C-Sections, Obesity, and Health-Care Specialization: Evidence from Mexico[*]

Catalina Herrera-Almanza[†] Fernanda Marquez-Padilla[‡] Silvia Prina[§]

June 13, 2022

Abstract

In Mexico, both cesarean sections (CS) and obesity have increased dramatically in the last decades. We create a measure of hospital-level obesity based on the fraction of obesity-related discharges for women of childbearing age to explore whether hospital-level increases in obesity affect mothers' individual probability of delivering via CS. We use temporal and hospital variation in this measure to identify its effects on the individual probability of a CS, and on newborn and maternal health in Mexico considering the census of birth records for 2008-2015. We find that higher hospital-level obesity increases a woman's probability of having a CS, particularly a planned CS. Moreover, delivery-related birth outcomes improve for planned CS. This evidence is consistent with hospital-level specialization in CS, which may lead to better birth outcomes for CS deliveries.

KEYWORDS: Healthcare specialization, c-sections, newborn health, obesity.
JEL CODES: I11, I18, J13, D22.

---

[*] We are grateful to Ana Costa-Ramón, Heather Royer and conference participants at University of Illinois, Urbana-Champaign, AAEA, ASHECON,PAA and at the ITAM Alumni Conference for helpful comments. We thank Ana Paola Paredes Rodriguez for outstanding research assistance. Catalina Herrera-Almanza thanks the International Seed Grant through the College of ACES Office of International Programs at University of Illinois, Urbana-Champaign. All errors are our own.

[†] Corresponding author: Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. E-mail: catahe@illinois.edu

[‡] Department of Economics, CIDE. E-mail: fernanda.marquez@cide.edu

[§] Department of Economics, Northeastern University. E-mail: s.prina@northeastern.edu

1 Introduction

Cesarean section (CS) procedures have increased worldwide from 12% to 21% between 2000 and 2015 (Boerma et al. 2018) and in some Latin American countries CS account for more than half of the births (Betran et al. 2021). These rates are beyond the 10–15% rates recommended by the World Health Organization, as CS can have adverse effects on maternal and child health (Costa-Ramón et al. 2018; Jachetta 2014). Parallel to CS increasing trends, the prevalence of overweight and obesity—a common risk factor for CS and adverse pregnancy outcomes (Fyfe et al. 2011; Kominiarek et al. 2010)—has also increased worldwide.

Empirical evidence—mostly from the US—has shown that substantial variation of CS rates across hospitals can be uncorrelated with medical needs, and that supply rather than demand factors might explain unnecessary CS procedures (Kozhimannil et al. 2014). Understanding the observed differences in the use of intensive treatments across hospitals which may have a limited impact on patients' health is a key policy concern. While there is some evidence of benefits for riskier patients (Doyle et al. 2015), the excessive use of unnecessary intensive treatments may also be wasteful in terms of resources.

In terms of understanding large variations in the use of CS across health facilities it is plausible that hospitals in places with high female obesity levels become specialized in performing CS, thus leading to further increases in CS use. Consistent with the evidence on productivity spillovers in health care (Chandra and Staiger 2007), specialization in CS due to differences in hospital-level average pregnancy risk may be more (less) beneficial to women for whom a CS is more (less) likely to be medically indicated. While recent evidence shows that CS hospital specialization affects maternal and health outcomes (Card et al. 2019), the relationship between hospital-level patient characteristics that may increase medically-indicated CS, such as obesity prevalence among mothers, and CS specialization is unclear, as are its effects on health outcomes of different types of patients.

This paper aims to fill this gap by studying whether public hospitals with a higher fraction of obesity-related hospital discharges have higher CS rates and are therefore more likely to become specialized in performing CS, thus affecting a woman's *individual* probability of having a CS. We also analyze the impacts on newborn and maternal health outcomes that are birth delivery-related and may be thus affected by hospitals' specialization in CS. We focus on Mexico, where CS rates doubled from 23% in the 1990s to 46% in 2016 and where at least 72% of the adult population is overweight or obese (OWOB), with women being more affected (Brenes-Monge et al. 2019).[1] Given these trends and considering that obesity is a risk factor for CS (Cnattingius et al. 2013), obesity could be a potential factor in explaining the high CS rate increase in Mexico. Indeed, a positive correlation between CS rates and OWOB prevalence among women of childbearing age in 2012 and 2016 at the state level can be observed in the data (see Figure A.1 in the Appendix).[2] Furthermore, anecdotal evidence from medical personnel suggests that higher CS rates are concentrated in larger hospitals that specialize in riskier pregnancies related to factors such as a high pre-gestational BMI and hypertension.[3] These risk factors are more likely to be prevalent among women who are obese and/or overweight.

We merge the panel of the universe of public hospitals with the census of birth records for 2008-2015, which contains information on birth type delivery and several newborn health outcomes as well as maternal characteristics. While the administrative health data contain detailed information on inpatient diagnoses, it lacks information on whether patients themselves are obese. To overcome this data limitation, we construct a novel obesity measure at the hospital level. To do so, we use patient diagnoses to identify all women of reproduc-

---

[1] In 2015, CS use was up to ten times more prevalent in Latin America than in other regions (Boerma et al. 2018). Moreover, Mexico, after Brazil, has the largest number of CS in Latin America (Gibbons et al. 2010).

[2] We focus on 2012 and 2016 female OWOB prevalence because these are the latest estimates at the state and national level that overlap with our study period.

[3] Executive Commission of Attention to Victims "Diagnosis on victimization due to Obstetric Violence in Mexico" last retrieved at `www.gob.mx/cms/uploads/attachment/file/194701/Diagno_stico_VO_port.pdf`

tive age admitted at a health facility who were diagnosed with a condition highly related to obesity based on the medical literature (Cnattingius et al. 2013; Kearns et al. 2014; Kotchen 2010). Our hospital-level obesity measure is strongly correlated with state-level female OWOB prevalence. We believe it to be an alternative measure of obesity levels that could be used in other settings when anthropometric data is unavailable. As in Card et al. (2019), we focus on the sample of first time mothers and low-risk first-time births (LRFB), defined as first time mothers with no prior clinical indication of having a CS delivery, and who are therefore more likely to be affected by hospital CS specialization.

Our empirical strategy uses variation in the health facility-level obesity index—both across hospitals and over time—to identify the effects of obesity prevalence at the hospital level on CS and on delivery-related health outcomes for newborns and mothers. Our models measure these effects using the hospital level obesity index as our main explanatory variable and condition on mother, pregnancy, and hospital-level characteristics, as well as time and hospital fixed effects. We estimate our models for the sample of all LRFBs as well as for what we identify as planned and unplanned CS, separately. We hypothesize that if increases in our measure of hospital-level obesity leads to CS specialization, then there should be stronger changes in planned CS and potential negative effects on vaginal deliveries, as these may be considered the "competing treatment."Furthermore, we show that our results are robust to alternative specifications of our hospital-level obesity index and fixed-effects models.

We find that the individual probability of delivering via CS is higher for low risk first-time mothers who give birth in public hospitals with a higher proportion of female obesity-related discharges, as measured by our hospital-level index.If higher obesity hospitals perform more CS due to medical reasons—as obesity is a known risk factor for CS—there may be productivity spillovers from knowledge, experience, and learning by physicians (as in Chandra and Staiger (2007)) that lead to specialization in CS, which may explain this result. We present suggestive evidence that our findings are consistent with increases in the individual probability of delivering via CS being driven by hospital specialization in these procedures among women, who do not have prior clinical risk of delivering via CS (i.e, low-risk first births-LRFB). The effects are larger and more statistically significant when the CS is planned rather than unplanned. We find similar effects across mothers' education levels, signaling that women's preferences over the type of birth delivery do not seem to drive our results, nor do alternative mechanisms such as doctors' medical or monetary incentives or changes in hospital congestion. Overall, the positive effect of our hospital-level obesity measure on an individual woman's likelihood of CS supports a hospital-level CS specialization argument.

Regarding newborns' health outcomes, we find better delivery-related birth outcomes for both planned and unplanned CS. In particular, we observe a reduction in birth injuries, birth trauma for both types of CS, and increased mother survival for planned CS. Additionally, we observe a negative effect on Apgar scores for vaginal births. This finding is consistent with the CS specialization hypothesis and similar to the negative externalities on patients receiving the competing treatment, as described in Chandra and Staiger (2007). We find additional evidence to support that these results on newborn health are associated with a hospital-level CS specialization story. First, we find that our hospital-obesity measure does not affect delivery-unrelated outcomes for LRFBs, such as low and very low birth weight, as these should not be affected by CS practices. Second, we find that our hospital-obesity measure decreases the probability of birth injury and trauma for the sample of preterm newborn babies, who are almost always delivered via CS and are thus unaffected by potential effects of obesity on delivery type choice.

Our paper contributes to the growing literature studying the determinants and consequences of increasing CS rates. Currently, the evidence for Mexico is limited, despite the very high CS prevalence (Boerma et al. 2018) and most of the evidence pertains to the US (Currie and

MacLeod 2008; Kozhimannil et al. 2014).[4] Our study is closest to Card et al. (2019) who show that proximity to hospitals with high CS rates leads to more cesarean deliveries and higher average Apgar scores among low-risk first births. Nevertheless, the evidence on the effects of CS on child health outcomes is not clear cut. While Jensen and Wust (2015) shows that breech births benefit from CS deliveries, Jachetta (2014) finds that CS leads to higher incidence of asthma and Costa-Ramón et al. (2018) shows that non-medically indicated CS delivery leads to lower Apgar scores.

More broadly, our paper relates to the literature analyzing the effects of medical practices on health outcomes (e.g. Chandra and Staiger (2007); Doyle et al. (2015); Card et al. (2019)), and our results extend beyond the effects of specialization on delivery mode. We build on this literature and contribute evidence of how patient characteristics may affect treatment choice and lead to specialization by focusing on how female obesity affects childbirth practices. Finally, our paper proposes a novel hospital-level obesity measure using data from patient diagnoses from the universe of public health facilities in Mexico which may be useful where patient-level anthropometric measurements are unavailable.

The rest of the paper is organized as follows. Section 2 describes the data sources and estimation sample as well as the construction of the hospital obesity index. Section 3 explains the empirical strategy while Section 4 presents the results and discusses the potential mechanisms driving our findings and Section 5 presents robustness checks. Section 6 concludes.

2 Data

Our first data source comprises the administrative health data from the universe of public health hospitals administered by the Ministry of Health (SSA) in Mexico. We include in

---

[4] Guendelman et al. (2017), using data from the 2014 birth certificates, shows that the type of insurance coverage and type of facilities (public vs. private) are factors associated with women's CS deliveries. Nevertheless, there is no evidence on the effects of hospital practices related to obesity-levels on CS rates.

our analysis all public SSA health facilities for which at least one birth was observed in every year between 2008 and 2015.[5] These data include information on inpatient hospital discharges for all SSA hospitals between 2008 and 2015 and contain detailed information for inpatient diagnosis recorded using the ICD-10 codes.[6] This database also includes patients' age, sex, and municipality of residence. We focus our analysis on a balanced panel of 267 hospitals.[7] We use this data to construct a monthly panel of public health facilities between 2008 and 2015.

Our second data source is the Mexican Birth Certificate Data, a census of all the registries of live births.[8] The birth certificate contains information related to the type of birth delivery (vaginal or cesarean), the newborn's sex, birth weight, gestational age (in weeks), Apgar score (a widely used diagnostic indicator of newborn health, ranging from 0 to 10 (Card et al. 2019); a higher score reflects a better health outcome),[9] whether there was any birth injury or trauma, and whether the mother survived after birth delivery.[10] It also includes information on whether the birth was a multiple birth, birth order, and some basic socioeconomic characteristics of the mother (age, education, civil status, and the municipality of birth and residence). We consider as women of reproductive age (WRA), women 15-45 years of age. Following Card et al. (2019), we restrict our analysis to first time mothers[11] and

---

[5] While the vast majority of these are "second and third level healthcare facilities"—general and specialized hospitals—some are smaller clinics where births sometimes take place. We refer to all healthcare facilities as hospitals hereafter.

[6] ICD-10 is the 10th revision of the International Statistical Classification of Diseases and Related Health Problems. It is a medical classification list by the World Health Organization (WHO). It contains codes for diseases, signs and symptoms, abnormal findings, complaints, social circumstances, and external causes of injury or diseases.

[7] Following Heckman (1981) and Greene (2001)'s rule of thumb, we focus on health facilities where there are at least eight deliveries per month in order to have meaningful estimates of CS rates.

[8] This census comes from the National Health Information System Birth Certificates (SINAC), collected by the Ministry of Health.

[9] As outcomes in our regressions, we use the Apgar total score and a dummy variable for whether the Apgar is less than 9 (Apgar< 9).

[10] We define birth injury as a dummy variable for any of the following ICD-10 codes: P10-P15, P209-P211, P219-P221, P228, P229,P240, P284,P285, P011, P032, P368, P369, P399, P545 and P914. We define birth trauma as a dummy variable for any of the ICD-10codes from P10 to P15. The dummy variables for birth injury, birth trauma, and mother survival after birth delivery are multiplied by 1000.

[11] Women who previously have a cesarean birth are more likely to undergo a CS in the subsequent birth.

the sample we identify as low-risk first births (LRFBs) given the variables available in our data. In particular, we exclude from our analysis births occurring before the 37th week of gestation, multiple births, women under 18 or over 35, or $\geq$ 20 pre-natal visits.[12]

Since the administrative data on hospital inpatient discharges and from birth certificates do not include information on patients' weight and height, we create a measure of hospital-level obesity. We use ICD-10 patient diagnoses to identify obesity-related hospital discharges based on the medical literature (Cnattingius et al. 2013; Kotchen 2010; Kearns et al. 2014). Then, we calculate the fraction of obesity-related discharges for WRA per month. Our measure of hospital obesity considers patient diagnoses for the following obesity-related diseases: pregestational hypertension (I10-I15, O10 and O11), pregestational diabetes (E10-E14 and 0240-O243), preeclampsia (O14 and O15), gestational diabetes (O244), hypertension, diabetes (E11.9), heart disease (I15.9, I20-I25, I25, I25.1), emphysema (J43.9), elevated blood pressure (R03.0), knee osteoarthritis (M17), gallbladder disease, hyperlipidemia (E78.5), chronic bronchitis (J41.0), stroke (I63.9), and asthma (J44.9, J69.8, J82).

We also consider pregnancy complications associated with obesity such as preeclampsia, gestational diabetes, pre-gestational diabetes, and pre-gestational hypertension. We argue that using diagnoses information from discharge data is an innovative way to obtain a useful and alternative measure of hospital-level obesity that may be valuable in other settings when patient-level BMI data is not available.

To test whether our measure of hospital-level obesity is a good index for actual obesity—and since obesity estimates are only available at the national and state level, but not at the municipal or hospital level—we show its correlation with OWOB prevalence for WRA at the state level. We use the 2012 Encuesta Nacional de Salud y Nutrición (ENSANUT), the latest available round of this survey overlapping with our study period.[13] We calculate state-level

---

[12] Due to data limitations we cannot identify vertex first births, mothers with BMI above the 90th percentile, and mothers with eclampsia, pre-eclampsia, growth restrictions, all of which are also excluded from the analysis in Card et al. (2019).

[13] ENSANUT is representative at the state level.

incidence rates for OWOB and obesity for WRA. Then, we regress these measures on our hospital-level obesity index aggregated at the state level for 2012. Appendix Table A.1 shows that our obesity index is strongly associated with obesity and OWOB incidence at the state level.[14] This measure represents a novel hospital-level obesity measure that exploits data from patient diagnoses

Table 1 shows descriptive statistics of the main variables used in 2008, for high- and low-obesity hospitals, as measured by our obesity index. It is worth noting that our main sample estimation only includes first time mothers and low-risk first births as earlier defined. A hospital is classified as high-obesity if its average obesity index in 2008 is higher than the median of the sample. Regarding mothers' characteristics, there are no statistically significant differences between high- and low-obesity hospitals in women's age and marital status. Mothers are slightly more educated in high-obesity hospitals but, this difference is relatively small in magnitude (0.3 of a year of schooling). In any case, all our models control for these mother characteristics.

Hospitals with high obesity prevalence tend to have a higher number of monthly CS deliveries than hospitals with low-obesity prevalence in 2008, the baseline year for our analysis period. The fraction of birth deliveries by CS is 39% in high-obesity hospitals and 34% in low-obesity hospitals. We do not find statistically significant differences between high- and low-obesity hospitals in delivery-related birth outcomes, such as average Apgar scores, frequencies of birth injury, birth trauma, and mother survival. Similarly, differences in delivery *unrelated* outcomes such as low birth weight (LBW), and very low birth weight (VLBW) are statistically indistinguishable between high- and low-obesity hospitals. Nevertheless, we observe that newborns are heavier in high-obesity hospitals, which is consistent with results linking heavier mothers to heavier newborns and fetal macrosomia (Khashan and Kenny

---

[14] We test different specifications of the obesity index by including different subsets of the obesity-related hospital diagnoses and the index that includes all diagnoses discussed above has the strongest correlation with obesity at the state level; see Appendix Table A.1.

2009). Finally, by construction, the obesity index is higher for hospitals with high obesity prevalence.

Over the time frame we study, ample variation in CS rates and obesity prevalence is observed both in time and across hospitals. Using our sample of hospitals, Figure 1 illustrates how CS rates and our measure of hospital-level obesity varied in time, with respect to 2008 and shows that substantial variation existed in both variables. Furthermore, Figure 2 presents the geographical variation in trends for both CS rates and obesity levels and shows that increases in neither CS nor obesity index were concentrated in a single geographic area. Together, these figures indicate that there is enough time and spatial variation to identify the effects of our hospital-level obesity measure on a woman's probability of having a CS and her newborn's delivery-related birth outcomes.

3 Empirical strategy

We start by analyzing the effect of hospital-level obesity prevalence on the likelihood of a woman having a cesarean birth. Our identification comes from variation across time and hospitals in the obesity index, conditioning on mother, pregnancy, and newborn characteristics, and time and hospital-fixed effects. We estimate the following model:

$$Y_{itc} = \alpha + \beta Obesityindex_{tc} + \gamma X_i + \delta_t + \theta_c + \epsilon_{itc} \tag{1}$$

where Y_{itc} is a dummy variable that captures whether birth i at time t (month) in hospital c was via CS. $Obesityindex_{tc}$ is the standardized obesity index for clinic c at time t.[15] We use the obesity index lagged by one quarter with respect to the delivery's month of birth.[16]

---

[15] We standardize the obesity index by subtracting the mean level across hospitals in 2008 and dividing by the standard deviation, also in 2008. Thus, all of our estimates can be interpreted in terms of an increase equivalent to one standard deviation at baseline.

[16] The lagged index is calculated as the monthly average of the lagged quarter (i.e., if the birth occurred

X_i is a set of control variables associated with birth i at time t in hospital c, including: mother's age, education, and marital status, number of prenatal visits, weeks of gestation, and total number of births in hospital c in month t. δ_t are time fixed effects (year-month). They allow us to capture country-wide time trends and the seasonality of births during the period of analysis. θ_c are hospital fixed effects. They control for all observed and unobserved time-invariant differences between hospitals. We cluster the standard errors at the hospital level. As mentioned earlier, our estimation sample consists of LRFBs defined as the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. We limit our analysis to the panel of 267 hospitals for which we observe births for every time-period. Our results are robust to including all hospitals.

We present our results for all LRFBs, as well as separately for "planned" vs "unplanned" CS birth delivery. The birth certificate does not specify whether a CS was scheduled or not. Thus, following Costa-Ramón et al. (2018) who find that the proportion of women that deliver via an unplanned CS is highest during nighttime, we classify a CS as unplanned if it occurred during the night hours (i.e. 8pm-8am) or weekends. We use the 8pm-8am range as the data show a discontinuity in CS rates at these times (see Figure A.2), that most likely are related to changes in medical staff shifts.[17] If increases in obesity lead to CS specialization we would expect to see stronger changes in planned CS rates (and less so in unplanned CS).

Using the same specification as in equation (1), we estimate the reduced form effects of hospital-level obesity prevalence on newborn health outcomes that could be affected by CS specialization as they may be affected during delivery (i.e. Apgar score, maternal survival, and whether there was birth trauma or injury). Any positive effects of higher hospital-obesity on birth outcomes are likely to be lower bounds of "true" effects, as in general, increases

---

on February-2010, we assigned the monthly average index of the last quarter of 2009 (October to December).

[17] We check whether our results are robust to alternative definitions of unplanned CS as the early morning hours mentioned in Costa-Ramón et al. (2018)

in mothers' weight may be associated to worse health outcomes in newborns (Gallardo et al. 2015; Khashan and Kenny 2009) and macrosomic newborns—more frequently born to OWOB mothers—are more likely to suffer from birth trauma or injury (McDonald et al. 2010; Wollschlaeger et al. 1999). Such bias would work against finding any *positive* effects of hospital-level obesity on newborns' health. As with our analysis of obesity on CS, we estimate effects separately for planned and unplanned CS deliveries. While obesity is likely to directly affect health outcomes for newborns from planned CS (as obesity itself is a risk factor for CS), a relationship between changes in obesity and health outcomes of newborns from *unplanned* CS is more likely to reflect spillovers of specialization (and weaker direct effects as might be the case when looking at planned CS).

Then, we analyze the effects of changes in obesity on the birth outcomes of newborns born vaginally. While benefits of CS specialization should in theory not affect birth outcomes for vaginal births, we argue that if obesity leads to increases in CS, and marginally risky mothers who would have otherwise delivered vaginally are induced to deliver via CS due to specialization, the average risk of women delivering vaginally falls. This would be consistent with an improvement in newborn health outcomes for newborns born vaginally—for both delivery-related and -unrelated health outcomes—due to selection. A similar (and positive) selection effect would be observed for CS newborns as the marginally risky mother switching from vaginal birth to CS would be relatively less risky than the average mother having a CS in the absence of specialization, thus decreasing average risk. However, specialization may also lead to worse delivery-related birth outcomes for vaginal births (the competing treatment) if physicians become less skilled at this procedure as they specialize in CS. Hence the expected direction of specialization on delivery-related birth outcomes for vaginal births is *a priori* ambiguous.

In addition, we analyze heterogeneous effects of the hospital obesity index on CS by mother's age and education. Finally, as a placebo test, we estimate our models using birth outcomes that are arguably not determined at time of delivery (i.e. birth weight, low birth weight, and very low birth weight). If our specialization hypothesis is correct, we would expect to see a null or small effect of the obesity index on these health outcomes, particularly for unplanned CS.

As a robustness test, we explore whether changes in the obesity index affect birth outcomes independently of their direct effect on the probability of birth via CS. In particular, we explore the association between the obesity index and delivery-related birth outcomes for a subgroup of newborns that are most frequently (almost always) born via CS: preterm newborns. A positive effect on delivery-related birth outcomes of the obesity index for this subgroup is likely to reflect an improvement in doctors' skills from specialization.

A relevant concern to our identification strategy would arise if women endogenously sorted into high/low specialization hospitals according to their underlying health risks. We argue that this type of endogenous selection of hospitals would be likely to bias our results against finding a positive effect of obesity on health outcomes, as relatively riskier women would choose to deliver in highly specialized CS hospitals (and if our hypothesis holds, in high obesity hospitals), thus leading to worse health outcomes in general. In any case, we estimate our preferred model for the effect of obesity index on CS rates separately for municipalities with only one hospital and for at least two hospitals separately. We argue that endogenous hospital choice is less likely to be present in municipalities with only one hospital. Additionally, these concerns are also alleviated as the setting we study is limited to women delivering in public hospitals where women are assigned the clinic they must attend and therefore have limited choice.

Furthermore, we estimate the effects of CS specialization on newborn health outcomes by using an instrumental variable (IV) approach in which we leverage the variation of the obesity index to instrument a mother's CS and thus address the endogeneity between mothers' type of delivery and child health. This complements our reduced form analysis where we show the effect of obesity directly on birth outcomes (and we can think of the models where we use CS as the dependent variable as a first stage). It is worth noting that IV estimates should be interpreted as LATE estimates, thus giving us information about the effect for women that delivered via CS because of doctors' specialization (i.e., compliers).

Finally, in section 5, we show that our findings are robust to alternative specifications. First, we estimate our models including alternative definitions of our quarter-lagged hospital-level obesity index. One might be concerned that our results are exclusively driven by the short-run fluctuation of the obesity index. Therefore, we test whether our results are robust to estimating our models with a one-year lagged index and the moving average index over the 12 months. Furthermore, we estimate model specifications that control for specific linear time trends to test that our findings are not subject to omitted variables. Finally, since our estimation sample is limited to the public hospitals that have at least eight birhts per month in every year of our study, and as such, we have a balanced panel of facilities; we estimate our models with all the hospitals in the SSA database, i.e. the unbalanced panel of hospitals.

4 Results

We first estimate the effects of the hospital-level obesity measure on women's likelihood of having a CS. Table 2 shows the estimates for all LRFBs (column 1), planned CS (column 2), and unplanned CS (column 3).

There is a positive relationship between changes in obesity at the hospital-level and changes in the individual probability that a woman delivers via CS. An increase of one standard deviation in hospital-level obesity in 2008 leads to a 0.3 percentage points (p.p.) increase in the probability of having a CS. Given the 2008 CS rates of 35%, this corresponds to an increase in CS of approximately 0.9%. This estimate is relevant as it corresponds to the sample of women who ex-ante have a lower risk of having a CS.

As expected, this effect is driven by CS identified as planned, and is statistically insignificant for CS identified as unplanned. For planned CS deliveries, an increase of hospital obesity of one standard deviation is associated with an increase in the probability of CS of 0.5 percentage points, or 1.25% with respect to the outcome mean in 2008. Moreover, this result is consistent with estimations of heterogeneous effects of our hospital-obesity index on CS by the day of the week (see Appendix Table A.2). We find that the obesity-index effects are driven by the CS birth deliveries occurring from Monday to Thursday, suggesting that these CS are more likely to be planned or scheduled. This evidence could be consistent with our hypothesis of specialization. However, other explanations might also be at work, as discussed in Section 4.1.

Next, we show the reduced form effects of our hospital-level obesity measure on newborn health for delivery-related and delivery-unrelated health outcomes. In Table 3,Panel A, we observe a significant decrease in the probability of experiencing birth trauma or birth injury. This result is consistent with higher physicians' specialization in CS due to an increase in risky pregnancies at the hospital level from a heavier population of women of reproductive age. As doctors are more likely to perform CS, they become more skilled at this procedure, and develop a preference for it. Delivery-related outcomes such as the likelihood of birth trauma or injury thus decrease with specialization. This effect is present for both types of CS (planned and unplanned), with an almost identical magnitude reduction in percentage terms for birth injury (6.8%) and birth trauma (8.5%). We also observe improvements in birth outcomes for vaginal births in the case of birth injury, but not of birth trauma, and the effect is smaller in magnitude. This finding could be interpreted as a selection effect: to the extent that specialization leads to marginally risky women to deliver via CS, the average risk of women delivering vaginally falls—thus improving delivery-related health for newborns born vaginally as well. Table 3 also shows an increase in the probability of mother survival after delivery. Consistent with our hypothesis of specialization, this effect is driven by planned CS.

Table 3 shows an increase in the probability of having an Apgar score < 9 for vaginal births. Low Apgar scores are often the result of prolonged labor (Card et al. 2019; Altman et al. 2015), which is more likely for vaginal births as CS tend to be quicker (Costa-Ramón et al. 2018). This finding supports our specialization hypothesis: a higher probability of a low Apgar in vaginal births can be explained by doctors becoming specialized in CS and less skilled in vaginal deliveries. This is in line with results on negative externalities on patients receiving the competing treatment (in our case, a vaginal birth as opposed to a CS) discussed in Chandra and Staiger (2007).

Table 4 shows the effects of our hospital-level obesity measure on delivery-unrelated health outcomes, namely on a set of transformations of the birth weight variable. We observe a positive effect of our hospital-level obesity index on the probability of a newborn being macrosomic (i.e. having a birth weight higher than 4,500 gr), driven by unplanned CS deliveries, and find no statistically significant effects on the probability of being LBW or VLBW. These results provide a falsification test adding validity to the interpretation of our results as evidence of CS specialization. While we would expect an association between hospital-level obesity and macrosomia as mother's obesity is a risk factor for fetal macrosomia (Khashan and Kenny 2009), we would not expect the probability of LBW and VLBW (conditional on gestational age) to be affected by our hospital-obesity index (McDonald et al. 2010).

4.1 Mechanisms

Our findings support the hypothesis that an increase in hospital-level obesity prevalence increases a woman's probability of CS affecting her newborn's delivery-related outcomes through the specialization channel. However, it is possible that other mechanisms might be at play. In Table A.3 in the Appendix, columns 2–4, we analyze differential effects by first time mothers' age. Variation in our measure of facility-level obesity on CS is concentrated among women under 24—although we also find a strong effect albeit marginally significant for women over 30. This result might indicate that the effect of CS specialization is probably concentrated in marginal pregnancies, where the underlying risk of having a CS is not too high. In addition, Table A.3, columns 5-6, shows that the effect of hospital-level obesity measure on CS is both larger and statistically stronger for women with lower than average schooling (i.e. less than 8 years of education). Overall, estimates from Table A.3 suggest that our results are unlikely to be driven by higher educated women's preferences over the type of birth delivery or by selection.

It is also possible that changes in CS are supply driven. In particular, if doctors in hospitals with higher increases in obesity face differential monetary incentives to perform CS, our estimates could be driven by the supply side. However, this is unlikely as physicians working at public hospitals are salaried workers who earn a monthly wage, and receive no additional benefits based on the number or type of deliveries they perform.

An alternative explanation to our results is that they could be driven by greater incentives to perform CS due to space limitations, if changes in obesity at the hospital level are correlated with changes in hospital congestion. For instance, CS deliveries take less time than vaginal ones (Costa-Ramón et al. 2018). However, our specifications control for changes in the contemporaneous monthly volume of births at the hospital level, which would capture changes in congestion. Hence, our estimates are not likely driven by congestion.

5 Robustness

First, we start by analyzing the effects of our hospital-level obesity measure on health outcomes for premature newborns. Table A.4 shows evidence consistent with a specialization hypothesis, as a positive association between the obesity index and delivery-related birth outcomes for preterm newborns (who are almost always delivered via CS) would (only) be expected if higher obesity improves physicians' CS skills through CS specialization. We observe that the probability of both birth injury and birth trauma decreases for preterm newborns as obesity levels increase at the hospital level.

Second, to alleviate concerns regarding endogenous hospital choice (i.e., women with riskier pregnancies choose a more specialized hospital), we estimate heterogeneous effects of our models by the number of hospitals in the woman's municipality of residence. The idea behind this estimation is that women living in municipalities with only one hospital do not have other choice of care. This is plausible in our setting, since 80% of the women in our sample have public health insurance and are assigned to have their birth deliveries in the closest public health clinic. In Table A.5 we observe that the association between the hospital-level obesity index and the probability of delivering via CS is positive and statistically significant for both municipalities with only one and at least two clinics. Furthermore, Table A.6 also shows that our results on delivery-related birth outcomes are similar across both types of municipalities. Overall, selection into hospital does not appear to be driving our results.

Finally, in Appendix Table A.7, we estimate the effects on newborn health using the obesity index as an instrument for CS. We estimate these IV models for the sample of all LRFBs. Consistent with our results on delivery-related health outcomes in Table 3, we find that CS decreases the likelihood of having birth injury or birth trauma and increases the likelihood of mother survival. CS also increases the probability of having an Apgar score$<$ 9, likely driven by "compliers" (i.e., women having CS in hospitals specializing in CS due to obesity increases that would have not had one in a low obesity hospital).[18] We also validate that the type of delivery does not affect the probability of being LBW or VLBW and that it has a statistically, and positive effect on the probability of a newborn being macrosomic (Khashan and Kenny 2009).

---

[18] Intuitively, these compliers are less likely to have a medically indicated CS and if a vaginal birth was attempted before the CS, prolonged labor may explain the low Apgar score (Card et al. 2019).

5.1 Alternative specifications

We show that our results are robust to a series of alternative specifications, where we modify either the sample of women/hospitals we use in our estimations, the way in which the obesity index is aggregated, or the definition of CS unplanned.

First, we test whether our results are robust to using an alternative definition of unplanned CS. Following Costa-Ramón et al. (2018), we define unplanned CS as those happening during the early hours of the night between 11pm and 4am. Table A.8 shows that our hospital-level obesity index increases the probability of a CS delivery, and the results are driven by planned CS as we earlier describe and that our results are thus robust to this alternative definition of unplanned CS. Similarly, Table A.9 shows that our results on delivery-related birth outcomes are also robust to this alternative specification of unplanned CS.

Second, we use alternative specifications to our monthly obesity measure that is lagged by one quarter with respect to the delivery date. In Appendix Table A.10, Panel A, we explore whether the results change when we use the obesity index lagged by one year (as opposed to quarter).[19] We show that our results are consistent with those in Table 2: our hospital-level obesity measure increases the probability of CS delivery and this effect is higher for planned CS. Furthermore, we estimate our models using a hospital-level obesity index calculated as a moving average of the obesity cases over the past 12 months.[20] Appendix Table A.10, Panel B, shows that this measure of obesity increases a woman's probability of CS delivery and the effect is larger for those women undergoing a planned CS. Together these exercises show that our results are not driven by short-run fluctuations in our hospital-obesity measure.

Third, we estimate our models using all public health facilities included in the SSA data by not restricting our estimation to hospitals that had at least eight monthly births during

---

[19] This lagged index is calculated as the average monthly index for the calendar year preceding the birth date.

[20] This lagged index is calculated as the average of the 12 months preceding the birth date.

every year over our study period. Appendix Table A.10, Panel C, shows that our results remain robust to this specification.

Fourth, we show that our results on the effects of our measure of hospital-level obesity on the probability of having a CS are robust to adding state-specific linear time trends in Appendix Table A.10, Panel D. Therefore, we are not concerned that seasonal or omitted trends at the state level are driving our results.

Finally, Panels A-D of Appendix Table A.11 show that our results for delivery-related birth outcomes for CS births are also robust to the different models discussed above: different specifications of the hospital-obesity index, the estimations with the unbalanced panel, and the addition of the state-linear time trends.[21]

6 Conclusion

Over the past decades CS rates have increased worldwide. Similarly, obesity prevalence—a risk factor for CS—has also dramatically increased. We build a novel measure of hospital-level obesity exploiting data from patient diagnoses. We study whether public hospitals with a higher obesity prevalence have higher CS rates and whether that has an impact on newborn health outcomes in Mexico. Our results thus speak to how the use of intensive treatments may affect health outcomes (as in Doyle et al. (2015)w) which is a key policy concern given the ample variation in treatment choice (i.e., CS) observed in Mexico and other contexts.

We find that hospital-level obesity increases a woman's probability of CS, particularly planned CS, among a sample of first time mothers and LRFBs. Our findings suggest a potential story of CS specialization in which doctors develop a preference for CS procedures in hospitals with high female obesity prevalence and become more skilled at performing CS.

---

[21] Our results on delivery-related birth outcomes by type of delivery (CS planned, CS unplanned and vaginal) are also robust to the alternative definitions of the obesity index, the addition of state-linear time trends, and estimations using the unbalanced panel. Results are available upon request.

While other mechanisms might be at play, our findings are not consistent with demand driven channels (e.g. higher educated women's preferences over the type of birth delivery), with differential monetary incentives to perform CS in higher-obesity hospital, or with greater incentives to perform CS due to hospital congestion.

Furthermore, we find some evidence that CS specialization may lead to better birth outcomes for certain sub-set of women, consistent with evidence on productivity spillovers in health care (Chandra and Staiger 2007). Delivery-related birth outcomes improve for planned CS: we observe a reduction in birth injuries, birth trauma, and increased mother survival. For unplanned CS, we also observe a reduction in the probability of birth injury and birth trauma—consistent with CS specialization. We find that for vaginal births there is an increased probability of having a low Apgar score, which may be explained by doctors becoming specialized in CS and less skilled in vaginal deliveries.

References

Altman, Maria, Anna Sandström, Gunnar Petersson, Thomas Frisell, Sven Cnattingius, and Olof Stephansson, "Prolonged second stage of labor is associated with low Apgar score," *European journal of epidemiology*, 2015, *30* (11), 1209–1215.

Betran, Ana Pilar, Jiangfeng Ye, Ann-Beth Moller, João Paulo Souza, and Jun Zhang, "Trends and projections of caesarean section rates: global and regional estimates," *BMJ Global Health*, 2021, *6* (6), e005671.

Boerma, T., C. Ronsmans, D. Y. Melesse, A. J. Barros, F. C. Barros, L. Juan, and M. Temmerman, "Global epidemiology of use of and disparities in caesarean sections," *The Lancet*, 2018, *392* (10155), 1341–1348.

Brenes-Monge, A., B. Saavedra-Avendaño, J. Alcalde-Rabanal, and B. G. Darney, "Are overweight and obesity associated with increased risk of cesarean delivery in Mexico? A cross-sectional study from the National Survey of Health and Nutrition," *BMC pregnancy and childbirth*, 2019, *19* (1), 239.

Card, D., A. Fenizia, and D. Silver, "The Health Impacts of Hospital Delivery Practices," 2019. National Bureau of Economic Research, Working Paper No. w25986.

Chandra, Amitabh and Douglas O Staiger, "Productivity spillovers in health care: evidence from the treatment of heart attacks," *Journal of political Economy*, 2007, *115* (1), 103–140.

Cnattingius, S., E. Villamor, S. Johansson, A. K. E. Bonamy, M. Persson, A. K. Wikström, and F. Granath, "Maternal obesity and risk of preterm delivery," *The Lancet*, 2013, *309* (22), 2362–2370.

Costa-Ramón, A. M., A. Rodríguez-González, M. Serra-Burriel, and C. Campillo-Artero, "It's about time: Cesarean sections and neonatal health," *Journal of Health Economics*, 2018, *59*, 46–59.

Currie, J. and W. B. MacLeod, "First do no harm? Tort reform and birth outcomes," *Quarterly Journal of Economics*, 2008, *123* (2), 795–830.

Doyle, Joseph J, John A Graves, Jonathan Gruber, and Samuel A Kleiner, "Measuring returns to hospital care: Evidence from ambulance referral patterns," *Journal of Political Economy*, 2015, *123* (1), 170–214.

Fyfe, E. M., N. H. Anderson, R. A. North, E. H. Chan, R. S. Taylor, G. A. Dekker, and Screening for Pregnancy Endpoints (SCOPE) Consortium, "Risk of first-stage and second-stage cesarean delivery by maternal body mass index among nulliparous women in labor at term," *Obstetrics & Gynecology*, 2011, *117* (6), 1315–1322.

Gallardo, Juan Manuel, Jaqueline Gómez-López, Patricia Medina-Bravo, Francisco Juárez-Sánchez, Alejandra Contreras-Ramos, Matilde Galicia-Esquivel, Rocío Sánchez-Urbina, and Miguel Klünder-Klünder, "Maternal obesity increases oxidative stress in the newborn," *Obesity*, 2015, *23* (8), 1650–1654.

Gibbons, L., J. Belizán, J. A. Lauer, A. P. Beltrán, M. Merialdi, and F. T. Althabe, "The global numbers and costs of additionally needed and unnecessary caesarean sections performed per year: Overuse as a barrier to universal coverage," Technical Report, WHO, Geneva, Switzerland 2010. Report No.: Background Paper 30.

Greene, William, "Estimating Econometric Models with Fixed Effects," Technical Report, New York University, Leonard N. Stern School of Business- 2001.

Guendelman, S., A. Gemmill, D. Thornton, D. Walker, M. Harvey, J. Walsh, and R. Perez-Cuevas, "Prevalence, disparities, and determinants of primary cesarean births among first-time mothers in Mexico," *Health Affairs*, 2017, *36* (4), 714–722.

Heckman, James J, *The incidental parameters problem and the problem of initial conditions in estimating a discrete time-discrete data stochastic process.*, Cambridge: MIT Press, 1981.

Jachetta, C., "Cesarean Sections and Later Child Health Outcomes," 2014.

Jensen, V. M. and M. Wust, "Can cesarean section improve child and maternal health? The case of breech babies," *Journal of Health Economics*, 2015, *39*, 289–302.

Kearns, K., A. Dee, A. P. Fitzgerald, E. Doherty, and I. J. Perry, "Chronic disease burden associated with overweight and obesity in Ireland: the effects of a small BMI reduction at population level," *BMC Public Health*, 2014, *14* (1), 143.

Khashan, Ali S and Louise C Kenny, "The effects of maternal body mass index on pregnancy outcome," *European journal of epidemiology*, 2009, *24* (11), 697.

Kominiarek, Michelle A, Paul VanVeldhuisen, Judith Hibbard, Helain Landy, Shoshana Haberman, Lee Learman, Isabelle Wilkins, Jennifer Bailit, Ware Branch, Ronald Burkman et al., "The maternal body mass index: a strong association with delivery route," *American journal of obstetrics and gynecology*, 2010, *203* (3), 264–e1.

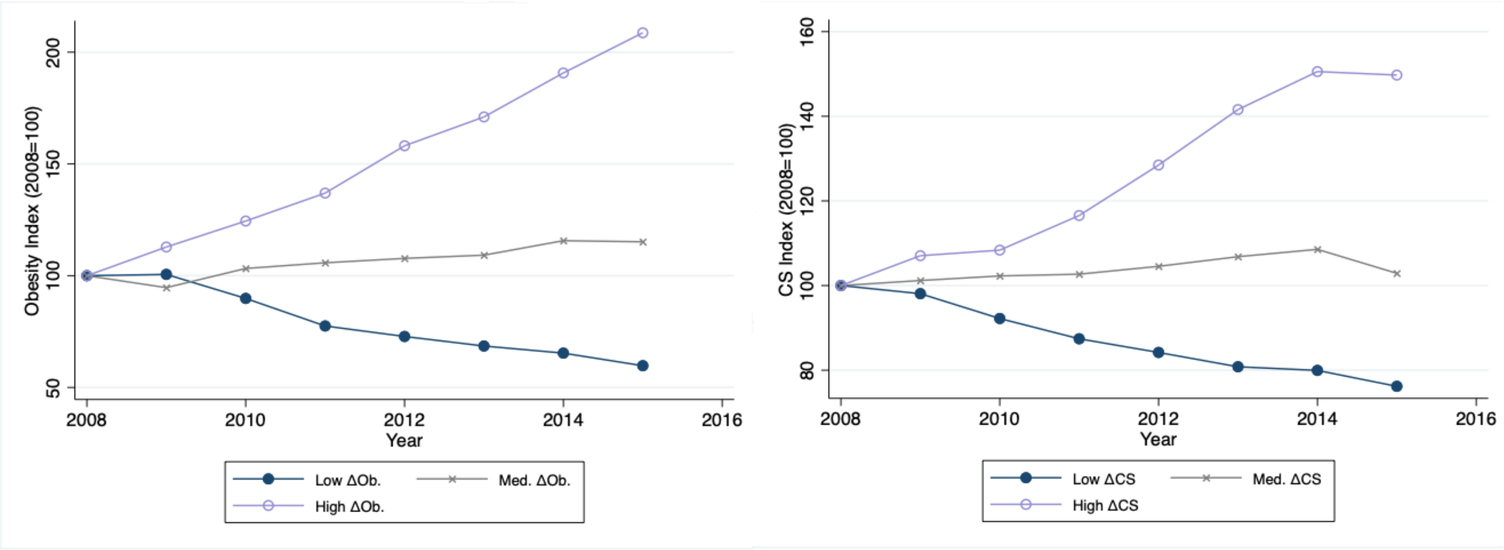
Kotchen, T. A., "Obesity-related hypertension: epidemiology, pathophysiology, and clinical management," *American Journal of Hypertension*, 2010, *23* (11), 1170–1178.

Kozhimannil, K. B., M. C. Arcaya, and S. V. Subramanian, "Maternal clinical diagnoses and hospital variation in the risk of cesarean delivery: Analyses of a national US hospital discharge database," *PLOS Medicine*, 2014, *11* (10), e1001745.

McDonald, Sarah D, Zhen Han, Sohail Mulla, and Joseph Beyene, "Overweight and obesity in mothers and risk of preterm birth and low birth weight infants: systematic review and meta-analyses," *Bmj*, 2010, *341.*

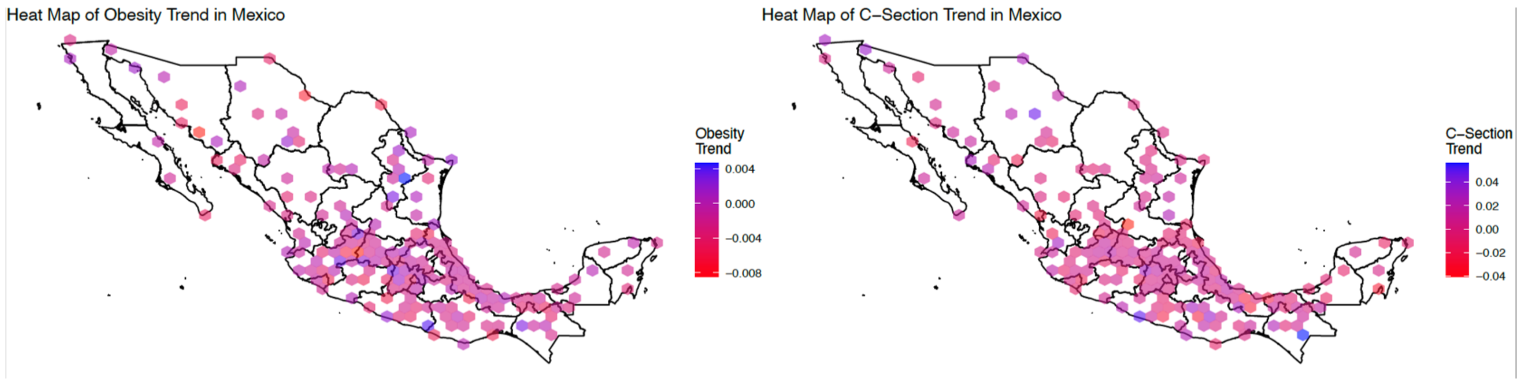
Wollschlaeger, Kerstin, Jürgen Nieder, Ingrid Köppe, and Katrin Härtlein, "A study of fetal macrosomia," *Archives of gynecology and obstetrics*, 1999, *263* (1), 51–55.

Figure 1: **Time variation in hospital-level CS and obesity rates**



Notes: obesity index (left) and CS rate (right) averaged within group according to the hospital type specified in the legend using year 2008 as the baseline year. Hospitals were classified as low/medium/high variable change according to their observed individual linear time trend for each variable, and sorted into groups of size according to it: low change (25%), medium (50%), high (25%). A hospital may be in one category for obesity changes and in another when it comes to CS changes (i.e. high obesity change but medium CS change).

Figure 2: **Geographic variation in CS and obesity time trends**



Notes: hospitals' linear trend for obesity index (left) or CS rate (right) over the study period (2008-2015). These are "Hexbin" maps which use density 2d technique plotted on top of a map. Each figure shows the distribution of a variable (obesity and c-section) on a map, splitting the map into a set of hexagons. The bandwidth chosen in the figures is 0.6, and only the hexagons with a positive count of points (hospitals) are shown on the map.

Table 1: **Summary statistics by hospital-level obesity index (2008)**

	High-obesity hospitals		Low-obesity hospitals			
	Mean	Std. Dev.	Mean	Std. Dev.	Diff	t-test
Panel A: Mother characteristics						
Age	21.51	0.45	21.52	0.38	0.01	(0.20)
Schooling	9.84	0.70	9.52	0.76	-0.32***	(-3.59)
Married	0.27	0.13	0.26	0.12	-0.01	(-0.59)
Panel B: Birth outcomes						
Delivery related outcomes						
CS	0.39	0.11	0.34	0.11	-0.05***	(-3.73)
Apgar	8.89	0.11	8.90	0.11	0.01	(1.07)
Apgar < 9	0.09	0.08	0.08	0.06	-0.01	(-1.28)
Birth injury	9.62	13.39	12.15	16.50	2.53	(1.38)
Birth trauma	4.69	7.68	6.56	12.17	1.87	(1.51)
Mother survival	996.24	6.63	997.26	5.52	1.03	(1.37)
No. prenatal visits	6.53	0.69	6.52	0.74	-0.01	(-0.09)
Non-delivery related outcomes						
Deliveries	50.55	43.03	39.55	36.80	-11.00**	(-2.24)
Gestational weeks	39.46	0.14	39.48	0.15	0.02	(1.04)
Low birth weight	0.02	0.01	0.02	0.01	-0.00	(-0.79)
Very low birth weight	0.00	0.00	0.00	0.00	-0.00	(-0.65)
Weight	3204.72	85.40	3182.54	82.55	-22.18**	(-2.16)
Obesity index	0.76	0.90	-0.54	0.35	-1.30***	(-15.47)
No. hospitals	134		133		267	

Notes: $^{*}p < 0.1,^{**}p < 0.05,^{***}p < 0.01$. High-obesity hospitals are hospitals with an average standardized obesity index higher than the sample median in 2008. Sample consists of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits. Apgar$<$ 9 is a dummy variable for whether the Apgar is less than 9. Birth injury is a dummy variable for having a birth injury multiplied by 1000. Birth trauma is a dummy variable for having a birth trauma multiplied by 1000. Mother survival is a dummy for mother survival multiplied by 1000. Low birth weight is a dummy variable for having low birth weight (lower than 2,500 gr). Very low birth weight is a dummy variable for having very low birth weight (lower than 1,500 gr). Obesity index: Standardized monthly obesity index.

TABLE 2: **Higher hospital obesity index increases the probability of CS**

	Planned & unplanned CS (1)	Planned CS (2)	Unplanned CS (3)
Obesity index (lagged one quarter)	0.003**	0.005***	0.001
	(0.001)	(0.002)	(0.001)
2008 dep. var. mean	0.35	0.40	0.32
No. mothers	1,093,036	460,862	632,174
No. hospitals	267	267	267

Notes: $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$. All models control for a woman's age, education, marital status, gestational weeks, number of prenatal visits, number of births, and month and hospital fixed effects. Standard errors clustered at the hospital level. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. CS unplanned if the birth occurred during the night hours (defined as 8pm to 8am) or weekends. Obesity index: monthly standardized and lagged one quarter.

TABLE 3: **Reduced form evidence: the effect of obesity index on delivery-related birth outcomes**

	Apgar (1)	Apgar< 9 (2)	Birth injury (3)	Birth trauma (4)	Mother survival (5)
Panel A: All births					
Obesity index	-0.001	0.001***	-0.476***	-0.274***	0.130*
	(0.001)	(0.000)	(0.141)	(0.103)	(0.072)
2008 dep. var. mean	8.86	0.10	7.29	3.49	989.61
No. mothers	1,064,186	1,072,757	1,072,757	1,072,757	1,072,757
Panel B: Planned CS					
Obesity index	-0.000	0.001	-0.497*	-0.360**	0.394**
	(0.002)	(0.001)	(0.285)	(0.165)	(0.181)
2008 dep. var. mean	8.88	0.09	6.66	1.82	986.82
No. mothers	186,494	187,765	187,765	187,765	187,765
Panel C: Unplanned CS					
Obesity index	-0.002	0.001	-0.641**	-0.452**	-0.088
	(0.002)	(0.001)	(0.310)	(0.183)	(0.184)
2008 dep. var. mean	8.86	0.10	7.69	2.61	985.91
No. mothers	198,383	199,970	199,970	199,970	199,970
Panel D: Vaginal births					
Obesity index	-0.001	0.001***	-0.378**	-0.142	0.140*
	(0.001)	(0.000)	(0.187)	(0.147)	(0.085)
2008 dep. var. mean	8.86	0.10	7.34	4.18	991.39
No. mothers	679,309	685,022	685,022	685,022	685,022

Notes: $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$. All models control for woman's age, schooling, and marital status, birth weight, gestational weeks, number of births, number of prenatal consults, and month and hospital fixed effects. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. 20 prenatal visits. Apgar< 9Apgar< 9 is a dummy variable for is a dummy variable for whether the Apgar is less than 9. Birth injury is a dummy variable for having a birth injury multiplied by 1000. Birth trauma is a dummy variable for having a birth trauma multiplied by 1000. Mother survival is a dummy for mother survival multiplied by 1000. Unplanned if the birth occurred during the night hours (i.e. 8pm-8am) or weekends. Obesity index standardized monthly.

Table 4: **The effect of the obesity index on delivery-unrelated birth outcomes**

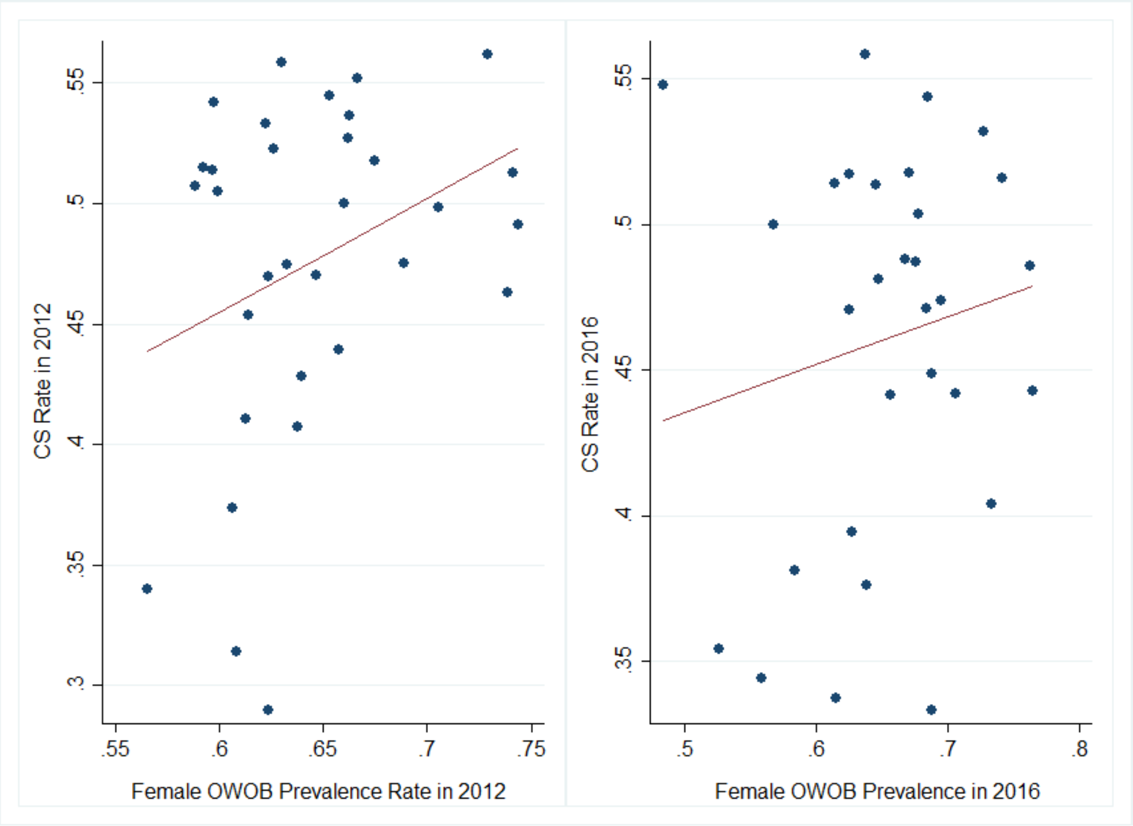
	Low birth weight (1)	Very low birth weight (2)	Macrosomia (3)
Panel A: All births			
Obesity index	-0.000	-0.000	0.001**
	(0.000)	(0.000)	(0.000)
2008 dep. var. mean	0.05	0.00	0.00
No. mothers	1,121,924	1,121,924	1,121,924
Panel B: Planned CS			
Obesity index	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.001)
2008 dep. var. mean	0.04	0.00	0.01
No. mothers	196,086	196,086	196,086
Panel C: Unplanned CS			
Obesity index	0.000	-0.000	0.001**
	(0.000)	(0.000)	(0.001)
2008 dep. var. mean	0.05	0.00	0.01
No. mothers	208,986	208,986	208,986
Panel D: Vaginal births			
Obesity index	-0.000	-0.000	0.001
	(0.000)	(0.000)	(0.000)
2008 dep. var. mean	0.05	0.00	0.00
No. mothers	716,852	716,852	716,852

Notes: $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$. All models control for woman's age, schooling, and marital status, gestational weeks, number of births, number of prenatal consults, and month and hospital fixed effects. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. Low birth weight is a dummy variable for having low birth weight (lower than 2,500 gr). Very low birth weight is a dummy variable for having very low birth weight (lower than 1,500 gr). Macrosomia is a dummy variable for having fetal macrosomia (birth weight higher than 4,500 gr). Unplanned if the birth occurred during the night hours (i.e. 8pm-8am) or weekends. Obesity index: standardized monthly.

C-Sections, Obesity, and Health-Care Specialization: Evidence from Mexico

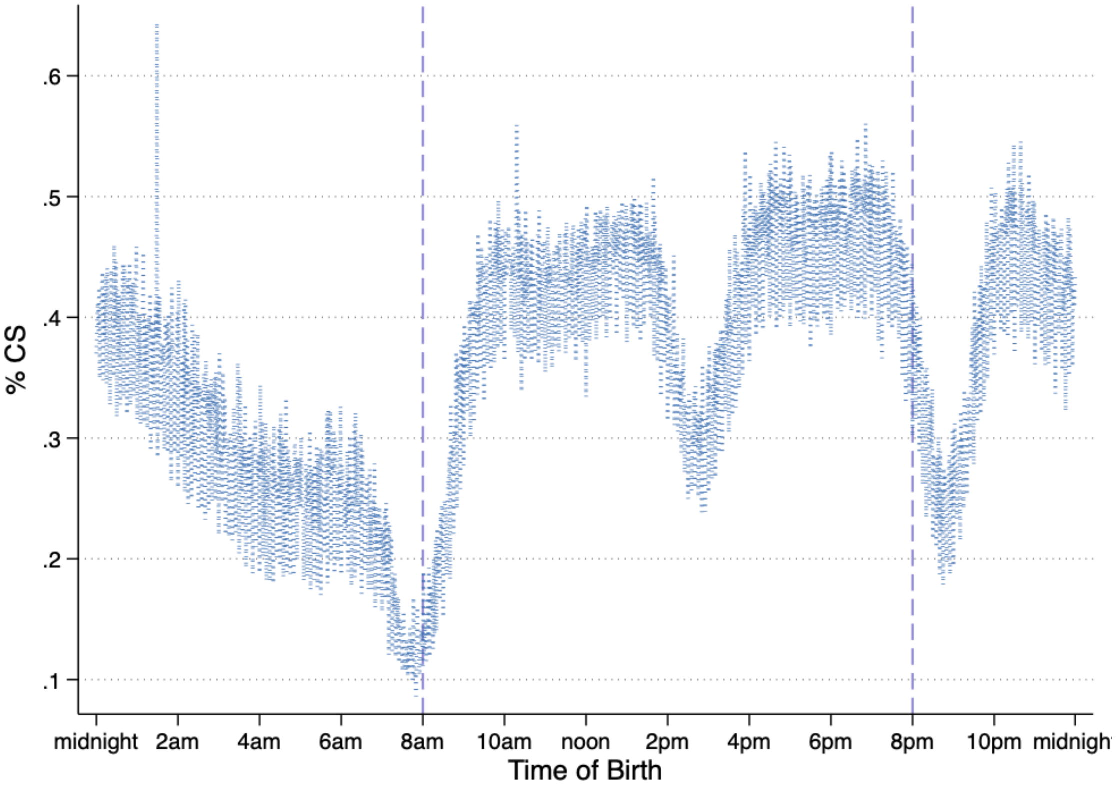
Online Appendix

Figure A.1: **2012 and 2016 Female overweight and obesity (OWOB) prevalence and CS rates at the state level (2012 and 2016)**



Source: National Surveys of Health and Nutrition (ENSANUT), 2012 and 2016.

Figure A.2: **Time of day variation in CS rates**



Notes: Minute-level CS rates are calculated for all hospitals.

Table A.1: **Correlation of the state obesity index with state-female overweight and obesity prevalence**

	Obese			Overweight and obese		
	(1)	(2)	(3)	(4)	(5)	(6)
State obesity index:						
A. restricted	0.021**			0.023***		
	(0.008)			(0.008)		
B. augmented		0.020**			0.017**	
		(0.008)			(0.008)	
C. full			0.025***			0.017**
			(0.008)			(0.008)
2008 dep. var. mean	0.32	0.32	0.32	0.65	0.65	0.65
Obs.	32	32	32	32	32	32

Notes: $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$. Dependent variable is the 2012 female obesity and overweight prevalence at the state level, calculated from the 2012 National Surveys of Health and Nutrition (Encuesta Nacional de Salud y Nutrición, ENSANUT). "Index A. restricted" includes hypertension and diabetes. "Index B. augmented" includes pregestational hypertension, pregestational diabetes, preeclampsia, gestational diabetes, hypertension and diabetes. "Index C. full" includes pregestational hypertension, pregestational diabetes, preeclampsia, gestational diabetes, hypertension, diabetes, heart disease, emphysema, elevated blood pressure, gallbladder disease, hyperlipidemia, chronic bronchitos and stroke. State obesity index standardized.

Table A.2: **Obesity index and CS: Heterogeneous effects by day of week**

	(1) All	(2) Monday-Thursday	(3) Friday	(4) Weekend
Obesity index (lagged one quarter)	0.003**	0.004***	0.001	0.000
	(0.001)	(0.002)	(0.003)	(0.002)
2008 mean dep. var.	0.35	0.36	0.37	0.32
No. mothers	1,093,036	644,925	157,640	290,471
No. hospitals	267	267	267	267

Notes: Significance levels: ${}^{*}p < 0.1, {}^{**}p < 0.05, {}^{***}p < 0.01$. Controls include mothers' age, education, marital status, gestational weeks, number of births, number of prenatal visits, and month and hospital fixed effects. Standard errors clustered at the hospital level. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. Obesity index: standardized monthly and lagged one quarter.

Table A.3: **Obesity and CS: Heterogeneous effects by mothers' age and education**

	All first-time mothers (1)	18-24 years old (2)	25-30 years old (3)	30-35 years old (4)	Low education (5)	High education (6)
Obesity index (lagged one quarter)	0.003**	0.003**	0.001	0.009*	0.004*	0.002
	(0.001)	(0.001)	(0.003)	(0.005)	(0.002)	(0.001)
2008 dep. var. mean	0.35	0.33	0.45	0.57	0.36	0.35
No. mothers	1,093,036	897,033	158,658	37,345	243,318	849,718
No. hospitals	267	267	267	267	267	267

Notes: Significance levels: ${}^{*}p < 0.1, {}^{**}p < 0.05, {}^{***}p < 0.01$. Controls include mothers' age, education, marital status, gestational weeks, number of births, number of prenatal visits, and month and hospital fixed effects. Standard errors clustered at the hospital level. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. Obesity index: standardized monthly and lagged one quarter.

Table A.4: **Validation test: the effect of obesity index on delivery-related birth outcomes for premature births**

	Apgar (1)	Apgar9 (2)	Birth Injury (3)	Birth Trauma (4)	Mother Survival (5)
Obesity index	-0.001	0.001	-1.000***	-0.251***	0.059
	(0.001)	(0.000)	(0.175)	(0.070)	(0.075)
2008 mean dep. var.	8.67	0.19	14.59	1.58	988.29
No. mothers	1,006,263	1,014,777	1,014,777	1,014,777	1,014,777

Notes: Significance levels:$^{*}p < 0.1, ^{**}p < 0.05, p < 0.01$. All models control for woman's age, schooling, marital status, gestational weeks, number of births, number of prenatal visits, and month and hospital fixed effects. Standard errors clustered at the hospital level. All models are estimated using the sample of mothers 15-45 years of age with 37 or less gestation weeks. Apgar is based on a total score between 0 and 10, where a higher score reflects a better health outcome. Apgar$<$ 9 is a dummy variable for whether the Apgar is less than 9. Birth injury is a dummy variable for having a birth injury multiplied by 1000. Birth trauma is a dummy variable for having a birth trauma multiplied by 1000. Mother survival is a dummy for mother survival multiplied by 1000. Obesity index: monthly standardized.

Table A.5: **Hospital obesity index and CS probability according to number of hospitals per municipality**

	Planned & unplanned CS (1)	Planned CS (2)	Unplanned CS (3)
Panel A: One clinic			
Obesity index	0.007***	0.006***	0.007***
	(0.001)	(0.001)	(0.001)
2008 mean dep. var.	0.36	0.42	0.32
No. mothers	538,353	234,570	303,783
No. hospitals	202	201	201
Panel B: More than one clinic			
Obesity index	0.003**	0.005***	0.002
	(0.001)	(0.002)	(0.001)
2008 mean dep. var.	0.34	0.38	0.31
No. mothers	583,471	238,441	345,030
No. hospitals	87	86	87

Notes: $^{*}p < 0.1,^{**}p < 0.05,^{***}p < 0.01$. All models control for woman's age, schooling, and marital status, birth weight, gestational weeks, number of births, number of prenatal consults, and month and hospital fixed effects. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. Unplanned if the birth occurred during the night hours (i.e. 8pm-8am) or weekends. Obesity index: monthly standardized.

Table A.6: **Effect of obesity index on delivery-related birth outcomes according to number of hospitals per municipality)**

	Apgar (1)	Apgar< 9 (2)	Birth injury (3)	Birth trauma (4)	Mother survival (5)
Panel A: One clinic					
Obesity index	-0.001	0.001***	-0.476***	-0.274***	0.130*
	(0.001)	(0.000)	(0.141)	(0.103)	(0.072)
2008 mean dep. var.	8.86	0.10	7.29	3.49	989.61
No. mothers	1,064,186	1,072,757	1,072,757	1,072,757	1,072,757
Panel B: More than one clinic					
Obesity index	-0.006***	0.003***	-0.901**	-0.686**	-0.425*
	(0.002)	(0.001)	(0.422)	(0.285)	(0.248)
2008 mean dep. var.	8.91	0.07	6.66	2.90	983.50
No. mothers	119,880	120,303	120,303	120,303	120,303

Notes: Significance levels: $^*p < 0.1,^{**} p < 0.05, p < 0.01$. All models control for woman's age, schooling, marital status, gestational weeks, number of births, number of prenatal visits, and month and hospital fixed effects.All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. 20 prenatal visits. Apgar< 9Apgar< 9 is a dummy variable for is a dummy variable for whether the Apgar is less than 9. Birth injury is a dummy variable for having a birth injury multiplied by 1000. Birth trauma is a dummy variable for having a birth trauma multiplied by 1000. Mother survival is a dummy for mother survival multiplied by 1000. Obesity index: monthly standardized.

TABLE A.7: **IV estimates: the effect of CS on birth outcomes**

	Apgar (1)	Apgar < 9 (2)	Birth injury (3)	Birth trauma (4)	Mother survival (5)	Low birth weight (6)	Very low birth weight (7)	Macro-somia (8)
All CS	-0.175	0.240***	-89.680***	-53.305***	21.795*	-0.034	-0.008	0.112**
	(0.127)	(0.061)	(26.479)	(18.745)	(12.656)	(0.035)	(0.005)	(0.047)
2008 dep. var. mean	8.86	0.10	7.29	3.49	989.61	0.05	0.00	0.00
No. mothers	1,112,848	1,121,924	1,121,924	1,121,924	1,121,924	1,121,924	1,121,924	1,121,924
F-stat: first stage	70.80	175.04	75.14	71.96	33.52	91.87	5.03	88.89

Notes: Significance levels:$^{*}p < 0.1,^{**}p < 0.05, p < 0.01$. All models control for woman's age, schooling, birth weight, marital status, gestational weeks, number of births, number of prenatal visits, and year and hospital fixed effects. Standard errors clustered at the hospital level. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. The F stat comes from the first stage of the IV model. Apgar is based on a total score between 0 and 10, where a higher score reflects a better health outcome. Apgar$<$ 9 is a dummy variable for whether the Apgar is less than 9. Birth injury is a dummy variable for having a birth injury multiplied by 1000. Birth trauma is a dummy variable for having a birth trauma multiplied by 1000. Mother survival is a dummy for mother survival multiplied by 1000. Low birth weight is a dummy variable for having low birth weight (lower than 2,500 gr). Very low birth weight is a dummy variable for having very low birth weight (lower than 1,500 gr).

Table A.8: **Hospital obesity index and CS probability (unplanned CS: 11pm–4am)**

	All (1)	CS planned (2)	CS unplanned (3)
Obesity index (lagged one quarter)	0.003**	0.005***	0.001
	(0.001)	(0.002)	(0.001)
2008 mean dep. var.	0.35	0.40	0.32
No. mothers	1,093,036	460,862	632,174
No. hospitals	267	267	267

Notes:*p <0.1,**p <0.05,***p <0.01. All models control for a woman's age, education, marital status,gestational weeks, number of prenatal visits, number of births, and month and hospital fixed effects. Standard errors clustered at the hospital level. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. CS unplanned if the birth occurred during the night hours (defined as 11pm to 4am) or weekends. Obesity index: monthly standardized and lagged one quarter.

Table A.9: **Obesity index effect on delivery-related birth outcomes (unplanned CS: 11pm–4am)**

	Apgar (1)	Apgar< 9 (2)	Birth injury (3)	Birth trauma (4)	Mother survival (5)
Panel A: All births					
Obesity index	-0.001	0.001***	-0.502***	-0.296***	0.131*
	(0.001)	(0.000)	(0.138)	(0.100)	(0.069)
MDV	8.86	0.10	7.29	3.49	989.61
No. mothers	1,112,848	1,121,924	1,121,924	1,121,924	1,121,924
Panel B: planned CS					
Obesity index	-0.001	0.001	-0.628**	-0.394***	0.340**
	(0.001)	(0.001)	(0.257)	(0.148)	(0.156)
MDV	8.87	0.09	6.72	1.92	986.45
No. mothers	249,338	251,120	251,120	251,120	251,120
Panel C: unplanned CS					
Obesity index	-0.002	0.002**	-0.506	-0.476**	-0.147
	(0.002)	(0.001)	(0.353)	(0.204)	(0.205)
MDV	8.85	0.10	7.96	2.73	986.18
No. mothers	152,716	153,952	153,952	153,952	153,952
Panel D: Vaginal births					
Obesity index	-0.001	0.001***	-0.418**	-0.171	0.141*
	(0.001)	(0.000)	(0.183)	(0.143)	(0.082)
MDV	8.86	0.10	7.34	4.18	991.39
No. mothers	710,794	716,852	716,852	716,852	716,852

Notes: $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. All models control for woman's age, schooling, and marital status, birth weight, gestational weeks, number of births, number of prenatal consults, and month and hospital fixed effects. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. 20 prenatal visits. Apgar< 9Apgar< 9 is a dummy variable for is a dummy variable for whether the Apgar is less than 9. Birth injury is a dummy variable for having a birth injury multiplied by 1000. Birth trauma is a dummy variable for having a birth trauma multiplied by 1000. Mother survival is a dummy for mother survival multiplied by 1000. Unplanned if the birth occurred during the night hours (i.e. 11pm–4am) or weekends. Obesity index: standardized monthly.

TABLE A.10: **Robustness tests: Hospital obesity index increases CS probability**

	Planned & unplanned CS (1)	Planned CS (2)	Unplanned CS (3)
Panel A: One year lagged			
Obesity index (lagged one year)	0.005***	0.008***	0.003
	(0.002)	(0.002)	(0.002)
2009 dep. var. mean	0.35	0.41	0.32
No. mothers	997,956	420,669	577,287
No. hospitals	267	267	267
Panel B: Moving average index			
Moving average index	0.0072***	0.0090***	0.0064***
	(0.002)	(0.002)	(0.002)
2008 dep. var. mean	0.35	0.40	0.32
No. mothers	1,114,932	470,365	644,567
No. hospitals	262	262	262
Panel C: Unbalanced panel			
Obesity index	0.002**	0.004***	0.002
	(0.001)	(0.001)	(0.001)
2008 dep. var. mean	0.36	0.41	0.32
No. mothers	1,560,443	662,575	897,868
No. hospitals	599	599	599
Panel D: Linear time trends			
Obesity index	0.003***	0.005***	0.002
	(0.001)	(0.002)	(0.001)
2008 dep. var. mean	0.35	0.40	0.32
No. mothers	1,093,036	460,862	632,174
No. hospitals	267	267	267

Notes: Significance levels: $^{*}p < 0.1, ^{**}p < 0.05, p < 0.01$. All models control for woman's age, schooling, gestational weeks, number of births, number of prenatal consults, and marital status and month and hospital fixed effects. Standard errors clustered at the hospital level. All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. Unplanned if the birth occurred during the night hours (i.e. 8pm-8am) or weekends. Obesity index: monthly standardized and lagged one year (Panel A); standardized moving average (Panel B); monthly standardized (Panels C and D).

Table A.11: **Robustness tests: Obesity index effect on delivery-related birth outcomes**

	Apgar (1)	Apgar< 9 (2)	Birth injury (3)	Birth trauma (4)	Mother survival (5)
Panel A: One year lagged					
Obesity index (one year lagged)	-0.489***	0.002**	-0.331	-0.128	0.870***
	(0.023)	(0.001)	(0.375)	(0.217)	(0.190)
2008 mean dep. var.	10.05	0.08	7.28	2.70	991.94
No. mothers	355,933	355,933	355,933	355,933	355,933
Panel B: Moving average index					
Moving average index	-0.380***	0.001	-0.466	-0.222	0.742***
	(0.024)	(0.001)	(0.366)	(0.212)	(0.222)
2008 mean dep. var.	9.72	0.09	6.96	2.19	986.39
No. mothers	403,782	403,782	403,782	403,782	403,782
Panel C: Unbalanced panel					
Obesity index	0.000	0.000	-0.563***	-0.315***	0.070
	(0.001)	(0.000)	(0.166)	(0.096)	(0.091)
2008 mean dep. var.	8.86	0.09	6.93	2.05	988.06
No. mothers	634,723	638,393	638,393	638,393	638,393
Panel D: Linear time trends					
Obesity index	-0.001	0.001	-0.844***	-0.558***	0.187
	(0.001)	(0.001)	(0.211)	(0.122)	(0.125)
2008 mean dep. var.	8.87	0.10	7.20	2.23	986.34
No. mothers	402,054	405,072	405,072	405,072	405,072

Notes: Significance levels: $^{*}p < 0.1,^{**} p < 0.05, p < 0.01$. All models control for woman's age, schooling, marital status, gestational weeks, number of births, number of prenatal visits, and month and hospital fixed effects.All models are estimated using the sample of first-time mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. Only CS births. Apgar is based on a total score between 0 and 10, where a higher score reflects a better health outcome. Apgar< 9 is a dummy variable for whether the Apgar is less than 9. Birth injury is a dummy variable for having a birth injury multiplied by 1000. Birth trauma is a dummy variable for having a birth trauma multiplied by 1000. Mother survival is a dummy for mother survival multiplied by 1000. Obesity index: monthly standardized and lagged one year (Panel A); standardized moving average (Panel B); monthly standardized (Panels C and D).