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Smoking Ban and Health at Birth

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Smoking Ban and Health at Birth

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Abstract

In 2012, smoking restrictions were extended to hospitality venues in Hungary. Women working in bars and restaurants were primarily affected by the intervention. In this research, we analyze the effect of this smoking ban on the outcomes of their intended pregnancies. Using complete individual live birth, fetal loss (miscarriage, stillbirth), and infant mortality registry data, we examine the probability of live birth, indicators of health at birth, and the probability of death in the first year of life. We perform a difference-in-differences estimation and show that the smoking ban has improved health at birth of the newborns of mothers working in bars and restaurants and has reduced infant mortality among them. Performing a series of robustness tests, we provide evidence that strongly supports the causal interpretation of our results. We also show that the ban was more beneficial for newborns of parents with low educational attainment and with lower fetal health endowments.

JEL classification: I18, J13

Keywords: smoking ban, policy evaluation, health at birth

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Dohányzási tilalom és születéskori egészség

Hajdu Tamás – Hajdu Gábor

Összefoglaló

A nemdohányzók védelméről szóló törvény 2012-es módosítása a dohányzási tilalom szigorítását eredményezte. A változás jelentős mértékben érintette a vendéglátóhelyeken dolgozó nőket. Kutatásunkban ennek az intézkedésnek a hatását vizsgáljuk a bárokban és éttermekben dolgozó nők terhességi kimeneteire. Egyéni szintű, adminisztratív adatbázisok segítségével elemezzük az élveszületés esélyének, a születéskori egészségi állapot indikátorainak és a csecsemőhalálozás kockázatának változását. Különbségek különbsége becslést alkalmazva megmutatjuk, hogy a jogszabályváltozást követően javult az érintett nők által szült újszülöttek egészségi állapota és csökkent körükben a csecsemőhalálozás valószínűsége. Robusztussági tesztek sorával támasztjuk alá az eredményeink oksági értelmezésének helyességét. Továbbá megmutatjuk azt is, hogy az intézkedés az alacsonyabb státuszú, illetve rosszabb egészségi állapotú gyerekre nagyobb hatással volt.

Tárgyszavak: dohányzási tilalom, hatásvizsgálat, születéskori egészség

JEL kódok: I18, J13

1. Introduction

There is vast evidence on the harmful effects of smoking and secondhand smoke exposure; therefore, governments try to reduce smoking prevalence and smoke exposure by enacting tobacco control policies. Tobacco control interventions can take many forms, from cessation support to tax policy to prohibiting smoking in certain places. The evaluations of such interventions are indispensable for planning future policies and for enhancing the well-being of the society.

In this paper, we focus on smoking bans and birth-related outcomes. The vast majority of the studies that evaluated the effect of policies prohibiting smoking in public places, workplaces, or hospitality venues on birth outcomes used data that covered the entire population. Many of them applied interrupted time-series (ITS) analysis (Been et al., 2015; Cox et al., 2013; Kabir et al., 2013; Mackay et al., 2012; McKinnon et al., 2015; Peelen et al., 2016; Vicedo-Cabrera et al., 2016). A meta-analysis of the papers using the ITS design found mixed results. A smoking ban in workplaces or public places is associated with a reduction in preterm births, but it does not influence low birth weight (Been et al., 2014); however, recent studies reported more significant impacts. Other papers used the panel data of countries, US states/counties, or other geographical units. They exploited geographical differences and variations in the timing of smoking bans to estimate their effect on infants' health or on the prevalence of sudden infant death syndrome (Bartholomew and Abouk, 2016; Hawkins et al., 2014; Hoynes et al., 2011; King et al., 2015; Markowitz, 2008; Markowitz et al., 2013; Page et al., 2012). Most of these studies concluded that smoking bans have limited effects.

One of the major methodological issues of the ITS estimation strategy is to appropriately model the pre-intervention time trend (Huesch et al., 2012; Lagarde, 2012). Another difficulty arises from the studies using data covering the entire population as follows. The (treatment on the treated) effect of workplace smoking bans might be underestimated, since many workplaces are smoke-free before the intervention (Been et al., 2015; Peelen et al., 2016). The higher the proportion of workplaces being smoke-free prior to the ban, the higher the probability that an intervention appears to be ineffective, even if it has significant impact on certain groups of people.

Studies that are able to identify a subset of the population where pre-intervention exposure is more common, and that can follow a difference-in-differences strategy, might be more successful in estimating causal treatment on the treated effects. Such a rare example is the paper of Bharadwaj, Johnsen, and Løken (2014), which analyzed a 2004 law change in Norway that restricted smoking in bars and restaurants. Applying a difference-in-differences approach, it found that health at birth of children of female restaurant and bar workers improved after the ban.

In this paper, we estimate the impact of the 2012 amendment to the Act on the protection of nonsmokers on several outcomes of intended pregnancies[1] of mothers working in bars and restaurants. The law change strengthened the existing Hungarian anti-smoking legislation and had the strongest effect on women working in bars and restaurants, as in most bars/pubs and in many restaurants smoking was allowed before 2012. We use complete individual live birth, fetal loss, and infant mortality registry data, and we examine the probability of live birth, various health at birth indicators of the newborns, and mortality in the first year of life. We perform a difference-in-differences estimation and show that the smoking ban has improved the health of newborns of the bar worker mothers and has reduced infant mortality among those newborns. We observed that birth weight increased by 56 grams, gestation length by 0.19 weeks, and Ponderal index by 0.04 points. After the ban, the affected newborns had 1.2 percentage points lower chance of being born with very low birth weight, 2.2 percentage points lower chance of being born with low birth weight, and 0.9 percentage points lower chance of being born very preterm. In addition, the probability of being born with a low Ponderal index and infant mortality has been reduced by 4.1 and 0.5 percentage points, respectively.

Performing a series of robustness tests, by which we can rule out (among others) the concern about selection on unobservables and model misspecification, we show that the estimated effects are very likely to be causal. We also show that the ban was more beneficial for the children of parents with low educational attainment. In addition, to our knowledge first in the literature, we provide evidence that newborns with lower fetal health endowments might benefit more from the smoking restrictions.

Our paper adds to the literature on the effect of smoking bans in several ways. First, we estimate the impact of a smoking ban not at the entire population level but for mothers working at workplaces where smoking was permitted and smoke exposure was intense prior to the law change. Second, unlike previous papers that usually focus on a couple of birth outcomes, we analyze the policy impact of the ban on a broad set of health indicators of every intended pregnancy. Using administrative micro datasets, we are able to follow every child from the conception until the age of 1. To our knowledge, our paper is the first to investigate the impact of a smoking ban on an indicator of fetal loss that includes miscarriages and stillbirths as well. Third, we use a continuous treatment variable (instead of a binary indicator) that measures the intensity of exposure to a smoke-free working environment precisely. In addition, our treatment variable takes into account the potential endogeneity of

[1] Unintended pregnancies end in induced abortions, whereas intended pregnancies end in live births or fetal losses (miscarriage or stillbirth).

gestation length. Fourth, we analyze the heterogeneity of the effects by parental education, and, first in the literature, by fetal health endowment. Most of the previous studies have focused on average population effects.

The paper is structured as follows. Section 2 introduces the 2012 law change in Hungary. Section 3 discusses our data and empirical strategy. Section 4 presents the results, and Section 5 provides a conclusion.

2. The Hungarian smoking ban in 2012

On April 26, 2011, an amendment to the Act on the protection of nonsmokers (Act XLII of 1999) was adopted by the Hungarian Parliament, which strengthened the existing Hungarian anti-smoking legislation. This law, which went into effect January 1, 2012, bans smoking in public-education institutions, in enclosed workplace areas, on public transport, in childcare and healthcare institutions, and in hospitality venues (including pubs, bars, and restaurants). In workplaces and most public places, smoking was allowed only in designated smoking areas even before 2012, which means that hospitals, educational facilities, and many other workplaces were already smoke-free prior to the amendment. However, the amendment had a substantial effect on bars and most restaurants where smoking was previously permitted. The ban took full effect on April 1, 2012; previously, during the first three months, the consequences of noncompliance resulted in warnings only.

Before 2012, exposure to cigarette smoke was intense in Hungarian bars and restaurants. According to the Eurobarometer survey conducted in 2009,[2] 78% of the Hungarian adult population experienced smoking inside bars, and 43% experienced smoking inside restaurants. After the ban, air quality in bars and restaurants substantially improved. In 2014, only 9% and 4% of people reported that people were allowed to smoke inside bars or restaurants, respectively.[3]A study that measured the level of indoor air pollution in 42 public locations in 2008 in Hungary reported that smoking was observed in all pubs and in four-fifths of the restaurants. Furthermore, bars and restaurants with smoking had much higher than average levels of particulate matter, less than 2.5 microns in diameter (PM2.5), compared with other public places with smoking observed, and it reached the level that is considered unhealthy according to the air quality standard of the US Environmental Protection Agency (Tárnoki et al., 2009). An assessment of the changes in the indoor air

[2]European Commission (2012): Eurobarometer 72.3 (Oct 2009). TNS OPINION & SOCIAL, Brussels [Producer]. GESIS Data Archive, Cologne. ZA4977 Data file Version 2.0.0, doi:10.4232/1.11140

[3]European Commission and European Parliament, Brussels (2015): Eurobarometer 82.4 (2014). TNS Opinion [Producer]. GESIS Data Archive, Cologne. ZA5933 Data file Version 5.0.0, doi:10.4232/1.12265

quality of hospitality venues after the ban showed that the ban was effective: concentration of PM2.5 has reduced by 90% (Beregszászi et al., 2012).

3. Data and empirical strategy

3.1. Data

We used individual live birth, fetal loss (miscarriages and stillbirths), and infant mortality registry data of the Hungarian Central Statistical Office. Infant mortality and live birth datasets are linked. The matching is almost perfect: more than 99% of the infant mortality records are linked to the live birth dataset. Using these datasets, we are able to observe every intended pregnancy in Hungary, and we can follow them until the age of 1.

These administrative data contain information on the exact date of the end of the pregnancy and characteristics of the mother (age, education, marital status, employment, pregnancy history, place of residence). Registry of live births collects information on the sex of the newborn and characteristics of the father as well (age, education, marital status, employment, place of residence). Importantly, the datasets include FEOR (the standard classification of occupations in Hungary) codes[4] of the parents. This four-digit code classifies almost 500 occupations. Using the occupation codes, we are able to identify waitresses and bartenders who were primarily affected by workplace smoke exposure before 2012.

Both registry of live births and registry of fetal losses contain information on pregnancy length, by which we are able to determine the date of conception. This way we can calculate our main indicator of smoke exposure in utero: the duration of pregnancy when the fetus was not exposed to cigarette smoke at the workplace of the mother. Our exposure variable is not based on the actual duration, but we use an exposure indicator that would have been observed if the pregnancy had lasted exactly 40 weeks. An exposure variable that uses the actual duration of pregnancy is potentially endogenous because parents' characteristics influence gestation length. Using an exposure indicator based on 40 weeks of gestation allows us to avoid this bias.

We use a broad set of health indicators as outcome variables:

1. Being born alive
2. Birth weight
3. Very low birth weight (<1500 g)
4. Low birth weight (<2500 g)
5. Week of delivery

[4]For a detailed description, see http://www.ksh.hu/docs/szolgaltatasok/eng/feor08/efeor08.pdf.

6. Very preterm birth (born before 32 weeks of gestation)
7. Preterm birth (born before 37 weeks of gestation)
8. Ponderal index[5]
9. Low Ponderal index (<2)
10. APGAR score (at 5 minutes)
11. Low APGAR score (<8)
12. Infant mortality

Outcomes 2–12 are analyzed only for pregnancies that ended in a live birth.

We exclude pregnancies if the mother is a non-Hungarian resident or if her place of residence is unknown because we have no information on the smoke exposure at her workplace. We also exclude twin births.

3.2. Estimation method

We employ a difference-in-differences strategy to estimate the impact of the smoking ban. We compare the health indicators of the children of mothers working in bars and restaurants to the health indicators of the control mothers' children. We estimate the following equation:

$$Y_{it} = \alpha + \beta_1 BAR_i + \beta_2 TI_t + \beta_3 BAR_i \times TI_t + \gamma X_{it} + \varepsilon_{it} \qquad (1)$$

where *i* denotes the individual (fetus/newborn) and *t* stands for time. BAR denotes mothers working in bars and restaurants (treatment group) and TI is a measure of treatment intensity. BAR takes the value 1 for mothers who are active on the labor market and work in bars and restaurants[6] and 0 for control mothers. TI takes a value between 0 and 1, depending on the duration of pregnancy when the fetus was not exposed to cigarette smoke at the mother's workplace. As we noted in the previous section, this exposure variable is not based on the actual duration of the pregnancy, but it is calculated for 40 weeks of gestation to rule out endogeneity.[7]Since the smoking ban took full effect only on April 1, 2012 and animal studies suggest that smoke exposure might have detrimental effects on birth outcomes even if it stopped just before conception (Hegazy and Almalki, 2013; Huang et al., 2009), we chose this date as the start of the treatment. Therefore, TI takes the value 1 if the pregnancy started in a smoke-free environment (the mother conceived after April 1, 2012), whereas it takes the value 0 if the 40th week of the pregnancy ended before the ban (before April 1, 2012). For the rest of the pregnancies (conception dates), it takes a value strictly greater than 0 and strictly less than 1.[8]

[5] Ponderal index = 100×(birth weight in g)/(birth length in cm)^3
[6] The FEOR codes are the following: 5132 and 5133.
[7]We can also perform an IV regression using this variable as an instrument. The results of this exercise are identical to the main results reported in Table 1 (see Table A16 in the Appendix).
[8]Figure A1 in the Appendix depicts treatment intensity by conception date.

Y denotes the birth outcomes, whereas X is the vector of control variables. The latter includes characteristics of the mother (age, age squared, dummies for marital status, dummies for education level, number of pregnancies/live births/abortions in log form), a nonlinear time trend, and a nonlinear seasonality measure. In addition, for outcomes 2–12, vector X includes the sex of the newborn, the number of days between the current and previous live birth (in log form), and the characteristics of the father (age, age squared, dummies for education level, dummies for labor market status) as well. The nonlinear time trend captures important factors that affect every pregnant woman in Hungary, whereas the nonlinear seasonality measure controls for the fact that mothers with different characteristics tend to conceive at different times of the year (Buckles and Hungerman, 2012; Currie and Schwandt, 2013) and for other seasonal differences. A continuous time variable based on conception date is used to control for time trend, whereas a continuous time variable based on the day of conception within the year (running from 1 to 365)[9] is used to capture seasonality. In both cases, nonlinearity is modeled by quadratic and cubic terms.

The key coefficient is β_3, which measures the policy effect on the outcome of interest for bar and restaurant workers. We report only this coefficient throughout the paper.

In the main analysis, we use those live birth and fetal loss data, where the pregnancy started between November 12, 2010 and November 11, 2012. We selected this period of 2 years in the following way. First, we took all conception days where our treatment intensity variable is strictly greater than 0 and strictly less than 1 (June 27, 2011–March 31, 2012). Then, we added equal numbers of conception days where TI=1 (the pregnancy started in a smoke-free environment) and TI=0 (the 40th week of the pregnancy ended before the ban). For robustness checks (e.g., randomization test), we use data for earlier and later periods as well.

The control group in the main analysis consists of working mothers who have similar personal characteristics to the bar worker mothers, but they were not exposed to cigarette smoke in their workplace even prior to the ban. The following occupations are included into the control group: (commercial occupations) shop salesperson, lender, street and market salesperson, street and market salesperson selling food and beverages, fast food restaurant assistant, shop cashier/ticket clerk, service station attendant, contact center salesperson, other commercial occupation, not elsewhere classified; (personal care and service workers) hairdresser, beautician, manicurist/pedicurist, babysitter/nurse; assistant nurse/dresser,

[9] February 29th is coded as February 28th in leap years.

home personal care worker, other personal care worker; (catering industry occupations) cook, confectioner, head-cook/chef.[10]

Since stable composition of the treated and control groups might be crucial in the difference-in-differences estimation strategy, in Table A1 in the Appendix we compare the characteristics of the bar worker and control mothers in terms of some important demographic variables for three periods: before (TI=0), intermediate (0<TI<1), and after (TI=1). Although there are some minor differences between the two groups, the differences are quite stable in time; they do not change considerably between the three periods.

We estimate equation (1) using an OLS regression. Standard errors are clustered at the conception-day level. Dummies are included for missing control variables.

4. Results

4.1. Main results

Table 1 shows the estimated effects (β_3 coefficients) of the 2012 smoking ban on the 12 birth outcomes. For seven outcomes, we get a significant coefficient at the 5% level, whereas for one additional outcome, we get a significant coefficient at the 10% level. For the probability of live birth, preterm birth, APGAR score, and low APGAR score, the point estimates suggest that the ban might have had a beneficial effect, but the coefficients are insignificant. The ban has increased the birth weight of newborns of mothers working in bars and restaurants by 56 grams. It means a 1.7% increase compared to the pre-ban average of the treated group (3264 grams). Due to the ban, the probability of being born with very low and low birth weight has decreased by 1.2 and 2.2 percentage points, respectively. These are substantial changes given the pre-ban prevalence of very low birth weight (1.9%) and low birth weight (7.7%). We see an improvement in gestation length (increase of 0.19 weeks) and very preterm birth (decrease of 0.9 percentage points). The pre-ban benchmark values are 38.8 weeks and 1.5%, respectively. There is a positive effect on the Ponderal index (0.037 with a pre-ban value of 2.37), whereas the probability of being born with a low Ponderal index has decreased by 4.1 percentage points from the 16.1% pre-ban prevalence. We also see a reduction in the probability of infant mortality (decrease of 0.5 percentage points).

[10] The FEOR codes are the following: (commercial occupations) 5113-5117, 5121, 5123-5129, 9235, (personal care and service workers) 5211-5213, 5221-5229, (catering industry occupations) 5134-5135, 3222.

Table 1

The effect of the smoking ban on birth outcomes

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth
Bar worker × Treatment	0.006	55.500*	-0.012*	-0.022+	0.189*	-0.009*
	(0.012)	(26.141)	(0.005)	(0.011)	(0.087)	(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.59	0.04	0.01	0.02	0.03	0.01
N	23467	18753	18753	18753	18755	18755
p-value	0.625	0.034	0.018	0.056	0.030	0.043

	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
Bar worker × Treatment	-0.019	0.037*	-0.041*	0.033	-0.006	-0.005*
	(0.012)	(0.017)	(0.017)	(0.034)	(0.006)	(0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.01	0.01	0.00
N	18755	18753	18753	18732	18732	18755
p-value	0.118	0.036	0.019	0.323	0.300	0.036

Control variables: (1)-(12) characteristics of the mother (age, age squared, dummies for marital status, dummies for education level, number of pregnancies/live births/abortions in log form), nonlinear time trend, nonlinear seasonality measure; (2)-(12) sex of the newborn, number of days between current and previous live birth (in log form), characteristics of the father (age, age squared, dummies for education level, dummies for labor market status).

Clustered standard errors in parentheses

$^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$

The estimated effects are substantial and highly plausible given the results of meta-analyses on the effect of smoking and smoke exposure. Exposure of nonsmoking pregnant women to tobacco smoke reduces birth weight by 30–60 grams (Leonardi-Bee et al., 2008; Salmasi et al., 2010), increases the prevalence of low birth weight by 16–30% (Leonardi-Bee et al., 2008; Salmasi et al., 2010), and increases the risk of stillbirths by 23% (Leonardi-Bee et al., 2011). These studies found no significant effects for spontaneous abortion (Leonardi-Bee et al., 2011), APGAR score (Salmasi et al., 2010), gestation length, and preterm birth (Leonardi-Bee et al., 2008; Salmasi et al., 2010). Maternal smoking increases the risk of preterm delivery by 27% (Shah and Bracken, 2000), and it is associated with around a 40% increase in the odds of stillbirth (Marufu et al., 2015) and around a 25–30% increase in the odds of miscarriage (Pineles et al., 2014).[11]

We also note that our results are remarkably similar to those estimated in the paper of Bharadwaj, Johnsen, and Løken (2014), whose empirical method is also very similar to ours. They found that the smoking ban in Norway that extended smoking restrictions to hospitality venues has increased birth weight by 54.9 grams (although it is not significant), decreased the probability of being born weighing less than 1500 grams and being born pre-term by 1.9 and 2.5 percentage points, respectively. However, they found zero effect on being born less than 2500 grams and an unexpected negative (but insignificant) effect on APGAR score.

In sum, our results suggest that the Hungarian smoking ban has improved birth outcomes for the newborns of women working in bars and restaurants.

4.2. Robustness

In this section, we test the robustness of our results by (i) implementing a placebo test, (ii) performing a randomization test, (iii) changing the control group, (iv) checking the common pre-ban trends assumption of the difference-in-differences approach, (v) changing the time period we used in the main analysis, (vi) changing the control variables, (vii) calculating standard errors in various ways, and (viii) changing the exposure indicator.

Although Table A1 shows that there is no substantial change in the difference between the treated and control groups in terms of some observable characteristics, the selection on unobservable variables may create omitted variables bias. The main concern is that women who would in any case have better pregnancy outcomes or healthier newborns might have started to work in bars after the ban. As the law on the smoking ban was adopted on April 26,

[11] In the recent literature, we did not find any meta-analysis on the effect of maternal smoking on birth weight. Individual studies reported that maternal smoking during pregnancy reduces birth weight by 150–250 grams (Bharadwaj et al., 2014; da Veiga and Wilder, 2007; Harris et al., 2015; Juárez and Merlo, 2013).

2011, it is also possible that more careful bar worker women decided to postpone their pregnancies until their workplaces became smoke-free. As a result of this sorting, the effect of the ban could look better than how it really is. To rule out these possibilities, we run a placebo regression where the outcome variables were changed to the health indicators of the older sibling of the newborns.[12] These outcomes could not have been affected by the ban, but should have been influenced by the unobserved, time-invariant "quality" of the mother. If we observe non-zero associations, then the causal interpretation of our results is false. In contrast, zero associations can prove that selection is not a serious problem in our analysis. Table 2 summarizes these estimations. The coefficients in the majority of the outcomes are much weaker than those presented in Table 1 and, in some cases, they point in the "wrong" direction. There is no significant coefficient at the 5% level. However, since many newborns are first children, the number of observations is much less than in Table 1, thus, to make a meaningful comparison, we have to re-estimate our main model to include only those who have an older sibling. In Table 3, we see that the point estimates from this exercise are very similar to the coefficients in Table 1, but since we used only 40% of the main sample, standard errors are much higher. Therefore, the coefficients are rarely significant. Nevertheless, these results suggest that change in the composition of the bar worker mothers is unlikely to be a problem in our estimations.

[12]The registry of live births contains information not only on the date of the actual birth event but on the date of the previous delivery (live birth) of the mother as well. Using this information, we are able to link siblings.

Table 2

The results of the placebo regressions

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Treatment	NA	8.039	0.006	-0.021	0.012	-0.000
		(49.568)	(0.008)	(0.021)	(0.158)	(0.009)
Controls		Yes	Yes	Yes	Yes	Yes
Adjusted R-squared		0.01	-0.00	0.01	0.01	0.00
N		7583	7583	7583	7578	7578
p-value		0.871	0.503	0.321	0.940	0.996
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Treatment	-0.021	0.017	-0.045	-0.029	0.017^{+}	-0.002
	(0.021)	(0.030)	(0.031)	(0.060)	(0.009)	(0.006)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.00	0.01	0.00	0.01	0.00	0.00
N	7578	7583	7583	7501	7501	7584
p-value	0.330	0.573	0.153	0.632	0.062	0.793

Note: In these estimations, the outcome variables from Table 1 were changed to the health at birth indicators of the older sibling of the newborns.

Clustered standard errors in parentheses

$^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$

Table 3

The effect of the smoking ban on birth outcomes (first children are excluded)

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Treatment	NA	88.253+	-0.013	-0.032	0.230	-0.010
		(46.762)	(0.009)	(0.020)	(0.151)	(0.009)
Controls		Yes	Yes	Yes	Yes	Yes
Adjusted R-squared		0.04	0.01	0.02	0.03	0.01
N		7583	7583	7583	7578	7578
p-value		0.060	0.147	0.107	0.128	0.244
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Treatment	0.008	0.000	-0.030	0.019	-0.006	-0.011*
	(0.020)	(0.030)	(0.028)	(0.056)	(0.009)	(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.02	0.01	0.00
N	7578	7583	7583	7501	7501	7584
p-value	0.692	0.998	0.284	0.734	0.546	0.031

Note: The estimations are similar to those reported in Table 1, but first children are excluded.

Clustered standard errors in parentheses

$^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$

To verify that our results indeed show the effect of the smoking ban, and are not just the result of coincidence or model misspecification, we performed a randomization test. In this exercise, we assumed that the smoking ban was not introduced on April 1, 2012, but on other random dates. We randomly selected 1000 days from the period January 1, 2002–December 31, 2010,[13] and then we re-estimated our main model using these dates as the start of the ban. Next, we compared the coefficients from Table 1 to the distribution of the 1000 coefficients we obtained from this randomization test to calculate empirical p-values. Table 4 presents the p-values, whereas Figure A2 in the Appendix shows the distribution of the coefficients. For example, in the case of birth weight, only 3 out of 1000 coefficients are higher than 55.500 (the coefficient reported in Table 1), which means that the empirical p-value is less than 1% (0.003). Looking at the other estimations, we can conclude that it is unlikely that our main estimations are the result of pure chance or model misspecification.

Table 4

The empirical p-values obtained from the randomization test

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
p-value	0.260	0.003	0.000	0.053	0.063	0.007
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
p-value	0.079	0.093	0.000	0.150	0.117	0.027

A different way to exploit the information that is provided by the randomization test is to take into account all 12 coefficients that we get from an individual estimation. Since for every outcome we have a strong expectation regarding the sign of the coefficient, we can count the number of coefficients with the expected sign for every random setting.[14] Our

[13] In this period, there was no tobacco control intervention that affected the treated group, but did not affect the control group (or vice versa).

[14] We expect to see a negative sign for very low birth weight, low birth weight, very preterm birth, preterm birth, low Ponderal index, low APGAR score, and infant mortality, whereas we expect a positive sign for live birth, birth weight, week of delivery, Ponderal index, and APGAR score.

benchmark value comes from the main results in Table 1, where all coefficients have the "right" sign, that is, our variable takes value 12. Column 2 in Table 5 shows the result for the 1000 random dates. We do not find any estimation where all the coefficients have the expected sign, and we see 11 correct signs (out of 12) in only 4 cases.

Table 5

The result of the randomization test

X: # of coefficients with the expected sign	# of estimations with X... coefficients with the expected sign	significant (at 10% level) coefficients with the expected sign
0	0	540
1	14	216
2	32	127
3	50	100
4	110	17
5	95	0
6	159	0
7	198	0
8	174	0
9	115	0
10	49	0
11	4	0
12	0	0
Total	1000	1000
Benchmark X (Table 1)	12	8

Next, we created a variable that shows not only the number of coefficients with the correct sign but also the number of statistically significant (at 10%) coefficients with the expected sign. In this case, our benchmark value is 8. Column 3 in Table 5 shows that there is no other estimation with similar results. The maximum number of statistically significant coefficients with the expected sign is only four. In sum, both the randomization test and the placebo test strongly support the causal interpretation of our results.

Next, we changed the control group. We selected three alternative control groups: (i) shop salespersons, (ii) active mothers, and (iii) all mothers. Table A3, Table A4, and Table A5 in the Appendix summarize the results, respectively. They show that our main results are not driven by the selection of the control group.

One of the key identification assumptions of the difference-in-differences estimation is that the time trends of the outcome variables are similar for the treatment and control groups prior to the ban. We investigated this assumption for the pre-ban (before) period in Table A6 in the Appendix assuming linear time trends. We estimate the following equation:

$$Y_{it} = \alpha + \beta_1 BAR_i + \beta_2 CDATE_t + \beta_3 BAR_i \times CDATE_t + \varepsilon_{it} \qquad (2)$$

where BAR denotes mothers working in bars and restaurants, and CDATE is a continuous time variable based on conception date. The results show that the time trends of the treatment and control groups are similar for most outcomes, and even if the time trends do not move in parallel (the common trend assumption does not stand), the diverging trends result in an underestimation of the effect of the smoking ban. For example, we see a significant increase in the probability of very low birth weight for the mothers working in bars and restaurants relative to the control group, which tends to make the effect of the smoking ban look worse than in reality.[15]

Next, we changed the 2-year period that we used in the main analysis. In a series of estimations, we added or removed 2 and 4 months.[16] Table A7 and Table A8 in the Appendix show that the results remain the same if we use a shorter estimation period (20 or 22 months instead of 24 months). If we use more than a 24-month estimation period, then the estimated coefficients become weaker (Table A9 and Table A10, Appendix). One of the main causes of the result is that the common trend assumption does not hold for longer periods prior to the ban, which distorts the results. As we discussed earlier, the differences in trends cause an underestimation of the effect of the ban. Besides, at the end of 2012 and in 2013, numerous changes were introduced regarding tobacco control policies. For example, since September 2012, all tobacco products have to be produced with warning images on the packaging, and

[15] If we increase the length of the pre-ban period, the diverging trends become more pronounced, but we note again that these differences in trends cause an underestimation of the expected effects.

[16] +/−1-1 month or 2-2 months from the beginning and the end of the estimation period.

from January 2013, only tobacco products with these images could be sold. In addition, from July 15, 2013, the availability of tobacco products was significantly reduced: tobacco products may only be sold in national tobacco stores.[17] It is possible that bar worker mothers (on the margin) have stopped smoking or reduced cigarette consumption due to the smoking ban, and, therefore, they were influenced less by the subsequent changes. In other words, warning images and reduced availability of tobacco products have improved health at birth in the control group to a greater extent. In sum, subsequent tobacco control policies might have decreased the initial positive effect of the ban.

We also estimated a model where the intermediate period was excluded (conception days where the treatment intensity variable is strictly greater than 0 and strictly less than 1). The result of this exercise is shown in Table A11 in the Appendix. We can see that these results are identical to those reported in Table 1.

In Table A12 in the Appendix, we estimated our models without any control variables. We can conclude that excluding controls has no substantial effect on the coefficients and p-values. We also experimented with controlling for time-invariant geographical differences by including microregion fixed effects into our estimation.[18] These additional controls do not influence our results (Table A13, Appendix).

In Table A14 in the Appendix, we performed a series of estimations with various ways of calculating standard errors. From this exercise, we report only p-values, since the coefficient estimates are identical. The first row shows p-values from Table 1. We cluster standard errors at the conception-month level and at the microregion level as well. We also report unclustered robust and conventional standard errors. None of these changes alter our results.

Finally, we changed our treatment intensity variable. In the main analysis, we assumed that the ban took full effect on April 1, 2012 because there was a 3-month grace period when the violation of the smoking ban did not result in a fine. Instead of this treatment variable, we created a new exposure indicator where the starting date of smoke-free bars is set to January 1, 2012. Then, we re-estimated our equations using the alternative treatment variable.[19] Table A15 in the Appendix shows the results of this estimation. In this case, we get weaker and mostly nonsignificant coefficients; however their signs are as we expected. Three independent mechanisms might explain these results. All of them might make the new treatment variable upwardly biased for many observations, resulting in an underestimation of the effect of the ban. First, until April 1, 2012 noncompliant bars and

[17] The number of tobacco shops fell from over 40,000 to around 6000 between 2011 and 2013 (Laki, 2015).

[18] Hungary consists of 174 micro-regions.

[19] The period of 2 years we used for this analysis has been changed along with the treatment intensity indicator. In the selection process, we used the same procedure as described in Section 3.2.

restaurants were not fined, so it is possible that some of them continued to allow their costumers to smoke even after January 1. Second, the effect of exposure to secondhand smoke might be persistent. It might take some time until the pollution is eliminated from human body. Although we have no experimental evidence on human subjects, animal studies suggest that smoke exposure might have detrimental effect on birth outcomes even if it stopped just before the conception (Hegazy and Almalki, 2013; Huang et al., 2009).[20] Third, Bharadwaj, Johnsen, and Løken (2014) found that the main mechanism behind the effect of the smoking ban in Norway is the changes in smoking behavior of the mothers. If many mothers do not stop smoking right after the ban but adjust their smoking behavior gradually or with some delay, then we observe the full effect of the intervention also with delay. Analyzing Swiss data, Boes, Marti, and Maclean (2015) provide evidence that public venue smoking bans reduce smoking prevalence, but the effect emerges with delay.[21]

4.3. Heterogeneity by parental education

Next, we analyze the heterogeneity of the estimated effects of the ban by parental education. We created two subsamples by education of the mother. We labeled those children as high status whose mothers are high school or university/college graduates.[22] Then, we repeated this exercise using the education of the father. Table 6 shows the estimations for mothers with low (panel A) and high education (panel B), whereas Table 7 presents the results for fathers with low (panel A) and high education (panel B). From these estimations we see that the effects of the ban are usually stronger for those whose parents have low education. In the subsample of high-status children, the coefficients are rarely significant and in many cases are close to zero. In addition, for some outcomes the point estimation has an unexpected sign. This is in line with previous studies that found that tobacco control policies are more effective among low-status individuals (Hawkins et al., 2014; Markowitz et al., 2013).

We have three hypotheses that can explain these differences. In general, all of them assume that avoidance behavior might be more pronounced among mothers with high education: they are more likely to take actions that lessen the smoke exposure of their fetuses

[20]Related to this, most non-experimental (observational) human studies reported that mothers who quit smoking in early pregnancy have infants with similar birth outcomes as those infants of non-smokers (McCowan et al., 2009; Wisborg et al., 2001; Yan and Groothuis, 2014). Others found that early quitters have somewhat worse outcomes (Juárez and Merlo, 2013).

[21] Other studies (based on the whole population) found no evidence that smoking bans reduce prevalence of smoking or smoking behavior in general (Adda and Cornaglia, 2010; Anger et al., 2011; Jones et al., 2015). However, individuals who are more affected by smoking bans seem to adjust their behavior (Anger et al., 2011; Bitler et al., 2010).

[22] In Hungary, primary education lasts 8 years, and it is followed by three types of secondary tracks: vocational training school, vocational high school, and general high school. Unlike vocational training schools, high schools prepare students for a school leaving exam (Matura exam), which serves as an entry exam into tertiary education of any kind.

than mothers with low education.[23] A smoking ban might affect the birth outcomes via two different ways: (i) the smoking habit of the mothers and (ii) the external effect of others' smoking. Our first hypothesis is related to the smoking habit of the mothers. Mothers with high education might stop smoking with a certain probability when they get pregnant irrespectively of the tobacco control interventions. Therefore, the 2012 smoking ban does not substantially influence their smoking behavior; however, it induces mothers with low education to stop smoking. In general, high-status mothers are more likely to discontinue smoking before or during their pregnancy (Balázs et al., 2014; Foley et al., 2011; Hiscock et al., 2012). It might mean that additional external incentives are less effective among them because of some kind of floor effect. In line with this, Colman, Grossman, and Joyce (2003) and Hawkins et al. (2014) report that the effect of increasing cigarette taxes on cessation of smoking during pregnancy is somewhat greater among women with less education.

The second and third hypotheses can explain why the exposure to secondhand smoke of high-status fetuses does not change due to the ban. Working in a non-smoke-free environment, mothers with higher educational attainment might go on maternity leave earlier than mothers with lower educational attainment. In this way, they might avoid the consequences of the cigarette-smoke exposure even prior to the ban. Similarly, an extreme sorting could explain the results. More educated women might be more likely to work in those bars and restaurants that were already smoke-free prior to the ban; thus only less-educated women were affected by the law change.

Without appropriate data (e.g., smoking of the mothers), we cannot test these theories; however, the results of previous studies (Bharadwaj et al., 2014) suggest that the difference in the smoking habit of the mothers during pregnancy might be the main mechanism behind the heterogeneous effects by parental education.

[23]Education is strongly correlated with healthier behaviors (Aizer and Currie, 2014; Cawley and Ruhm, 2011; Cutler and Lleras-Muney, 2010). In addition, there is empirical evidence that environmentally motivated migration is more pronounced among richer people (Banzhaf and Walsh, 2008; Currie et al., 2013).

Table 6

The effect of the smoking ban on birth outcomes by mothers' education

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
A) Mothers with low education												
Bar worker × Treatment	0.006 (0.020)	110.518* (42.931)	-0.023* (0.009)	-0.061** (0.020)	0.320* (0.149)	-0.018* (0.009)	-0.024 (0.020)	0.026 (0.027)	-0.032 (0.025)	0.119+ (0.061)	-0.024* (0.010)	-0.007 (0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.58	0.05	0.01	0.02	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.00
N	9812	7568	7568	7568	7568	7568	7568	7568	7568	7556	7556	7568
p-value	0.784	0.010	0.013	0.002	0.032	0.037	0.224	0.344	0.209	0.051	0.015	0.175
B) Mothers with high education												
Bar worker × Treatment	0.008 (0.012)	10.257 (31.537)	-0.002 (0.006)	0.008 (0.014)	0.074 (0.107)	-0.003 (0.005)	-0.012 (0.015)	0.043+ (0.023)	-0.043+ (0.024)	-0.027 (0.040)	0.007 (0.006)	-0.004 (0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.59	0.04	0.01	0.01	0.03	0.01	0.02	0.01	0.00	0.01	0.00	0.00
N	13571	11150	11150	11150	11152	11152	11152	11150	11150	11141	11141	11152
p-value	0.535	0.745	0.759	0.561	0.492	0.515	0.410	0.067	0.076	0.503	0.259	0.129

Note: low education = vocational training school or less, high education = high school or more

Clustered standard errors in parentheses

$^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$

Table 7

The effect of the smoking ban on birth outcomes by fathers' education

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
A) Fathers with low education												
Bar worker × Treatment	NA	94.016* (36.646)	-0.007 (0.005)	-0.052** (0.016)	0.283** (0.105)	-0.004 (0.004)	-0.023 (0.016)	0.041^{+} (0.024)	-0.053* (0.023)	0.071 (0.048)	-0.016* (0.008)	-0.005 (0.004)
Controls		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared		0.03	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00
N		8853	8853	8853	8853	8853	8853	8853	8853	8843	8843	8853
p-value		0.011	0.171	0.001	0.007	0.298	0.153	0.095	0.021	0.141	0.042	0.174
B) Fathers with high education												
Bar worker × Treatment	NA	-0.001 (38.115)	-0.003 (0.007)	0.018 (0.016)	-0.034 (0.124)	-0.010 (0.006)	-0.003 (0.017)	0.025 (0.026)	-0.031 (0.030)	-0.069 (0.043)	0.011^{+} (0.006)	-0.008^{+} (0.005)
Controls		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared		0.03	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
N		8599	8599	8599	8601	8601	8601	8599	8599	8596	8596	8601
p-value		1.000	0.656	0.269	0.783	0.122	0.838	0.347	0.300	0.113	0.066	0.087

Note: low education = vocational training school or less, high education = high school or more

Clustered standard errors in parentheses

$^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$

4.4. Heterogeneity by fetal health endowment

In the last part of the paper, we examine the effects by fetal health endowment. In this exercise, we follow the approach of Wehby et al. (2009), who measure the effect of prenatal care utilization at different parts of the birth weight distribution using quantile regression. They argue that the unobserved fetal health endowment is strongly correlated with birth weight quantile order; hence estimating the effects at lower and higher quantiles of the birth weight distribution could provide insight into the heterogeneity by fetal health endowment.

In this analysis, we estimate Eq. (1), performing quantile regressions (Koenker and Hallock, 2001) at seven different quantiles (0.05, 0.10, 0.20, 0.50, 0.80, 0.90, 0.95). Since most of our dependent variables are binary or ordinal (with highly clustered distribution), we can perform this estimation only for birth weight and the Ponderal index. Table 8 and Table 9 report the results.

Table 8

The effect of the smoking ban on birth weight by fetal health endowment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	p5	p10	p20	p50	p80	p90	p95
Bar worker × Treatment	155.674^{**} (51.021)	98.075^{+} (51.216)	58.081 (36.726)	35.156 (29.254)	39.637 (34.156)	54.189^{+} (30.723)	26.095 (60.445)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.04	0.03	0.02	0.03	0.02	0.02	0.02
N	18753	18753	18753	18753	18753	18753	18753
p-value	0.002	0.056	0.114	0.229	0.246	0.078	0.666

Dependent variable: birth weight

Estimation method: quantile regression

Robust standard errors in parentheses

$^{+}p< .10$, $^{*}p< .05$, $^{**}p< .01$

For both dependent variables, we see that the point estimates are usually higher at the lower part of the fetal health distribution, and they are more likely to be significant; however, we note that the 95% confidence intervals overlap. Nevertheless, the estimated effects at the lower quantiles are sizeable, not only in absolute but in relative terms as well. For example, the 156 and 98 grams increase at the 5th and 10th percentile means an almost 7% and 4% increase compared to the pre-ban values of the treated group, respectively. In addition, the estimated effect at the 5th and 10th percentile of the Ponderal index distribution means a 2.0% and 2.7% increase, respectively, compared to the pre-ban values. Summing up, our results suggest that newborns with lower fetal health endowments benefit more from the smoking restrictions.

Table 9

The effect of the smoking ban on Ponderal index by fetal health endowment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	p5	p10	p20	p50	p80	p90	p95
Bar worker × Treatment	0.036^{+} (0.020)	0.051** (0.017)	0.038* (0.018)	0.035 (0.025)	0.027 (0.028)	0.029 (0.029)	0.035 (0.037)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N	18753	18753	18753	18753	18753	18753	18753
p-value	0.002	0.056	0.114	0.229	0.246	0.078	0.666

Dependent variable: Ponderal index

Estimation method: quantile regression

Robust standard errors in parentheses

$^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$

5. Conclusion

In this paper, we estimated the impact of the 2012 Hungarian smoking ban on several outcomes of intended pregnancies of mothers working in bars and restaurants. We found that the ban has improved the health at birth of newborns and has reduced infant mortality among them. We observed birth weight to increase by 56 grams and gestation length by 0.19 weeks. Due to the ban, the probability of being born with very low and low birth weight has decreased by 1.2 and 2.2 percentage points, respectively, and we see a 0.9 percentage points reduction in the chance of being born very preterm. We also observe a decrease in the probability of infant mortality (decrease of 0.5 percentage points) and in the probability of being born with a low Ponderal index (decrease of 4.1 percentage points). For the probability of live birth and APGAR score, the estimations suggest that the ban might have had beneficial effects, but the coefficients are insignificant. Performing a series of robustness tests (including a randomization test that used pseudo-bans and a placebo test), we provided evidence that strongly support the causal interpretation of our results. We also found that the effects are higher for newborns with low educated parents and with lower fetal health endowments.

In sum, our estimations provide evidence that a smoking ban has a positive impact on those newborns whose mothers work at workplaces where smoking was allowed prior to the ban, and, therefore, are most directly affected by the law change.

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Appendix

Tables

Table A1

Differences between the treatment group and the control group

	Period	Bar worker	Control	Diff.	p	$N_{Bar\ worker}$	$N_{Control}$
Married mother	Before	0.36	0.52	-0.16	0.00	945	6470
	Intermediate	0.36	0.50	-0.14	0.00	1214	7961
	After	0.33	0.48	-0.15	0.00	916	5961
Mother's age	Before	29.18	30.35	-1.17	0.00	945	6470
	Intermediate	28.83	30.38	-1.55	0.00	1214	7961
	After	28.77	30.36	-1.59	0.00	916	5961
Mother's education: primary school or less	Before	0.09	0.06	0.03	0.00	938	6440
	Intermediate	0.09	0.06	0.03	0.00	1212	7940
	After	0.09	0.06	0.03	0.00	909	5944
Mother's education: vocational school	Before	0.37	0.36	0.01	0.94	938	6440
	Intermediate	0.34	0.35	-0.01	0.26	1212	7940
	After	0.32	0.35	-0.03	0.03	909	5944
Mother's education: high school	Before	0.51	0.54	-0.03	0.13	938	6440
	Intermediate	0.53	0.54	-0.01	0.47	1212	7940
	After	0.54	0.54	0.00	0.76	909	5944
Mother's education: college/university	Before	0.04	0.04	0.00	0.64	938	6440
	Intermediate	0.04	0.05	-0.01	0.53	1212	7940
	After	0.05	0.05	0.00	0.73	909	5944
# of abortions	Before	0.38	0.27	0.11	0.00	945	6470
	Intermediate	0.37	0.25	0.12	0.00	1214	7961
	After	0.34	0.25	0.09	0.00	916	5961
# of live births	Before	1.35	1.45	-0.10	0.00	945	6470
	Intermediate	1.37	1.48	-0.11	0.00	1214	7961
	After	1.37	1.49	-0.12	0.00	916	5961
# of pregnancies	Before	2.09	2.17	-0.08	0.07	945	6470
	Intermediate	2.08	2.16	-0.08	0.07	1214	7961
	After	2.06	2.17	-0.11	0.03	916	5961
Place of residence: Budapest	Before	0.13	0.14	-0.01	0.74	945	6470
	Intermediate	0.17	0.15	0.02	0.10	1214	7961
	After	0.15	0.13	0.02	0.14	916	5961
Father's age	Before	32.72	33.15	-0.43	0.07	707	4786
	Intermediate	32.29	33.23	-0.94	0.00	926	5985

	After	32.75	33.28	-0.53	0.03	715	4559
Active father	Before	0.94	0.94	0.00	0.82	696	4698
	Intermediate	0.93	0.95	-0.02	0.07	907	5890
	After	0.94	0.94	0.00	0.83	706	4495
Father's education: primary school or less	Before	0.08	0.08	0.00	0.85	697	4710
	Intermediate	0.09	0.08	0.01	0.25	915	5904
	After	0.08	0.08	0.00	0.58	712	4516
Father's education: vocational school	Before	0.49	0.43	0.06	0.00	697	4710
	Intermediate	0.43	0.42	0.01	0.58	915	5904
	After	0.44	0.42	0.02	0.33	712	4516
Father's education: high school	Before	0.38	0.39	-0.01	0.36	697	4710
	Intermediate	0.42	0.40	0.02	0.23	915	5904
	After	0.40	0.40	0.00	0.75	712	4516
Father's education: college/university	Before	0.06	0.10	-0.04	0.00	697	4710
	Intermediate	0.06	0.10	-0.04	0.00	915	5904
	After	0.08	0.10	-0.02	0.07	712	4516

Note: Before = Treatment intensity is equal to 0; Intermediate = Treatment intensity is strictly greater than 0 and strictly less than 1; After = Treatment intensity is equal to 1.

Table A2

Differences in outcomes between the treatment group and the control group

	Period	Bar worker	Control	Diff.	p	$N_{Bar\ worker}$	$N_{Control}$
Live birth	Before	0.822	0.780	0.042	0.00	945	6470
	Intermediate	0.849	0.793	0.056	0.00	1214	7961
	After	0.858	0.805	0.053	0.00	916	5961
Birth weight	Before	3264.5	3318.6	-54.2	0.01	777	5048
	Intermediate	3292.1	3298.0	-6.0	0.74	1031	6313
	After	3317.9	3308.3	9.6	0.64	786	4798
Very low birth weight	Before	0.019	0.010	0.010	0.06	777	5048
	Intermediate	0.008	0.011	-0.003	0.25	1031	6313
	After	0.008	0.009	-0.002	0.65	786	4798
Low birth weight	Before	0.077	0.055	0.022	0.03	777	5048
	Intermediate	0.063	0.062	0.002	0.85	1031	6313
	After	0.050	0.057	-0.008	0.36	786	4798
Week of delivery	Before	38.8	38.8	0.0	0.97	777	5049
	Intermediate	38.9	38.7	0.1	0.02	1031	6314
	After	39.0	38.8	0.2	0.00	786	4798
Very preterm birth	Before	0.015	0.009	0.007	0.16	777	5049
	Intermediate	0.007	0.009	-0.002	0.37	1031	6314
	After	0.006	0.009	-0.003	0.37	786	4798
Preterm birth	Before	0.076	0.064	0.012	0.23	777	5049
	Intermediate	0.070	0.072	-0.003	0.77	1031	6314
	After	0.047	0.067	-0.020	0.02	786	4798
Ponderal index	Before	2.365	2.381	-0.016	0.23	777	5048
	Intermediate	2.369	2.359	0.010	0.38	1031	6313
	After	2.405	2.378	0.028	0.04	786	4798
Low Ponderal index	Before	0.161	0.141	0.020	0.16	777	5048
	Intermediate	0.147	0.152	-0.004	0.73	1031	6313
	After	0.117	0.142	-0.025	0.05	786	4798
APGAR score	Before	9.662	9.686	-0.024	0.39	773	5046
	Intermediate	9.732	9.700	0.033	0.15	1031	6304
	After	9.695	9.685	0.009	0.72	786	4792
Low APGAR score	Before	0.017	0.012	0.005	0.29	773	5046
	Intermediate	0.009	0.010	-0.001	0.69	1031	6304
	After	0.012	0.009	0.002	0.54	786	4792
Infant mortality	Before	0.004	0.003	0.001	0.64	777	5049
	Intermediate	0.007	0.004	0.002	0.35	1031	6314
	After	0.000	0.006	-0.006	0.00	786	4798

Note: Before = Treatment intensity is equal to 0; Intermediate = Treatment intensity is strictly greater than 0 and strictly less than 1; After = Treatment intensity is equal to 1.

Table A3

The effect of the smoking ban on birth outcomes (control group: shop salespersons)

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth
Bar worker × Treatment	0.004 (0.012)	57.212* (27.170)	-0.010+ (0.005)	-0.024* (0.012)	0.212* (0.090)	-0.008 (0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.59	0.04	0.01	0.02	0.03	0.01
N	15171	12198	12198	12198	12198	12198
p-value	0.722	0.036	0.051	0.047	0.019	0.103
	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
Bar worker × Treatment	-0.020 (0.013)	0.043* (0.019)	-0.042* (0.018)	0.034 (0.035)	-0.003 (0.006)	-0.006* (0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.02	0.01	0.00
N	12198	12198	12198	12184	12184	12198
p-value	0.112	0.023	0.023	0.331	0.583	0.025

Note: Control group consists of shop salesperson.

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A4

The effect of the smoking ban on birth outcomes (control group: active mothers)

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Treatment	0.004	56.338*	-0.012*	-0.019+	0.168*	-0.009*
	(0.011)	(25.120)	(0.005)	(0.011)	(0.085)	(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.55	0.05	0.01	0.02	0.02	0.01
N	125119	105895	105895	105895	105902	105902
p-value	0.725	0.025	0.016	0.080	0.048	0.044
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Treatment	-0.014	0.036*	-0.040*	0.018	-0.006	-0.004+
	(0.011)	(0.016)	(0.016)	(0.032)	(0.005)	(0.002)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.02	0.01	0.02	0.01	0.00
N	105902	105895	105895	105789	105789	105902
p-value	0.223	0.027	0.013	0.568	0.238	0.071

Note: Control group consists of (non-bar worker) mothers who are active on the labor market.

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A5

The effect of the smoking ban on birth outcomes (control group: all mothers)

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Treatment	0.011	52.972*	-0.012*	-0.017	0.151+	-0.009+
	(0.011)	(24.910)	(0.005)	(0.011)	(0.084)	(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.56	0.09	0.01	0.04	0.04	0.01
N	204051	170617	170617	170617	170642	170642
p-value	0.291	0.034	0.021	0.125	0.073	0.057
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Treatment	-0.012	0.029+	-0.039*	0.004	-0.005	-0.004
	(0.011)	(0.016)	(0.016)	(0.032)	(0.005)	(0.002)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.03	0.02	0.01	0.02	0.01	0.00
N	170642	170617	170617	170294	170294	170642
p-value	0.288	0.068	0.015	0.904	0.360	0.124

Note: Control group consists of all (non-bar worker) mothers.

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A6

Pre-ban trends for the treatment and control group

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Time trend	-0.00012	-0.300	0.00016*	0.00016	-0.002	0.00012+
	(0.00023)	(0.348)	(0.00007)	(0.00015)	(0.001)	(0.00006)
Time trend (linear)	0.00002	0.076	-0.00003	-0.00002	-0.001+	-0.00004*
	(0.00008)	(0.120)	(0.00002)	(0.00005)	(0.000)	(0.00002)
Controls	No	No	No	No	No	No
Adjusted R-squared	0.00	0.00	0.00	0.00	0.00	0.00
N	7415	5825	5825	5825	5826	5826
p-value (interaction)	0.613	0.389	0.032	0.275	0.115	0.062
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Time trend	0.00013	-0.00003	0.00028	0.00011	-0.00009	-0.00001
	(0.00013)	(0.00021)	(0.00023)	(0.00041)	(0.00007)	(0.00002)
Time trend (linear)	0.00011*	-0.00002	-0.00010	-0.00012	0.00000	0.00000
	(0.00005)	(0.00009)	(0.00008)	(0.00016)	(0.00002)	(0.00001)
Controls	No	No	No	No	No	No
Adjusted R-squared	0.00	0.00	0.00	0.00	0.00	0.00
N	5826	5825	5825	5819	5819	5826
p-value (interaction)	0.322	0.876	0.222	0.785	0.240	0.624

Note: Before period only (Treatment intensity=0; 11 November 2010 – 26 June 2011).

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A7

The effect of the smoking ban on birth outcomes (estimation period: 20 months)

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Treatment	0.002 (0.013)	58.194+ (30.147)	-0.015** (0.006)	-0.022+ (0.013)	0.240* (0.101)	-0.015** (0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.58	0.04	0.01	0.02	0.03	0.01
N	19391	15501	15501	15501	15503	15503
p-value	0.872	0.054	0.007	0.096	0.018	0.004
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Treatment	-0.022 (0.014)	0.021 (0.020)	-0.035+ (0.020)	0.029 (0.038)	-0.004 (0.006)	-0.005+ (0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.01	0.01	0.00
N	15503	15501	15501	15487	15487	15503
p-value	0.116	0.284	0.075	0.453	0.470	0.086

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A8

The effect of the smoking ban on birth outcomes (estimation period: 22 months)

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Treatment	0.003 (0.012)	53.643+ (27.927)	-0.015** (0.005)	-0.023+ (0.012)	0.207* (0.093)	-0.013** (0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.59	0.04	0.01	0.02	0.03	0.01
N	21439	17133	17133	17133	17135	17135
p-value	0.778	0.055	0.005	0.062	0.026	0.005
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Treatment	-0.025* (0.013)	0.038* (0.018)	-0.039* (0.018)	0.020 (0.036)	-0.006 (0.006)	-0.006* (0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.01	0.01	0.00
N	17135	17133	17133	17115	17115	17135
p-value	0.047	0.041	0.033	0.583	0.336	0.033

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A9

The effect of the smoking ban on birth outcomes (estimation period: 26 months)

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth
Bar worker × Treatment	0.003 (0.011)	38.668 (24.413)	-0.010* (0.004)	-0.016 (0.011)	0.143+ (0.081)	-0.008* (0.004)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.59	0.04	0.01	0.02	0.03	0.01
N	25551	20411	20411	20411	20413	20413
p-value	0.772	0.114	0.026	0.144	0.075	0.046

	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
Bar worker × Treatment	-0.019+ (0.011)	0.031+ (0.017)	-0.024 (0.016)	0.030 (0.032)	-0.005 (0.005)	-0.005* (0.002)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.01	0.01	0.00
N	20413	20411	20411	20389	20389	20413
p-value	0.087	0.062	0.141	0.343	0.305	0.035

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A10

The effect of the smoking ban on birth outcomes (estimation period: 28 months)

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Treatment	0.003 (0.010)	26.996 (23.717)	-0.006 (0.004)	-0.015 (0.010)	0.094 (0.078)	-0.005 (0.004)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.59	0.04	0.01	0.02	0.03	0.01
N	27673	22101	22101	22101	22103	22103
p-value	0.764	0.255	0.136	0.161	0.229	0.220
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Treatment	-0.013 (0.011)	0.026 (0.016)	-0.021 (0.015)	0.013 (0.031)	-0.004 (0.005)	-0.005+ (0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.01	0.00	0.00
N	22103	22101	22101	22078	22078	22103
p-value	0.226	0.102	0.183	0.663	0.447	0.080

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A11

The effect of the smoking ban on birth outcomes (without pregnancies started in the intermediate period)

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth
Bar worker × Treatment	0.001	60.444*	-0.011*	-0.029*	0.217*	-0.010+
	(0.013)	(29.312)	(0.006)	(0.012)	(0.097)	(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.59	0.05	0.01	0.02	0.03	0.01
N	14292	11409	11409	11409	11410	11410
p-value	0.950	0.040	0.049	0.022	0.026	0.071
	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
Bar worker × Treatment	-0.031*	0.046*	-0.046*	0.031	-0.003	-0.007*
	(0.013)	(0.019)	(0.019)	(0.036)	(0.006)	(0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.01	0.01	0.00
N	11410	11409	11409	11397	11397	11410
p-value	0.018	0.017	0.016	0.389	0.661	0.011

Note: without those conception days where 0<TI<1 (intermediate period).

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A12

The effect of the smoking ban on birth outcomes (without control variables)

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth
Bar worker × Treatment	0.016 (0.018)	56.069* (26.607)	-0.011* (0.005)	-0.022+ (0.012)	0.199* (0.089)	-0.009+ (0.005)
Controls	No	No	No	No	No	No
Adjusted R-squared	0.00	0.00	0.00	0.00	0.00	0.00
N	23467	18753	18753	18753	18755	18755
p-value	0.394	0.035	0.025	0.058	0.025	0.056

	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
Bar worker × Treatment	-0.020 (0.012)	0.035* (0.018)	-0.040* (0.018)	0.032 (0.034)	-0.005 (0.006)	-0.005* (0.003)
Controls	No	No	No	No	No	No
Adjusted R-squared	0.00	0.00	0.00	0.00	0.00	0.00
N	18755	18753	18753	18732	18732	18755
p-value	0.103	0.043	0.024	0.354	0.331	0.037

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A13

The effect of the smoking ban on birth outcomes (with micro-region fixed effects)

	(1)	(2)	(3)	(4)	(5)	(6)
	Live birth	Birth weight	Very low birth weight	Low birth weight	Week of delivery	Very preterm birth
Bar worker × Treatment	0.002 (0.012)	54.837* (26.343)	-0.011* (0.005)	-0.023* (0.011)	0.186* (0.087)	-0.009+ (0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Micro-region FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.59	0.05	0.01	0.02	0.03	0.01
N	23467	18753	18753	18753	18755	18755
p-value	0.842	0.038	0.026	0.046	0.033	0.056
	(7)	(8)	(9)	(10)	(11)	(12)
	Preterm birth	Ponderal index	Low Ponderal index	APGAR score	Low APGAR score	Infant mortality
Bar worker × Treatment	-0.018 (0.012)	0.041** (0.014)	-0.043** (0.017)	0.049 (0.031)	-0.005 (0.006)	-0.006* (0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Micro-region FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.31	0.10	0.23	0.01	0.00
N	18755	18753	18753	18732	18732	18755
p-value	0.139	0.005	0.010	0.115	0.350	0.032

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A14

p-values obtained from various standard error estimations

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth
Clustered at the conception day level	0.625	0.034	0.018	0.056	0.030	0.043
Clustered at the conception month level	0.557	0.015	0.034	0.031	0.020	0.036
Clustered at the micro-region level	0.621	0.028	0.019	0.051	0.014	0.025
Robust	0.600	0.036	0.027	0.068	0.032	0.052
Conventional	0.629	0.035	0.018	0.060	0.032	0.046

	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
Clustered at the conception day level	0.118	0.036	0.019	0.323	0.300	0.036
Clustered at the conception month level	0.140	0.051	0.011	0.178	0.302	0.036
Clustered at the micro-region level	0.085	0.050	0.014	0.356	0.314	0.030
Robust	0.118	0.038	0.017	0.331	0.301	0.038
Conventional	0.130	0.037	0.019	0.331	0.254	0.088

Table A15

The effect of the smoking ban on birth outcomes (smoking ban starts on 1 January 2012)

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth
Bar worker × Treatment	0.006	31.169	-0.007+	-0.011	0.086	-0.007+
	(0.012)	(26.365)	(0.004)	(0.012)	(0.087)	(0.004)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.58	0.04	0.01	0.02	0.03	0.01
N	23660	18808	18808	18808	18810	18810
p-value	0.607	0.238	0.085	0.333	0.323	0.096

	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
Bar worker × Treatment	-0.009	0.021	-0.016	0.036	-0.009+	-0.002
	(0.013)	(0.017)	(0.017)	(0.032)	(0.006)	(0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.01	0.00	0.00
N	18810	18808	18808	18790	18790	18810
p-value	0.494	0.204	0.343	0.261	0.097	0.614

Note: The starting date of smoke-free bars is set to 1 January 2012 instead of 1 April 2012.

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Table A16

The effect of the smoking ban on birth outcomes (IV regression)

	(1) Live birth	(2) Birth weight	(3) Very low birth weight	(4) Low birth weight	(5) Week of delivery	(6) Very preterm birth
Bar worker × Treatment	0.006 (0.012)	55.317* (25.973)	-0.012* (0.005)	-0.022+ (0.011)	0.188* (0.086)	-0.009* (0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.59	0.05	0.01	0.02	0.03	0.01
N	23467	18753	18753	18753	18755	18755
p-value	0.627	0.033	0.018	0.055	0.030	0.043
	(7) Preterm birth	(8) Ponderal index	(9) Low Ponderal index	(10) APGAR score	(11) Low APGAR score	(12) Infant mortality
Bar worker × Treatment	-0.019 (0.012)	0.036* (0.017)	-0.041* (0.017)	0.033 (0.033)	-0.006 (0.006)	-0.005* (0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.02	0.01	0.01	0.01	0.01	0.00
N	18755	18753	18753	18732	18732	18755
p-value	0.116	0.035	0.019	0.321	0.298	0.035

Note: The treatment intensity variable calculated for 40 weeks of gestation is used as an instrument for the treatment intensity calculated for the real gestation length.

Clustered standard errors in parentheses

+p< .10, *p< .05, **p< .01

Figures

Figure A1

Treatment intensity by conception day

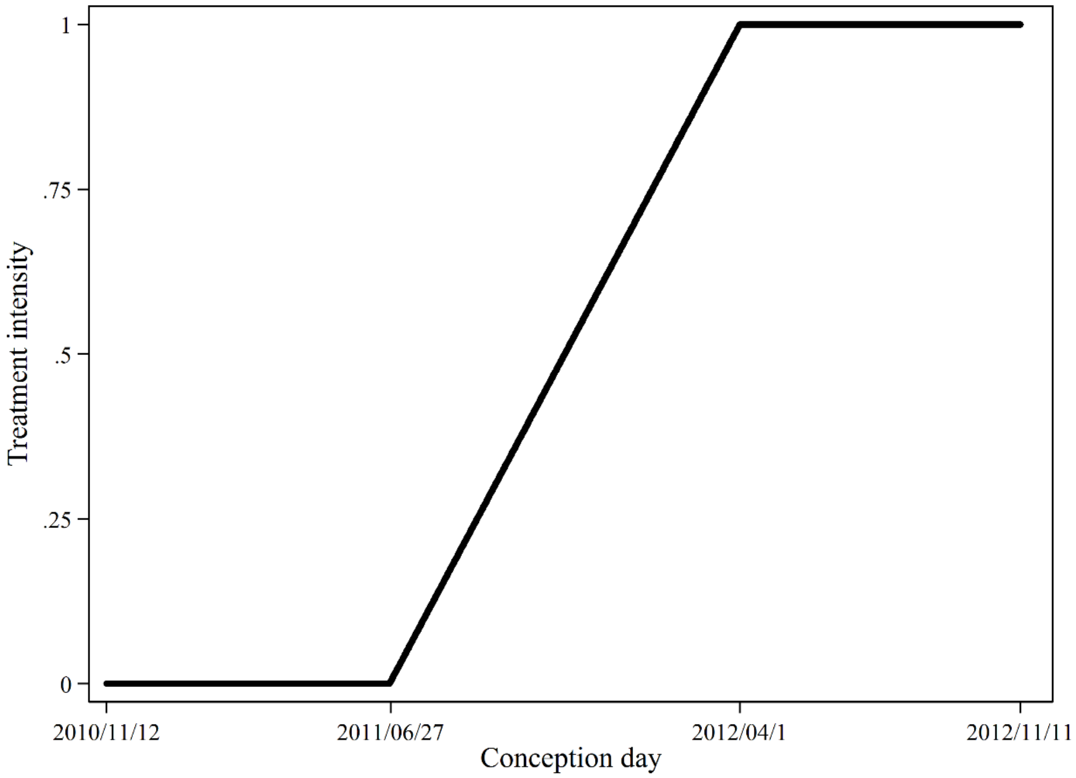
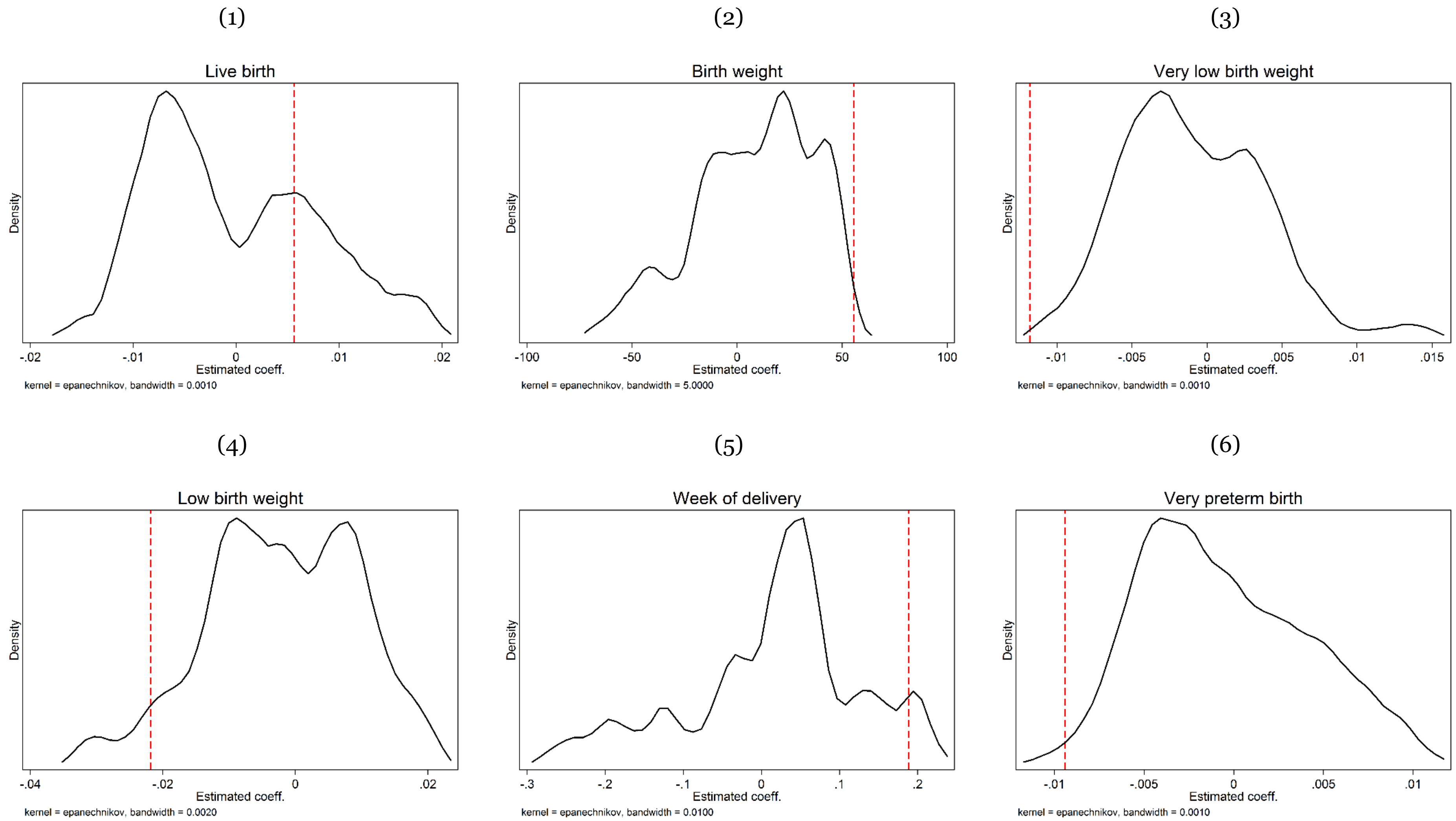


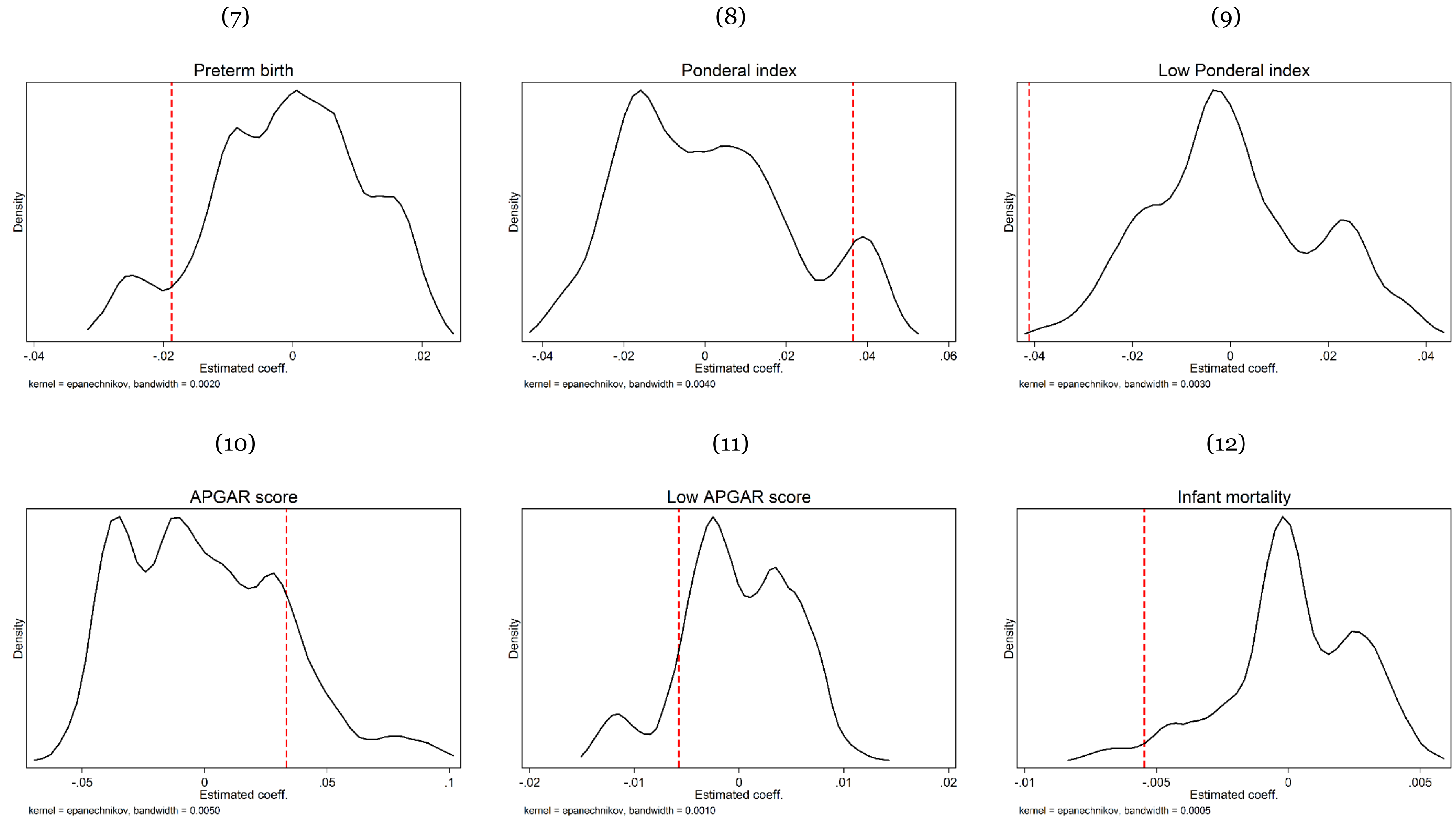
Figure A2

The distribution of the coefficients obtained from the randomization test



Note: the red dashed linesindicate the coefficients from Table 1

Figure A1 (continued)



Note: the red dashed lines indicate the coefficients from Table 1