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The Effect of E-Cigarette Minimum Legal Sale Age Laws on Traditional Cigarette Use and Birth Outcomes among Pregnant Teenagers

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ABSTRACT

We use United States birth record data to estimate the effect of e-cigarette minimum legal sale age laws on cigarette use and birth outcomes for pregnant teenagers. While these laws may have reduced e-cigarette use, we hypothesize that these laws may have also increased cigarette use during pregnancy by making it more difficult to use e-cigarettes to reduce/quit smoking. We use cross-sectional and panel data models to find that e-cigarette minimum legal sale age laws increase underage pregnant teenagers' smoking by 2.1 percentage points. The laws may have also modestly improved select birth outcomes, perhaps by reducing overall nicotine exposure from vaping and smoking combined.

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Introduction

Smoking has long been known to be one of the leading causes of poor birth outcomes in the United States (U.S. Department of Health Human Services 2014). At the same time, pregnancy is a period when women smokers may be especially motivated to quit, with subsequent health benefits for both themselves and their children.

In this paper, we explore the effect of recent e-cigarette minimum legal sale age laws on traditional cigarette use and birth outcomes (e.g. gestation length) among pregnant teens. 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 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).

We hypothesize that minimum legal sale age (MLSA) laws increase the costs of using ENDS and hence encourage cigarette use, since ENDS and cigarettes are substitute products (Friedman 2015, Pesko, Hughes, and Faisal 2016, Pesko et al. 2015, Huang, Tauras, and Chaloupka 2014). Two published studies have explored the effect of ENDS MLSA laws on cigarette use using cross-sectional data (Friedman 2015, Pesko, Hughes, and Faisal 2016), but ours is the first to focus on pregnant women and to explore this relationship using panel data. Within-individual variation in cigarette use is provided by trimester-specific cigarette use information available in the newest ("revised") administrative birth records. We exploit this trimester-specific cigarette use information to ask how ENDS MLSA laws that were enacted

during pregnancy caused changes in cigarette use beyond the normal declines in cigarette use as pregnancy progresses (Curtin and Mathews 2016).

We also evaluate the effect of ENDS MLSA laws on birth outcomes. Among a general population, there is an emerging consensus that ENDS are substantially safer than combustible tobacco products (Viscusi 2016). The Royal College of Physicians in England state that e-cigarettes are unlikely to exceed 5% of the risk associated with combustible tobacco products (Royal College of Physicians 2016). However, this finding may not be generalizable to pregnant women because nicotine, which is in most ENDS, is a threat to the developing fetus. According to a Surgeon General's report, nicotine from smoking accounts for a large proportion of the decline in gestational length observed in infants of smokers compared to non-smokers, and for a modest share of the reduction in birth weight (other toxicants in cigarettes account for the larger share of the effects on birth weight) (U.S. Department of Health Human Services 2014). Hence, it is possible that reducing pregnant minor's access to ENDS could have a positive overall effect on birth outcomes even if some minors subsequently were more likely to smoke traditional cigarettes.

By exploring the effect of ENDS MLSA laws on birth outcomes, we have the opportunity to explore the relative risks of vaping versus smoking during pregnancy. In addition to this specific contribution, to our knowledge our study is the first to examine the effect of ENDS policies on health outcomes.

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 2015). 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). This may be due to obstetricians and gynecologists (OBGYNs) often not referring pregnant women for behavioral health interventions and often not prescribing nicotine replacement therapy (NRT) because nicotine is a developmental toxicant. Pharmacotherapy interventions for tobacco cessation for pregnant women continues to receive an incomplete grade from the United States Preventive Services Task Force due to uncertain evidence of the overall health benefits (U.S. Preventive Services Task Force 2015).

Given 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 these devices may be effective in eliminating and reducing cigarette consumption (McRobbie et al. 2014). 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 two national surveys, 2014 was the first year that more teens vaped ENDS over the past 30 days than smoked cigarettes (Arrazola et al. 2015, Miech et al. 2014). In response, states have enacted laws to reduce access to ENDS devices. The most commonly used regulatory strategy to date is enacting ENDS MLSA laws, which have been enacted by 40

states between 2010-2014, compared to only 1 state (Minnesota) taxing ENDS during this time (Centers for Disease Control and Prevention 2016).

Two published studies have used difference-in-differences models to evaluate the effect of enacting these ENDS MLSA laws on use of tobacco among teens. Both have documented that when ENDS MLSA laws are implemented, teen cigarette use rises. This is a concerning pattern of substitution because ENDS are estimated to be only 5% as harmful as traditional cigarettes (Royal College of Physicians 2016). One study found that recent teen cigarette use increased by 0.9 percentage points using data from the National Survey on Drug Use and Health (Friedman 2015). A second study found that following the enactment of ENDS MLSA laws, regular teen cigarette use increased by 0.8 percentage points using data from the Youth Risk Behavior Surveillance System. Additionally, this second study did not find evidence of the enactment of these laws having an effect on the use of marijuana or smokeless tobacco (Pesko, Hughes, and Faisal 2016).

Therefore, ENDS MLSAs may inadvertently increase tobacco smoking among some pregnant teens by removing access to a smoking cessation device from a group of highly-motivated quitters. At the same time, the intent of the laws is to reduce the use of ENDS by minors and to the extent that the laws are successful, they may reduce the overall use of nicotine among pregnant teens. Hence, the net effect of ENDS MLSA laws on birth outcomes is ambiguous and requires empirical investigation.

Conceptual Model

ENDS MLSAs are a recent policy that, if properly enforced, could make it more difficult for pregnant teens to obtain ENDS. Pregnant teens may be highly motivated to quit cigarette use,[1] and if they can legally buy ENDS from a store then this is an easily accessible smoking cessation strategy that is available to them. In states where they cannot legally buy an ENDS, it would be more difficult to access this smoking cessation option. Therefore, the implementation of these new purchasing laws for ENDS (which were already in place for traditional cigarettes) can be used to explore if ENDS are substitutes or complements for cigarettes. The law change may have increased the non-monetary and/or monetary costs of purchasing ENDS. For example, non-monetary costs may be increased by the inconvenience of using an intermediary to obtain ENDS, and any associated time delays, compared to being able to purchase ENDS directly in stores. Monetary costs may have increased as well if intermediaries require a mark-up, or shipping costs are added to online purchases. Traditional cigarettes have long been subject to MLSAs, so the cost of using traditional cigarettes does not change over our sample period. The relative rise in ENDS costs versus cigarette costs caused by the enactment of ENDS MLSA laws permits us to ask whether traditional cigarettes and ENDS are substitutes or complements in the population of pregnant minors. While the change in relative costs to pregnant minors is difficult to measure, previous work showing non-trivial changes in cigarette

[1] According to data from the National Survey on Drug Use and Health, teens that became pregnant had nearly twice the rate of past-year substance use than teens that hadn't become pregnant (58.8% versus 35.2%). Past 30-day substance use was higher among pregnant teens than non-pregnant teens (24.9% versus 18.7%), but this difference was less pronounced than for past-year substance use (Salas-Wright et al. 2015) This suggests that teens that became pregnant were motivated to reduce their high rates of substance use. The high rates of substance use prior to pregnancy also motivates our exploration of the effect of ENDS policy within this population.

use following ENDS MLSA laws among minors more generally suggest that the change in relative costs is non-trivial.

The enactment of an ENDS MLSA law does not necessarily mean that stores will abide by the law. To the extent that stores continue to sell ENDS directly to underage teens regardless of MLSA laws, then we would expect to find no effect of ENDS MLSA laws on cigarette consumption. If, however, stores follow the law to some extent and underage teens are forced to purchase ENDS through different channels that increases the hassle costs or monetary costs, then the relative costs of obtaining ENDS compared to cigarettes has increased, and substitution may result.

ENDS MLSA laws may be anticipated to have different effects depending on the pregnant woman's smoking status prior to her pregnancy. For smokers, ENDS MLSA laws may have two effects: 1) they may make it less likely that the 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 MLSA laws 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). We do not have access to ENDS use information in birth records, but we can test hypotheses examining the effect of ENDS MLSA laws on cigarette use directly.

Further, we can explore the effects of the laws on birth outcomes, which could deteriorate if more pregnant teens now smoke and smoking is more dangerous to the developing fetus than vaping, or could improve if the laws increase complete abstinence from

nicotine. The Surgeon General suggests that nicotine accounts for a small share of the negative effect that cigarettes have on decreased fetal growth (with other toxicants in cigarettes accounting for a larger effect), and that nicotine accounts for a larger share of the negative effect that cigarettes have on gestation (U.S. Department of Health Human Services 2014). 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.

Data

For our analysis, we used administrative birth records with geocode information (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 asks about smoking 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, (Howland et al. 2015) 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 Mathews 2016). In addition to improving the accuracy of smoking by using the new form, trimester-specific smoking

[2] All states were using the revised birth records in 2015 (Centers for Disease Control and Prevention 2014).

information is also available in the new form which permits us to exploit within-individual variation in cigarette use in response to ENDS MLSA laws 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 for birth records.

We perform our analysis among all women whose estimated conception (16 days after pregnancy week 0 or last menstrual period) was between 1/1/2010 and 2/1/2014.[3] We choose 2010 to start our analysis in order to maximize the number of states that were using revised birth records for the full period of our study. The first state (New Hampshire) in our study enacted an ENDS MLSA law in July, 2010. We exclude 16 states that were not using revised birth records at some point during this time period.[4] Further, we exclude 5 states and 6 counties because they had an MLSA over 18, poor data reporting on cigarette use, and/or MLSA laws that had been passed primarily at the city level.[5] Our sample of 30 states (minus NYC and Suffolk County, and including Washington DC) meet three conditions: 1) They use revised birth records throughout the full study period of 2010 to 2014, 2) they have a cigarette MLSA of 18, and 3) if they had an ENDS MLSA, the ENDS MLSA is 18 as well (Centers for Disease Control and Prevention 2016).

[3] This strategy avoids bias arising from our sample being more likely to contain premature births at the end of our data, since only at the point of birth is a birth certificate generated. As of October, 2016, year 2015 birth record data is not yet available.

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

[5] We exclude 3 states (Florida, Georgia, and Michigan) because they were missing cigarette use data entirely from one or more years. We exclude Massachusetts because an unusually large number of ENDS laws were enacted at the city/town levels (New Jersey Global Advisors Smokefree Policy 2015) for which we do not have geocode information in the birth data. We also remove Utah, New York City, and Suffolk County, NY from our analysis, because these places had an MLSA higher than 18 at some point during the study (New Jersey Global Advisors Smokefree Policy 2015).

We perform our analysis among women giving birth before their 18th birthday, so that the women were younger than the ENDS MLSA throughout the full length of their pregnancy. As a comparison group, we use women giving birth at age 19, who were above the ENDS MLSA throughout the full length of their pregnancy. We make the following exclusions: 1) women giving birth at age 18 because they were likely to be both younger than and older than the MLSA at different points in their pregnancies and we do not know the mother's birth month which would help us to determine partial treatment, 2) all women giving birth at age 20 and above because they are likely less comparable to mothers who are minors, 3) non-singleton births because they are more likely to have poor birth outcomes for reasons that have little to do with smoking behavior, and 4) 0.14% of sample births with unknown gestational length. The population meeting these conditions was 547,176 births.

Using the month of birth information (provided in the birth records), we assume that the infant was born at the mid-point of the month recorded in the birth record (the exact day was not provided in our version of the data from the National Center for Health Statistics). We then use gestational length in weeks (also provided in the birth records), to identify the estimated point of conception and the start of the three trimesters.[6]

We match ENDS MLSA laws onto the point of conception for our cross-sectional analysis, or to the start of each trimester for our panel data analysis. We obtain dates of the implementation of ENDS MLSA laws at the state-level from the CDC State System (Centers for Disease Control and Prevention 2016) and from the National Conference of State Legislatures

[6] The first trimester is defined as the point of ovulation that led to pregnancy. The second trimester is defined as week 14 of pregnancy (14 weeks after last menstrual period). And the third trimester is defined as week 28 of pregnancy.

(National Conference of State Legislatures 2016). We obtained county-level MLSA laws from a white paper (New Jersey Global Advisors Smokefree Policy 2015). Table 1 provides the states in our sample and the dates of their respective ENDS MLSA laws, if any. It also provides all county-level ENDS MLSA laws that we used in our analysis. Figure 2 shows maps of states and counties adopting the ENDS MLSA laws at different points in time.

We control for three tobacco control policies that may reflect anti-smoking sentiment and may simultaneously directly affect tobacco use by teens: cigarette tax rates, private workplace indoor restrictions on cigarette use (no restrictions, smoking permitted in some areas, or comprehensive ban), and private workplace indoor restrictions on ENDS use (no restrictions or comprehensive ban).[7,8] We match these controls to the point of conception for our cross-sectional analysis, or the start of the trimester for our panel data analysis. We obtain this data from the CDC State System (Centers for Disease Control and Prevention 2016). We did not use ENDS taxes as a control variable because only Minnesota had an ENDS tax over our study period and this state was previously excluded.

We provide descriptive statistics for the 547,176 births and merged data in Table 2, separately for mother's aged ≤17 and for mothers aged 19. This table shows that 40.8% of these births were to women ≤17 years of age and 59.2% were to women at age 19. 19-year-old mothers were more likely to be White, non-Hispanic (35.7%) than ≤17-year-olds (27.3%).

[7] No states in our sample had partial indoor vaping restrictions; therefore, full coverage is compared to no coverage. We do not use restaurant and bar indoor use restrictions because it seemed improbable that these venues are accessible to teens (bars) or that they would offer teens a discrete location to use tobacco (restaurants).

[8] Previous studies have used tobacco control policies to proxy changing anti-tobacco sentiment; for example, (Maclean, Kessler, and Kenkel 2015, Maclean, Webber, and Marti 2014)

Medicaid paid for over 70% of births for both populations. 19-year-old mothers were more likely to smoke during their pregnancy (14%) than ≤17-year-olds mothers (7.3%), which may reflect the influence of being able to legally purchase cigarettes. Mothers ≤17-years old had worse birth outcomes for premature births (13.8% versus 11.0%), very premature births (2.7% versus 1.9%), small-for-gestational age births (31.3% versus 30.7%), and Apgar 5 scores (8.74 versus 8.76). Small-for-gestational age identifies birth weight in the bottom 25th percentile for each week of gestation, using all births nationally. The Apgar 5 score is a method to quickly summarize the health of a newborn baby. Five criteria of skin color, pulse rate, reflex irritability grimace, activity, and respiratory effort are given a score of 0, 1, or 2 and summed with 10 being the "healthiest" score. The score is recorded by the physician 5 minutes following the birth.

These comparisons suggest that 19-year-old mothers are less disadvantaged than mothers who are minors and that their infants are healthier. This observation provides a motivation for supplementing cross-sectional analyses with within-mother panel-data analysis where possible.

At the bottom of Table 2, the merged data shows similarities between the two groups in terms of the tobacco control policy environments. All policy data was merged on as of the date of conception.

Methods

Our cross sectional analysis estimates the effect of enacting ENDS MLSA laws on cigarette use and birth outcomes, using 19-year-olds as a control group. For cigarette use, we

model a traditional cigarette demand equation. We first calculate the effect of ENDS MLSA laws on smoking participation (extensive margin), and then on cigarettes consumed monthly and setting this equal to 0 for non-smokers.[9] We estimate the following two difference-in-difference-in-difference (DDD) models:

(1) $any\ smoking_{ict} = a + X_i + (ENDS\ MLSA_{ct} * under\ MLSA_i) + ENDS\ MLSA_{ct} + under\ MLSA_i + cig\ tax_{st} + indoor\ use_{st} + \gamma_c + \gamma_t + e_{ict}$

(2) $total\ cig\ use_{ict} = a + X_i + (ENDS\ MLSA_{ct} * under\ MLSA_i) + ENDS\ MLSA_{ct} + under\ MLSA_i + cig\ tax_{st} + indoor\ use_{st} + \gamma_c + \gamma_t + e_{ict}$

where subscripts denote individual *i* living in county *c* of state *s* at time *t*. γ_t includes a set of birth year-by-month fixed effects as well as gestation year-by-month fixed effects. γ_c is a set of county fixed effects. We use three differences in our DDD analysis: space, time, and age.

The dependent variable *any smoking*$_{ict}$ captures smoking at the extensive margin at any point in the pregnancy (0 for teen mothers who have not smoked, 1 for teen mothers who have). Smoking at both the intensive and extensive margin is the dependent variable in equation 2, which is the number of cigarettes that individuals have consumed over the past month, with 0 used for non-smokers.

We include on our right-hand side control variables of c*ig tax*$_{st}$ (the state-level cigarette tax) and *indoor use*$_{st}$ (restricting the indoor use of cigarettes and ENDS in private workplaces).

[9] We do not present a conditional-on-positive regression using average daily cigarette use among smokers as the dependent variable because we demonstrate an impact of the policy on the participating sample (smokers). A changed sample reduces our ability to causally study the effect of the policy on conditional cigarette consumption (Angrist and Pischke 2008).

We also control for a mother's individual-level socio-demographic characteristics of race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other or missing, or Hispanic), age (age in years, bottom-coded at 14 years old), and her payment source (Medicaid, private insurance, self-pay, Indian Health Service, CHAMPUS/TRICARE, other government insurance, other, or unknown).

ENDS MLSA$_{ct}$ equals 0 when a county does not have an ENDS MLSA law in place at the moment of a pregnant teen's conception, and equals 1 when it does. In this way, this variable captures two differences, in space and time. Pregnant teens with partial exposure to the law change (e.g. the law changed during their pregnancy) are counted as part of the control group in this specification, but we also separate these effects in an event study analysis. We interact the ENDS MLSA policy implementation with a third difference, a mother being 17 or younger at the time of her child's birth compared to being 19 years of age.[10]

We then modify equations 1 and 2 by including indicators intended to capture whether the ENDS MLSA law came into effect before, during, or after a pregnancy: We include indicators for pregnant teens who conceived 18 to 9 months before the ENDS MLSA law came into effect, 9 to 0 months before the ENDS MLSA law came into effect, and after the ENDS MLSA law came into effect. This event study formulation helps us to distinguish between the effects of partial and full exposure to the law since pregnant teens conceiving 9 to 0 months before the ENDS MLSA laws came into effect were likely partially exposed to the law. We use these cut-offs based on conception because actual partial exposure to the laws is determined in part by

[10] We initially used a standard difference-in-difference model for only women aged 17 and under, but the event study for this specification showed evidence of non-parallel time trends. We attempt to correct this problem by estimating DDD models instead.

gestation length, which is one of our outcomes; that is, teens with longer pregnancies mechanically have a greater chance of being exposed to a policy change.

To conduct our panel data analysis, we use models similar to equations 1 and 2 to see how experiencing a law change during pregnancy affects cigarette use. For this model, we use daily cigarette use information for three months prior to pregnancy and for each trimester of pregnancy.[11] This within-pregnancy analysis controls for all time invariant mother-specific omitted variables that could potentially bias the estimated effect of the ENDS MLSA law on smoking; however, unobserved person-specific time varying omitted variables remain a potential threat. For this reason, we include time-varying controls and again use the 19-year-olds as a comparison group for those 17 or younger at the time of giving birth. We estimate two equations (one for any smoking and the other for the number of cigarettes), using the following modified equations:

(3) $any\ smoking_{it} = a + (ENDS\ MLSA_t * under\ MLSA_i) + ENDS\ MLSA_t + under\ MLSA_i + cig\ tax_{st} + indoor\ use_{st} + \gamma_i + \gamma_t + e_{it}$

(4) $number\ of\ cigarettes_{it} = a + (ENDS\ MLSA_t * under\ MLSA_i) + ENDS\ MLSA_t + under\ MLSA_i + cig\ tax_{st} + indoor\ use_{st} + \gamma_i + \gamma_t + e_{it}$

where *t* now denotes trimester (including the period 3 months prior to pregnancy) rather than time. $any\ smoking_{it}$ now denotes cigarette use at the extensive margin and

[11] Less than 1% of mothers did not report daily cigarette use for all three trimesters, and were excluded from analyses with cigarettes as the dependent variable. There was substantial variation in which trimester(s) had missing information. We keep these records with missing cigarette use information in our analyses of birth outcomes.

$number\ of\ cigarettes_{it}$ denotes the total amount smoked for pregnant teen *i* at trimester t. We remove individual-level characteristics from equations 1-2 and replace these with pregnancy fixed effects (γ_i). The pregnancy fixed effects also controls for the time in which the mother conceived and gave birth. We also use trimester fixed effects (γ_t). In this specification, cigarette taxes and indoor use laws for cigarettes and ENDS are as of the start of each trimester. Estimates from these equations show how ENDS MLSA laws that were enacted during pregnancy caused changes in cigarette use beyond the normal declines in cigarette use that occur as pregnancy progresses (Curtin and Mathews 2016).

We modify equations 3 and 4 in two ways. First, we interact the term ENDS $MLSA_t$ * under $MLSA_i$ with the indicator for each trimester, γ_t, in order to evaluate how law changes in each trimester of pregnancy differentially affects cigarette use. We hypothesize that a law change early in pregnancy will have a larger effect than a law change later in pregnancy since 75% of the decline in smoking among pregnant women occurs between the 1st and 2nd trimester (Curtin and Mathews 2016). The availability of ENDS may therefore have a larger impact on smoking cessation early in pregnancy.

Second, we perform the analysis only for women who were not smoking prior to their pregnancies. It is possible that some of these women were using ENDS prior to pregnancy, and ENDS MLSAs might cause some of them to switch to cigarettes. Alternatively, some women who might have started using ENDS might be less likely to do so after the passage of these laws.

To explore the effects of ENDS MLSA laws on birth outcomes, we replace the dependent variable in equations 1 and 2 with one of four birth outcomes, shown in equation (5) below. We cannot use our panel data model to explore birth outcomes because there is just one birth

outcome for each mother (whereas for smoking we have data about behavior at four different points in the pregnancy).

(5) $$birth\ outcome_{ict} = a + X_i + (ENDS\ MLSA_{ct} * under\ MLSA_i) + ENDS\ MLSA_{ct} + under\ MLSA_i + cig\ tax_{st} + indoor\ use_{st} + \gamma_c + \gamma_t + e_{ict}$$

The four birth outcomes that we examine are 1) premature birth (<37 weeks), 2) very premature birth (<32 weeks), 3) 25th percentile of the distribution of small-for-gestational age,[12] and 4) 5-minute Apgar score. The policy lags of our event study analysis will then permit us to test for policy endogeneity in the pre-period as well as for the point in pregnancy that the law has an effect (if any).

In a sensitivity analysis, we used both revised and unrevised birth records to explore the effect of ENDS MLSA laws on birth outcomes over a longer period of time, by including policy leads in three one-year intervals. We were unable to conduct a similar analysis for smoking because the collection of cigarette use information was done differently in the revised form compared to the unrevised form, and because the revised form was implemented in different states at different times.

While our main results focus on all underage pregnant mothers compared to 19-year-old mothers, for robustness we also re-estimate all of our models comparing only 17-year-old mothers and 19-year-old mothers. This more focused comparison yields a smaller sample size,

[12] We also explored birth weight outcomes of low birth weight and very low birth weight, and these results were similar to what we found using small-for-gestational age.

but arguably makes the two populations more similar. All analyses are estimated using linear probability models, with standard errors clustered at the level of state.[13]

Results

Estimates of the effects of ENDS MLSA laws on cigarette use among pregnant teens (equation 1-2) are presented in Table 3. Section A shows the effect that an ENDS MLSA law enacted at the point of conception has on cigarette use for an underage pregnant woman compared to a 19-year-old pregnant woman. In Section B, we examine the effects of partial or full exposure to the law change.

In Table 3, Section A, we present results from our cross-sectional models. The point estimates suggest sizable substitution of cigarettes for ENDS following ENDS MLSA passage, although the estimates are imprecise. They suggest that underage smoking participation rose relative to 19-year-old smoking participation by 2.2 percentage points in response to ENDS MLSA laws. Section B of Table 3 suggests that most of the effect of ENDS MLSA laws on smoking occurred among pregnant women conceiving after ENDS MLSA laws were passed; that is among pregnant women who were treated for the full length of their pregnancies. While imprecisely estimated, the negative coefficients for pregnant women giving birth before ENDS MLSA laws came into place suggest that the laws were not passed in response to rising cigarette use.

In Table 4, we explore the effect of ENDS MLSA laws on smoking outcomes using a panel data design. The estimates show that smoking declines with each trimester of pregnancy;

[13] We cluster at the level of state because this is the primary level at which the treatment of ENDS MLSA laws occurs. In unreported results, we also clustered our analysis at the county level, which typically resulted in smaller standard errors. In this way, our choice of clustering at the state level results in our inference being conservative.

therefore, our estimates of the effect of ENDS MLSA laws show how the laws affect this trajectory of declining cigarette use as pregnancy progresses.

Section A of Table 4 indicates that ENDS MLSA laws caused a 2.1 percentage point increase in underage smoking participation in each trimester relative to 19-year-old smoking participation (p<0.001). If we focus on the comparison of 17-year-olds and 19-year-olds, we see a 1.7 percentage point increase in 17-year-old smoking participation in each trimester relative to 19-year-old smoking participation (p<0.001). The average underage pregnant woman consumed approximately half of an extra cigarette daily following the law change (p<0.01). These figures suggest that ENDS MLSA laws halve the reduction in cigarette consumption that a pregnant minor would otherwise experience in the first trimester. The point estimates are similar to those observed in the cross-sectional design, but the panel data design substantially reduces the size of the standard errors. The coefficients for ENDS MLSA laws on whether there is any smoking are similar regardless of whether we use cross-sectional design or a panel data design, but the coefficient estimates for the models of number of cigarettes are approximately twice as large when using the panel data design.

The contrast between the models with all minors and those with only 17-year-olds (shown in each table in the last two columns) suggests that ENDS MLSA laws have the largest effects on the youngest minors. Possibly 17-year-olds are less hindered by the law in terms of their access to ENDS; for example, they may be more likely to have fake identifications or they may have a greater ability to travel to locations without ENDS MLSA laws.

In Table 4, Section B, we show predicted smoking at each of the four points in time for underage pregnant women exposed to ENDS MLSA laws and those who were not exposed. In

locations without ENDS MLSA laws, the estimates suggest that 15% smoked in the 3 months prior to their pregnancies, 12.3% smoked in the first trimester, 10.8% smoked in the second trimester, and 10.3% smoked in the third trimester. In locations passing ENDS MLSA laws, the smoking rate started lower but ended higher. In locations passing ENDS MLSA laws, estimates suggest that 13.7% smoked in the 3 months before pregnancy, 12.4% smoked in the 1st trimester, 11.3% smoked in the 2nd trimester, and 11.1% smoked in the last trimester.[14] These results provide an illustration of how ENDS MLSA laws slow the decline in cigarette use during pregnancy that would otherwise occur in the absence of the laws. In the first trimester, the percentage point decline in cigarette consumption from the pre-pregnancy baseline was twice as great in states not adopting ENDS MLSA laws compared to states that did, suggesting that pregnant women have an especially high demand for smoking cessation products early in their pregnancies.

In Table 4, Section C, we restrict our analysis to only those mothers not smoking prior to their pregnancies. It is possible that ENDS MLSA laws could increase the probability that a non-smoking pregnant woman takes up smoking when her access to ENDS is reduced, but we expect to find only small positive effects of ENDS MLSA laws in this group. Our results support this hypothesis, as the coefficients are virtually 0 and statistically insignificant. Therefore, we conclude that the main effect of ENDS MLSA laws on pregnant minors is to discourage minors who smoked before pregnancy from reducing cigarette consumption by using ENDS.

In Table 5, we turn to evaluating the effect of ENDS MLSA laws enacted at the point of conception on birth outcomes. ENDS MLSA laws may influence birth outcomes by decreasing

[14] For both groups, smoking declined from period to period (p<0.05).

ENDS use, including among individuals who would otherwise only vape, and also by raising cigarette use. Since nicotine is found in both cigarettes and ENDS and is particularly harmful to the fetus, it is unclear what the overall effect of the laws will be on birth outcomes.

In Table 5, Section A, we show that ENDS MLSA laws decreased very premature births and raised Apgar 5 scores. Very premature births decreased by 0.13 percentage points (5.9% of the mean) and Apgar 5 scores increased by 0.02 points (0.2% of the mean) for underage pregnant women giving birth compared to 19-year-old pregnant women. Results are similar if we focus on comparing 17-year-olds to 19-year-olds.

In Table 5, Section B, our results suggest that there was no effect on very premature birth or Apgar 5 scores for women conceiving 18-9 months before ENDS MLSA laws; however, there was a sizable negative "effect" on premature births in the before-period, which may result in our DDD estimate for premature birth being biased towards the null of no effect.

In Table 6, we explore the robustness of our birth outcome results by estimating models that include "leads" of the ENDS MLSA variables. In this analysis, we use all revised and unrevised birth records (except excluded locations)[15] from 2007 to 2014 (compared to using revised birth records from 2010 onwards in our main analyses). We now include indicators for conceiving 2 to 3 years before the adoption of a law, and for conceiving 1 to 2 years before the adoption of a law. The indicator for 1 to 2 years before is never statistically significant. However, the indicator for 2 to 3 years before the law is significant in the models for Apgar 5. Our DD estimates of effects of exposure to the laws stay the same as in Table 5 for the two outcomes of very premature birth and Apgar 5. But the precision of our estimates for 17- and

[15] See Figure 2 for excluded locations, and footnote 5 for an explanation.

19-year-olds decreases, resulting in a loss of statistical significance in this smaller sample, despite the associations themselves having increased in magnitude. In sum, despite finding evidence that ENDS MLSAs increase cigarette smoking by pregnant teens, we find, if anything, evidence of slightly positive effects on birth outcomes. This result may indicate that the positive effects of discouraging teens from vaping outweigh the negative effects of having some pregnant teens turn to cigarettes instead. Or it may indicate that cigarettes and vaping are about equally harmful to fetal health.

Discussion

We show that ENDS MLSA laws had the unintended effects of increasing pregnant teen's cigarette use. Our study is the first to explore the effect of ENDS MLSA laws on cigarette use using panel data. We found an increase in smoking of 19.2% among all teens and 13.8% among 17-year-olds. These increases are larger in percentage terms than previously estimated effects of ENDS MLSA laws on smoking among teens more generally: Friedman (2015) reports a 9.1% increase in smoking participation using data from the National Survey on Drug Use and Health and Pesko, Hughes, and Faisal (2016) reports a 11.7% increase in regular smoking participation among teens in the Youth Risk Behavior Surveillance Survey. The higher estimate in this study suggests cigarette demand among pregnant teens is highly elastic and is substantially impacted by the availability of substitute products.

However, perhaps because ENDS MLSA laws reduce overall nicotine exposure by reducing vaping, we do not find any evidence of negative effects on birth outcomes despite the

increase in cigarette smoking. If anything, there may be positive effects in terms of reductions in the incidence of very premature births and increases in Apgar 5 scores.

One significant 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 nicotine replacement therapy.

A second limitation is that that we are unable to look at the health of the mother or later-life health outcomes of the infants. Viscusi (2016) argues that the smoking mortality risks are between 100 to 1,000 times more than the same risk from vaping. Teens who miss an opportunity to quit smoking during a pregnancy may be less likely to quit smoking later in life, and hence may incur these higher risks. Additionally, if the new mothers continue to smoke following their pregnancies, this endangers their child's immediate and later-life health due to secondhand smoke exposure (Simon 2013, U.S. Department of Health Human Services 2014) although it is currently unknown whether the risks from second hand vaping fumes are comparable. Therefore, while our study sheds light on some health consequences of ENDS MLSAs, the full health costs and benefits await future study.

Our study does suggest that there is high unmet demand among pregnant women for smoking cessation products, which is why we believe that many turn to vaping. Pregnancy may provide a unique window when women are open to guidance about resources and products

available to help them to quit smoking. In the absence of such guidance, pregnant women may be more likely to use ENDS. Tobacco cessation pharmacotherapy interventions for pregnant women have received an “incomplete” grade from the United States Preventive Services Task Force due to uncertain evidence about their overall health benefits (U.S. Preventive Services Task Force 2015). Our results suggest there may be substantial value in encouraging pregnant women's use of tobacco cessation pharmacotherapy interventions, and in physicians providing counselling and assistance to pregnant women who are trying to quit smoking.

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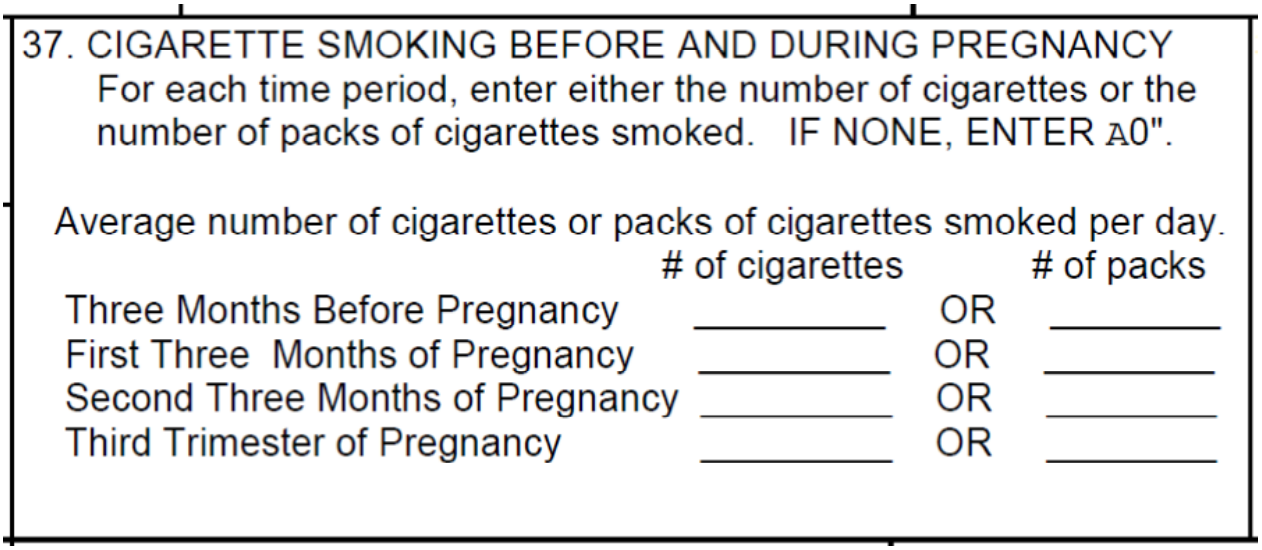
Figure 1: Cigarette Question from Revised Birth Record



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 "0".

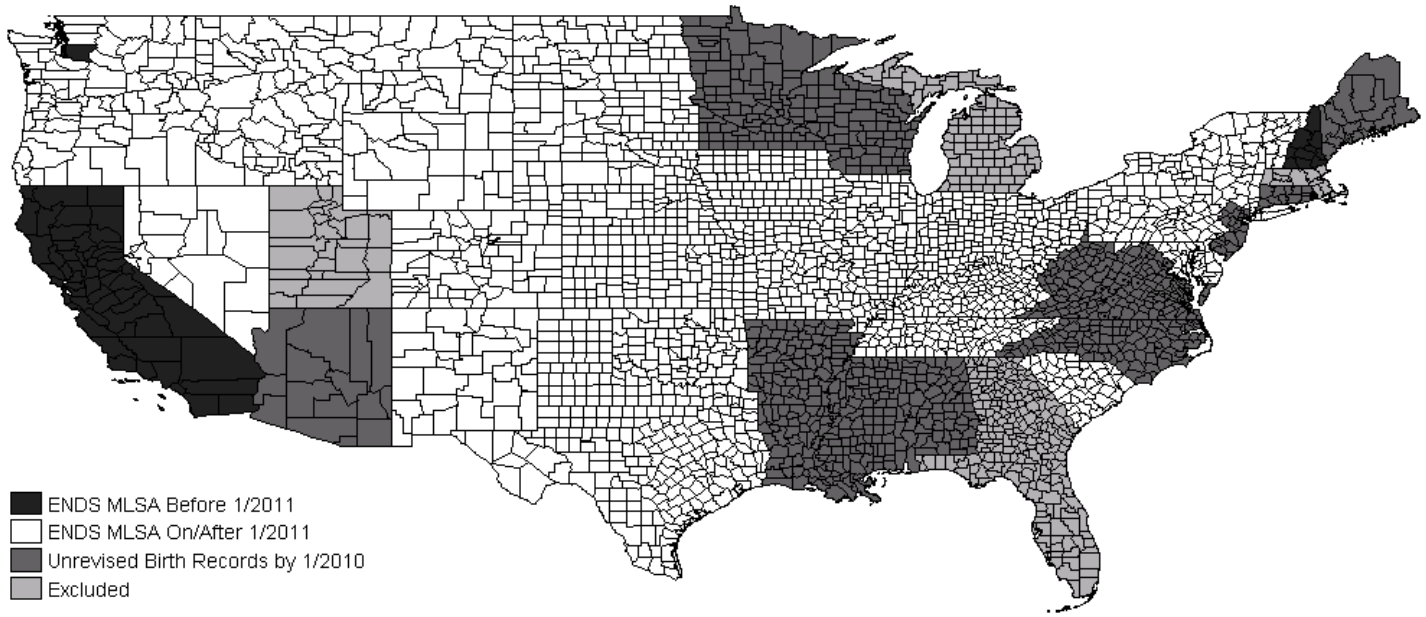
Average number of cigarettes or packs of cigarettes smoked per day.

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

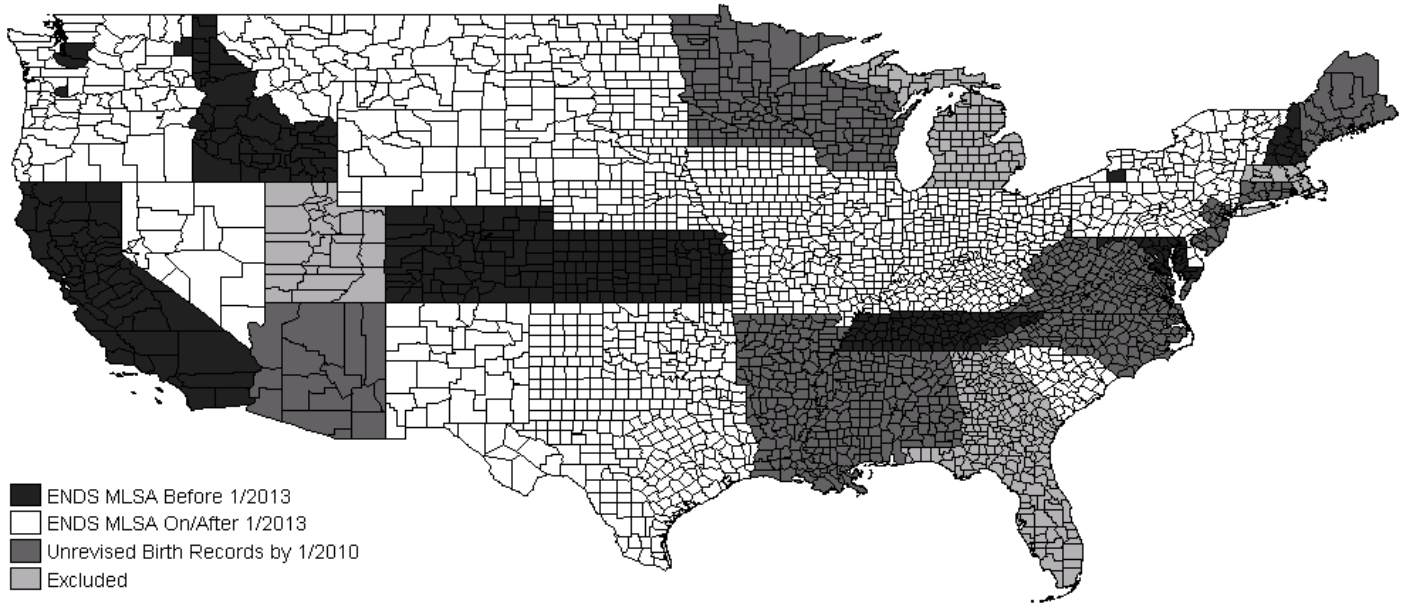
Source: CDC, http://www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf

Figure 2: Map of ENDS Policy Environment

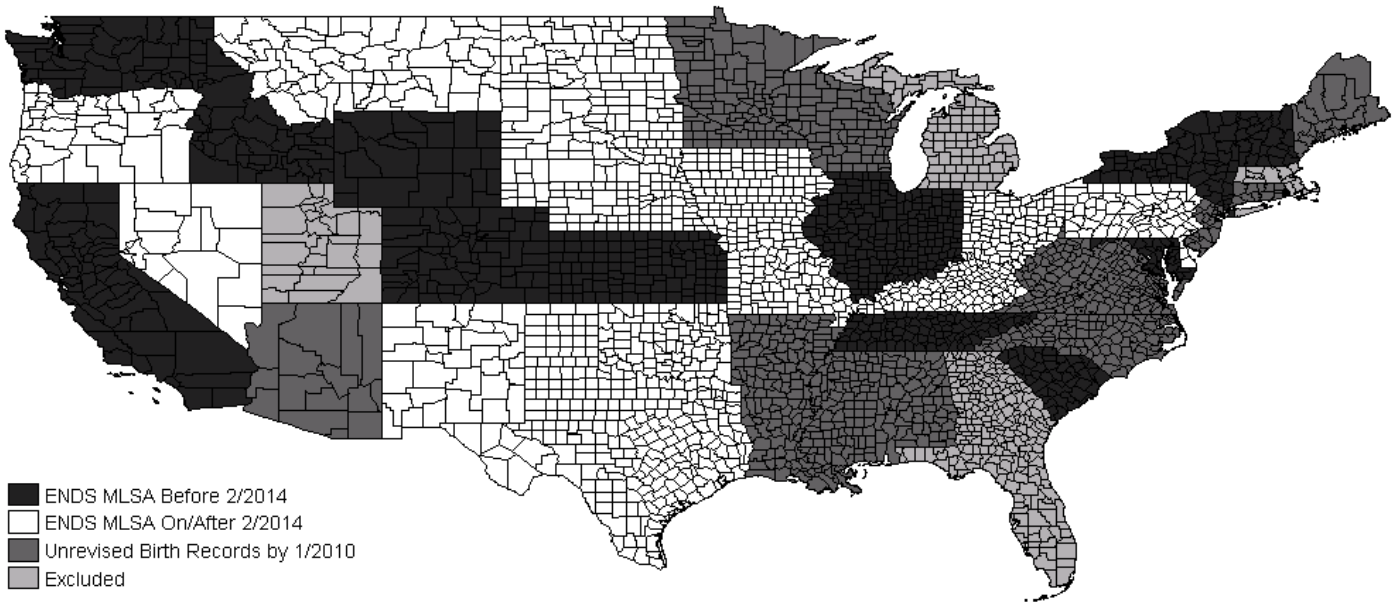
Section A: January, 2011



Section B: January, 2013



Section C: February, 2014



Note: Hawaii and Alaska both used unrevised birth records. Records are excluded due to having an MLSA >18, poor data quality, and/or MLSA laws primarily being passed at the city level.

Table 1: ENDS MLSA Law Enactment Dates for States and Counties Meeting Inclusion Criteria

State	Date of ENDS MLSA Law
California	9/27/2010
Colorado	3/25/2011
Delaware*	6/12/2014
District of Columbia*	10/1/2015
Idaho	7/1/2012
Illinois	1/1/2014
Indiana	7/1/2013
Iowa*	7/1/2014
Kansas	7/1/2012
Kentucky*	4/10/2014
Maryland	10/1/2012
Missouri*	9/10/2014
Montana*	1/1/2016
Nebraska*	4/9/2014
Nevada*	10/1/2015
New Hampshire	7/31/2010
New Mexico*	4/9/2015
New York	1/1/2013
North Dakota*	8/1/2015
Ohio*	8/2/2014
Oklahoma*	11/1/2014
Oregon*	1/1/2016
Pennsylvania**	8/8/2016
South Carolina	6/7/2013
South Dakota*	7/1/2014
Tennessee	7/1/2011
Texas*	5/28/2015
Vermont	7/1/2013
Washington	7/28/2013
Wyoming	3/13/2013
County	**Date of ENDS MLSA Law**
Santa Fe County, NM*	2/13/2014
Cattaraugus County, NY	2/14/2012
Multnomah County, OR*	4/4/2015
Philadelphia County, PA*	3/27/2014
King County, WA	12/16/2010
Spokane County, WA	3/31/2011
Pierce County, WA	6/2/2011
Clark County, WA	6/23/2011

Note: This table shows states used in the analysis, all of which began using the revised birth record form on or before 2010. In addition to the state-level variation, we also show counties with an ENDS MLSA law in the absence of a state law. * Indicates enactment of law after 2/1/2014, which is the cutoff of conception date for our sample of births. ** Passage due to the Food and Drug Administration's 2016 Deeming Rule.

Table 2: Descriptive Statistics for Pregnant Teens Aged ≤17 and 19

	Age ≤17		Age 19	
	Mean	**SD**	**Mean**	**SD**
RACE				
White non-Hispanic	0.273	-	0.357	-
Black non-Hispanic	0.232	-	0.214	-
Other non-Hispanic or missing	0.029	-	0.029	-
Hispanic	0.466	-	0.399	-
AGE				
14 or younger	0.039	-	-	-
15	0.120	-	-	-
16	0.294	-	-	-
17	0.547	-	-	-
19	-	-	1.000	-
PAYMENT				
Medicaid	0.742	-	0.729	-
Private insurance	0.155	-	0.168	-
Self-pay	0.042	-	0.035	-
Indian Health Service	0.002	-	0.001	-
CHAMPUS/TRICARE	0.003	-	0.010	-
Other government insurance	0.013	-	0.015	-
Other	0.032	-	0.028	-
Unknown	0.013	-	0.013	-
OUTCOMES				
Smoking participation (extensive)	0.073	-	0.140	-
Smoking intensity (intensive)	6.979	7.029	7.658	7.095
Smoking total	0.507	2.621	1.071	3.754
Premature (<37 weeks)	0.138	-	0.110	-
Very premature (<32 weeks)	0.027	-	0.019	-
Small-for-gestational age (25th percentile)	0.313	-	0.307	-
5-Minute Apgar Score	8.738	0.924	8.760	0.884
MERGE DATA				
ENDS MLSA (state or county)	0.220	-	0.233	-
Cigarette taxes (state and federal, in 2014 dollars)	2.345	0.733	2.342	0.778
Cigarette private workplace indoor use law: None	0.329	-	0.298	-
Cigarette private workplace indoor use law: Partial	0.266	-	0.271	-
Cigarette private workplace indoor use law: Full	0.404	-	0.431	-
ENDS private workplace indoor use law: None	0.999	-	0.999	-
ENDS private workplace indoor use law: Full	0.001	-	0.001	-

Note: N = 547,176 for both populations, N=223,461 for ≤17, and 323,715 for 19-year-olds.

Table 3: E-cigarette MLSA Laws and Cigarette Use

	All Underage and 19-Year-Olds		17- and 19-Year-Olds	
	(1)	(2)	(3)	(4)
	Any Smoking	Number of Cigarettes	Any Smoking	Number of Cigarettes
Section A: DDD				
ENDS MLSA * Underage	0.0217 (0.0184)	0.1906 (0.1799)	0.0153 (0.0143)	0.1307 (0.1473)
ENDS MLSA	-0.0079 (0.0059)	-0.0604 (0.0593)	-0.0019 (0.0029)	-0.0023 (0.0320)
Underage	-0.0886*** (0.0195)	-0.6892*** (0.1773)	-0.0401*** (0.0078)	-0.3498*** (0.0842)
Section B: Event Study				
Conception 18-9 Months Before ENDS MLSA * Underage	-0.0063 (0.0159)	-0.0760 (0.1596)	-0.0066 (0.0117)	-0.0503 (0.1220)
Conception 9-0 Months Before ENDS MLSA * Underage	0.0127 (0.0204)	0.1097 (0.2072)	0.0064 (0.0153)	0.0447 (0.1640)
Conception After ENDS MLSA * Underage	0.0228 (0.0220)	0.1986 (0.2161)	0.0156 (0.0167)	0.1326 (0.1732)
Tobacco Policy Controls	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
County Indicators	Yes	Yes	Yes	Yes
Birth Year-by-Month Indicators	Yes	Yes	Yes	Yes
Gestation Year-by-Month Indicators	Yes	Yes	Yes	Yes
N	543,168	543,168	442,787	442,787
Dependent Variable Mean	0.1125	0.8407	0.1256	0.9483

Note: Section A shows results from a traditional DDD equation. Section B shows these results as an event study, with each coefficient representing the change compared to those conceiving >18 months before an ENDS MLSA law was enacted. Equations are estimated using a linear probability model, with standard errors clustered at the level of state. Demographic controls are race/ethnicity, age, and insurance type (if any). Tobacco policy controls are cigarette tax rates and private workplace indoor restrictions on cigarette use and ENDS use. + $p<0.10$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$

Table 4: Panel Data Analysis of E-cigarette MLSA Laws on Cigarette Use

	All Underage and 19-Year-Olds		17- and 19-Year-Olds	
	(1)	(2)	(3)	(4)
	Any Smoking	Number of Cigarettes	Any Smoking	Number of Cigarettes
Section A: Panel Data Model				
ENDS MLSA * Underage	0.0205*** (0.0048)	0.4452** (0.1292)	0.0165*** (0.0036)	0.3474** (0.0991)
ENDS MLSA	-0.0034 (0.0086)	-0.0473 (0.2173)	0.0010 (0.0084)	0.0558 (0.2195)
1st Trimester	-0.0375*** (0.0072)	-0.8448*** (0.2071)	-0.0417*** (0.0077)	-0.9554*** (0.2268)
2nd Trimester	-0.0574*** (0.0114)	-1.1863*** (0.2952)	-0.0636*** (0.0121)	-1.3341*** (0.3217)
3rd Trimester	-0.0631*** (0.0126)	-1.3041*** (0.3273)	-0.0700*** (0.0134)	-1.4673*** (0.3565)
Section B: Trimester-Specific Panel Data Model (Predicted Values)				
No ENDS MLSA * Underage * Pre-Pregnancy	0.1497 (0.0073)	2.0252 (0.2004)	0.1670 (0.0077)	2.2816 (0.2198)
No ENDS MLSA * Underage * 1st Trimester	0.1228*** (0.0017)	1.4627*** (0.0458)	0.1351*** (0.0016)	1.5813*** (0.0417)
No ENDS MLSA * Underage * 2nd Trimester	0.1076*** (0.0036)	1.2103** (0.0586)	0.1176*** (0.0042)	1.2864** (0.0796)
No ENDS MLSA * Underage * 3rd Trimester	0.1030** (0.0051)	1.1233* (0.0921)	0.1121** (0.0057)	1.1768** (0.1196)
ENDS MLSA * Underage * Pre-Pregnancy	0.1374 (0.0072)	1.7696 (0.1794)	0.1540 (0.0083)	1.9733 (0.2036)
ENDS MLSA * Underage * 1st Trimester	0.1238* (0.0040)	1.4875+ (0.1170)	0.1368* (0.0042)	1.6196+ (0.1233)
ENDS MLSA * Underage * 2nd Trimester	0.1134** (0.0056)	1.3401* (0.1370)	0.1244* (0.0065)	1.4386* (0.1559)
ENDS MLSA * Underage * 3rd Trimester	0.1108** (0.0062)	1.2930* (0.1422)	0.1212** (0.0073)	1.3822* (0.1657)
Tobacco Policy Controls	Yes	Yes	Yes	Yes
Pregnancy Fixed Effect	Yes	Yes	Yes	Yes
N	2,171,896	2,171,896	1,770,476	1,770,476
Section C: Panel Data Model for Non-Smokers Prior to Pregnancy				
ENDS MLSA * Underage	-0.0001 (0.0001)	-0.0000 (0.0025)	0.0002 (0.0002)	0.0021 (0.0031)
ENDS MLSA	-0.0003 (0.0002)	-0.0023 (0.0024)	-0.0003+ (0.0002)	-0.0025 (0.0024)
1st Trimester	0.0014*** (0.0002)	0.0139*** (0.0031)	0.0015*** (0.0002)	0.0154*** (0.0033)

2nd Trimester	0.0008*** (0.0002)	0.0054*** (0.0012)	0.0009*** (0.0002)	0.0060*** (0.0014)
3rd Trimester	0.0012*** (0.0003)	0.0083*** (0.0022)	0.0013*** (0.0003)	0.0090** (0.0025)
Tobacco Policy Controls	Yes	Yes	Yes	Yes
Pregnancy Fixed Effect	Yes	Yes	Yes	Yes
N	1,854,120	1,854,120	1,481,528	1,481,528

Note: Section A shows results from a panel data equation. Section B shows predicted smoking for underage women both not exposed to ENDS MLSA laws and exposed to ENDS MLSA laws in each trimester of pregnancy, with statistical significance referring to differences in predicted smoking compared to the prior trimester/pre-pregnancy period. Section C shows results from a DDD model that includes only those not smoking prior to pregnancy. Equations are estimated using a fixed effect linear probability model, with standard errors clustered at the level of state. Tobacco policy controls are cigarette tax rates and private workplace indoor restrictions on cigarette use and ENDS use. + $p<0.10$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$

Table 5: E-cigarette MLSA Laws and Birth Outcomes

	All Underage and 19-Year-Olds				17- and 19-Year-Olds			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Premature (<37 weeks)	Very Premature (<32 weeks)	Small-for-Gest Age	Apgar 5 Score	Premature (<37 weeks)	Very Premature (<32 weeks)	Small-for-Gest Age	Apgar 5 Score
Section A: DDD								
ENDS MLSA * Underage	-0.0007	-0.0013*	0.0029	0.0135*	-0.0011	-0.0014+	-0.0009	0.0121*
	(0.0017)	(0.0006)	(0.0057)	(0.0059)	(0.0018)	(0.0008)	(0.0046)	(0.0047)
ENDS MLSA	0.0010	0.0009	0.0032	-0.0066	0.0007	0.0004	0.0066+	-0.0056
	(0.0013)	(0.0008)	(0.0029)	(0.0118)	(0.0013)	(0.0009)	(0.0033)	(0.0120)
Underage	0.0329***	0.0091***	-0.0019	-0.0319*	0.0081***	0.0009+	0.0026	-0.009*
	(0.0031)	(0.0020)	(0.0057)	(0.0129)	(0.0004)	(0.0005)	(0.0033)	(0.0033)
Section B: Event Study								
Conception 18-9 Months Before ENDS MLSA * Underage	-0.0059*	-0.0003	0.0100	0.0093	-0.0021	0.0001	0.0109	-0.0067
	(0.0026)	(0.0016)	(0.0076)	(0.0134)	(0.0025)	(0.0023)	(0.0086)	(0.0154)
Conception 9-0 Months Before ENDS MLSA * Underage	0.0005	-0.0010	0.0003	0.0126+	-0.0003	-0.0005	-0.0010	0.0125+
	(0.0017)	(0.0015)	(0.0099)	(0.0072)	(0.0021)	(0.0012)	(0.0079)	(0.0072)
Conception After ENDS MLSA * Underage	-0.0010	-0.0014*	0.0036	0.0157*	-0.0013	-0.0015+	-0.0003	0.0132*
	(0.0018)	(0.0006)	(0.0069)	(0.0069)	(0.0020)	(0.0008)	(0.0053)	(0.0050)
Tobacco Policy Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year-by-Month Indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gestation Year-by-Month Indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	547,176	547,176	546,812	544,988	445,985	445,985	445,694	444,245
Dependent Variable Mean	0.1212	0.0221	0.3092	8.7508	0.1149	0.0202	0.308	8.7562

Note: Section A shows results from a traditional DDD equation. Section B shows these results as an event study, with each coefficient representing the change compared to those conceiving >18 months before an ENDS MLSA law was enacted. Equations are estimated using a linear probability model, with standard errors clustered at the level of state. Demographic controls are race/ethnicity, age, and insurance type (if any). Tobacco

policy controls are cigarette tax rates and private workplace indoor restrictions on cigarette use and ENDS use. + $p<0.10$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$

Table 6: E-cigarette MLSA Laws and Birth Outcomes, including Unrevised Birth Records (2007-2014)

	All Underage and 19-Year-Olds				17- and 19-Year-Olds			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Premature (<37 weeks)	Very Premature (<32 weeks)	Small-for-Gest Age	Apgar 5 Score	Premature (<37 weeks)	Very Premature (<32 weeks)	Small-for-Gest Age	Apgar 5 Score
Section A: DDD								
ENDS MLSA * Underage	-0.0007	-0.0013**	-0.0005	0.0184**	-0.0001	-0.0017	-0.0016	0.0137
	(0.0015)	(0.0005)	(0.0042)	(0.0054)	(0.0028)	(0.0012)	(0.0038)	(0.0091)
ENDS MLSA	-0.0018	-0.0005	0.0031	-0.0083	0.0015	0.0005	0.0039	-0.0196
	(0.0023)	(0.0006)	(0.0028)	(0.0149)	(0.0012)	(0.0006)	(0.0029)	(0.0163)
Underage	0.0338***	0.0076***	0.0034	-0.0456***	0.0075***	0.0013***	0.0048*	-0.0120***
	(0.0016)	(0.0011)	(0.0029)	(0.0101)	(0.0005)	(0.0003)	(0.0018)	(0.0027)
Section B: Event Study								
Likely Pre Treatment								
Conception 3-2 Years Before ENDS MLSA * Underage	0.0000	-0.0000	-0.0011	0.0123**	0.0002	0.0007	0.0009	0.0115*
	(0.0014)	(0.0007)	(0.0029)	(0.0044)	(0.0013)	(0.0008)	(0.0028)	(0.0046)
Conception 2-1 Years Before ENDS MLSA * Underage	-0.0013	-0.0009	0.0000	0.0057	-0.0009	-0.0001	0.0021	0.0033
	(0.0013)	(0.0007)	(0.0030)	(0.0052)	(0.0015)	(0.0008)	(0.0030)	(0.0062)
Likely Partial Treatment								
Conception 1-0 Years Before ENDS MLSA * Underage	0.0013	-0.0011+	-0.0028	0.0122**	0.0011	-0.0009	-0.0027	0.0150**
	(0.0012)	(0.0006)	(0.0023)	(0.0039)	(0.0015)	(0.0008)	(0.0028)	(0.0048)
Likely Full Treatment								
Conception 0-1 Years After ENDS MLSA * Underage	-0.0006	-0.0022*	-0.0026	0.0231***	-0.0008	-0.0018+	-0.0046	0.0270***
	(0.0021)	(0.0009)	(0.0056)	(0.0063)	(0.0024)	(0.0009)	(0.0042)	(0.0065)
Conception >1 Years After ENDS MLSA * Underage	0.0001	0.0010	0.0026	0.0025	-0.0004	0.0005	0.0009	-0.0050
	(0.0016)	(0.0008)	(0.0041)	(0.0058)	(0.0014)	(0.0007)	(0.0033)	(0.0066)
Tobacco Policy Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year-by-Month Indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gestation Year-by-Month	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Indicators								
N	1,621,395	1,621,395	1,619,950	1,614,361	1,311,828	1,311,828	1,310,685	1,306,363
Dependent Variable Mean	0.1286	0.0237	0.313	8.758	0.1216	0.0215	0.3114	8.7642

Note: Section A shows results from a traditional DDD equation. Section B shows these results as an event study, with each coefficient representing the change compared to those conceiving >3 years before an ENDS MLSA law was enacted. Equations are estimated using a linear probability model, with standard errors clustered at the level of state. Demographic controls are race/ethnicity, age, and insurance type (if any). Tobacco policy controls are cigarette tax rates and private workplace indoor restrictions on cigarette use and ENDS use. + $p<0.10$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$