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The Effect of E-Cigarette Indoor Vaping Restrictions on Adult Prenatal Smoking and Birth Outcomes

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Abstract

We estimate the effect of county-level e-cigarette indoor vaping restrictions on adult prenatal smoking and birth outcomes using United States birth record data for 7 million pregnant women living in places already comprehensively banning the indoor use of traditional cigarettes. We use both cross-sectional and panel data to estimate our difference-in-difference models. Our panel model results suggest that adoption of a comprehensive indoor vaping restriction increased prenatal smoking by 2.0 percentage points, which is double the estimate obtained from a cross-sectional model. We also document heterogeneity in effect sizes along lines of age, education, and type of insurance.

Keywords

smoking; vaping; electronic nicotine delivery systems; e-cigarettes; indoor air laws; tobacco control; pregnancy; birth outcomes

JEL Classification Numbers

I12; I18

I Introduction

Smoking has long been known to be one of the leading causes of poor birth outcomes in the United States (US Department of Health and Human Services, 2014). The rising popularity of e-cigarettes has provided pregnant woman with another smoking cessation product option, similar to the availability of FDA-approved smoking cessation medications and nicotine replacement therapy (NRT) products (Food and Drug Administration, 2017).

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However, the effectiveness of e-cigarettes as smoking cessation devices and the safety of trying to use e-cigarettes to quit smoking while pregnant is unknown.

E-cigarettes are part of a broader class of devices (including vape pens and tank systems) known as electronic nicotine delivery systems (ENDS). ENDS simulate the smoking experience by “vaping” a mist containing water, propylene glycol, vegetable glycerin, and, in most cases, nicotine and flavorings (Royal College of Physicians in England, 2016). ENDS may also contain trace levels of other toxicants and metals, but in levels estimated to be 9–450 times lower than a conventional cigarette (Goniewicz et al., 2014). Among the general population, there is an emerging consensus that ENDS are substantially safer than combustible tobacco products (Viscusi, 2016). E-cigarettes are unlikely to exceed 5% of the risk associated with combustible tobacco products for non-pregnant women, but the risks may be much higher for pregnant women because nicotine, which is in most ENDS, is a threat to the developing fetus (Royal College of Physicians in England, 2016). The safety of using e-cigarettes for smoking cessation during pregnancy has an inconclusive grade from the United States Preventive Services Task Force (Siu, 2015).

One recent policy change that may impact demand for ENDS is indoor vaping restrictions (IVRs). ENDS IVRs may reduce the attractiveness of ENDS by requiring the user to make an additional investment of time to use the devices either outdoors or in non-regulated indoor areas. Indeed, ENDS IVRs have been found to reduce demand for ENDS in an experimental market (Marti et al., 2016). This added inconvenience of using ENDS may both reduce the use of ENDS and increase cigarette use if fewer people use ENDS for successful smoking cessation. Additionally, ENDS IVRs may provide information to individuals about the relative risks of smoking versus vaping, and cause people to perceive ENDS to be more dangerous, which could also reduce their demand for ENDS.

The objective of this paper is to explore the effect of ENDS IVRs on cigarette use and birth outcomes (e.g. gestation length) among adult pregnant women. A main feature of our paper is that in our preferred specification we take advantage of cigarette use information provided at four points in time for each pregnant woman, which we use to estimate person fixed effect models that free our estimates from unobserved person-specific sources of omitted variable bias.

While several studies have evaluated the effect of ENDS minimum legal purchase age laws on traditional cigarette use (Friedman, 2015; Pesko et al., 2016; Pesko and Currie, 2016; Dave et al., 2017; Abouk and Adams, 2017), no published estimates exist on the effect of ENDS IVRs on cigarette use. In our current study, we estimate the impact of ENDS IVRs on adult pregnant women, rather than teenagers, to study this relationship unhindered by state efforts to restrict youth ENDS access through channels other than ENDS IVRs.

II Background

Pregnant women have a high interest in quitting smoking: 55% of women smoking 3 months before their pregnancy are successfully able to quit smoking during their pregnancy (Centers for Disease Control and Prevention, 2017b). Despite these high rates of successful quitting

during pregnancy, few pregnant women use an approved smoking cessation method to help them to quit (Tong et al., 2008). One study found that only 2.6% of pregnant women smokers in a Medicaid managed care program in Maryland used a prescribed pharmacotherapy for smoking cessation (Jarlenski et al., 2015). This low rate may be due to obstetricians and gynecologists (OBGYNs) often not referring pregnant women for behavioral health interventions and often not prescribing NRT because nicotine is a developmental toxicant. Pharmacotherapy interventions for tobacco cessation for pregnant women continue to receive an incomplete grade from the United States Preventive Services Task Force due to uncertain evidence of the overall health benefits (Siu, 2015).

Given the risks in prescribing NRT to pregnant women, it is possible that pregnant women motivated to quit smoking may look elsewhere for help in quitting. Early evidence from randomized controlled trials suggests that ENDS may be effective in eliminating and reducing cigarette consumption (McRobbie et al., 2016). Given low utilization of smoking cessation methods among pregnant women, it is possible that pregnant women may disproportionately look to ENDS to reduce cigarette consumption. According to 2014 National Health Interview Survey data, ever use of e-cigarettes among all childbearing age adult women (18–45) was 15.2% and past 30-day use was 4.0%. One small randomized controlled trial of pregnant women in Connecticut and Massachusetts that were unable to quit smoking on their own during pregnancy found that 14% vaped during pregnancy, usually to try to quit (Oncken et al., 2017).

States and counties are increasingly using IVRs and taxes to regulate ENDS. New Jersey was the first state to pass an ENDS IVR in 2010, and 10 states and numerous counties/municipalities banned the use of ENDS in at least one type of indoor location by the end of 2016. Minnesota had the first ENDS tax in the nation in 2010, but it wasn't until June, 2015 that a second state (North Carolina) enacted an ENDS tax.

Our study is similar to the literature that has evaluated the effect of ENDS minimum legal purchase age laws. Five studies have used difference-in-differences models to evaluate the effect of enacting these ENDS minimum legal sale age laws on use of tobacco among teens, with four of these studies suggesting that the laws raise teenage cigarette use (Friedman, 2015; Pesko et al., 2016; Pesko and Currie, 2016; Dave et al., 2017) and a fifth study suggesting that it does not and may even lower cigarette use for certain populations (Abouk and Adams, 2017).

Our study is also similar to Markowitz et al. (2011), which used data from the Population Risk Assessment Monitoring System from 2000 to 2005 to find that restricting smoking in the workplace was associated with small increases in gestational length for women 25–34 years of age. A literature review using 11 studies employing interrupted time-series designs also found that smoke-free legislation is associated with small decreases in preterm birth, but with no obvious effects on birth weight (Been et al., 2014).

ENDS IVRs may have different effects depending on smoking status prior to pregnancy. For smokers, ENDS IVRs may have two effects: 1) they may make it less likely that pregnant woman will switch from cigarettes to ENDS; or 2) they may make it more likely that

pregnant women will switch from cigarettes to complete abstinence from nicotine. For non-smokers, ENDS IVRs may have two effects: 1) they may make it less likely that pregnant women will use ENDS (which they may have been using earlier); and 2) they may make it more likely that non-smokers will use cigarettes (since access to ENDS has now been restricted).¹ Unfortunately, ENDS use information is not recorded in birth records, but we can test hypotheses examining the effect of ENDS IVRs on cigarette use directly.

Further, we can explore the effects of the laws on birth outcomes, which could deteriorate if more adult pregnant women now smoke and smoking is more dangerous than vaping to the developing fetus, or could improve birth outcomes if the laws increase complete abstinence from nicotine. Given the unique risks of nicotine and the presence of nicotine in cigarettes and most ENDS, it is unclear if pregnant woman who use ENDS instead of smoking traditional cigarettes will experience improved birth outcomes.

Finally, we also explore heterogeneity in the effects of the laws depending on age, education, and health insurance status. According to 2014 National Health Interview Survey data, lifetime and current e-cigarette use is slightly higher among younger adults < 25 (17.3%/4.4%) than older adults ≥ 25 (14.4%/3.9%); is higher among low-educated women (18.3%/5.5%) than high-educated women (13.7%/3.3%); and is higher among uninsured women (18.1%/5.5%) and Medicaid women (19.3%/4.7%) than privately-insured women (13.4%/3.3%). We might expect that populations using e-cigarettes more will be more impacted by ENDS IVRs. However, we find this assumption unconvincing because interest in using ENDS during pregnancy could increase dramatically for women trying to quit smoking. We believe that a more useful prediction for which populations may be disproportionately impacted by ENDS IVRs during pregnancy are those populations with higher prenatal smoking rates.

There are other factors besides level differences in vaping and smoking prior to pregnancy that may also influence responsiveness to ENDS IVRs. For one, higher education has been found to reduce risk beliefs of the impact of e-cigarettes on lung cancer (Viscusi, 2016), so higher educated pregnant women may also be more likely to believe that vaping instead of smoking during pregnancy is healthier as well (and hence these women could be more affected when ENDS IVRs are passed if it disproportionately reduces their attempts to quit smoking). The impact of ENDS IVRs may also be influenced by access to other close substitute smoking cessation products through health insurance programs. In 2010, the Affordable Care Act required coverage of tobacco cessation in all non-grandfathered private plans and for pregnant women on Medicaid (American Lung Association, 2017). Uninsured women, however, may not have access to cost reduction benefits available to insured patients, and so this group could be disproportionately influenced by ENDS IVRs.

Given this background on e-cigarettes, we empirically test the following hypotheses: 1) ENDS IVRs increase prenatal smoking overall, 2) ENDS IVRs increase prenatal smoking

¹However, the magnitude of this latter effect (pregnant women initiating or resuming smoking as a result of ENDS IVRs) is likely minuscule since pregnant women generally attempt to reduce risk during pregnancy.

rates by pregnant women with higher rates of smoking (e.g. younger, lower educated, and Medicaid recipients), and 3) ENDS IVRs have ambiguous impacts on birth outcomes.

III Data

We combined three data sources to conduct our analysis: birth records data from the National Center for Health Statistics, ENDS IVR data from the American Nonsmokers' Rights Foundation, and population data on counties and municipalities from the U.S. Census Bureau. The birth records provide smoking behavior, demographic information, and infant health outcomes with linked county of residence for the mother. We used county of residence to link the ENDS IVR data and population data to determine mothers' level of exposure to IVRs. This section will describe each of our three data sources and explain the restrictions we imposed on our sample before analysis.

The main data source for our analysis was administrative birth records (the universe of all births in the United States) provided by the National Center for Health Statistics. The Standard Certificate of Live Birth was revised in 2003 and the new form was slowly rolled out in different states over time.² The old form asked only about smoking at any time during the pregnancy. The new form collects information about smoking at four points in time: prior to pregnancy and in each trimester. The accuracy of cigarette use during pregnancy is significantly improved in the new form relative to the old form. Maternal smoking in the old form agreed with hospital records 84% of the time in one study (Buescher et al., 1993), but this agreement improved to 94% with the new form (Howland et al., 2015). The introduction of the revised birth record resulted in statistically significant increases in smoking in 21 out of 31 states, suggesting that the old form underreported smoking compared to the new (Curtin and Matthews, 2016). In addition to improving the accuracy of smoking by using the new form, trimester-specific smoking information is also available in the new form which permits us to exploit within-individual variation in cigarette use in response to ENDS IVRs in a panel data analysis.

Figure 1 shows the question capturing cigarette use information as it appears on the revised birth record form. No information about vaping is currently collected in birth records.

We impose the following sample restrictions on our data. The sample includes all mothers whose estimated conception (16 days after pregnancy week 0 or last menstrual period) was between 1/1/2010 and 1/1/2015. We exclude mothers with missing data on weeks of gestation. We exclude mothers under age 18 at the estimated time of conception to avoid confounding from state efforts to regulate youth access to ENDS through other means, such as with minimum legal purchase age laws. We exclude non-singleton births because they often have adverse birth outcomes for reasons unrelated to smoking behavior.

We make several exclusions to derive our final sample of 755 counties from 15 states and Washington D.C. First, we exclude from our sample seventeen states which were not using the revised birth record form by 1/1/2010.³ Second, three additional states were excluded

²All states were using the revised birth records in 2015 (Centers for Disease Control and Prevention, 2017b).

³These excluded states are: AK, AL, AR, AZ, CT, HI, LA, MA, ME, MN, MS, NC, NJ, RI, VA, WI, and WV.

because they were missing a substantial percentage of data on smoking behavior for entire years.⁴ Third, we also exclude fifteen remaining states that did not have comprehensive prohibitions on smoking cigarettes in bars, workplaces, and restaurants (minor exceptions allowed).⁵ We obtained this data on indoor smoking restrictions from the CDC State System (Centers for Disease Control and Prevention, 2017a). Governments likely place higher priority on first banning smoking from public places before banning vaping from public places; therefore, we believe that studying the impact of ENDS IVRs in places already comprehensively banning indoor smoking provides more policy-relevant results. We also avoid complex interaction effects between partial smoking restrictions and ENDS IVRs. After our various restrictions, we use birth records for approximately 7 million adult pregnant women, representing 37.7% of births nationally during this time period that otherwise meet our exclusion criteria of being singleton births to women conceiving during adulthood and without missing gestational length information on the birth certificate.

IVR data were provided by the American Nonsmokers' Rights Foundation U.S. Tobacco Control Laws Database. These data include all known ENDS IVRs at the state, county, and municipality levels. We focused on the most widespread ENDS IVRs: those applying to bars, workplaces, and restaurants. These data also include IVRs applying to gambling establishments or specific public places such as parks or government buildings, but these policies were rare and did not likely have large impacts on pregnant mothers. Figure 2 shows the evolution of the ENDS IVR environment over time (including both partial and comprehensive IVR laws), with states excluded from our sample in gray. From among the 16 states (including D.C.) and 755 counties in our sample, 6 counties had an ENDS IVR in place on 1/1/2011, 38 counties had an ENDS IVR in place on 1/1/2013, and 68 counties had an ENDS IVR in place on 1/1/2015. In Figure 3, we show the percent of mothers covered by ENDS IVR laws in these 16 states over time, with approximately 45% of mothers living in these states covered by the beginning of 2015.

Quarterly cigarette excise taxes were used as a control variable and were provided by the CDC State System (Centers for Disease Control and Prevention, 2017a).

The final data source was the U.S. Census which included yearly estimates of county and municipality populations. The population data were merged with the data on bar, workplace, and restaurant ENDS IVRs to calculate the percentage of county population affected by each policy, with each of the three venues receiving equal weight.⁶ This policy variable was merged with the cross-sectional birth records data at the estimated point of conception and at the start of the trimester in our panel data analysis.

⁴These excluded states are: FL, GA, and MI.

⁵These excluded states are: ID, IN, KS, KY, MO, ND, NH, NV, OK, PA, SC, SD, TN, TX, and WY.

⁶Our policy variable is constructed by considering both the percentage of population affected and by a linear combination of three types of policies. For example, if an entire county population was affected by bar and restaurant ENDS IVRs, but none of the county was affected by a workplace ENDS IVR, the final ENDS IVR variable would take a value of two thirds. As another example, suppose the population of the unincorporated areas of a county was one half of the entire county population. If only these unincorporated areas were affected by comprehensive bar, restaurant, and workplace ENDS IVR, our final policy variable would take a value of one half because only half of the county population was affected.

Table 1 shows descriptive statistics for our sample. The first column shows means for the entire sample, while the remaining columns split the sample into counties in which there was no ENDS IVR adopted prior to 2015 and counties in which there was an ENDS IVR adopted in part or all of the county prior to 2015. Counties that adopted ENDS IVRs have a higher share of minority pregnant women, lower Medicaid enrollment, higher private insurance enrollment, lower prenatal smoking, and somewhat better premature birth outcomes. We model away observable differences between our two groups by including demographics and payment source as control variables in regression analyses. Additionally, our modelling strategy reduces concerns about our outcome variables having different levels since the modelling strategy uses differences in outcome in the pre-adoption period as the baseline level in which to evaluate the policy change in the post-adoption period.

IV Methods

Our first approach to estimating the effects of ENDS IVRs on smoking behavior and birth outcomes is to use cross-sectional data and difference-in-difference (DD) models. We analyze two variables that capture smoking behavior. First, smoking participation is an indicator variable that takes a value of one when the mother reports smoking any cigarettes during the pregnancy. Second, we take the average of reported daily cigarettes smoked during each trimester, and multiply it by 30 to calculate average cigarettes smoked per month during pregnancy. We use these two dependent variables in DD models specified as follows:

$$smoking_any_{ict} = \alpha + \beta_1 IVR_{ct} + \beta_2 cig_tax_{st} + \delta X_{ict} + \gamma_c + \gamma_t + \varepsilon_{ict} \quad (1)$$

$$cigs_per_month_{ict} = \alpha + \beta_1 IVR_{ct} + \beta_2 cig_tax_{st} + \delta X_{ict} + \gamma_c + \gamma_t + \varepsilon_{ict} \quad (2)$$

where i represents mother, c represents county of state s , and t represents year-month combination. We include time fixed effects (both birth-year-month and conception-year-month) and county fixed effects. County fixed effects allows us to control for time-invariant county-level factors that are unobservable and implies that our regression models are identified off within-county variation in ENDS IVRs. Our time fixed effects control for time varying omitted variables that affect the nation as a whole (e.g. national anti-smoking campaigns, national economic conditions). Cigarette taxes are also controlled for since these vary over time.⁷ Finally, individual-level controls included in X_{ict} are race/ethnicity, age, mother's delivery payment method,⁸ marital status, level of education, and the number of the current birth (i.e. number of previous births plus one).

⁷We do not control for ENDS taxes. Only MN had an ENDS tax for any meaningful period of time in our study, and we already excluded MN for not using revised birth records. North Carolina passed an ENDS tax in June, 2015 and Louisiana passed an ENDS tax in July, 2015. These states were also excluded for not using revised birth records. The District of Columbia passed an ENDS tax in Oct., 2015, but this will not impact our population in any meaningful way since we restricted to women conceiving prior to January 1, 2015.

⁸Payment method also helps control for the mother's economic condition. Besides payment source, birth records do not provide any direct information on the mother's employment status or financial well-being.

In equation 1, we estimate the effect of ENDS IVRs on extensive margin smoking using the full sample of births. We estimate equation 2 twice, once for just the sample of smokers (to estimate the effect of ENDS IVRs on intensive margin smoking) and again using all births (to estimate the effect of ENDS IVRs on extensive and intensive smoking combined).

Our treatment variable IVR_{ct} is continuous in our initial specification, but we explore the robustness of our results to estimating a more traditional DD equation in which we drop counties with partial restrictions so that we derive an indicator, rather than continuous, treatment variable. We lose about 33% of our observations in this specification, but our results are broadly similar with those keeping partially-treated counties.

We hypothesize that our primary coefficient of interest, β_1 , will be positive for our extensive margin and combined margin model to indicate an increase in prenatal smoking in response to ENDS IVRs. We suspect that the coefficient will be positive for the intensive margin model as well, although this coefficient will reflect both the change in the number of cigarettes consumed by smokers and any compositional changes in extensive margin smoking as a result of ENDS IVRs.

A necessary assumption for the DD model to recover causal estimates is that the treatment (i.e. counties adopting ENDS IVRs) and the comparison (i.e. counties not adopting ENDS IVRs) would follow the same trend in the post-treatment period, had the treatment states not been treated. However, this assumption is untestable. We instead attempt to provide evidence on this assumption by modifying equations 1 and 2 to evaluate the parallel trends assumption. We include only mothers who conceived 9 months before ENDS IVR adoption (actual or placebo) and add an interaction between a linear time trend (using date of conception) and an indicator for whether the county ever adopted a law or not.

$$smoking_any_{ict} = \alpha + \beta_1 ever_adopt_c * time_t + \beta_2 cig_tax_{st} + \delta X_{ict} + \gamma_c + \gamma_t + \varepsilon_{ict} \quad (3)$$

$$cigs_per_month_{ict} = \alpha + \beta_1 ever_adopt_c * time_t + \beta_2 cig_tax_{st} + \delta X_{ict} + \gamma_c + \gamma_t + \varepsilon_{ict} \quad (4)$$

In these equations, we do not need to control for $ever_adopt_c$ and $time_t$ separately because our fixed effects are perfectly nested smaller units. If we cannot reject the null hypothesis that β_1 is zero in these two equations, then this suggests that trends are parallel in the pre-period. We also modify equations 3 and 4 by replacing $time_t$ with four one-year intervals leading up to ENDS IVR adoption to test for evidence of non-parallel time trends at different points in time in the pre-adoption period.

After providing evidence that our results satisfy the parallel trends assumption, we modify equations 1 and 2 to perform an event study (Auer, 2003). We continue to exclude partial IVRs and we replace the previous DD variable with a set of mutually exclusive policy lead and lag variables that divides the time period before and after adoption in 3 month intervals (using date of conception): > 18 months before (reference), 18–15 months before, 15–12 months before, 12–9 months before, 9–6 months before (likely 3rd trimester treatment), 6–3

months before (likely 2nd trimester treatment), 3–0 months before (likely 1st trimester treatment), 0–3 months after (likely full treatment), and > 3 months after. In this way, we can evaluate effects of the law among pregnant women fully and partially treated, as well as test for unexpected changes in smoking in places that will pass an ENDS IVR in the future (which could suggest anticipatory behaviors or reverse causality).

A central feature of our paper is our ability to exploit the impact of ENDS IVRs on within-mother smoking by using a panel data analysis. For this analysis, we use smoking information provided in revised birth records for the three months before pregnancy and for each trimester, yielding four observations per mother. Our panel data regressions have the following specifications:

$$smoking_any_{ict} = \alpha + \beta_1 IVR_{ct} + \beta_2 cig_tax_{st} + \gamma_i + \gamma_t + \varepsilon_{ict} \quad (5)$$

$$cigs_per_month_{ict} = \alpha + \beta_1 IVR_{ct} + \beta_2 cig_tax_{st} + \gamma_i + \gamma_t + \varepsilon_{ict} \quad (6)$$

where i represents mother, c represents county of state s , and t represents trimester. The ENDS IVR variable now represents the policy at the start of the trimester instead of at the time of conception. All specifications include mother and trimester fixed effects. We hypothesize that our primary coefficient of interest, β_1 , will be positive to indicate an increase in smoking in that trimester in response to ENDS IVRs. In some specifications we also add to equations 5 and 6 trimester-year-month fixed effects, absorbing the effect of being in a certain trimester at a specific time. We do not include county fixed effects in these specifications because birth fixed effects are perfectly nested smaller units. Similar to our cross-sectional results, we estimate equation (6) twice, once conditional on smoking in that trimester and a second time without this condition.

We estimate stratified models using our panel data design to test for heterogeneity in effects of ENDS IVRs along lines of age (< 25 and ≥ 25), education (high school degree or less, some college or more), and health insurance (Medicaid, private insurance, and self-pay).

Finally, we estimate the effects of ENDS IVRs on birth outcomes in a cross-sectional DD specification by modifying equations 1 and 2 and replacing the smoking outcome variables with birth outcomes:

$$birth_outcome_{ict} = \alpha + \beta_1 IVR_{ct} + \beta_2 cig_tax_{st} + \delta X_{ict} + \gamma_c + \gamma_t + \varepsilon_{ict} \quad (7)$$

The birth outcomes we examine include premature birth (indicator for less than 37 weeks of gestation), very premature birth (indicator for less than 32 weeks of gestation), small for gestational age (indicator for 25th percentile or lower birth weight for a given gestational length), extra small for gestational age (indicator for 10th percentile or lower), low weight (indicator for less than 2500 grams), and Apgar 5-minute score (continuous measure from 0–10, with 10 being the healthiest score).⁹ For the weight and gestation length outcomes, β_1

could be positive (higher probability of a bad birth outcome) if more adult pregnant women now smoke and smoking is more dangerous than vaping to the developing fetus, or could be negative if the laws increase complete abstinence from nicotine.

Standard errors are clustered at the state level in all regression models, which is the highest level at which our policy varies. We estimate all equations using linear models for continuous variables (cigarettes per month, Apgar 5 score) and linear probability models for indicator variables (smoking participation, premature birth, small for gestational length, low birth weight).

V Results

In Table 2, Section A, we show results for our standard DD model from equations 1 and 2 for three smoking outcomes of any smoking during pregnancy, average number of cigarettes smoked per month during pregnancy (conditional on smoking), and average number of cigarettes smoked per month during pregnancy (non-conditional). The IVR in this case is a continuous variable ranging from 0 to 1, with 1 representing a 100% ENDS IVR (i.e. a complete county-wide ban on indoor vaping in bars, workplaces, and restaurants). Switching from no ENDS IVR to a comprehensive ENDS IVR is associated with a 0.9 percentage point increase in smoking during a mother's pregnancy (14.1% of the mean), and smokers consume 10.3 more cigarettes per month (4.2% of the mean). Without conditioning on smoking, the average pregnant woman smoked 3.2 extra cigarettes per month (19.8% of the mean).

In Table 2, Section B, we remove from the sample partial ENDS IVRs so that we have an indicator variable for no ENDS IVR or a comprehensive ENDS IVR. We lose 2.3 million mothers from 31 counties¹⁰ that were previously treated by ENDS IVRs that were non-comprehensive in nature, and so our sample size is attenuated from 6.8 million observations to 4.6 million observations. Using this reduced sample, comprehensive ENDS IVRs are associated with a 1.3 percentage point increase in smoking (14.5% of the mean) compared to not having any ENDS IVRs, and are associated with 4.1 extra monthly cigarettes smoked (unconditional, 18.7% of the mean). As a percentage change of the mean, effect sizes were similar when keeping or excluding counties with partial ENDS IVRs.

We estimate equations 3 and 4 to explore if time trends are different between adopting and non-adopting counties (Table 3, Section A). We cannot reject the null hypothesis that counties adopting ENDS IVRs and counties not adopting ENDS IVRs followed similar trends in outcomes in the pre-adoption period, as our interaction term coefficients are small and relatively precise. These results suggest that the parallel trends assumption holds and we can interpret our DD results causally.

In Table 3, Section B, we use one-year intervals rather than a continuous time variable to assess the parallel trends assumption. We continue to use the same estimation sample as we

⁹We cannot estimate a panel data model for birth outcomes because each outcome appears only once for each birth.

¹⁰The largest of these counties were Los Angeles County, CA, Cook County, IL, Alameda County, CA, San Diego County, CA, and Santa Clara County, CA.

did in the linear parallel time trends test. Compared to the year closest to policy adoption, smoking outcomes are not statistically significant different between adopting and non-adopting counties in the full second and third year before policy adoption. This suggests that trends are parallel in the three years leading up to policy adoption. Statistically significant differences were observed in year four and earlier (compared to the full year closest to policy adoption), which may be driven by heterogeneity in terms of which counties contribute data to this period of time furthest from policy adoption.¹¹

In Table 4, we estimate an event study to examine the effects of a policy change at various stages of pregnancy. We continue to use our sample excluding counties with less-than-comprehensive IVRs. We further plot these coefficients in the first two graphs of Figure 4. The coefficients on the policy leads 18–15 months before the policy, 15–12 months before, and 12–9 months before are all statistically insignificant and small. Wald tests show that they are jointly statistically insignificant. Collectively, these results suggest the absence of any anticipatory behaviors or reverse causality.

The event study results further show that effect sizes begin to increase 3–0 months before conception (for mothers likely treated with the policy during their first trimester). For mothers conceiving 0–3 months after ENDS IVR adoption, we observe a 0.6 percentage point increase in smoking (6.6% of the mean) and 1.7 extra cigarettes per month (unconditional, 7.7% of the mean). For mothers conceiving more than 3 months after the policy, we observe a 1.4 percentage point increase in smoking (16.2% of the mean) and 4.6 extra cigarettes per month (unconditional, 21.0% of the mean). This may suggest delayed enforcement of the ENDS IVRs or county-level heterogeneity in which the effect of early-adopting ENDS IVRs was larger than later-adopting ENDS IVRs.

In Table 5, we estimate our models using a panel data analysis as presented in equations 5 and 6. This within-pregnancy analysis controls for all time invariant mother-specific omitted variables that could potentially bias the estimated effect of ENDS IVRs on smoking. We use all ENDS IVRs, including partial laws, in this evaluation. In columns 1 and 3, we find a larger effect of ENDS IVRs than in the cross-sectional analysis, with smoking participation increasing by 2.0 percentage points and extra cigarettes per month among all pregnant women increasing by 12.6 cigarettes per month. Results were not materially affected when we additionally controlled for trimester-year-month fixed effects in columns 4 through 6. Our consistent finding of a 2.0 percentage point increase in prenatal smoking is relatively twice the most directly comparable cross-sectional results of a 0.9 percentage point increase (Table 2, Section A). On the intensive margin (columns 2 and 5), the change in cigarettes per month was similar to the change shown in our cross-sectional model (Table 2, Section A), suggesting that the overall larger increase in cigarettes per month in the panel data analysis (columns 3 and 6) is driven by the doubling of smoking on the extensive margin.

In Table 6, we use our panel data model to explore heterogeneity in effect sizes of ENDS IVRs depending on age, education, and health insurance. ENDS IVRs had a disproportionate

¹¹Among the sample of 1,554,889 mothers used in columns 1 and 3 of Table 3, 42.4% of the sample is part of the first full year before ENDS IVRs, 31.6% are part of the second year, 18.1% are part of the third year, and only 7.9% are part of the fourth year or earlier.

effect on smoking participation for adults under 25 years old (3.2 percentage points) compared to those over 25 years old (1.5 percentage points); however, as a percent of mean smoking both groups responded roughly proportionately to ENDS IVRs (roughly a 30% increase). Lower educated individuals were also more likely than higher educated individuals to smoke in response to ENDS IVRs (2.3 percentage points compared to 1.7 percentage points); however, given the lower smoking rate among higher educated individuals, their smoking increased roughly 45% compared to a 22% increase among lower educated individuals. These results are consistent with our hypothesis that smoking may increase by more among higher educated individuals given evidence that they believe ENDS to be safer products (Viscusi, 2016).

We found similar heterogeneity within payment source stratifications, with the Medicaid population increasing their smoking in response to ENDS IVRs by the most with a 2.4 percentage point increase, compared to a 1.5 percentage point increase for the privately insured and a 1.3 percentage point increase for the uninsured. However, as a share of the mean smoking rate, privately insured mothers' smoking increased roughly 52% compared to more modest increases of roughly 25% for Medicaid mothers and uninsured mothers. This result did not confirm our hypothesis that uninsured pregnant women would be most likely to use ENDS due to higher cost barriers for close substitutes of FDA-approved smoking cessation products.

In Appendix Table A1, we perform a robustness check using only non-smokers in the 3 months prior to pregnancy, hypothesizing that ENDS IVRs should have little to no impact on this population. Our hypothesis was validated, as we observe precisely estimated zeros. Smoking participation decreased by 0.03 percentage points and unconditional cigarettes smoked per month decreased by roughly 1/10th of a cigarette.¹² In Appendix Table A1, Sections B and C, we stratify these results by younger pregnant women (< 25 years of age) and older pregnant women (≥ 25 years of age), and while ENDS IVRs had roughly twice the impact on reducing smoking participation among the younger sample, both results continued to be economically insignificant. In sum, we can conclude that the 2.0 percentage point increase in smoking found earlier is being driven by individuals smoking in the 3 months prior to pregnancy rather than by non-smokers in the 3 months prior to pregnancy.

Finally, in Table 7 we explore the effect of ENDS IVRs on birth outcomes, using equation 7. Both our coefficients and standard errors are small in magnitude, and the coefficients are statistically insignificant.¹³ Therefore, it appears that the laws have no impact on birth outcomes, possibly because substituting one source of nicotine for another results in no differences in birth outcomes (Royal College of Physicians in England, 2016). We identified similar null effects among non-smokers prior to pregnancy (Appendix Table A2), whom we hypothesized would be most likely to benefit from ENDS IVRs by potentially promoting complete abstinence from nicotine through reducing stand-alone vaping.

¹²We suspect that these results reflect decreased propensities of relapsing back into smoking (having smoked earlier than 3 months before the pregnancy) rather than initiating smoking for the first time.

¹³For example, 95% confidence intervals permit us to detect statistically significant differences in premature birth of 0.6 percentage points (6.9% of the mean) and statistically significant differences in low birth weight of 0.2 percentage points (3.3% of the mean). Therefore, we believe that our analysis is sufficiently powered to detect reasonable effect sizes.

Our event study coefficients for birth outcomes (Figure 4 and Appendix Table A3) basically uphold these null results, except for the finding of premature births and very premature births possibly decreasing for mothers likely exposed to the ENDS IVRs in their first trimester of pregnancy (conceiving 3–0 months before an IVR). Our weak evidence of preterm birth improving and no effect on birth weight as a result of ENDS IVRs appears to echo the literature on the effect of cigarette indoor air laws, which has found small decreases in preterm birth, but with no obvious effects on birth weight (Been et al., 2014; Markowitz et al., 2011).

VI Discussion

Our panel data model results document a doubling of the effect of ENDS IVRs on smoking compared to cross-sectional results. This suggests the presence of substantial unobservable individual-level heterogeneity that is correlated with both ENDS IVR adoption and smoking. Given the differences in treatment effects that we observe in our study, future studies evaluating the effect of policies on prenatal smoking should consider adopting a panel data evaluation strategy similar to our own to eliminate the possibility of omitted variable bias from unobservable individual-level heterogeneity.

Our estimate that ENDS IVRs increased prenatal smoking by 2.0 percentage points is large, representing approximately a 31.0% increase in the mean smoking rate. We suspect that these large effect sizes are due to not only the added inconvenience of vaping, but also due to changed perceptions of the risks of ENDS. For a non-pregnant woman, the relative risks of ENDS compared to traditional cigarettes has been estimated to be no more than 5% (Royal College of Physicians in England, 2016). Therefore, if ENDS IVRs are causing perceptions of the risks of ENDS to dramatically increase, and people reduce their attempts to quit smoking by using ENDS as a result, this may result in deteriorated health outcomes overall. Governments should be cautious on the messaging they send, through regulations, on the relative risks of different products. Ideally, products should be regulated proportionate to their level of risk (Chaloupka et al., 2015).

One limitation of our study is that that we are unable to look at the health of the mother or later-life health outcomes of the infants. Among women who quit smoking during pregnancy, 60% were still not smoking within 6 months after delivery (Centers for Disease Control and Prevention, 2017b). Therefore, if ENDS IVRs reduce quitting during pregnancy, some of the largest health effects of the law may be on the mother post-partum. Additionally, higher post-partum smoking rates could also endanger the child's immediate and later-life health due to secondhand smoke exposure (Simon, 2016; US Department of Health and Human Services, 2014).

Another limitation of our study is that birth records have no information about vaping, so we are unable to examine this behavior directly. The trimester-specific smoking information provided in revised birth records provides powerful data for researchers to evaluate the effect of a variety of tobacco control policies. However, with the increasing use of ENDS to obtain nicotine, states should consider adding ENDS use information to the birth records as well.

Additionally, states may also wish to consider adding questions on other sources of nicotine exposure, such as through use of NRT.

A final limitation is that the generalizability of our findings may be reduced by using only 37.7% of births nationally that occurred in states using revised birth records since 2010 and that had comprehensive cigarette smoking restrictions in place.¹⁴

Our study focuses on pregnant women, with the benefit of being able to conduct our analysis using panel data that is rare in studies of tobacco control policies. Future work is needed to evaluate the effect of ENDS IVRs on other populations besides pregnant women, including on the use of tobacco products and perceptions of risk. Additionally, as of January, 2017, seven states now tax e-cigarettes, and these policies will similarly be in need of evaluation (Campaign for Tobacco Free Kids, 2017).¹⁵

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Appendix

Table A1

Panel Data Analysis, Non-Smokers in 3 Months Prior to Pregnancy Only

	(1) Smoking Participation	(2) Avg. Cigs Per Month	(3) Smoking Participation	(4) Avg. Cigs Per Month
Section A: All Mothers				
Indoor Vaping Restriction	-0.0003* (0.0001)	-0.0723* (0.0329)	-0.0003 ⁺ (0.0001)	-0.0728 ⁺ (0.0361)
Mother FE	Yes	Yes	Yes	Yes
Trimester FE	Yes	Yes	Yes	Yes
Trimester-Year-Month FE	No	No	Yes	Yes
<i>N</i>	25,710,404	25,710,404	25,710,404	25,710,404
Dep Var. Mean	0.0004	0.1099	0.0004	0.1099
Section B: Mothers Under 25				
Indoor Vaping Restriction	-0.0005 ⁺ (0.0002)	-0.1098 (0.0819)	-0.0005 ⁺ (0.0003)	-0.1199 (0.0917)
Mother FE	Yes	Yes	Yes	Yes
Trimester FE	Yes	Yes	Yes	Yes
Trimester-Year-Month FE	No	No	Yes	Yes

¹⁴Our primary reasons for imposing these constraints on our analysis were to reduce confounding from cigarette indoor air laws, to increase the policy relevance of our results (since states will likely ban indoor smoking before vaping), and to take advantage of panel data on smoking available in revised birth records.

¹⁵See footnote 7 for more information.

	(1) Smoking Participation	(2) Avg. Cigs Per Month	(3) Smoking Participation	(4) Avg. Cigs Per Month
<i>N</i>	6,177,412	6,177,412	6,177,412	6,177,412
Dep Var. Mean	0.0007	0.1797	0.0007	0.1797
Section C: Mothers 25 and Older				
Indoor Vaping Restriction	−0.0002 [*] (0.0001)	−0.0597 ⁺ (0.0282)	−0.0002 ⁺ (0.0001)	−0.0579 ⁺ (0.0310)
Mother FE	Yes	Yes	Yes	Yes
Trimester FE	Yes	Yes	Yes	Yes
Trimester-Year-Month FE	No	No	Yes	Yes
<i>N</i>	19,532,992	19,532,992	19,532,992	19,532,992
Dep Var. Mean	0.0003	0.0878	0.0003	0.0878

Notes: Only mothers age 18 and older included. Controls for cigarette taxes in county. Standard errors in parentheses, clustered at state level.

⁺ $p < 0.1$

^{*} $p < 0.05$

^{**} $p < 0.01$

^{***} $p < 0.001$

Table A2

Cross-Sectional, Non-Smokers Prior to Pregnancy Only, Birth Outcomes

	(1) Premature (<37 Weeks)	(2) Very Premature (<32 Weeks)	(3) Small for Gest. Age	(4) Extra Small for Gest. Age	(5) Low Weight (<2500 Grams)	(6) Apgar 5 Score
Indoor Vaping Restriction	0.0002 (0.0015)	−0.0002 (0.0006)	−0.0006 (0.0072)	−0.0004 (0.0031)	0.0003 (0.0005)	−0.0095 (0.0079)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	6,270,487	6,270,487	6,268,429	6,268,429	6,268,430	6,248,741
Dep. Var. Mean	0.0835	0.0123	0.2293	0.0844	0.0529	8.8506

Notes: Only mothers age 18 and older included. Controls for mother's age, marital status, race, education, payment source, number of current birth, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

⁺ $p < 0.1$

^{*} $p < 0.05$

^{**} $p < 0.01$

^{***} $p < 0.001$

Table A3

Cross-Sectional Event Study, Birth Outcomes

	(1) Premature (<37 Weeks)	(2) Very Premature (<32 Weeks)	(3) Small for Gest. Age	(4) Extra Small for Gest. Age	(5) Low Weight (<2500 Grams)	(6) Apgar 5 Score
Conception 18–15 Mo. Before IVR	0.0012 (0.0019)	−0.0002 (0.0004)	0.0007 (0.0033)	0.0001 (0.0016)	0.0007 (0.0006)	0.0092 (0.0060)
Conception 15–12 Mo. Before IVR	0.0003 (0.0012)	−0.0003 (0.0003)	0.0043 ⁺ (0.0019)	0.0029 ⁺ (0.0013)	0.0002 (0.0013)	0.0052 (0.0063)
Conception 12–9 Mo. Before IVR	0.0014 (0.0020)	−0.0006 (0.0008)	0.0004 (0.0046)	0.0007 (0.0022)	−0.0011 (0.0011)	0.0014 (0.0089)
Conception 9–6 Mo. Before IVR	0.0014 (0.0025)	0.0001 (0.0006)	0.0029 (0.0034)	−0.0002 (0.0022)	−0.0002 (0.0011)	0.0095 (0.0098)
Conception 6–3 Mo. Before IVR	−0.0013 (0.0014)	0.0002 (0.0007)	0.0015 (0.0048)	−0.0011 (0.0013)	0.0008 (0.0012)	0.0028 (0.0102)
Conception 3–0 Mo. Before IVR	−0.0034 ⁺ (0.0013)	−0.0012 ⁺ (0.0005)	0.0052 (0.0049)	0.0012 (0.0027)	0.0002 (0.0014)	−0.0069 (0.0072)
Conception 0–3 Mo. After IVR	0.0002 (0.0007)	−0.0005 (0.0006)	0.0025 (0.0051)	−0.0001 (0.0023)	0.0017 (0.0022)	−0.0049 (0.0060)
Conception 3+ Mo. After IVR	−0.0000 (0.0009)	−0.0006 (0.0007)	0.0028 (0.0074)	0.0014 (0.0030)	0.0012 (0.0008)	−0.0139 (0.0087)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	4,591,515	4,591,515	4,589,490	4,589,490	4,589,491	4,577,551
Dep. Var. Mean	0.0901	0.0138	0.2364	0.0904	0.0580	8.8270
P-Value for Wald Test of Policy Leads	0.8784	0.6002	0.1370	0.1884	0.2105	0.2347

Notes: Excluded time category is “Conception earlier than 18 mo. before policy.” Excludes counties that had only part of county population covered by indoor vaping restrictions at any time in sample. Only counties with 0% or 100% population covered by all three restrictions (bar, restaurant, workplace) remain. Only mothers age 18 and older included. Wald test of policy leads includes 18–15 months before conception, 15–12 months before conception, and 12–9 months before conception. Controls for mother’s age, marital status, race, education, payment source, number of current birth, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

⁺
 $p < 0.1$

^{*}
 $p < 0.05$

^{**}
 $p < 0.01$

^{***}
 $p < 0.001$

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37. CIGARETTE SMOKING BEFORE AND DURING PREGNANCY

For each time period, enter either the number of cigarettes or the number of packs of cigarettes smoked. IF NONE, ENTER A0".

Average number of cigarettes or packs of cigarettes smoked per day.

	# of cigarettes	OR	# of packs
Three Months Before Pregnancy	_____	OR	_____
First Three Months of Pregnancy	_____	OR	_____
Second Three Months of Pregnancy	_____	OR	_____
Third Trimester of Pregnancy	_____	OR	_____

Figure 1.

Cigarette Question from Revised Birth Record

Source: CDC, <https://www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf>

Figure 2.
Map of ENDS Policy Environment. Section A: January 1, 2011
Section B: January 1, 2013
Section C: January 1, 2015

Figure 3.

Percent of Births in Sample with Exposure to ENDS IVRs

Notes: Percent of births in 15 states plus Washington D.C. that are exposed to any IVR at the estimated time of conception.

Figure 4.
Event Study Marginal Effects

Notes: Marginal effects from event study regressions are plotted. The plotted coefficients and standard errors are taken from the estimates in Table 4 for smoking behavior outcomes and Table A3 for birth outcomes.

Table 1

Descriptive Statistics

	(1)		(2)		(3)	
	All Counties		No IVR before 2015		IVR before 2015	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Demographics:						
Age	28.8514	5.7943	28.2948	5.6783	29.5561	5.8626
Number of Current Birth	2.4971	1.5738	2.5896	1.6331	2.3802	1.4874
Married	0.6254	—	0.6022	—	0.6549	—
Race: White (Non-Hispanic)	0.3303	—	0.3921	—	0.2520	—
Race: Black (Non-Hispanic)	0.1671	—	0.1556	—	0.1818	—
Race: Hispanic	0.4247	—	0.4017	—	0.4539	—
Race: Other Race (Non-Hispanic)	0.0701	—	0.0472	—	0.0992	—
Edu: Less than High School	0.1499	—	0.1511	—	0.1485	—
Edu: High School Diploma	0.2318	—	0.2440	—	0.2162	—
Edu: Some College	0.2848	—	0.3093	—	0.2538	—
Edu: Bachelor's Degree or Higher	0.3152	—	0.2884	—	0.3491	—
Payment Method:						
Medicaid	0.4213	—	0.4375	—	0.4009	—
Private Insurance	0.4948	—	0.4727	—	0.5227	—
Self-Pay	0.0296	—	0.0281	—	0.0315	—
Indian Health	0.0005	—	0.0009	—	0.0001	—
Champus/Tricare	0.0133	—	0.0196	—	0.0053	—
Other Government	0.0194	—	0.0180	—	0.0211	—
Unknown Pay Method	0.0099	—	0.0100	—	0.0098	—
Smoking Behavior:						
Smoking Participation	0.0654	0.2472	0.0995	0.2994	0.0222	0.1473
Cigs per Month (Conditional on Smoking)	242.6866	213.2711	248.4231	208.6388	210.1141	235.2339
Cigs per Month (Unconditional Mean)	15.8711	81.0827	24.7245	99.3136	4.6626	46.7531
N	7,071,887		3,951,386		3,120,501	

	(1)		(2)		(3)	
	All Counties		No IVR before 2015		IVR before 2015	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Tobacco Policy:						
Indoor Vaping Restriction	0.0617	0.2236	0.0000	0.0000	0.1399	0.3200
Indoor Smoking Restriction	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
Cigarette Tax	1.7758	1.2209	1.9949	1.2493	1.4984	1.1243
Birth Outcomes:						
Premature Birth (<37 Weeks)	0.0869	–	0.0919	–	0.0807	–
Very Premature Birth (<32 Weeks)	0.0133	–	0.0145	–	0.0118	–
Small for Gestational Age	0.2376	–	0.2358	–	0.2398	–
Extra Small for Gestational Age	0.0897	–	0.0906	–	0.0885	–
Low Birth Weight (<2500 Grams)	0.0570	–	0.0592	–	0.0543	–
Apgar 5 Score	8.8427	0.7342	8.8182	0.7924	8.8736	0.6518
<i>N</i>	7,071,887		3,951,386		3,120,501	

Notes: Dataset includes all live singleton births to adult women, with conception occurring between 1/1/2010 and 1/1/2015. Only includes states with comprehensive indoor smoking restrictions on cigarettes during entire sample period. Column 1 includes mothers from all counties. Column 2 includes only mothers from counties that never adopted the policy. Column 3 includes only mothers from counties that eventually adopted the policy within the sample period.

Table 2

Cross-Sectional, Smoking Outcomes

	(1) Smoking Participation (All Mothers)	(2) Avg. Cigs per Month (Smokers)	(3) Avg. Cigs Per Month (All Mothers)
Section A: All Counties			
Indoor Vaping Restriction	0.0093 ⁺ (0.0035)	10.2786 ^{**} (3.0687)	3.1682 ^{**} (0.9401)
County FE	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes
<i>N</i>	6,837,486	451,281	6,837,486
Dep. Var. Mean	0.0660	242.4162	15.9997
Section B: Binary Treated Counties Only			
Indoor Vaping Restriction	0.0128 ^{**} (0.0037)	8.8345 ^{***} (1.6321)	4.0867 ^{**} (1.1670)
County FE	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes
<i>N</i>	4,574,436	404,559	4,574,436
Dep. Var. Mean	0.0884	246.3900	21.7905

Notes: Section A includes all counties, while Section B excludes counties that had only part of the county population covered by indoor vaping restrictions at any time in the sample. Only counties with 0% or 100% population covered by all three restrictions (bar, restaurant, workplace) remain. Only mothers age 18 and older included. Controls for mother's age, marital status, race, education, payment source, number of current birth, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

⁺ $p < 0.1$

^{*} $p < 0.05$

^{**} $p < 0.01$

^{***} $p < 0.001$

Table 3

Test of Parallel Trends Assumption

	(1) Smoking Participation (All Mothers)	(2) Avg. Cigs per Month (Smokers)	(3) Avg. Cigs Per Month (All Mothers)
Section A: Linear Time Trend			
Linear Time Trend * Ever Adopt	0.0001 (0.0001)	-0.0653 (0.1948)	0.0314 (0.0184)
County FE	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes
<i>N</i>	1,554,889	141,102	1,554,889
Dep. Var. Mean	0.0907	246.0517	22.3285
Section B: Non-Linear Time Trend			
Conception 21–9 Mo. Before IVR * Ever Adopt	Ref.	Ref.	Ref.
Conception 33–21 Mo. Before IVR * Ever Adopt	0.0010 (0.0024)	3.4829 (3.3723)	-0.0286 (0.4500)
Conception 45–33 Mo. Before IVR * Ever Adopt	-0.0008 (0.0020)	3.8169 (4.3942)	-0.7388 (0.4751)
Conception 45+ Mo. Before IVR * Ever Adopt	-0.0047* (0.0020)	-3.5644 (11.5211)	-1.4011* (0.6343)
County FE	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes
<i>N</i>	1,554,889	141,102	1,554,889
Dep. Var. Mean	0.0907	246.0517	22.3285

Notes: Only mothers that conceived at least 9 months before actual/placebo policy adoption are included to evaluate trends in the period before any partial exposure. Excludes counties that had only part of county population covered by indoor vaping restrictions at any time in sample. Only counties with 0% or 100% population covered by all three restrictions (bar, restaurant, workplace) remain. Only mothers age 18 and older included. Controls for mother's age, marital status, race, education, payment source, number of current birth, and cigarette taxes in state at time of conception. Counties that never adopted an IVR policy are assigned a random placebo policy date, with each day between 1/1/2010 and 12/31/2014 being equally likely. Standard errors in parentheses, clustered at state level.

+
p < 0.1

*
p < 0.05

**
p < 0.01

p < 0.001

Table 4

Cross-Sectional Event Study, Smoking Outcomes

	(1) Smoking Participation (All Mothers)	(2) Avg. Cigs per Month (Smokers)	(3) Avg. Cigs Per Month (All Mothers)
Conception 18–15 Mo. Before IVR	0.0003 (0.0039)	–4.3106 (5.3555)	–0.0439 (1.2564)
Conception 15–12 Mo. Before IVR	0.0008 (0.0045)	–8.2553 (5.4538)	–0.1589 (1.3736)
Conception 12–9 Mo. Before IVR	–0.0004 (0.0034)	–5.6749 (6.6881)	–0.2337 (1.2119)
Conception 9–6 Mo. Before IVR	0.0009 (0.0035)	3.7833 (7.2195)	0.5932 (1.1582)
Conception 6–3 Mo. Before IVR	0.0002 (0.0044)	–3.5442 (7.5206)	0.1359 (1.2564)
Conception 3–0 Mo. Before IVR	0.0019 (0.0031)	0.1862 (10.1623)	0.6947 (1.1541)
Conception 0–3 Mo. After IVR	0.0059 ⁺ (0.0026)	–2.7730 (5.3494)	1.6780 ⁺ (0.8235)
Conception 3+ Mo. After IVR	0.0144 ^{**} (0.0039)	6.8597 (4.1224)	4.5990 ^{**} (1.2716)
County FE	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes
<i>N</i>	4,574,436	404,559	4,574,436
Dep. Var. Mean	0.0884	246.3900	21.7905
P-Value for Wald Test of Policy Leads	0.9273	0.3932	0.8989

Notes: Omitted time category is “Conception earlier than 18 mo. before policy.” Excludes counties that had only part of county population covered by indoor vaping restrictions at any time in sample. Only counties with 0% or 100% population covered by all three restrictions (bar, restaurant, workplace) remain. Only mothers age 18 and older included. Wald test of policy leads includes 18–15 months before conception, 15–12 months before conception, and 12–9 months before conception. Controls for mother’s age, marital status, race, education, payment source, number of current birth, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

⁺ $p < 0.1$

^{*} $p < 0.05$

^{**} $p < 0.01$

^{***} $p < 0.001$

Table 5

Panel Data Analysis

	(1) Smoking Participation (All Mothers)	(2) Avg. Cigs Per Month (Smokers)	(3) Avg. Cigs Per Month (All Mothers)	(4) Smoking Participation (All Mothers)	(5) Avg. Cigs Per Month (Smokers)	(6) Avg. Cigs Per Month (All Mothers)
Indoor Vaping Restriction	0.0198 * (0.0069)	11.6961 (28.0007)	12.6388 * (5.1943)	0.0200 * (0.0071)	11.1657 (28.0848)	12.5131 * (5.2848)
Mother FE	Yes	Yes	Yes	Yes	Yes	Yes
Trimester FE	Yes	Yes	Yes	Yes	Yes	Yes
Trimester-Year-Month FE	No	No	No	Yes	Yes	Yes
<i>N</i>	28,135,516	1,795,748	28,135,516	28,135,516	1,795,748	28,135,516
Dep. Var. Mean	0.0638	316.3686	20.1922	0.0638	316.3686	20.1922

Notes: Only mothers age 18 and older included. Controls for cigarette taxes in county. Standard errors in parentheses, clustered at state level.

+ $p < 0.1$

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 6

Panel Data Analysis, Stratified by Age, Education, and Payment Method

	(1) Smoking Participation (Age < 25)	(2) Smoking Participation (Age 25)	(3) Smoking Participation (Low Edu.)	(4) Smoking Participation (High Edu.)	(5) Smoking Participation (Medicaid)	(6) Smoking Participation (Private Ins.)	(7) Smoking Participation (Self Pay)
Indoor Vaping Restriction	0.0323* (0.0128)	0.0146** (0.0049)	0.0227* (0.0101)	0.0174** (0.0056)	0.0238* (0.0105)	0.0153** (0.0049)	0.0125+ (0.0068)
Mother FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trimester FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trimester-Year-Month FE	No	No	No	No	No	No	No
<i>N</i>	7,194,068	20,941,448	10,716,456	16,915,556	11,829,904	13,955,876	833,496
Dep. Var. Mean	0.1048	0.0497	0.1052	0.0387	0.1037	0.0297	0.0471

Notes: Column 1 includes only mothers between ages 18 and 24 (inclusive). Column 2 includes only mothers age 25 or older. All remaining columns include only mothers age 18 or older. Columns 3 and 4 include only mothers with a high school degree or less, and some college or more, respectively. Columns 5, 6, and 7 include only mothers with Medicaid, private insurance, and self-pay, respectively. Controls for cigarette taxes in county. Standard errors in parentheses, clustered at state level.

+ $p < 0.1$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table 7

Cross-Sectional, Birth Outcomes

	(1) Premature (<37 Weeks)	(2) Very Premature (<32 Weeks)	(3) Small for Gest. Age	(4) Extra Small for Gest. Age	(5) Low Weight (<2500 Grams)	(6) Apgar 5 Score
Indoor Vaping Restriction	0.0002 (0.0014)	-0.0003 (0.0006)	0.0009 (0.0066)	0.0006 (0.0028)	0.0008 (0.0004)	-0.0083 (0.0081)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	6,867,005	6,867,005	6,864,621	6,864,621	6,864,622	6,843,308
Dep. Var. Mean	0.0864	0.0131	0.2372	0.0895	0.0565	8.8449

Notes: Only mothers age 18 and older included. Controls for mother's age, marital status, race, education, payment source, number of current birth, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

⁺ $p < 0.1$

^{*} $p < 0.05$

^{**} $p < 0.01$

^{***} $p < 0.001$