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DOI	https://doi.org/10.1002/soej.12564
Download date	2026-02-18 14:38:27
Link to Item	https://hdl.handle.net/20.500.14694/4858

The Effect of E-Cigarette Indoor Vaping Restrictions on Infant Mortality

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JEL Classification Numbers: I12, I18

Keywords: smoking, vaping, electronic nicotine delivery systems, e-cigarettes, indoor air laws, tobacco control, infant mortality

Acknowledgements: The authors have no conflicts of interest to disclose. We thank Joanna Seirup and Manyao Zhang for excellent data management. We thank participants for helpful comments at the 2018 American Society of Health Economists conference, the 2018 Southeastern Health Economics Study Group conference, and the 2018 Latin American and Caribbean Economics Association Health Economics Network conference. Research reported in this publication was supported by the National Institute on Drug Abuse of the National Institutes of Health under Award Number R01DA045016 (PI: Michael Pesko), Award Number R01DA039968 (PI: Dhaval Dave), and Award Number P30DA040500 (PI: Bruce Schackman). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Abstract

We estimate the effect of county-level e-cigarette indoor vaping restrictions (IVRs) on infant mortality using United States birth certificates from 2010 to 2015. We estimate difference-in-differences models and find that e-cigarette indoor vaping restrictions increased infant mortality by 0.39 infants per 1,000 live births (12.9%). These effects were disproportionately higher for infants born to younger mothers and in locations with higher baseline levels of prenatal smoking. Infant mortality increased by 34.1% between 100 days to 1 year after IVRs. Infant mortality due to infections and neoplasms were particularly elevated.

1 INTRODUCTION

Traditional cigarette 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 and other forms of electronic nicotine delivery systems (ENDS) (which people *vape* rather than *smoke*)[1] has provided pregnant woman with another smoking cessation product option, similar to the availability of Food and Drug Administration-approved smoking cessation medications and nicotine replacement therapy (NRT) products. According to National Health Interview Survey data from 2014-2017, 38.9% of pregnant smokers used ENDS compared to only 13.5% of non-pregnant, reproductive age women smokers (Liu et al., 2019). The high rates of ENDS use among pregnant women that smoke could be due to pregnant women trying to quit conventional cigarette smoking with ENDS. Vaping is unlikely to exceed 5% of the risks of smoking for non-pregnant women, but the risks of vaping may be much higher for pregnant women because nicotine, which is in most ENDS, is particularly harmful to the developing fetus (Royal College of Physicians in England, 2018). The safety of using ENDS for smoking cessation during pregnancy has an inconclusive grade from the United States Preventive Services Task Force (Siu, 2015). However, England's National Health Services (NHS) recommends that pregnant women use e-cigarettes if it helps them to stop smoking because e-cigarettes do not contain tar nor carbon monoxide, the latter of which is particularly hazardous to the developing baby (National Health Service, 2020).

One recent policy change that may impact demand for ENDS is indoor vaping restrictions (IVRs). 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, IVRs have been found to reduce demand for ENDS in an experimental market (Marti et al., 2018). 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, individuals may interpret the passage of IVRs as a signal of the risks of ENDS,[2] and cause people to perceive ENDS more dangerously than before, which could also reduce the demand for using ENDS as smoking cessation products.

In Cooper and Pesko (2017), we explored effects of county-level IVRs on prenatal smoking and select birth outcomes recorded on the birth certificate.[3] We used revised birth records (which provide self-reported smoking information for the 3 months prior to pregnancy and in each trimester of pregnancy) for 15 states + Washington DC that had comprehensive indoor smoking bans in restaurants, bars, and private workplaces. Our main results are reprinted in Appendix Table 1. We found that IVRs reduced smoking cessation during pregnancy by 0.9 percentage points (pp) using a cross-sectional model. Further, each pregnant woman (averaged across smokers and non-smokers) smoked on average 3.2 extra cigarettes monthly in places with comprehensive IVRs compared to places without them.[4] While IVRs reduced smoking cessation, we did not find evidence that they changed birth outcomes of premature birth, low birth weight birth, small-for-gestational age, and Apgar 5 score (Appendix Table 1, columns 3-8).[5] Possible explanations for our findings of prenatal smoking increasing but birth outcomes not being affected may be that the policy-induced change in smoking was not large enough to meaningfully affect birth outcomes, and that substituting ENDS for cigarettes was not health improving for developing fetuses, since both cigarettes and ENDS contain nicotine, which is one of the leading toxicants for developing fetuses.

In this study, we explore infant mortality as an alternative measure of infant health, which unlike birth outcomes could be impacted by changes in secondhand vape and smoke exposure, whether through the mother or another caregiver. Current evidence suggests that secondhand smoke exposure is significantly more dangerous than secondhand vape exposure. The United States' Centers for Disease Control and Prevention (CDC) warns that secondhand smoke contains hundreds of toxic chemicals and about 70 that can cause cancer. From 1964-2014, 2.5 million Americans died due to secondhand smoke exposure (Centers for Disease Control and Prevention, 2018). In contrast, the Surgeon General concludes that ENDS aerosol generally contains fewer toxicants than combustible tobacco products (although they caution that the aerosol is not harmless) (US Department of Health and Human Services, 2016). The Surgeon General report notes that secondhand exposure to vaping causes similar levels of serum cotinine compared to secondhand exposure to smoking, but otherwise there are no documented adverse health effects of secondhand vape exposure. England's NHS mentions that e-cigarettes do not contain carbon monoxide (National Health Service, 2020).

The objective of this paper is to explore the effect of IVRs on infant mortality. Even if infants are rarely in locations regulating smoking and vaping (e.g. bars, restaurants, workplaces), IVRs could still affect infant mortality by causing changes in prenatal smoking or causing changes in smoking among caregivers in the infant's home environment, for example. We hypothesize that IVRs could affect infant mortality through at least two channels. Indoor vaping restrictions could decrease infant mortality by decreasing nicotine use from vaping during pregnancy and by decreasing secondhand vape exposure post-pregnancy (through mothers or other cargivers). Indoor vaping restrictions could also increase infant mortality by increasing smoking during pregnancy and increasing more dangerous secondhand smoke exposure post-pregnancy (again, through mothers or other caregivers). Our results suggest that on net IVRs increase infant mortality.

2 BACKGROUND

The CDC defines infant mortality as the death of an infant before their first birthday. In 2011, the infant mortality rate was 6.1 per 1,000 live births (tlb). In the same year, the CDC identified the 5 leading causes of infant mortality as congenital malformations (1.26 deaths/tlb), short gestation/low birthweight (1.04/tlb), SIDS (0.43/tlb), maternal complications (0.40/tlb), and unintentional injuries (0.28/tlb) (MacDorman et al., 2013).

While our study is the first to estimate the effect of IVRs on infant mortality, several studies have examined the effect of indoor smoking restrictions on certain types of infant mortality.[6] Markowitz (2008) used a two-way fixed effect model to examine the effects of cigarette prices/taxes and indoor smoking restrictions on SIDS in the United States from 1973-2003. The study found that higher cigarette prices and taxes and stronger indoor smoking restrictions reduced SIDS. For private workplace indoor smoking laws, the restriction requiring separate ventilation had the largest effect of all the workplace regulations and was associated with a reduction of 3.5 SIDS deaths nationally per quarter. Total bans on smoking in restaurants were associated with four fewer SIDS deaths nationally per quarter.

Another study found no effect of smoke-free air laws on SIDS using a panel of 23 developed countries over the years 1990 to 2009 (King et al., 2015).

At least two studies have used interrupted time series designs to study the effect of smoke-free air law policies on infant mortality. The July 2007 national, comprehensive smoke-free legislation in England was found to cause an immediate 7.8% reduction in stillbirth and a 7.6% reduction in neonatal mortality, but no impact on SIDS (Been et al., 2015). Another study found marginally statistically significant evidence that a 2008 law banning smoking in bars and restaurants reduced early neonatal mortality (within the first 7 days of birth) in the Netherlands, but this policy occurred simultaneously with an increase in cigarette taxes and the launching of an anti-tobacco campaign (Peelen et al., 2016); therefore, the authors were unable to isolate the effect of only the smoke-free air law part of this policy change.

At least two studies examined the impact of cigarette taxes on overall infant mortality, with both finding that higher cigarette taxes reduce infant mortality. A 10% increase in cigarette taxes reduced infant mortality by 1.7-1.8% in Canada (Sen and Piérard, 2011) and a $1 increase in cigarette taxes reduced infant mortality by 0.19 pp in the United States (Patrick et al., 2016).

In Cooper and Pesko (2017), we documented that IVRs increased prenatal smoking but did not change gestational length and birth weight outcomes, nor did we see a change in Apgar 5 score that could indicate changes in congenital malformations (reprinted in Appendix Table 1, columns 3-8). However, infant mortality may capture the health endowment of newborns in different ways than birth weight, gestational length, and Apgar 5 score. IVRs could also increase infant mortality through increased secondhand smoke exposure during the infant's first year of life. If IVRs reduce smoking cessation during pregnancy (which we found in our prior study), then the mother would have lost a valuable opportunity to quit smoking[7] and hence could subject her infant to more post-natal secondhand smoke exposure, which is considered more dangerous than secondhand vape exposure. Additionally, IVRs could cause other family members and caregivers to be more likely to smoke traditional cigarettes (instead of attempting to quit with ENDS) as well, thus additionally exposing infants to more harmful smoke exposure. We can test for this directly by exploring if there were changes in mortality later in the infant's first year of life, or if there were changes in causes of infant death associated with secondhand smoke exposure versus gestation-related complications.

In theory, IVRs could also affect infant mortality through nicotine poisonings; however, ENDS account for a small share of overall nicotine exposures (cigarettes remain the dominant source of exposure) and there has only been one death linked to exposure to ENDS liquid nicotine through April, 2015 (Kamboj et al., 2016), which corresponds closely to the ending point of our study period.

3 DATA

We supplement the data that we used in Cooper and Pesko (2017) with period-linked death certificate data. The linked Birth/Infant Death Period Data contains all births in a given calendar year and provides death certificate data for if the infant died in the same calendar year in which they were born.[8] This data captures approximately 86% of infant mortality, only missing mortality for infants that were born in one calendar year and died in the next calendar year (but within one year of their birth).[9]

The Standard Certificate of Live Birth was revised in 2003 and the new form was slowly rolled out in different states over time.[10] In our prior study, we used only states that implemented revised birth records by 2010 to take advantage of smoking information recorded at four points in time before and during a mother's pregnancy.[11] We continue to use revised birth records in this study for ease of comparing results in this study with our prior work, and so that we can estimate stratified models using payment source information that is only available in revised birth records.

We use the sample restrictions as in our previously published paper 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.[12] Second, we exclude three additional states because they were missing a substantial percentage of data on smoking behavior for entire years.[13] Third, we exclude fifteen remaining states that did not have comprehensive prohibitions on smoking cigarettes in bars, workplaces, and restaurants (minor exceptions allowed) at the start of 1/1/2010.[14] We obtain this data on indoor smoking bans from the CDC State System (Centers for Disease Control and Prevention, 2017).[15] Our rationale for using only states with comprehensive prohibitions on smoking cigarettes in bars, workplaces, and restaurants is that 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 IVRs in places already comprehensively banning indoor smoking provides more policy-relevant results.[16] We also avoid complex interaction effects between partial smoking restrictions and IVRs.

Our sample includes all adult 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 non-singleton births to avoid confounding from fertility treatment availability (Kulkarni et al., 2013). 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 inclusion criteria of being singleton births to women conceiving during adulthood and without missing gestational length information on the birth certificate.

We use IVR data from the American Nonsmokers' Rights Foundation U.S. Tobacco Control Laws Database. These data include all known IVRs at the state, county, and municipality levels. We focus on the most widespread IVRs: those applying to bars, workplaces, and restaurants. Only six counties had an IVR in place before 1/1/2011, but 66 counties had an IVR in place before 1/1/2015. Of these 66 counties, 35 had comprehensive laws that banned vaping in bars, workplaces, and restaurants throughout the entire county. In contrast, 31 counties had partial bans, either because the bans did not affect the entire county (22 counties), were not comprehensive for all three types of establishments (1 county), or for both reasons (8 counties). The average non-comprehensive county had 28.7% population exposure to IVRs, which justifies our decision to treat these counties as non-adopters (or to drop them in a sensitivity analysis). From among the counties adopting comprehensive IVRs, 29 of these were in Utah and 6 were outside of Utah. Four of these six counties (King, WA; New York, NY; Suffolk, NY; and San Francisco, CA) have populations larger than the entire state of Utah, while two counties (Topkins, NY; Lewis and Clark, NY) have smaller populations than Utah. Approximately 8.3% of births in our sample occurred in counties adopting comprehensive IVRs. Appendix Figure 1 shows the IVR environment at the end of our sample period.

We also use quarterly cigarette excise taxes (Centers for Disease Control and Prevention, 2017) and both state- and county-level e-cigarette minimum legal purchase age laws as control variables (Pesko and Currie, 2019). We link both the IVR data and cigarette tax data using the mother's county of residence and date of conception.

Table 1 shows descriptive statistics for our sample. The first set of columns shows means for individuals residing in counties that had not adopted a comprehensive IVR before the end of 2015 and the second set of columns shows means for individuals residing in counties that had adopted a comprehensive IVR before the end of 2015. We further split counties adopting comprehensive IVRs (column 2) into before and after adoption (columns 3 and 4). Women giving birth in counties adopting comprehensive IVRs were more likely to be older, be married, be white (non-Hispanic), have a college degree, have private insurance, and live in a state with higher cigarette taxes. We model away observable differences between our two groups by including demographics and payment source as control variables in regression analyses.

In comparing adopting counties before and after adoption, infant mortality increased from 3.17/tlb before IVR adoption to 3.57/tlb after IVR adoption. In counties adopting comprehensive IVRs, 59.8% of infant mortality was in the infant's first week of life (2.03/tlb) and 74.4% was in the infant's first 28 days of life (2.52/tlb). We also explore the effects of IVRs on select causes of death using coding from the Tenth Revision 130 Selected Causes of Infant Death. The causes of death that we explore (and share of infant mortality in counties adopting comprehensive IVRs) are congenital deformation/abnormal birth (25.9%), premature birth/malnutrition (13.4%), respiratory diseases/distress (8.2%), SIDS (7.1%), infections (1.6%), neoplasms (0.9%), delivery complications (13.6%), accidents (3.4%), and all other causes (25.9%).[17] We hypothesize these categories could be particularly influenced by tobacco use, except for delivery complications and accidents, which we use as a placebo test.

In Appendix Table 2, we tabulate causes of infant mortality with timing of infant mortality. Almost all infant mortality due to premature birth/malnutrition and delivery complications occurs in the first week of life. Infant mortality due to SIDS, infections, and accidents mostly occurs after the first month of life. The other causes of infant mortality reasonably track the mean in each time period.

In Figure 1, we show unadjusted trends over time in infant mortality for counties adopting comprehensive IVRs versus counties not adopting. The visual evidence shows higher levels of infant mortality in locations not adopting comprehensive IVRs. In both adopting and non-adopting locations, infant mortality appeared to be slowly falling until year 2013, after which it increased in locations adopting ENDS but remained unchanged in locations never adopting. In Figure 2, we further break down the unadjusted trends for counties adopting comprehensive IVRs in ≤2012 or ≥2013. Reassuringly, the increase in infant mortality observed among adopting counties in year 2013 occurred only in counties adopting in year 2013 or after.

4 METHODS

We estimate an identical cross-sectional difference-in-differences (DD) model as in Cooper and Pesko (2017), but this time we use infant mortality as the outcome:

$$infant\_mortality_{ict} = \alpha + \beta_1 IVR_{ct} + \beta_2 TC_{st} + \delta X_{ict} + \gamma_c + \gamma_t + \varepsilon_{ict} \tag{1}$$

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)[18] and county fixed effects. County fixed effects allow 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 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).[19] IVRs vary over time and are at the point of conception. TC represents other tobacco control policies of cigarette taxes and e-cigarette minimum legal purchase age laws, the latter of which we include as a proxy for anti-vaping sentiment since our sample is of adults only. We do not control for ENDS taxes because these were not in place during our study period for our baseline sample.[20] Finally, X_{ict} is for individual-level controls of race/ethnicity, age, mother's delivery payment method,[21] marital status, level of education, and the number of the current birth (i.e. number of previous births plus one).

Our treatment variable IVR_{ct} is whether the county had a comprehensive IVR in place at the time of conception. Our rationale for examining the effect of comprehensive IVRs is that having an IVR in only part of the county or in only select establishments is more easy to evade. Further, the average non-comprehensive county had 28.7% population exposure to IVRs. Therefore, the approximately 33% of births in our sample that were affected by IVRs that were not comprehensive (either because the county did not ban vaping from all three establishments of bars, restaurants, and private workplaces, or because only part of the county adopted a comprehensive law) are treated as part of the control group in our main analysis, or are dropped in a sensitivity analysis.

A necessary assumption for the DD model to recover causal estimates is that the treatment (i.e. counties adopting comprehensive IVRs) and the comparison (i.e. counties not adopting comprehensive IVRs) would follow the same trend in infant mortality in the post-treatment period, had the treatment counties not been treated. However, this assumption is untestable. We instead attempt to provide evidence on this assumption by modifying equation 1 by including an interaction between a monthly linear time trend (using date of conception) and an indicator for whether the county ever adopted a law or not. We estimate this equation using only data from the pre-adoption period.[22]

$$infant\_mortality_{ict} = \alpha + \beta_1 ever\_adopt_c * time_t + \beta_2 TC_{st} + \delta X_{ict} + \gamma_c + \gamma_t + \varepsilon_{ict} \quad (2)$$

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 equation 1 to perform an event study Autor (2003). 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 6 month intervals, except for infants exposed to an IVR during gestation in which case we use 3 month intervals corresponding to exposure in each trimester. Our event study allows us to evaluate effects of the law for infants exposed to

IVRs in different trimesters of pregnancy or in the first year of life, as well as test for unexpected changes in smoking in places that will pass an IVR in the future (which could suggest anticipatory behaviors or reverse causality).

Similar to Alpert et al. (2018), we also estimate a "bite" model in which we explore if comprehensive IVRs had differential effects in counties with higher prenatal smoking rates at baseline (year 2010). We hypothesize that IVRs have a larger impact on infant mortality in counties with higher prenatal smoking rates.

Standard errors are clustered at the state level in all regression models, which is the highest level at which our policy varies. However, we show that our main results are largely insensitive to clustering at the county level. We estimate all equations using linear probability models.

5 RESULTS

Standard DD results from equation 1 are presented in Table 2. We estimate a pooled model in column 1 and stratified models by age, education, and payment source in columns 2-7. Overall, we find that comprehensive IVRs increased infant mortality by 0.39/tlb (12.9% of the mean for treated counties, pre-treatment, $p<0.01$), which closely matches unadjusted differences in infant mortality rates shown in Table 1, columns 3-4.

In columns 2-7, we show that infant mortality increased by a similar magnitude regardless of education and payment source, although as a percent of the mean the increase was larger for higher educated mothers and privately insured mothers. Cooper and Pesko (2017) also found higher percentage increases in prenatal smoking for higher educated mothers and privately insured mothers. However, the primary heterogeneity appears to come from age, with women <30 years of age experiencing infant mortality rates of 0.58/tlb (16.4%) compared to 0.19/tlb for women ≥ 30 years of age (7.5%). Younger individuals have higher ENDS use rates (Wang et al., 2018), which may be contributing to the disproportionate effect of IVRs for this population.

We show the corresponding parallel time trends tests and event studies for these DD results in Appendix Tables 3 and 4. In Appendix Table 3, we present evidence of parallel time trends using equation 2, which uses data only from the period of time before comprehensive IVR adoption (actual or placebo). We find evidence of parallel time trends for all mothers, with the coefficient small in magnitude and are not statistically significant. Two subgroups show evidence of non-parallel time trends: older and high educated mothers. DD coefficients for these two subgroups should therefore be interpreted cautiously.

In Appendix Table 4, we estimate an event study to examine the effects of a policy change at various points in time before and after conception. We also plot these coefficients in Figures 3 and 4. The reference period for our event study is conception occurring 10-12 months before an IVR was passed, which is the period of time right before a fetus would otherwise be exposed to IVRs during gestation.

For the full sample (Appendix Table 4, column 1), there was no evidence of differences in infant mortality for infants conceived prior to adoption in places adopting comprehensive IVRs compared to places not adopting. The coefficients prior to the reference category were small in magnitude and statistically insignificant, and these coefficients were jointly insignificant. There is some evidence that IVRs becoming effective during pregnancy reduce infant mortality, but laws effective for the full pregnancy are found to increase infant mortality.

The event studies for models stratified by age, education, and insurance show evidence of non-parallel trends (based on the joint significance of the policy leads, $p<0.05$) for mothers with high education and receiving Medicaid, which again suggests caution in interpreting the stratified DD coefficients for these subgroups.

In Table 3, we turn to examining how IVRs affect infant mortality at different points in time. We find statistically significant increases in infant mortality occurring in the first week of life (0.21/tlb, 11.8% of the mean) and >100 days after birth (0.10/tlb, 34.6%). The percent increase in infant mortality as a percent of the mean was similar for 7-27 days after birth (14.3%) compared to the first week of life (11.8%), although it was not statistically significant. The particularly elevated rates of infant mortality >100 days after birth suggest that changes in secondhand smoke exposure were a particularly important mechanism through which IVRs caused higher infant mortality.

In Table 4, we explore the effect of IVRs on specific causes of infant mortality. We were able to detect statistically significant increases in infant mortality for congenital deformation/abnormality (0.12/tlb, 15.2%), infections (0.05/tlb, 141%), neoplasms (0.04/tlb, 176%), and other causes (0.07/tlb, 9.2%). While estimates in terms of percent of the mean for infections and neoplams are very large, this could be due in part to their rare nature, as together they account for only 2.5% of all infant mortality in adopting counties.

While not statistically significant owning to lower prevalence, we estimate that infant mortality due to premature birth and malnutrition increased by 18.3% and respiratory disease/distress increased by 28.8%. We did not find evidence of IVRs changing infant mortality from SIDS, which is consistent with one study finding no effect of indoor smoking restrictions on SIDS using a cross-country panel design (King et al., 2015), but contrasts with another study using data from the United States (Markowitz, 2008). Reassuringly, we did not find evidence that IVRs increased delivery complications or accidents—the latter actually decreased at $p<0.10$.

In Table 5, we show that IVRs disproportionately increased infant mortality in counties with higher rates of prenatal smoking at baseline. In column (1), our results suggest that IVRs increase infant mortality by 0.049/tlb in hypothetical counties with no prenatal smoking, and by 0.069/tlb in counties for each 1 pp increase in prenatal smoking.[23]

We perform a variety of robustness and sensitivity analyses. First, we examine if IVRs impact fetal deaths, which if so could bias our results if only the healthiest fetuses survive until pregnancy. For this analysis we pooled all National Center for Health Statistics data on live births and fetal deaths.[24] We create a binary variable that is a 1 for a fetal death and 0 for a live birth. We estimate equation (1) using this dependent variable, and using a more limited set of mother characteristics (age, race) that were available in both fetal death and live birth data. As shown by Appendix Table 5, IVRs have no effect on fetal deaths.[25] Additionally, IVRs have no effect on live birth counts.[26] Taken together, these results suggest that higher infant mortality from IVRs cannot be explained by changes in fertility or fetal deaths.

In Appendix Tables 6 to 8 (represented graphically in Appendix Figures 2 and 3), we show that our results were similar if we exclude counties adopting partial IVRs.

In Appendix Table 9, we estimate models separately for Utah and the six other counties (four of them with larger population than Utah) with IVR laws. With the other counties, someone could potentially drive to any of the bordering counties to vape indoors. However, with Utah (particularly the interior counties), the driving possibility is mitigated. Therefore, we would expect to find larger effects in Utah than the other counties. This is indeed the case, with the coefficient estimate for Utah being approximately double that for the other counties in the pooled sample.

In Appendix Table 10, we add back to our sample two states, Massachusetts and Minnesota, that were using unrevised birth records in January 2010, but that otherwise met inclusion criteria of having a comprehensive statewide indoor smoking ban and no significant missing smoking data. We previously excluded these states in Cooper and Pesko (2017) because they do not provide information on payment source or trimester-specific smoking. One additional Minnesota county adopted a comprehensive IVR during this time. Results were substantially similar to those previously reported in Table 2 that did not include these two additional states.

Our infant mortality information misses approximately 14% of first-year infant mortality when the infant dies in the calendar year after they were born. In Appendix Table 11 we drop December live births (which has the greatest share of missing infant mortality) and show our results are substantially similar to baseline results in Table 2.

In Appendix Table 12, we exclude women that were first exposed to an IVR during their pregnancy. IVRs increase infant mortality in this case by 0.26/tlb (p<0.10), which represents a somewhat attenuated effect compared to Table 2 (8.4% increase compared to a 12.9% increase).

In Appendix Tables 13 and 14, we control for monthly linear time trends at the state or county level to remove potential sources of omitted variable biases that vary within areas and linearly over time. IVRs continue to increase overall infant mortality in this case by 0.48/tlb controlling for state-specific linear time trends and by 0.57/tlb controlling for county-specific linear time trends.

In Appendix Table 15, we show results if we drop month of birth fixed effects and keep only month of conception fixed effects. IVRs increase infant mortality in this case by 0.31/tlb (10.4%, p<0.01) overall.

We also show in Appendix Table 16 that standard errors for our main DD results are somewhat larger if we cluster at the county level rather than the state level, but all previously statistically significant coefficients in Table 2 remained so at the 10% level except for older mothers.

6 DISCUSSION

Our results suggest that IVRs increase infant mortality by approximately 12.9%, with especially large effects for women under the age of 30 (16.4% increase). While the policy was intended to improve public health, we find evidence by examining infant mortality that it did not. States and localities may therefore wish to reconsider adopting future IVRs. A $1 increase in cigarette prices has been found to reduce infant mortality by 0.19 pp (Patrick et al., 2016); therefore, our results suggest that the effect of an IVR on infant mortality is analogous to reducing cigarette prices by $2, or approximately 33% of the average retail price per pack cigarettes in 2015 of $5.96 (Orzechowski and Walker, 2015).

According to our calculations using the American Nonsmokers' Rights Foundation U.S. Tobacco Control Laws Database, in 2018 45.1% of the population lived in a state or county banning the indoor use of e-cigarettes in bars, restaurants, and private workplaces. Given that there were 3,788,235 births in 2018 and our baseline estimate of 0.39 deaths/tlb, we estimate that there were 661 extra first-year infant deaths in 2018 due to e-cigarette indoor vaping bans. In contrast, there has been concern recently in the United States about e-cigarette-related pulmonary illness that has resulted in 68 deaths as of 2/18/2019 (Centers for Disease Control and Prevention, 2020b).[27] Documented deaths from pulmonary illness is therefore only 10.3% of estimated 2018 infant mortality from e-cigarette indoor vaping bans.

Among our sample, infant mortality was 6.45/tlb for mothers that prenatally smoked, and 3.46/tlb for mothers that did not prenatally smoke; therefore, prenatal smoking increases infant mortality by 3.0/tlb (unadjusted). Our main result suggests a 0.387/tlb increase in infant mortality as a result of IVRs, which therefore accounts for approximately 1/8th of the unadjusted effect of prenatal smoking on infant mortality. Given that IVRs increased prenatal smoking by less than 1/8 (Cooper and Pesko, 2017), this suggests that mechanisms beyond the effect of IVRs on prenatal smoking affect infant mortality. One potential mechanism is secondhand smoke exposure, which is supported by infant mortality increasing $>$100 days after birth and for certain causes of infant mortality that could be due to changes in secondhand smoke exposure.

However, one area where we do not find an increase in infant mortality is with SIDS, which has been the primary form of infant mortality studied so far in studies of tobacco policies, though with mixed results (Markowitz, 2008; King et al., 2015). Our study identifies several other forms of infant mortality that may be affected by changes in tobacco control policies; in particular, congenital deformation/abnormality, infections, and neoplasms, which could serve as supplemental outcomes for examining the effect of tobacco control policies on infant mortality in the future.

The results of our study suggest that examination of traditional birth outcomes of premature birth and low birth weight birth may not provide the full picture of the effect of a policy change on infant health. While we did not find that IVRs impacted key measures of premature birth and low birth weight birth in Cooper and Pesko (2017) (reprinted in Appendix Table 1), we find evidence in the current study that infant mortality did increase. Future studies may wish to supplement birth certificate outcomes with death certificate outcomes to more comprehensively evaluate the effects of policies on infant health.

A randomized control trial of roughly 1,000 pregnant women given real or placebo nicotine replacement therapy patches during pregnancy found some evidence that women given real nicotine replacement therapy patches during pregnancy had lower rates of smoking for up to two years after pregnancy (Coleman et al., 2012), and their infants were less likely to have developmental impairment two years later (Cooper et al., 2014). Our study complements this literature by exploring the effect of restricting the usability of another nicotine replacement product–ENDS, on a different health outcome–infant mortality. Our results also suggest potential health benefits of using nicotine replacement products for pregnant women that smoke, in our case by not limiting their ability to use ENDS.

One question that arises out of our current work is how to optimally communicate health information. The United States' CDC and England's NHS are currently using different messaging strategies on e-cigarette use during pregnancy. The CDC's messaging strategy is to heed off all e-cigarette use during pregnancy, warning "e-cigarettes and other products containing nicotine are not safe to use during pregnancy," (Centers for Disease Control and Prevention, 2020a) whereas the NHS's messaging acknowledges benefits, "If using an e-cigarette helps you to stop smoking, it is much safer for you and your baby than continuing to smoke" (National Health Service, 2020). It's unclear how much of these messaging strategy differences are due to disagreement on communication strategy and how much of it is due to disagreement on how to interpret the available literature on the risks of nicotine product use during pregnancy. Assuming that e-cigarettes are safer to use during pregnancy, a reasonable argument can be made that providing risk mitigation messaging similar to NHS helps to create rational actors, which in theory should lead to more economic efficiency.

This research also shows an example of negative health effects as a result of unintended consequences of government policy reducing free market activity. Other examples abound in the tobacco control space, including cigarette taxes raising obesity (Courtemanche et al., 2018; Tchernis et al., 2021) and e-cigarette taxes raising combustible tobacco product use (Abouk et al., 2020; Cotti et al., 2020; Pesko et al., 2020; Saffer et al., 2020; Abouk et al., 2021). Regulation is justified to correct market externalities, but in the case of e-cigarettes in which risks are potentially low and smoking cessation benefits high, it's unclear if any regulation is economically justifiable.

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Notes

[1]We henceforth refer to the act of vaping as using an ENDS product, such as an e-cigarette.

[2]For example, e-cigarette taxes has been shown to raise perceptions of e-cigarette risks for teens (Abouk et al., 2021)

[3]The birth certificates do not include infant mortality, but infant mortality can be linked using death certificates.

[4]Additionally, we used a panel data model to estimate that IVRs reduced smoking cessation within a given trimester by 2.0 pp and the number of cigarettes monthly by 12.6 cigarettes.

[5]Other studies have also found evidence of higher prenatal smoking without statistically significant changes in birth outcomes in places regulating ENDS. Pesko and Currie (2019) found that rural underage pregnant teenagers were 0.6 pp more likely to smoke in a given trimester in counties adopting ENDS minimum legal sale age laws, and no statistically significant effect on birth outcomes. Abouk et al. (2020) found that a $1 increase in e-cigarette taxes increases pre-pregnancy and prenatal smoking by 0.4 percentage points, and also no statistically significant effect on birth outcomes.

[6]Lakdawala and Simon (2017) provide an excellent overview of this literature.

[7]For women that quit smoking during pregnancy, 40% remain abstinent 6 months after delivery (Colman and Joyce, 2003).

[8]We use the numerator file to obtain additional death certificate information, such as timing of death and cause of death.

[9]We show in a sensitivity analysis that our results are not impacted by excluding births in the month of December that have the greatest share of missing mortality information.

[10]All states were using the revised birth records in 2015.

[11]Birth records do not collect information on prenatal vaping.

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

[13]These excluded states are: FL, GA, and MI.

[14]These excluded states are: ID, IN, KS, KY, MO, ND, NH, NV, OK, PA, SC, SD, TN, TX, and WY. ND adopted a comprehensive IVR and smoking ban at the same time in 2012, and was excluded for not having a comprehensive smoking ban in place at the start of 2010. Otherwise, only 3 other counties adopting comprehensive IVRs were excluded because the state did not have a comprehensive prohibition on smoking cigarettes in bars, workplaces, and restaurants.

[15]From amongst our 15 state + Washington DC sample, most of the state indoor smoking bans had been in place for years before 2010. Only NE and OR adopted their bans in 2009, for example.

[16]As evidence of this, 7 of 8 states implementing comprehensive IVRs by the end of 2015 did so with a comprehensive smoking ban already in place. The remaining state North Dakota adopted both at the same time in 2012.

[17]Tenth Revision 130 Selected Causes of Infant Death codes are as follows: congenital deformations or abnormalities (118-133), gestational length/birth weight (86-90), respiratory diseases/distress (53-62; 93-104), sudden infant death syndrome (135), infections (1-22), delivery complications (75-85; 92), accidents (138-158), and other (all remaining codes). See `https://wonder.cdc.gov/wonder/sci_data/natal/linked/type_txt/cohort99/130Cause99.pdf` for more information.

[18]We additionally run a sensitivity analysis only controlling for conception-year-month FE.

[19]We additionally control for state-specific time trends or county-specific time trends in sensitivity analyses.

[20]Only Minnesota had an ENDS tax for any meaningful period of time in our study, and we al-

ready excluded Minnesota 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 Colombia 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. Therefore, by keeping the sample consistent with Cooper and Pesko (2017), we avoid the wave of e-cigarette taxes that resulted in 25 states having an e-cigarette tax by Sept. 2020 (Public Health Law Center, 2020).

[21]Payment 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.

[22]We include only mothers who conceived before IVR adoption (actual or placebo). For counties not adopting comprehensive IVRs by the end of 2015, we assigned a placebo implementation date between 1/1/2010 and 12/31/2014.

[23]We use county-wide baseline prenatal smoking rates for these stratified models, not subgroup-specific baseline prenatal smoking rates.

[24]In the United States, state laws require the reporting of fetal deaths, and federal law mandates national collection and publication of fetal death data. Most states report fetal deaths of 20 weeks of gestation or more and/or birth weight of 350 grams . However, a few states report fetal deaths for all periods of gestation.

[25]We did not stratify by smoking, education, or insurance because these variables were not available in fetal death data.

[26]We estimate that IVRs decrease live births by 0.60 (se=2.40, p=0.806, 0.41% of the mean, N=46,321 year-by-month-by-county cells), controlling for female population 15-44 years of age, cigarette taxes and e-cigarette minimum legal purchase age laws at point of conception, county fixed effects, and time fixed effects.

[27]82% of tested samples have tested positive for tetrahydrocannabinol (THC) (Centers for Dis-

ease Control and Prevention, 2020b) and one study has linked EVALI to unregulated THC product use (Wing et al., 2020).

Table 1: Descriptive Statistics

	(1) Never Adopting		(2) Adopting		(3) Adopting, Before		(4) Adopting, After	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Demographics:								
Age	28.744	5.799	29.836	5.643	29.950	5.757	29.744	5.547
Married	0.612	–	0.756	–	0.762	–	0.752	–
Number of Current Birth	2.498	1.571	2.501	1.604	2.415	1.591	2.572	1.612
Race: White (Non-Hispanic)	0.477	–	0.609	–	0.594	–	0.621	–
Race: Black (Non-Hispanic)	0.110	–	0.055	–	0.055	–	0.055	–
Race: Hispanic	0.295	–	0.186	–	0.187	–	0.186	–
Race: Other Race (Non-Hispanic)	0.117	–	0.150	–	0.164	–	0.138	–
Edu: Less than High School	0.155	–	0.108	–	0.110	–	0.107	–
Edu: High School	0.239	–	0.168	–	0.157	–	0.178	–
Edu: Some College	0.286	–	0.279	–	0.266	–	0.290	–
Edu: Bachelor's Degree or Higher	0.302	–	0.428	–	0.452	–	0.409	–
Payment: Medicaid	0.437	–	0.288	–	0.299	–	0.279	–
Payment: Private Insurance	0.481	–	0.623	–	0.615	–	0.630	–
Payment: Self Pay	0.028	–	0.034	–	0.035	–	0.033	–
Payment: Indian Health	0.001	–	0.000	–	0.000	–	0.000	–
Payment: Champus/Tricare	0.013	–	0.009	–	0.009	–	0.009	–
Payment: Other Government	0.020	–	0.015	–	0.013	–	0.017	–
Payment: Unknown	0.010	–	0.005	–	0.005	–	0.005	–
Observations	6,403,910		576,503		258,939		317,564	

Notes: Table continued on next page. Column 1 includes only mothers in counties that never adopted a comprehensive IVR. Column 2 includes only mothers in counties that adopted a comprehensive IVR. Column 3 includes only mothers in counties that adopted a comprehensive IVR and with the estimated conception date before the IVR was implemented. Column 4 includes only mothers in counties that adopted a comprehensive IVR and had the infant estimated conception date after the IVR was implemented.

Table 1: Descriptive Statistics (Continued)

	(1) Never Adopting		(2) Adopting		(3) Adopting, Before		(4) Adopting, After	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Tobacco Policy/Usage:								
IVR at Conception	0.000	–	0.551	–	0.000	–	1.000	–
Indoor Smoking Ban	1.000	–	1.000	–	1.000	–	1.000	–
Cig. Tax	2.802	1.227	3.722	1.272	3.548	1.406	3.863	1.131
Prenatal Smoking Rate	0.068	–	0.032	–	0.028	–	0.035	–
Infant Mortality:								
Infant Mortality Rate	3.986	–	3.391	–	3.174	–	3.568	–
Timing: 0-6 Days	2.442	–	2.028	–	1.892	–	2.138	–
Timing: 7-27 Days	0.566	–	0.494	–	0.475	–	0.510	–
Timing: 28-100 Days	0.634	–	0.533	–	0.525	–	0.538	–
Timing: $>$ 100 Days	0.343	–	0.337	–	0.282	–	0.381	–
Cause: Congenital Deformation or Abnormality	0.954	–	0.878	–	0.838	–	0.910	–
Cause: Premature Birth and Malnutrition	0.727	–	0.456	–	0.467	–	0.447	–
Cause: Respiratory Disease/Distress	0.335	–	0.278	–	0.251	–	0.299	–
Cause: SIDS	0.240	–	0.241	–	0.232	–	0.249	–
Cause: Infections	0.074	–	0.054	–	0.035	–	0.069	–
Cause: Neoplasms	0.017	–	0.031	–	0.023	–	0.038	–
Cause: Delivery Complications	0.510	–	0.460	–	0.398	–	0.510	–
Cause: Accidents	0.181	–	0.116	–	0.120	–	0.113	–
Cause: Other	0.946	–	0.878	–	0.811	–	0.932	–
Observations	6,403,910		576,503		258,939		317,564	

Notes: Table continued from previous page. Column 1 includes only mothers in counties that never adopted a comprehensive IVR. Column 2 includes only mothers in counties that adopted a comprehensive IVR. Column 3 includes only mothers in counties that adopted a comprehensive IVR and with the infant estimated conception date before the IVR was implemented. Column 4 includes only mothers in counties that adopted a comprehensive IVR and had the infant estimated conception date after the IVR was implemented. Mortality numbers are scaled to represent deaths per 1,000 live births.

Table 2: Diff-in-Diff Results

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
IVR at Conception	0.387**	0.576**	0.192^{+}	0.359^{+}	0.405*	0.394^{+}	0.387**
	(0.110)	(0.177)	(0.101)	(0.185)	(0.159)	(0.203)	(0.124)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,801,021	3,700,658	3,100,363	2,656,660	4,144,361	2,886,436	3,361,863
Lower Bound	0.153	0.199	-0.024	-0.036	0.066	-0.037	0.123
Upper Bound	0.622	0.953	0.408	0.753	0.744	0.826	0.651
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
Percent Change	0.129	0.164	0.075	0.082	0.161	0.096	0.163

Notes: Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Diff-in-Diff Results, Timing of Death

	(1) 0-6 Days	(2) 7-27 Days	(3) 28-100 Days	(4) $>$ 100 Days
IVR at Conception	0.208^{*}	0.066	0.017	0.097^{+}
	(0.090)	(0.045)	(0.037)	(0.047)
County FE	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes
Observations	6,801,021	6,801,021	6,801,021	6,801,021
Lower Bound	0.016	-0.031	-0.062	-0.004
Upper Bound	0.399	0.162	0.096	0.198
Dep. Var. Mean[a]	1.765	0.461	0.504	0.280
Percent Change	0.118	0.143	0.033	0.346

Notes: Each column replaces the outcome variable with an indicator for whether the infant died in the specified time period. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Diff-in-Diff Results, Cause of Death

	(1) Congenital Deformation or Abnormality	(2) Premature Birth and Malnutrition	(3) Respiratory Disease/Distress	(4) Sudden Infant Death Syndrome	(5) Infections
IVR at Conception	0.119^{+}	0.080^{+}	0.069	-0.016	0.050^{*}
	(0.067)	(0.043)	(0.061)	(0.068)	(0.018)
County FE	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes
Observations	6,801,021	6,801,021	6,801,021	6,801,021	6,801,021
Lower Bound	-0.024	-0.012	-0.062	-0.160	0.012
Upper Bound	0.262	0.172	0.200	0.128	0.088
Dep. Var. Mean[a]	0.784	0.437	0.240	0.228	0.035
Percent Change	0.152	0.183	0.288	-0.070	1.413

Notes: Table continued on next page. Each column replaces the outcome variable with an indicator for whether the infant died of a certain cause. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Diff-in-Diff Results, Cause of Death (Continued)

	(6) Neoplasms	(7) Delivery Complications	(8) Accidents	(9) Other Causes
IVR at Conception	0.041***	0.021	-0.049+	0.071+
	(0.007)	(0.030)	(0.025)	(0.039)
County FE	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes
Observations	6,801,021	6,801,021	6,801,021	6,801,021
Lower Bound	0.027	-0.043	-0.103	-0.012
Upper Bound	0.056	0.085	0.005	0.155
Dep. Var. Mean[a]	0.024	0.366	0.122	0.772
Percent Change	1.756	0.058	-0.402	0.092

Notes: Table continued from previous page. Each column replaces the outcome variable with an indicator for whether the infant died of a certain cause. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: 2010 County-Level Pre-Pregnancy Smoking Rate and IVR Interaction

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
IVR at Conception	0.049	0.696**	-0.548	0.402	-0.013	-0.140	0.310*
	(0.137)	(0.223)	(0.397)	(0.649)	(0.120)	(0.221)	(0.106)
IVR at Conception	0.069**	-0.023	0.166*	-0.008	0.090***	0.107***	0.016
$\times$ 2010 County Smoking Rate	(0.023)	(0.019)	(0.063)	(0.090)	(0.010)	(0.022)	(0.010)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,801,021	3,700,658	3,100,363	2,656,660	4,144,361	2,886,436	3,361,863
Lower Bound	0.020	-0.063	0.031	-0.200	0.067	0.061	-0.005
Upper Bound	0.118	0.018	0.300	0.184	0.112	0.154	0.038
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
P-value for Wald test	0.000	0.019	0.000	0.023	0.000	0.000	0.015

Notes: "2010 County Smoking Rate" refers to the mean 2010 county-level pre-pregnancy smoking rate. The county smoking rate values may range from 0 to 100 (not from 0 to 1). The county smoking rate is not included as a separate term in the regression because it would be perfectly collinear with the county fixed effects. Coefficients are scaled to represent deaths per 1,000 live births. The Wald test includes the indicator for IVR at Conception and the interaction of IVR at Conception and the 2010 County Smoking Rate. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1: Mean Infant Mortality by IVR Adoption.
Notes: The figure displays yearly mean infant mortality per 1,000 live births separately in counties that adopted comprehensive IVR policies by the end of the sample period and in counties that did not adopt comprehensive IVR policies.

Figure 2: Mean Infant Mortality by IVR Adoption Timing.
Notes: The figure displays yearly mean infant mortality per 1,000 live births separately in counties that adopted comprehensive IVR policies before January 1, 2013, counties that adopted comprehensive IVR policies after January 1, 2013, and counties that did not adopt comprehensive IVR policies during the sample period. The red vertical line indicates the 2013 cutoff that separates the two groups of counties that adopted IVR policies.

Figure 3: Event Study.
Notes: Figure continued on next page. The figure plots coefficients from the corresponding event study regressions. See corresponding table for numerical values. Ninety-five percent confidence intervals are displayed as blue vertical bars. A red horizontal line is displayed at zero. Two red vertical lines separate observations with conception before the policy, conception after the policy but birth before the policy, and birth after the policy.

Figure 4: Event Study (Continued).
Notes: Figure continued from previous page. The figure plots coefficients from the corresponding event study regressions. See corresponding table for numerical values. Ninety-five percent confidence intervals are displayed as blue vertical bars. A red horizontal line is displayed at zero. Two red vertical lines separate observations with conception before the policy, conception after the policy but birth before the policy, and birth after the policy.

Figure 1

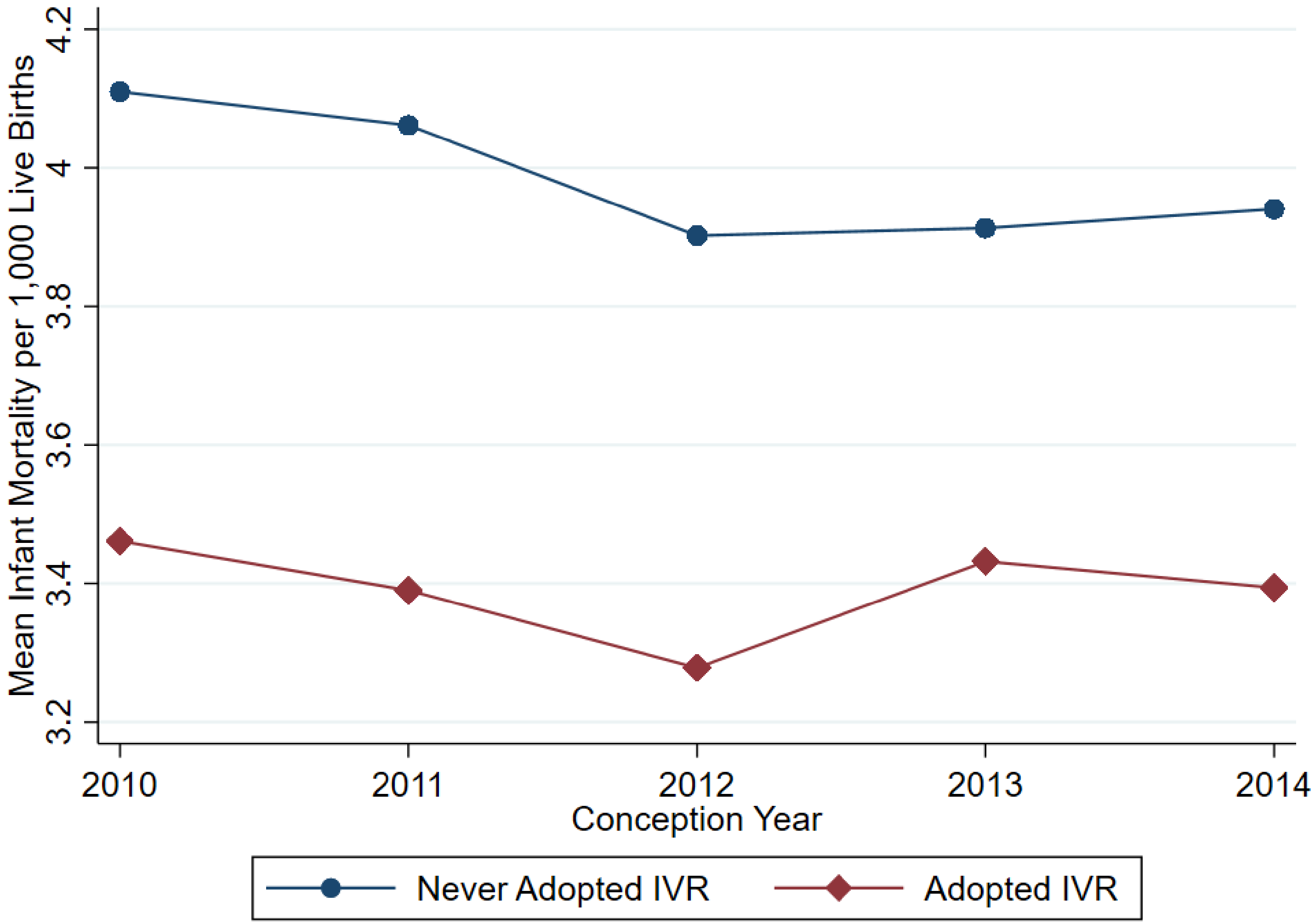

Mean Infant Mortality per 1,000 Live Births
3.2
3.4
3.6
3.8
4
4.2
2010
2011
2012
2013
2014
Conception Year
Never Adopted IVR
Adopted IVR

Figure 2

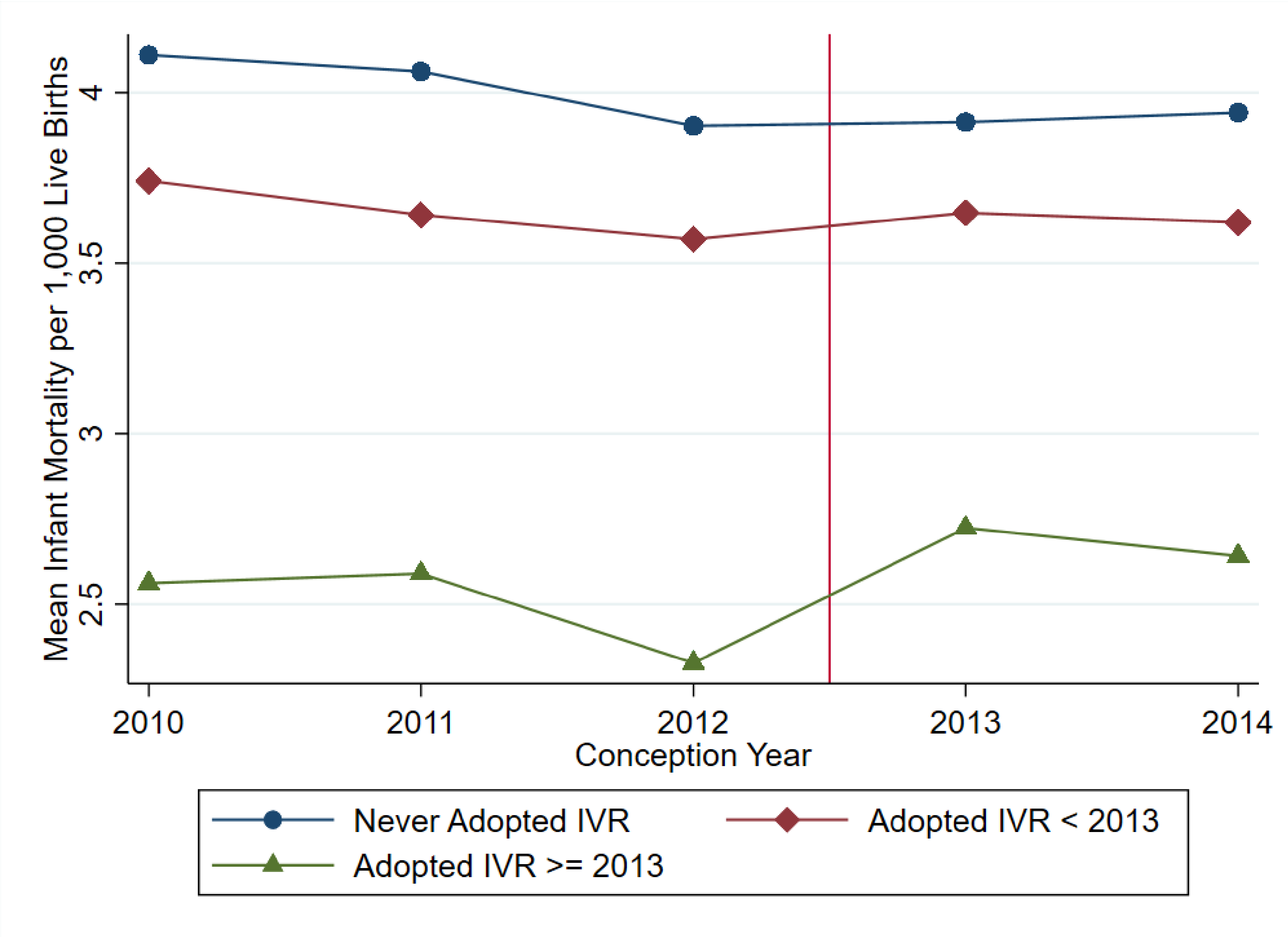

Mean Infant Mortality per 1,000 Live Births
4
3.5
3
2.5
2010
2011
2012
2013
2014
Conception Year
Never Adopted IVR
Adopted IVR < 2013
Adopted IVR >= 2013

Figure 3

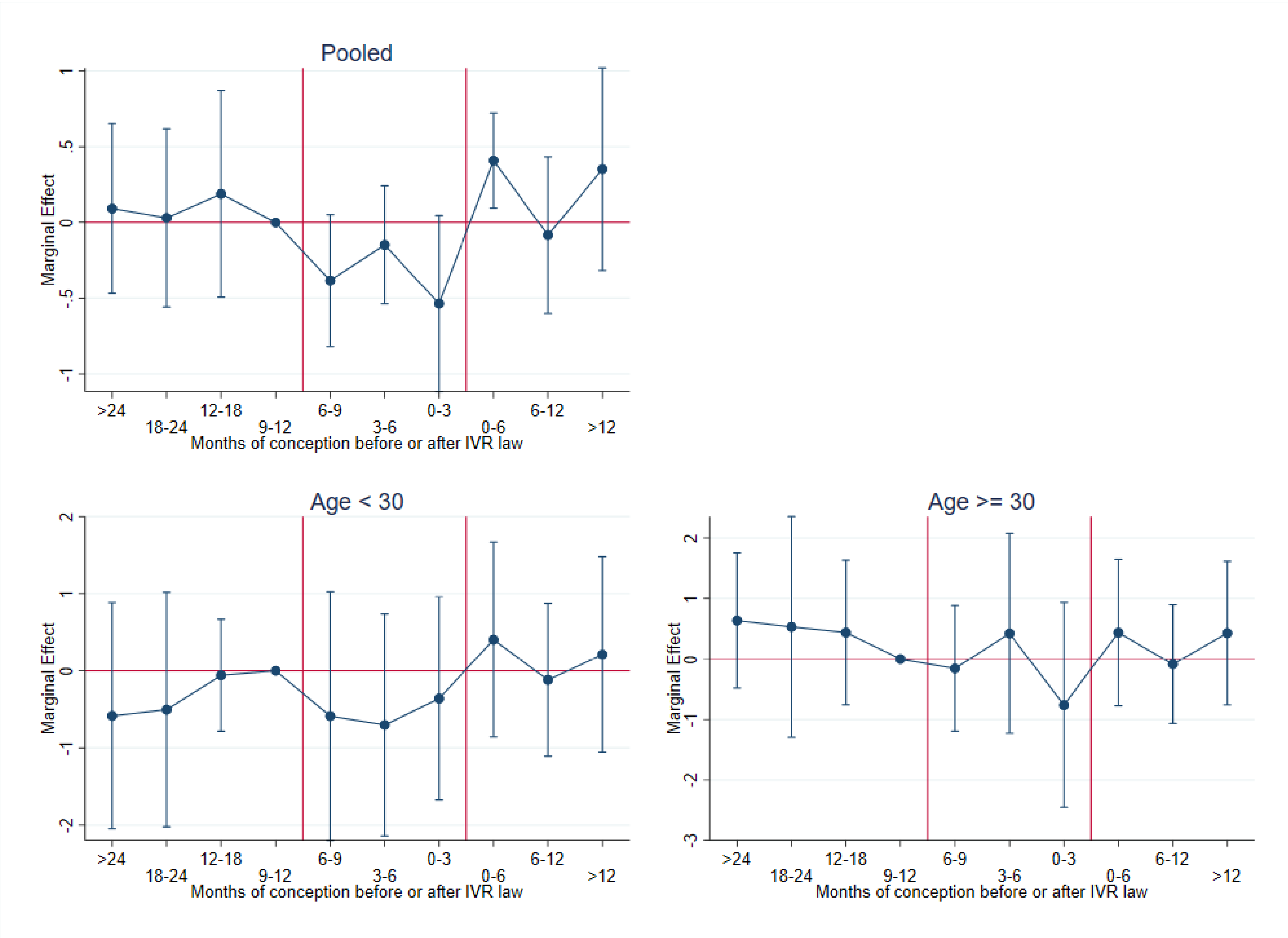
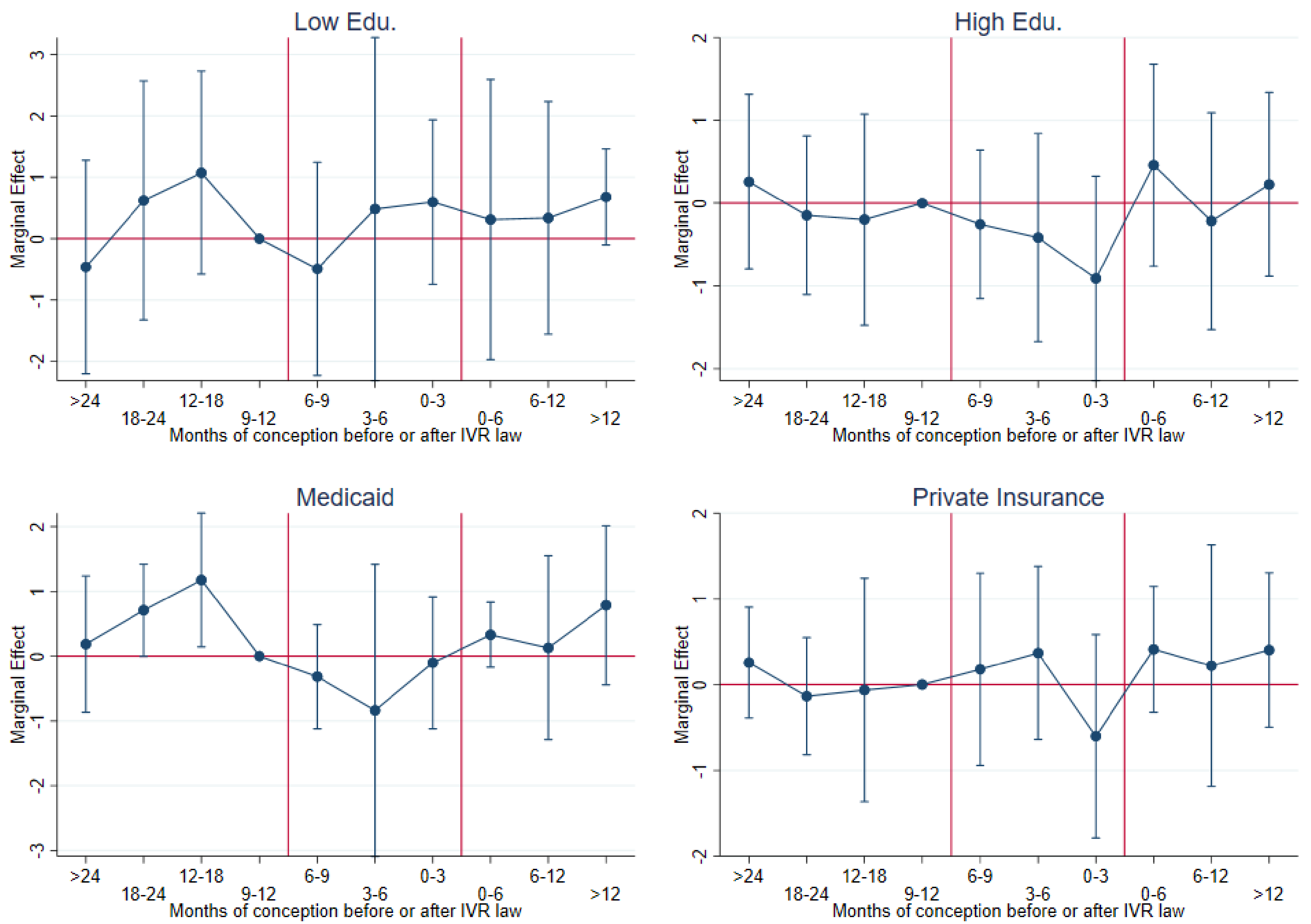
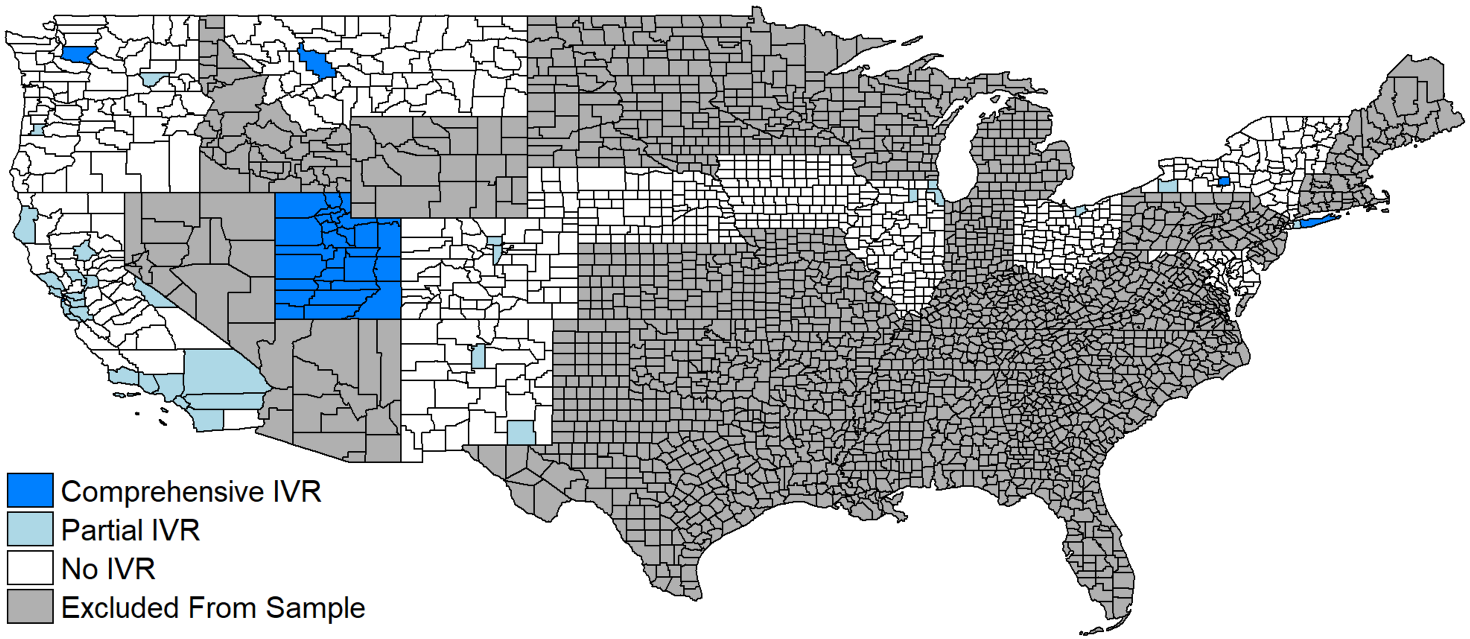

Pooled
Age < 30
Age >= 30
Marginal Effect
Months of conception before or after IVR law
>24
18-24
12-18
9-12
6-9
3-6
0-3
0-6
6-12
>12

Figure 4


Low Edu.
High Edu.
Medicaid
Private Insurance
Marginal Effect
>24
18-24
12-18
9-12
6-9
3-6
0-3
0-6
6-12
>12
Months of conception before or after IVR law

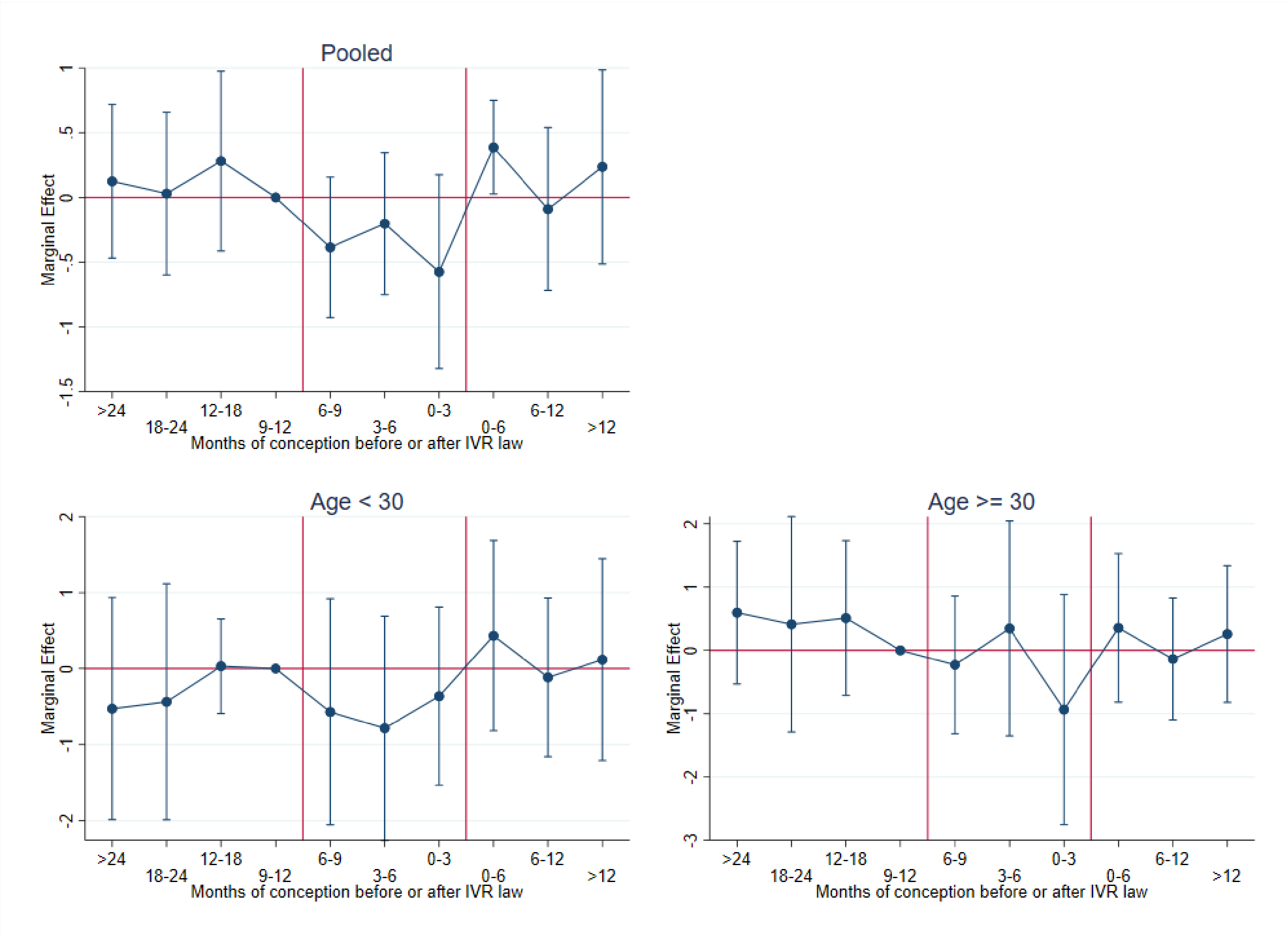
Appendix A

Figure A1: Map of IVR by County



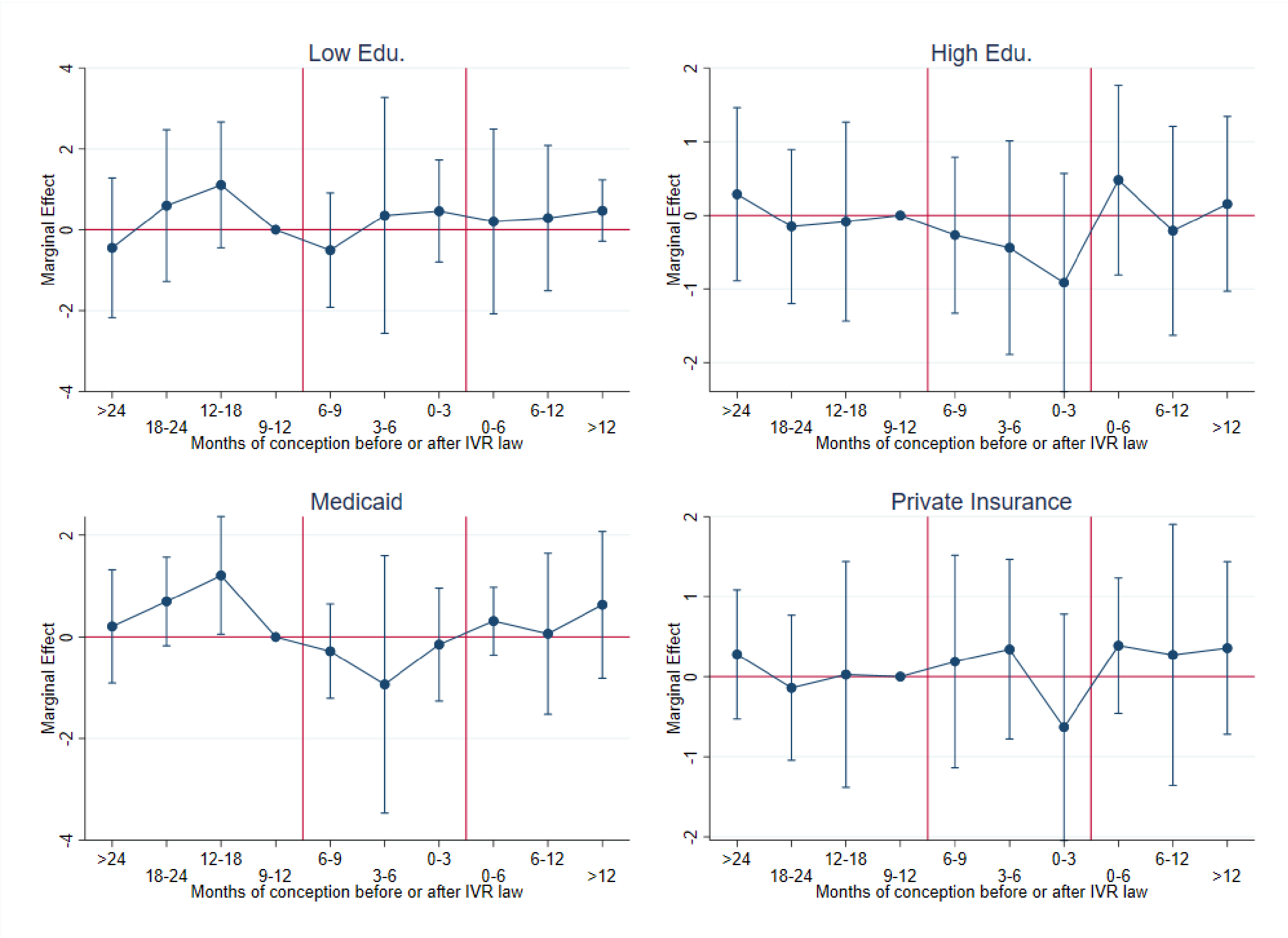
Notes: The map shows different levels of IVR policies by county. Grey counties are excluded from the sample. Bright blue counties have comprehensive IVR policies by the end of the sample period, while light blue counties have partial IVR policies by the end of the sample period.

Figure A2: Event Study, Excluding Partially Treated Counties



Notes: Figure continued on next page. The figure plots coefficients from the corresponding event study regressions. Coefficients are scaled to represent deaths per 1,000 live births. See corresponding table for numerical values. Ninety-five percent confidence intervals are displayed as blue vertical bars. A red horizontal line is displayed at zero. Two red vertical lines separate observations with conception before the policy, conception after the policy but birth before the policy, and birth after the policy.

Figure A3: Event Study, Excluding Partially Treated Counties (Continued)



Notes: Figure continued from previous page. The figure plots coefficients from the corresponding event study regression. Coefficients are scaled to represent deaths per 1,000 live births. See corresponding table for numerical values. Ninety-five percent confidence intervals are displayed as blue vertical bars. A red horizontal line is displayed at zero. Two red vertical lines separate observations with conception before the policy, conception after the policy but birth before the policy, and birth after the policy.

Table A1: Diff-in-Diff Outcomes from JHE Paper

	(1) Smoking Participation	(2) Avg. Cigs per Month	(3) Premature (<37 Weeks)	(4) Very Premature (<32 Weeks)	(5) Small for Gest. Age	(6) Extra Small for Gest. Age	(7) Low Weight (<2500 Grams)	(8) Apgar 5 Score
Indoor Vaping Restriction	0.0093^{*}	3.1682^{**}	0.0002	-0.0003	0.0009	0.0006	0.0008	-0.0083
	(0.0035)	(0.9401)	(0.0014)	(0.0006)	(0.0066)	(0.0028)	(0.0004)	(0.0081)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Conception Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year-Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6,837,486	6,837,486	6,867,005	6,867,005	6,864,621	6,864,621	6,864,622	6,843,308
Dep. Var. Mean	0.0660	15.9997	0.0864	0.0131	0.2372	0.0895	0.0565	8.8449

Notes: Includes partially treated counties. Only mothers age 18 and older are 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.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A2: Tabulation of Infant Mortality Timing and Cause

	Mortality Timing				
	0-6 Days	7-27 Days	28-100 Days	> 100 Days	Total
Mortality Cause:					
Congenital Deformation or Abnormality	60.3%	18.2%	14.6%	6.9%	100.0%
Premature Birth and Malnutrition	95.1%	2.8%	1.6%	0.4%	100.0%
Respiratory Disease/Distress	61.5%	17.2%	11.9%	9.5%	100.0%
Sudden Infant Death Syndrome	2.4%	12.2%	54.4%	31.0%	100.0%
Infections	2.8%	9.1%	73.5%	14.6%	100.0%
Neoplasms	32.0%	21.1%	22.7%	24.2%	100.0%
Delivery Complications	96.2%	2.6%	1.0%	0.2%	100.0%
Accidents	5.1%	11.0%	47.8%	36.1%	100.0%
Other Causes	48.3%	25.4%	16.9%	9.5%	100.0%
All Causes (Pooled)	61.2%	14.2%	15.9%	8.7%	100.0%

Notes: The table shows the timing of infant deaths in the sample for each cause of death. Each row breaks down the prevalence of mortality timing within one cause, with the values in each row summing to 100%.

Table A3: Parallel Trends Test

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pooled	Age	Age	Low	High	Medicaid	Private
		< 30	≥ 30	Edu.	Edu.		Ins.
Linear Time	-0.006	0.017	-0.017*	0.045	-0.021**	0.002	-0.006
Trend $\times$ Ever Adopt	(0.011)	(0.033)	(0.007)	(0.036)	(0.005)	(0.013)	(0.015)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,054,512	1,703,320	1,351,192	1,201,586	1,852,926	1,307,793	1,506,525
Dep. Var. Mean[a]	3.330	3.883	2.876	4.765	2.793	4.566	2.594

Notes: 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. Only observations with conception dates before the actual/placebo policy adoption in their county are included to evaluate pre-policy trends. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A4: Event Study

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
Conception $>$ 24 months before IVR	0.092	-0.583	0.637	-0.462	0.258	0.185	0.257
	(0.263)	(0.687)	(0.524)	(0.815)	(0.495)	(0.494)	(0.303)
Conception 18-24 months before IVR	0.030	-0.502	0.532	0.622	-0.148	0.707^{+}	-0.135
	(0.276)	(0.713)	(0.858)	(0.912)	(0.449)	(0.333)	(0.321)
Conception 12-18 months before IVR	0.189	-0.059	0.440	1.073	-0.198	1.176^{*}	-0.063
	(0.320)	(0.341)	(0.561)	(0.775)	(0.598)	(0.484)	(0.611)
Conception 9-12 months before IVR	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Conception 6-9 months before IVR	-0.383^{+}	-0.586	-0.156	-0.492	-0.256	-0.319	0.178
	(0.204)	(0.756)	(0.488)	(0.814)	(0.420)	(0.377)	(0.526)
Conception 3-6 months before IVR	-0.148	-0.702	0.424	0.481	-0.416	-0.838	0.369
	(0.183)	(0.675)	(0.777)	(1.311)	(0.590)	(1.057)	(0.474)
Conception 0-3 months before IVR	-0.535^{+}	-0.359	-0.761	0.595	-0.910	-0.103	-0.602
	(0.273)	(0.618)	(0.795)	(0.629)	(0.579)	(0.478)	(0.556)

Notes: Table continued on next page. Omitted category is "Conception 9-12 months before IVR." Wald test of policy leads includes "Conception $>$ 24 months before IVR," "Conception 18-24 months before IVR," and "Conception 12-18 months before IVR." Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, 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 A4: Event Study (Continued)

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
Conception 0-6 months after IVR	0.408*	0.403	0.438	0.309	0.459	0.328	0.412
	(0.147)	(0.592)	(0.568)	(1.070)	(0.572)	(0.236)	(0.344)
Conception 6-12 months after IVR	-0.083	-0.118	-0.085	0.336	-0.217	0.127	0.221
	(0.243)	(0.464)	(0.461)	(0.890)	(0.614)	(0.667)	(0.660)
Conception > 12 months after IVR	0.352	0.211	0.429	0.678+	0.226	0.784	0.404
	(0.313)	(0.594)	(0.557)	(0.366)	(0.520)	(0.577)	(0.422)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,801,021	3,700,658	3,100,363	2,656,660	4,144,361	2,886,436	3,361,863
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
P-value for Wald test of policy leads	0.883	0.107	0.171	0.290	0.002	0.000	0.253

Notes: Table continued from previous page. Omitted category is "Conception 9-12 months before IVR." Wald test of policy leads includes "Conception $>$ 24 months before IVR," "Conception 18-24 months before IVR," and "Conception 12-18 months before IVR." Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A5: Diff-in-Diff Results, Fetal Deaths

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30
IVR at Conception	0.223	0.539	-0.232
	(0.952)	(0.738)	(1.248)
County FE	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes
Observations	7,096,122	3,841,599	3,254,523
Lower Bound	-1.805	-1.034	-2.893
Upper Bound	2.251	2.113	2.428
Dep. Var. Mean[a]	38.652	27.584	47.991
Percent Change	0.006	0.020	-0.005

Notes: Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, race, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.
[a] treatment counties, pre-period.
$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A6: Diff-in-Diff Results, Excluding Partially Treated Counties

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
IVR at Conception	0.317**	0.507*	0.140	0.246	0.362*	0.301	0.364*
	(0.102)	(0.175)	(0.147)	(0.180)	(0.163)	(0.193)	(0.130)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,535,340	2,571,846	1,963,494	1,737,383	2,797,957	1,909,090	2,236,921
Lower Bound	0.099	0.135	-0.173	-0.137	0.016	-0.110	0.086
Upper Bound	0.534	0.879	0.453	0.629	0.709	0.712	0.642
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
Percent Change	0.105	0.144	0.055	0.057	0.144	0.074	0.153

Notes: Excludes counties that had only part of the county population covered by IVRs at any time in the sample. Only counties with 0% or 100% population covered by all three restrictions (bar, restaurant, and workplace) remain. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.
[a] treatment counties, pre-period.
$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A7: Parallel Trends Test, Excluding Partially Treated Counties

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
Linear Time	-0.010	0.012	-0.022*	0.036	-0.022***	0.003	-0.014
Trend $\times$ Ever Adopt	(0.008)	(0.033)	(0.009)	(0.034)	(0.005)	(0.016)	(0.010)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,180,635	1,254,495	926,140	848,686	1,331,949	929,956	1,061,031
Dep. Var. Mean[a]	3.330	3.883	2.876	4.765	2.793	4.566	2.594

Notes: 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. Only observations with conception dates before the actual/placebo policy adoption in their county are included to evaluate pre-policy trends. Excludes counties that had only part of the county population covered by IVRs at any time in the sample. Only counties with 0% or 100% population covered by all three restrictions (bar, restaurant, and workplace) remain. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A8: Event Study, Excluding Partially Treated Counties

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
Conception > 24 months before IVR	0.124	-0.525	0.593	-0.447	0.286	0.206	0.279
	(0.278)	(0.685)	(0.528)	(0.809)	(0.550)	(0.523)	(0.378)
Conception 18-24 months before IVR	0.029	-0.435	0.410	0.599	-0.152	0.697	-0.140
	(0.294)	(0.728)	(0.799)	(0.878)	(0.491)	(0.408)	(0.425)
Conception 12-18 months before IVR	0.281	0.031	0.508	1.108	-0.085	1.211*	0.026
	(0.326)	(0.291)	(0.573)	(0.729)	(0.633)	(0.543)	(0.662)
Conception 9-12 months before IVR	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Conception 6-9 months before IVR	-0.386	-0.568	-0.231	-0.504	-0.268	-0.281	0.188
	(0.254)	(0.696)	(0.511)	(0.664)	(0.497)	(0.435)	(0.622)
Conception 3-6 months before IVR	-0.203	-0.784	0.345	0.354	-0.439	-0.934	0.342
	(0.258)	(0.690)	(0.797)	(1.365)	(0.681)	(1.188)	(0.526)
Conception 0-3 months before IVR	-0.574	-0.363	-0.935	0.462	-0.912	-0.149	-0.631
	(0.351)	(0.549)	(0.854)	(0.590)	(0.694)	(0.521)	(0.662)

Notes: Table continued on next page. Omitted category is “Conception 9-12 months before IVR.” Wald test of policy leads includes “Conception $>$ 24 months before IVR,” “Conception 18-24 months before IVR,” and “Conception 12-18 months before IVR.” Excludes counties that had only part of the county population covered by IVRs at any time in the sample. Only counties with 0% or 100% population covered by all three restrictions (bar, restaurant, and workplace) remain. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother’s age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, 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 A8: Event Study, Excluding Partially Treated Counties (Continued)

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
Conception 0-6 months after IVR	0.387*	0.433	0.353	0.207	0.479	0.312	0.388
	(0.169)	(0.586)	(0.550)	(1.071)	(0.603)	(0.313)	(0.396)
Conception 6-12 months after IVR	-0.090	-0.115	-0.138	0.289	-0.209	0.063	0.272
	(0.295)	(0.489)	(0.451)	(0.843)	(0.664)	(0.742)	(0.765)
Conception $>$ 12 months after IVR	0.235	0.118	0.257	0.473	0.154	0.631	0.357
	(0.352)	(0.622)	(0.506)	(0.355)	(0.556)	(0.679)	(0.506)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,535,340	2,571,846	1,963,494	1,737,383	2,797,957	1,909,090	2,236,921
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
P-value for Wald test of policy leads	0.769	0.127	0.364	0.291	0.017	0.000	0.335

Notes: Table continued from previous page. Omitted category is "Conception 9-12 months before IVR." Wald test of policy leads includes "Conception $>$ 24 months before IVR," "Conception 18-24 months before IVR," and "Conception 12-18 months before IVR." Excludes counties that had only part of the county population covered by IVRs at any time in the sample. Only counties with 0% or 100% population covered by all three restrictions (bar, restaurant, and workplace) remain. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A9: Diff-in-Diff Results, Effect of Statewide IVR in Utah

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
Panel A: Keep Utah, Drop Other Treated Counties							
IVR at Conception	0.433***	0.569*	0.254**	0.235*	0.496**	0.553***	0.426*
	(0.103)	(0.194)	(0.078)	(0.096)	(0.130)	(0.121)	(0.150)
Observations	6,590,608	3,626,797	2,963,811	2,598,083	3,992,525	2,821,373	3,225,660
Lower Bound	0.212	0.156	0.089	0.030	0.219	0.296	0.107
Upper Bound	0.653	0.982	0.420	0.440	0.773	0.811	0.746
Dep. Var. Mean[a]	3.571	3.614	3.510	4.489	3.181	4.341	3.102
Percent Change	0.121	0.157	0.072	0.052	0.156	0.127	0.137
Panel B: Drop Utah, Keep Other Treated Counties							
IVR at Conception	0.176	0.152	0.216	0.603	0.065	0.025	0.133
	(0.114)	(0.293)	(0.163)	(0.494)	(0.093)	(0.279)	(0.094)
Observations	6,563,591	3,554,917	3,008,674	2,587,224	3,976,367	2,825,872	3,218,643
Lower Bound	-0.069	-0.476	-0.133	-0.457	-0.134	-0.573	-0.069
Upper Bound	0.420	0.781	0.566	1.662	0.264	0.623	0.335
Dep. Var. Mean[a]	2.424	3.340	1.980	4.050	1.893	3.829	1.713
Percent Change	0.072	0.046	0.109	0.149	0.034	0.007	0.078

Notes: Panel A retains Utah in the sample while dropping all other counties treated by comprehensive IVR policies. Panel B drops Utah from the sample and retains all other treated counties. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A10: Diff-in-Diff Results, Including Unrevised Birth Records

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
IVR at Conception	0.377***	0.569**	0.180	0.368+	0.376*	0.375+	0.359**
	(0.091)	(0.154)	(0.106)	(0.193)	(0.133)	(0.190)	(0.103)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,386,569	3,979,912	3,406,657	2,816,819	4,569,750	3,036,675	3,726,372
Lower Bound	0.185	0.243	-0.044	-0.040	0.094	-0.026	0.142
Upper Bound	0.569	0.895	0.404	0.776	0.657	0.776	0.575
Dep. Var. Mean[a]	3.030	3.544	2.585	4.402	2.514	4.122	2.391
Percent Change	0.125	0.161	0.070	0.084	0.149	0.091	0.150

Notes: States not using revised birth records, but still satisfying the criteria of comprehensive indoor smoking bans and no significant missing smoking data were added back into the sample. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A11: Diff-in-Diff Results, Dropping December Births

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pooled	Age < 30	Age ≥ 30	Low Edu.	High Edu.	Medicaid	Private Ins.
IVR at Conception	0.421***	0.589**	0.241**	0.382	0.437*	0.445*	0.431**
	(0.096)	(0.162)	(0.062)	(0.273)	(0.159)	(0.157)	(0.145)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,237,480	3,389,612	2,847,868	2,428,764	3,808,716	2,639,776	3,091,920
Lower Bound	0.216	0.245	0.108	-0.199	0.097	0.110	0.123
Upper Bound	0.626	0.933	0.373	0.964	0.777	0.780	0.740
Dep. Var. Mean[a]	3.106	3.678	2.616	4.488	2.596	4.178	2.453
Percent Change	0.136	0.160	0.092	0.085	0.168	0.106	0.176

Notes: Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A12: Diff-in-Diff Results, Dropping Women Partially Treated During Pregnancy

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
IVR at Conception	0.258^{+}	0.619^{***}	-0.125	0.513	0.187	0.061	0.424^{*}
	(0.140)	(0.073)	(0.143)	(0.357)	(0.260)	(0.189)	(0.168)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,726,949	3,664,864	3,062,085	2,636,841	4,090,108	2,865,485	3,315,692
Lower Bound	-0.041	0.464	-0.429	-0.248	-0.367	-0.342	0.065
Upper Bound	0.557	0.774	0.180	1.273	0.740	0.465	0.782
Dep. Var. Mean[a]	3.075	3.622	2.623	4.335	2.605	4.322	2.322
Percent Change	0.084	0.171	-0.047	0.118	0.072	0.014	0.182

Notes: Drops mothers who were first exposed to IVR during pregnancy. Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A13: Diff-in-Diff Results with State-Specific Linear Time Trends

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pooled	Age	Age	Low	High	Medicaid	Private
		< 30	≥ 30	Edu.	Edu.		Ins.
IVR at Conception	0.476^{**}	0.496	0.529^{**}	0.243	0.596^{**}	0.217	0.533^{***}
	(0.131)	(0.360)	(0.154)	(0.448)	(0.198)	(0.160)	(0.035)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Yr-Mo Linear Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,801,021	3,700,658	3,100,363	2,656,660	4,144,361	2,886,436	3,361,863
Lower Bound	0.198	-0.271	0.200	-0.712	0.174	-0.124	0.459
Upper Bound	0.755	1.264	0.857	1.198	1.019	0.558	0.606
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
Percent Change	0.158	0.141	0.206	0.056	0.237	0.053	0.224

Notes: Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A14: Diff-in-Diff Results with County-Specific Linear Time Trends

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
IVR at Conception	0.573***	0.612**	0.592*	0.239	0.695**	0.442	0.497***
	(0.116)	(0.181)	(0.258)	(0.507)	(0.218)	(0.311)	(0.077)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Yr-Mo Linear Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,801,021	3,700,658	3,100,363	2,656,660	4,144,361	2,886,436	3,361,863
Lower Bound	0.326	0.227	0.041	-0.842	0.230	-0.221	0.333
Upper Bound	0.820	0.998	1.142	1.319	1.160	1.105	0.662
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
Percent Change	0.190	0.174	0.230	0.055	0.277	0.108	0.209

Notes: Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A15: Diff-in-Diff Results without Birth Year-Month Fixed Effects

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
IVR at Conception	0.313**	0.429**	0.208	0.401	0.302***	0.349*	0.293***
	(0.088)	(0.141)	(0.233)	(0.280)	(0.035)	(0.141)	(0.037)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	No	No	No	No	No	No	No
Observations	6,801,021	3,700,658	3,100,363	2,656,660	4,144,361	2,886,436	3,361,863
Lower Bound	0.125	0.128	-0.288	-0.197	0.227	0.048	0.214
Upper Bound	0.501	0.730	0.705	0.999	0.376	0.650	0.373
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
Percent Change	0.104	0.122	0.081	0.092	0.120	0.085	0.123

Notes: Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at state level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A16: Diff-in-Diff Results, County Clustered SE

	(1) Pooled	(2) Age < 30	(3) Age ≥ 30	(4) Low Edu.	(5) High Edu.	(6) Medicaid	(7) Private Ins.
IVR at Conception	0.387**	0.576**	0.192	0.359^{+}	0.405*	0.394^{+}	0.387^{+}
	(0.123)	(0.189)	(0.198)	(0.194)	(0.161)	(0.234)	(0.201)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Concep. Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Yr-Mo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,801,021	3,700,658	3,100,363	2,656,660	4,144,361	2,886,436	3,361,863
Lower Bound	0.146	0.205	-0.197	-0.022	0.088	-0.064	-0.008
Upper Bound	0.628	0.947	0.581	0.739	0.721	0.853	0.782
Dep. Var. Mean[a]	3.009	3.522	2.569	4.350	2.511	4.089	2.378
Percent Change	0.129	0.164	0.075	0.082	0.161	0.096	0.163

Notes: Coefficients are scaled to represent deaths per 1,000 live births. Only mothers age 18 and older are included. Controls for mother's age, marital status, race, education, payment source, number of current birth, minimum legal purchase age laws, and cigarette taxes in state at time of conception. Standard errors in parentheses, clustered at county level.

[a] treatment counties, pre-period.

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$