readmissions, and ambulatory surgery and services at both the state and federal levels. This paper will utilize their publicly available data on hospital costs at the national level.

3.2 Empirical Strategy

T21 laws are designed to limit tobacco consumption for individuals under 21. These laws were enacted at different times, depending on the state. The first level of treatment applies to states that enacted T21 laws before December 2019, and the second level of treatment applies to pregnant individuals under 21 at the time of birth. I consider two cases: first, where everyone in the population is included, and second, where the sample is restricted to individuals aged at the previous MLPA (i.e., 18 or 19 dependent on the state's law) and older. Although the law targets those under 21, individuals under 18 were already prohibited from purchasing cigarettes legally before the T21 enactment.

The first stage examines the impact of T21 laws on maternal smoking. To estimate this effect, I use a two-part model to analyze both the extensive and intensive margins of smoking. The first part, the extensive margin of smoking, is modeled as follows:

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

where c represents the average number of cigarettes smoked during pregnancy, τ is the real cigarette tax rate in 2019 dollars, T21 is a binary indicator that equals 1 when a state enacts T21 at time t and beyond, $\mathbb{1}[< 21]$ is a binary indicator for pregnant individuals under the age of 21, and ϕ_s, γ_t, and α_a denote state, birth year, and mother's age fixed effects. The extensive margin compares cases where $c = 0$ to $c > 0$, where $c > 0$ is coded as a smoking indicator equal to 1. This model assumes a normal cumulative distribution function.

The second part, the intensive margin of smoking or conditional demand function, is specified as

$$\mathbb{E}(c|\cdot)_{ist} = \Pr(c > 0|\cdot)_{ist}\exp\Big(\beta_0 + \beta_1\tau_{st} + \beta_2\left(\mathrm{T21}_{st} \times \mathbb{1}[< 21]_i\right) + \beta_3\mathrm{T21}_{st} + \tilde{\phi}_s + \tilde{\gamma}_t + \tilde{\alpha}_a + X'_{ist}d + \varepsilon_{ist}\Big) \tag{2}$$

Here, c is assumed to follow a Gamma distribution, appropriate for the positive and skewed nature of cigarette consumption, as shown in Figure 6. To address heterogeneity and avoid potential bias from $\mathbb{E}(\epsilon) \neq 0$, I use a generalized linear model (GLM), following Tauras (2005). The link function is logarithmic, relating the expected number of cigarettes smoked to covariates in an exponential form.

Since smoking is strongly associated with low birth weight, preterm birth, and Cesarean delivery, I use an instrumental variables approach to analyze how smoking affects these health outcomes, to avoid omitted variable bias,

$$\Pr(Y|\cdot)_{ist} = \Phi\Big(\gamma_0 + \gamma_1\widehat{\Pr(c > 0)}_{ist} + \theta_s + \lambda_t + \chi_a + X'_{ist}\beta + \eta_{ist}\Big) \tag{3}$$

In the model above, Y denotes the health outcomes, $\Pr(\hat{c} > 0)$ is the predicted probability of smoking, and θ_s, λ_t, and χ_a are fixed effects for state, birth year, and age, respectively, with controls for education, race, and ethnicity. η represents the error term, allowing for an examination of how changes in smoking probability affect adverse health outcomes.

Following Tauras et al. (2017), I calculate excess healthcare costs due to prenatal smoking as

$$EHC = \left(S \times \hat{Y}^S + NS \times \hat{Y}^{NS}\right) \times ehc \tag{4}$$

where EHC represents the net extra healthcare costs, $\hat{Y}^j$ is the predicted probability of adverse birth outcomes conditional on smoking status j from Equations 1 and 3, ehc is the average excess cost per adverse birth, S is the number of mothers who smoke, and NS is the number who do not smoke. To assess the impact of T21 laws on additional hospital costs, the annual change in EHC is computed as

$$\Delta EHC = \left(\Delta S \cdot \hat{Y}^S + \Delta NS \cdot \hat{Y}^{NS}\right) \times ehc \tag{5}$$

where the change in the number of smoker status that have adverse birth outcomes are represented by ΔS and ΔNS. All dollar amounts are expressed in 2019 dollars using the medical expenditures CPI.

4 Results and Discussion

4.1 Effects on Smoking During Pregnancy

Table 1. Two-Part Model: Extensive Margin (Probit)

	Whole Sample	**18/19 +**	**Age 18/19-23**
Real Tax	-0.018*** (0.008)	-0.018*** (0.008)	-0.028*** (0.010)
T21	0.013 (0.021)	0.013 (0.021)	0.034 (0.040)
T21 $\times \mathbb{1}[> 21]$	-0.130*** (0.035)	-0.142*** (0.037)	-0.018 (0.027)
Observations	36,031,809	35,233,408	8,069,399
Pseudo R^2	0.124	0.126	0.113

Standard errors in parentheses and clustered at state-level. * p < 0.1, ** p < 0.05, *** p < 0.01.
Control for education, race/ethnicity, and includes state, age, and birth-year fixed effects.

Table 2. Two-Part Model: Intensive Margin (GLM)

	Whole Sample	**Age Min +**	**Age 18/19-23**
Real Tax	-0.016*** (0.004)	-0.016*** (0.004)	-0.010** (0.004)
T21	-0.049** (0.021)	-0.047** (0.021)	-0.064** (0.029)
T21 $\times \mathbb{1}[> 21]$	-0.030* (0.019)	-0.024 (0.016)	-0.027** (0.013)
Observations	2,871,646	2,815,978	991,215
AIC	5123.25	5098.47	2301.56

Standard errors in parentheses and clustered at state-level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Control for education, race/ethnicity, and includes state, age, and birth-year fixed effects.

4.2 Adverse Birth Outcomes and Cost Savings

5 Robustness

6 Conclusion

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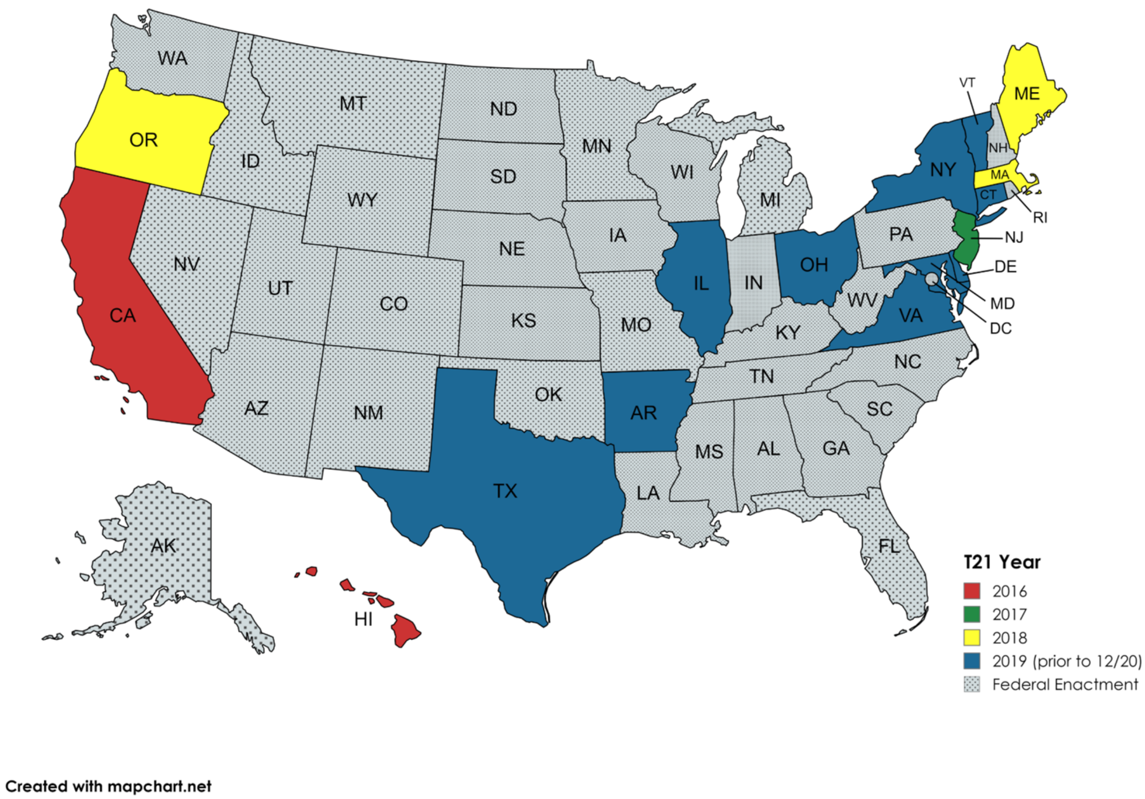
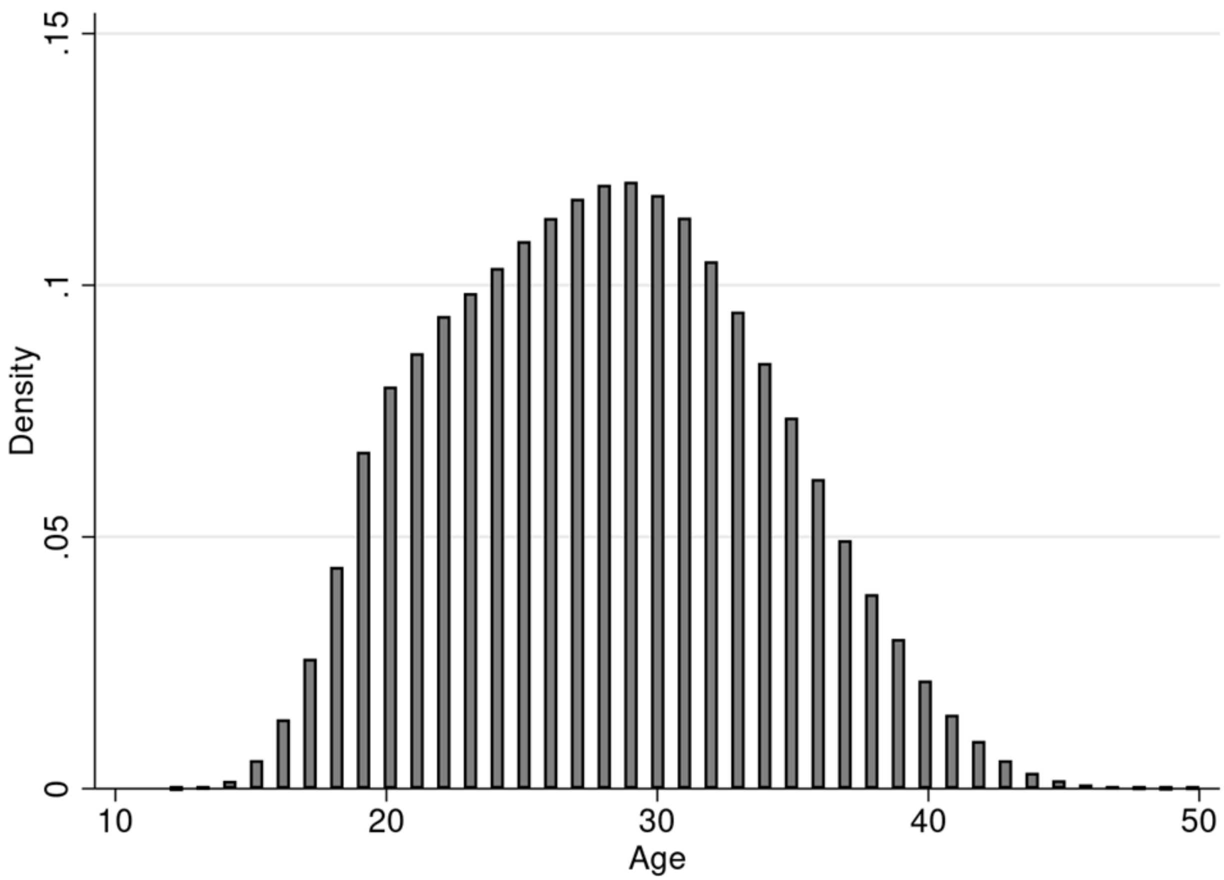
Figure 1. T21 Laws and State Implementation



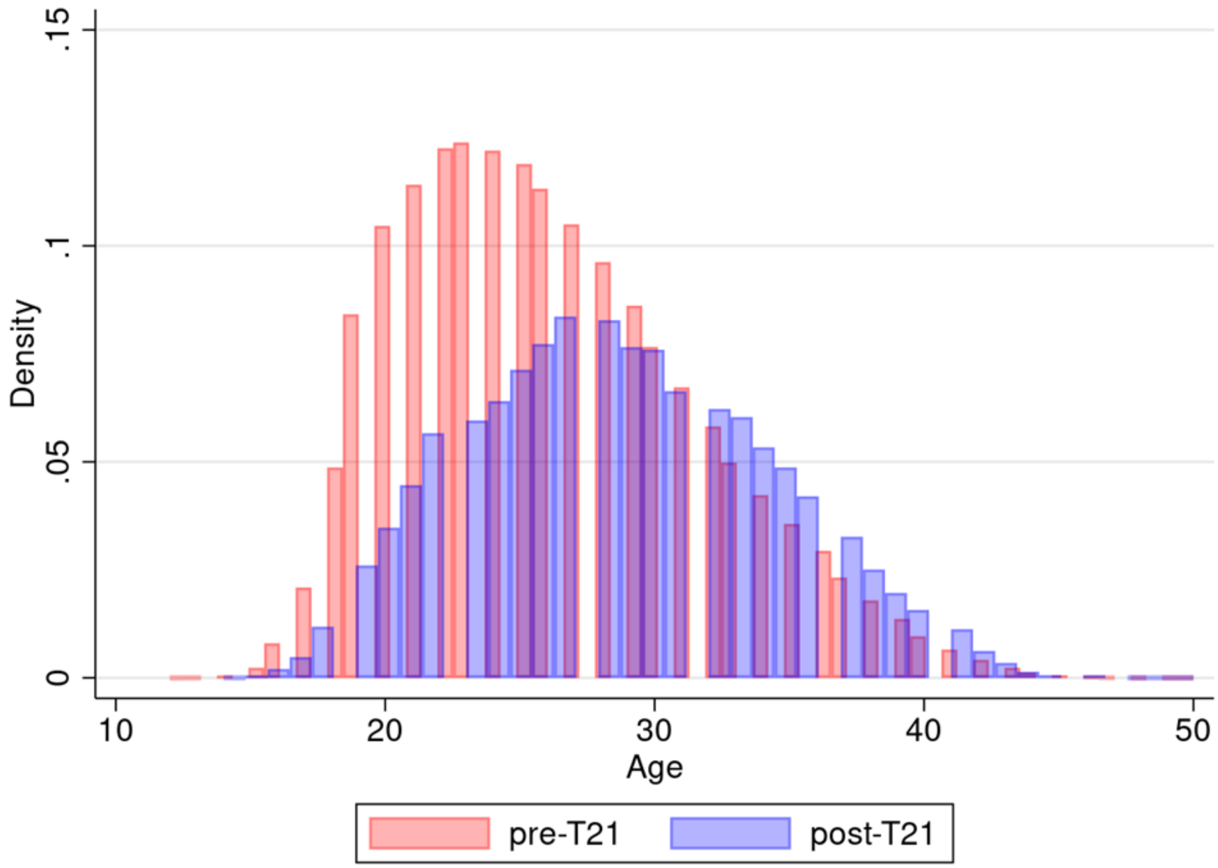
The data comes from Campaign for Tobacco-Free Kids (2020).

Figure 2. Pregnancy Distribution over Age



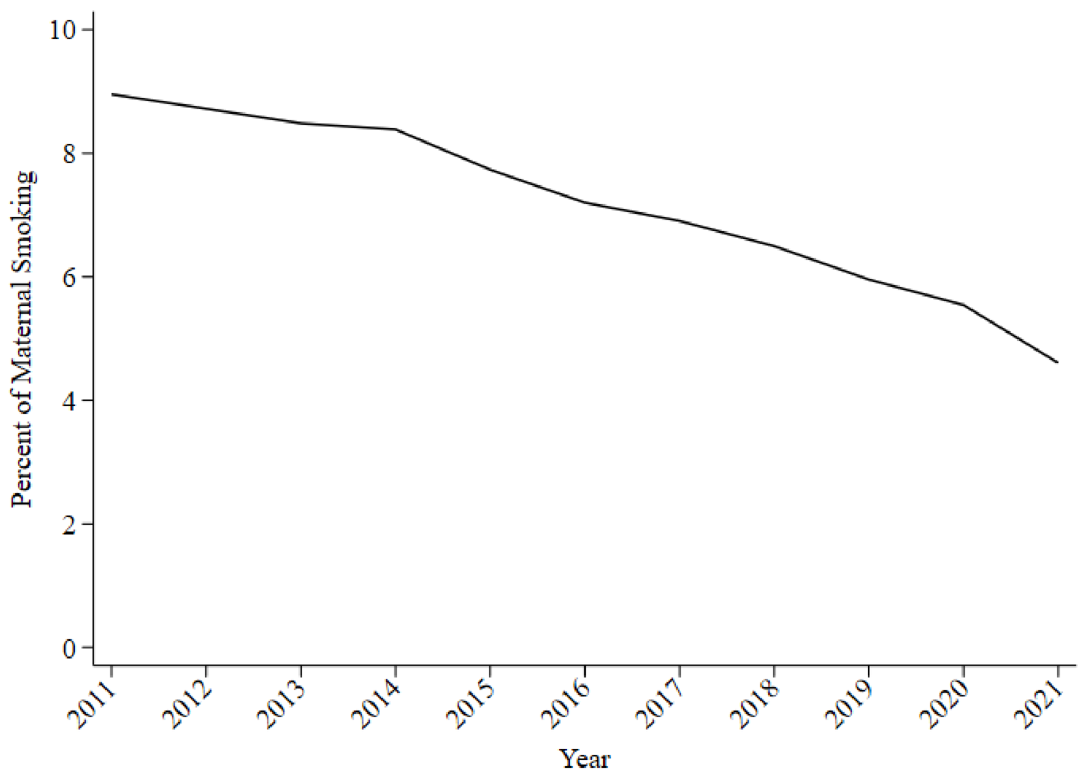
The data comes from NCHS (2019).

Figure 3. Smoking During Pregnancy Distribution over Age and Pre/Post T21



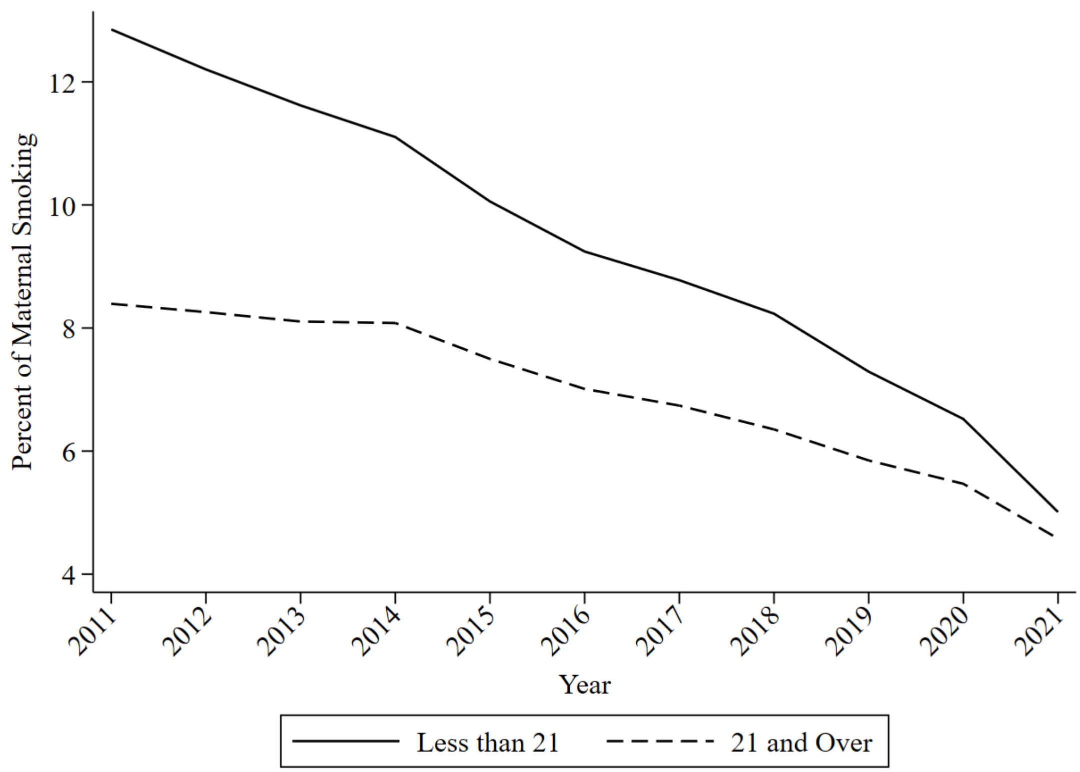
The data comes from NCHS (2019).

Figure 4. Smoking Prevalence During Pregnancy per Year



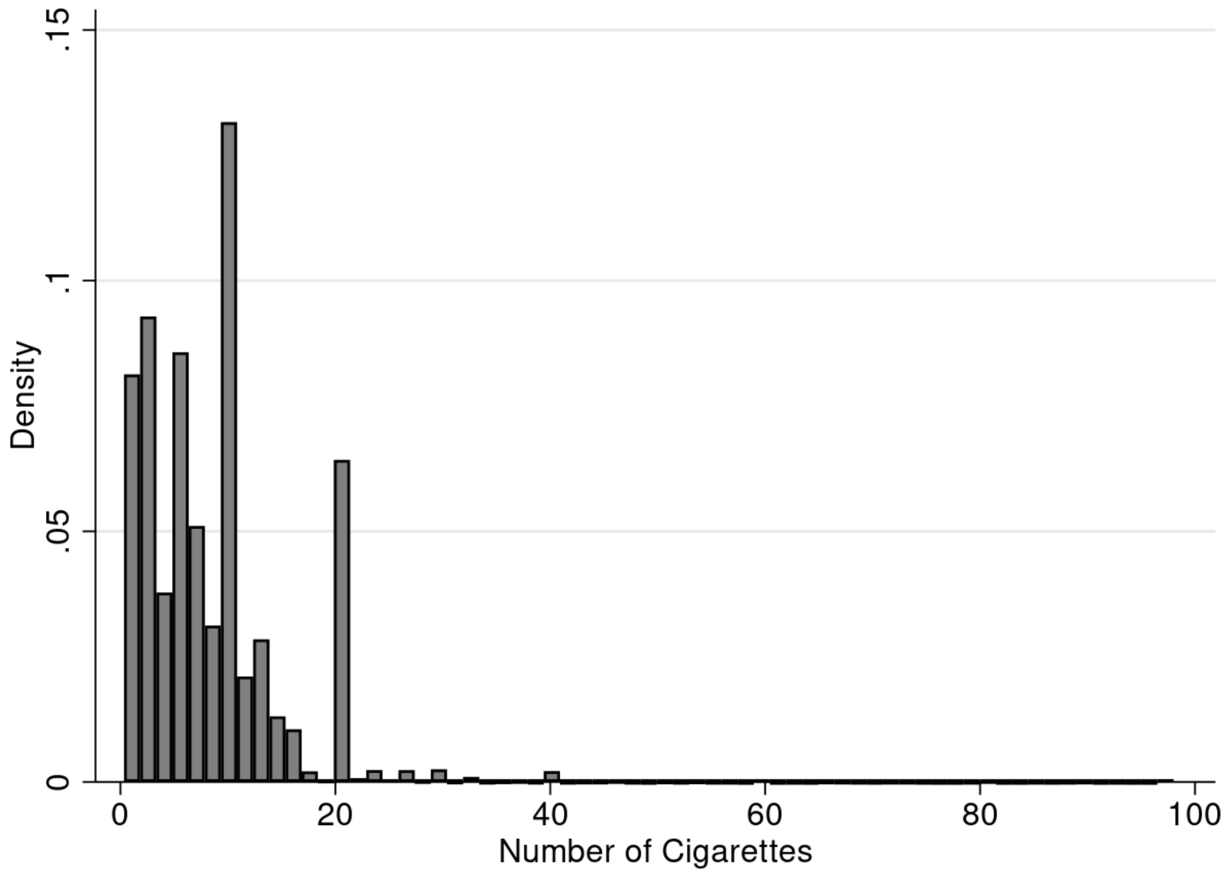
The data comes from NCHS (2019).

Figure 5. Smoking Prevalence During Pregnancy per Year



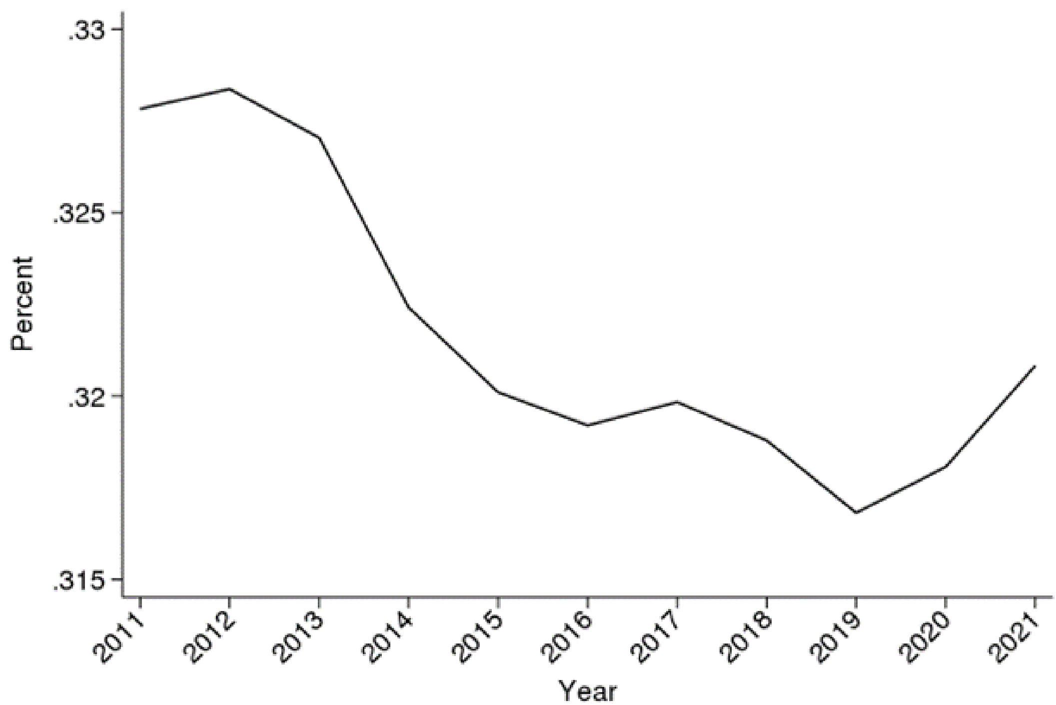
The data comes from NCHS (2019).

Figure 6. Distribution of Average Daily Number of Cigarettes Smoked



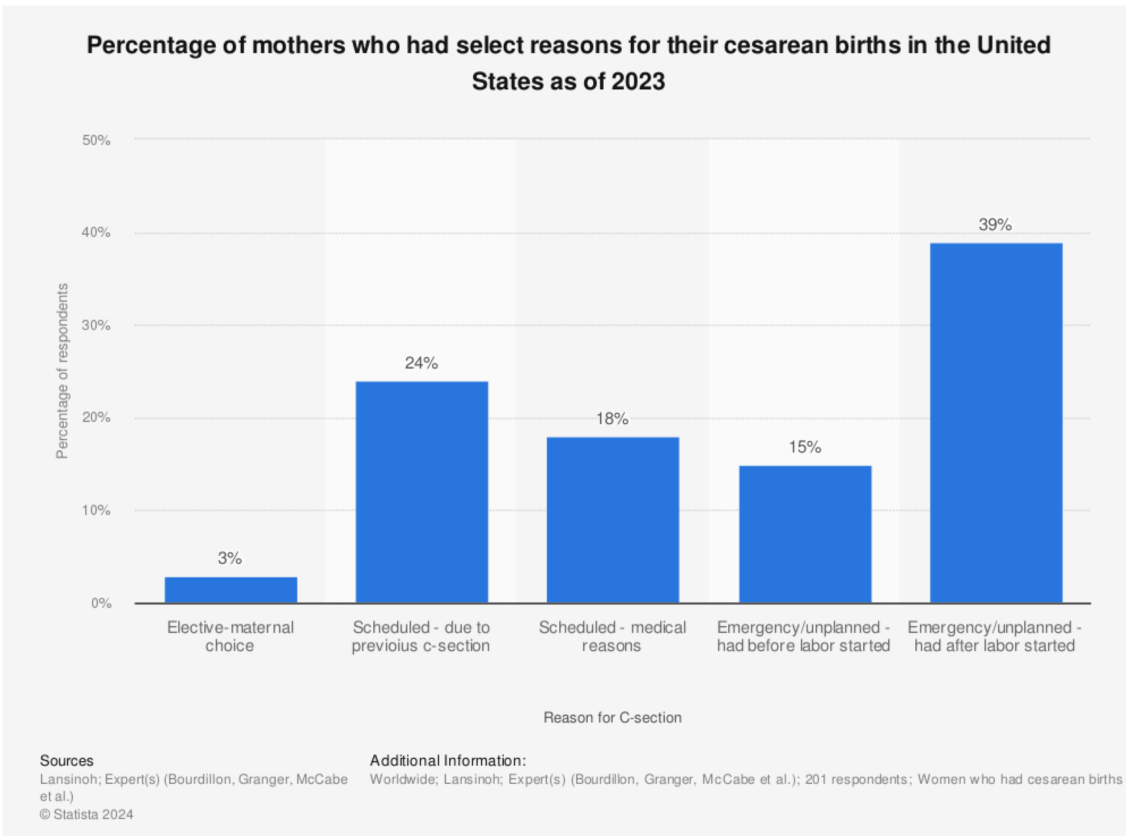
The data comes from NCHS (2019).

Figure 7. Cesarean Delivery Rates



The data comes from NCHS (2019).

Figure 8. Reasons for Cesarean Delivery



The figure is taken directly from Statistica (2024).