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

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Abstract

This study explores whether hospitals with higher increases in obesity levels have higher CS rates and the consequential effects on maternal and newborn health in Mexico for 2008-2015. It models how changes in the obesity level of hospitals' patient pools may affect the quantity and quality of care by focusing on the use of CS and the potential returns to specialization. And it creates a measure of hospital-level obesity, based on the fraction of obesity-related discharges for women of childbearing age. Exploiting temporal and hospital variation of this measure, results show that higher hospital-level obesity increases a woman's probability of having a CS. Also, delivery-related birth outcomes improve: maternal mortality, birth injuries, and birth trauma decrease. The evidence is consistent with hospital-level specialization in CS leading to better birth outcomes.

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

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Cesarean section (CS) procedures have increased worldwide from 7% to 21% between 1990 and 2018 with the largest increases in low- and middle-income countries (Betran et al., 2021). These rates are beyond the 10–15% rates recommended by the World Health Organization (WHO), as CS may 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 becoming a major health issue in low- and middle-income countries (Popkin et al., 2020). Despite these trends, the literature on the determinants and consequences of CS rates pertains to high-income (Currie and MacLeod, 2008; Card et al., 2023; Costa-Ramón et al., 2018; Kozhimannil et al., 2014) rather than developing countries, where the inefficiency and inequality of the health systems are more salient, and where maternal and infant mortality are high and remain targets of the Sustainable Development Goals (SDGs). As CS are surgical procedures that can save the lives of mothers and children, it is a pressing question to investigate which factors play a role in maximizing their benefits in contexts where health systems are resource-constrained.

Empirical evidence—mostly from the US—has shown that substantial variation of CS rates across hospitals may be uncorrelated with medical needs, and that supply rather than demand factors might explain unnecessary CS procedures (Kozhimannil et al., 2014). On the one side, while there is some evidence of benefits for riskier patients (Doyle et al., 2015), the excessive use of unnecessary intensive treatments may be wasteful in terms of resources. On the other side, if underutilized, increasing their use efficiently may lead to important gains for population health. Thus, 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. This issue is especially important in developing countries with increasing CS rates and scarce resources. While in sub-Sahara Africa, an average CS rate of 5% might indicate under utilization and unmet needs for CS, in Latin America and the Caribbean a 42% CS rate suggests overuse leading to health consequences of unnecessary procedures, and waste of human and financial resources (Betran et al., 2021).

Recent evidence from the US shows that the large variations in the use of CS across health facilities may be explained by hospital delivery practices and that CS hospital specialization may affect maternal and health outcomes (Card et al., 2023). However, even in high-income countries, the relationship between hospital-level patient characteristics that may increase medically-indicated

CS (e.g. obesity-prevalence among mothers) and CS specialization is unclear. Similarly, the effects of hospital specialization on health outcomes of different types of patients are ambiguous.

This paper aims to fill these two gaps: the relative lack of evidence of the determinants and consequences of CS in low- and middle-income settings and the effects of changes in the patient pool on procedure use. It studies whether hospitals with a higher fraction of obesity-related discharges have higher CS rates and are more likely to become specialized in performing CS. In addition, it analyzes the effects of specialization on newborn and maternal health outcomes at birth. In order to help predict the effects of increases in obesity and hospital specialization, it develops a model of CS choice, specialization, and health outcomes, based on (Bozzoli et al., 2009). CS choice is modeled as a function of the health (obesity) burden of a hospital's population. A useful feature of the model is that its predictions are presented in terms of the mean hospital-level health (i.e. they are independent of an individual mothers specific weight). Thus, it is straightforward to link the empirical findings to the model's predictions and to interpret the results in terms of specialization.

The study focuses 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) (Brenes-Monge et al., 2019). As Appendix Figure A1.1 shows, there is a positive correlation between these variables.[1] It is well documented that obesity is a risk factor for CS (Fyfe et al., 2011; Kominiarek et al., 2010; Cnattingius et al., 2013). In Mexico, mothers obesity is explicitly listed as a risk factor during pregnancy in terms of risk of preterm delivery and is highlighted as a condition under which VBAC (vaginal birth after CS) is not recommended by the clinical guidelines of the Mexican Health Ministry (Consejo de Salubridad General 2010, 2017). 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.[2] Hence, obesity could be a potential factor in explaining the high CS rate increase in Mexico. In addition, studying the consequences of CS on maternal and neonatal health is particularly relevant in the Mexican case. Although maternal mortality rate decreased substantially from 88 maternal deaths per 100,000 live births in 1990 to 38 in 2016,[3] this rate is far above Mexico's SDGs target

[1]The 2012 and 2016 female OWOB prevalence are the latest estimates at the state and national level overlapping with the study period.

[2]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`

[3]Dirección General de Información en Salud, Ministry of Health.

of 22. Moreover, women who are poor, less educated, and indigenous are at higher risk of maternal mortality (Rodríguez-Aguilar, 2018).

The analysis merges the panel of all public hospitals with the census of birth records for 2008–2015, which contains information on birth type delivery and several birth 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, this study constructs a novel obesity measure at the hospital level, using patient diagnoses to identify all women of reproductive 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). The hospital-level obesity measure is strongly correlated with state-level female OWOB and obesity prevalence at the state level. This is an alternative measure of obesity levels that could be used in other settings when anthropometric data is unavailable.

The 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. The sample includes all mothers with a low risk of having a CS. The hospital-level obesity index is the main explanatory variable, conditionomg on mother, pregnancy, and hospital-level characteristics, as well as time and hospital fixed effects. The main threats to identification come from endogenous selection and differential changes in patient composition at high- versus low-obesity hospitals. To alleviate these concerns, the analysis considers municipalities with only one clinic, as this limits patient choice in terms of place of delivery. In addition, as shown, the obesity index does not predict predetermined maternal characteristics such as age, marital status or education. Moreover, the results are robust to alternative specifications of the hospital-level obesity index and fixed-effects models.

The study has two main findings. First, the individual probability of delivering via CS increases as the proportion of female obesity-related discharges in public hospitals increases. Overall, the positive effect of the hospital-level obesity measure on an individual woman's likelihood of CS is consistent with a hospital-level CS specialization argument. 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. Alternative mechanisms such as womens preferences over the type of birth delivery do not seem to drive the results: the effects across mothers' education levels are similar. Furthermore, doctors' medical or monetary incentives or changes in hospital congestion are also unlikely to explain the results.

Second, increases in the hospital-level obesity index improve birth delivery-related outcomes: there is a significant reduction in maternal mortality and newborns birth injury and trauma for all mothers with low-risk of CS. It is worth noting that the hospital-obesity measure does not affect delivery-unrelated outcomes, such as low-birth weight (LBW), as these should not be affected by CS practices. Moreover, the hospital-obesity measure increases mother survival and decreases the probability of birth injury and trauma for preterm newborns, who are almost always delivered via CS and are thus unaffected by the potential effects of obesity on delivery type choice. Overall, this evidence supports the hospital-level CS specialization hypothesis.

This paper contributes to the emerging literature studying the determinants and consequences of increasing CS rates in low- and middle-income countries.[4] Despite the high CS prevalence (Boerma et al., 2018), the evidence for Mexico is limited.[5] This study is closest to Card et al. (2023) who show, for the US, 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. This paper highlights that CS specialization can reduce maternal mortality. This is a relevant finding for low- and middle-income countries with high maternal mortality rates.

Finally, this study relates to the literature on the effects of medical practices on health outcomes (Chandra and Staiger, 2007; Doyle et al., 2015; Card et al., 2023). The results extend beyond the effects of specialization on delivery mode and are applicable to less developed contexts. They also highlight how mothers' obesity prevalence may affect treatment choice in a context where the health system is more resource-constrained (Lagarde and Blaauw, 2022).

[4]Recent studies have analyzed the effects of policy changes in the health sector on CS rates and newborn health in Brazil (Melo and Menezes-Filho, 2023; De Oliveira et al., 2022) and Chile (de Elejalde and Giolito, 2021).

[5]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.

The rest of the paper is organized as follows. Section 1 presents a model of selection into CS and specialization. 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.

1 Model

This section presents a simple model of procedure (CS) choice, specialization, and health outcomes. This paper builds on Bozzoli et al. (2009) and adapts it to model CS choice as a function of the health burden of the population at a given hospital. It also propose an extension where doctors may become specialized.

1.1 Baseline model

Suppose that each pregnancy carries a certain risk which is negatively correlated with the underlying health of the newborn, denoted by h_i. Assume that health is distributed in the population with distribution function $F(h)$ and considers populations to be defined at the hospital level. The decision to perform a CS depends on the pregnancy risk and a CS will be performed when pregnancy risk is higher than a given cutoff, i.e. when a newborn's health is below a cutoff z. Hence, the CS rate is being given by $F(z)$.

Then, consider an additional "health burden," which reduces newborns' health endowment and increases pregnancy risk. This additional burden is denoted by v_t and, in the context of this study, is captured by obesity. v_t can vary year to year. Larger values of v_t indicate riskier pregnancies. This increase in pregnancy risk leads to an increase in the CS rate, where a delivery will occur via CS if the health of the newborn "net" of the obesity burden is less than z, or if $h_i - v_t \leq z$ and the CS rate, given the burden of obesity, v_t, is given by $\%CS_t = F(z + v_t)$.

It is worth noting that z may vary either over time or across hospitals, as specialization, physician skills, or resources available may lead to different thresholds for using CS. This scenarios are considered in the next subsection.

To include the potential "stunting" (or "scarring" as in Bozzoli et al. 2009) effect of obesity on newborns' health, assume that a fraction $0 \leq \theta \leq 1$ of v_t will be subtracted from a newborn's health stock, h_i. A newborn's (observed) health will therefore be given by $\widetilde{h_{it}} = h_i - \theta v_t$.

Given the effective cutoff at which CS are performed, the average health of newborns born by procedure $T \in \{V, CS\}$, where V stands for vaginal and CS stands for c-section, is given by:

$$\bar{h}_t^{CS}(v_t) = \frac{\int_{-\infty}^{z+v_t} h dF(h)}{F(z+v_t)} - \theta v_t \tag{1}$$

$$\bar{h}_t^{V}(v_t) = \frac{\int_{z+v_t}^{\infty} h dF(h)}{1 - F(z+v_t)} - \theta v_t. \tag{2}$$

The first term for both equations reflects how average health for a given procedure changes as the threshold varies, which may be interpreted as a selection effect. This pure selection effect could be observed if $\theta = 0$, i.e. if no stunting was associated with obesity. It is worth noting that for $\theta = 0$:

$$\bar{h}_t^{T}(v_t) > \bar{h}_t^{T}(0) \qquad \forall v_t > 0 \tag{3}$$

for both $T \in \{V, C\}$. Intuitively, as the threshold for performing a CS moves to the right, marginally healthier babies are delivered via CS (left of the threshold)—increasing average health of those born via CS—while the least healthy babies are "removed" from those born via vaginal delivery (right of the threshold)—thus, also increasing the average health of those born vaginally. This is referred to as a pure selection effect.

Given that it is likely that $\theta > 0$, the effect of v_t on average newborn health can be rewritten by differentiating equations (1) and (2), respectively:

$$\frac{\partial \bar{h}_t^{CS}}{\partial v_t} = (z - \bar{h}^{CS} + (1-\theta)v_t)\frac{f(z+v_t)}{F(z+v_t)} - \theta, \tag{4}$$

$$\frac{\partial \bar{h}_t^{V}}{\partial v_t} = (\bar{h}^{V} - z - (1-\theta)v_t)\frac{f(z+v_t)}{1 - F(z+v_t)} - \theta. \tag{5}$$

For both equations (4) and (5), the first term on the right hand side is always positive (at the limit, for CS the healthiest individual has $h_i = z + v_t - \theta v_t$, while for vaginal births the least healthy individual has $h_i = z + v_t - \theta v_t$). The final sign of the equation may be either positive or negative, as it can change sign over the range of v_t. In this context, it implies that an increase in obesity may lead to more or less healthy newborns, and may actually have a non-monotonic relationship depending on the parameters (θ). The overall health of newborns is given by:

$$\bar{h}_t^{all}(v_t) = \int_{-\infty}^{\infty} hdF(h) - \theta v_t. \tag{6}$$

Note that while the average health of both types of births may be increasing or decreasing with v_t, the overall health is always decreasing in v_t, as long as $\theta > 0$.

1.2 Specialization

Specialization in CS (intensive treatment) in introduced in the model via an additional term, s_t, that modifies the threshold under which CS are performed (effectively moving it to the right). In particular, a delivery will be a CS if $h_i - v_t \leq z + s_t$ and the CS rate, given the burden of obesity, v_t, and the specialization, s_t, is now given by $\%CS_t = F(z + v_t + s_t)$.

Additionally, consider that specialization in CS will be associated with higher physician skill in performing the intensive treatment and potentially in decreased skill in the competing treatment (as in Chandra and Staiger (2007); Currie and MacLeod (2008); Currie and MacLeod (2017)). This feature is introduced by adding the term δs_t for CS deliveries and subtracting the term γs_t for vaginal deliveries to health outcomes that are *delivery related*. For outcomes that are *delivery unrelated*, such as birth weight, assume that $\delta = \gamma = 0$. s_t depends linearly on the obesity burden faced by the hospital, v_t, so that $s_t(v_t) = \pi v_t$, with $\pi \geq 0$, as doctors treating a pool of riskier pregnancies are more likely to become specialized. With this setup, the mean (delivery related) health of newborns born via procedure T, $\bar{h}_t^{T,s}(v_t, s(v_t))$, is:

$$\bar{h}_t^{CS,s}(v_t, s_t(v_t)) = \frac{\int_{-\infty}^{z+(1+\pi)v_t} hdF(h)}{F(z + (1+\pi)v_t)} - \theta v_t + \pi\delta v_t \tag{7}$$

$$\bar{h}_t^{V,s}(v_t, s_t(v_t)) = \frac{\int_{z+(1+\pi)v_t}^{\infty} hdF(h)}{1 - F(z + (1+\pi)v_t)} - \theta v_t - \pi\gamma v_t \tag{8}$$

Note that for a given $\bar{v}$, the mean health of newborns will be larger when specialization is allowed, as $\bar{h}_t^{CS,s}(\bar{v}, s(\bar{v})) > \bar{h}_t^{CS}(\bar{v})$. However, the relationship between $\bar{h}_t^{V,s}(\bar{v}, s_t)$ and $\bar{h}_t^{V}(\bar{v})$ will depend on the specific parameters. More formally, for a given $\bar{v}$, it is possible to calculate how average health (overall and by type of delivery) varies as the degree obesity-driven specialization, captured by the parameter π, increases (note that the case of no specialization is captured by $\pi = 0$). In particular:

$$\frac{\partial \bar{h}_t^{CS,s}}{\partial \pi} = (z + (1+\pi)\bar{v} - (\theta - \pi\delta)\bar{v} - \bar{h}^{CS}\bar{v})\bar{v}\frac{f(z+(1+\pi)\bar{v})}{F(z+(1+\pi)\bar{v})} + \delta\bar{v}, \tag{9}$$

$$\frac{\partial \bar{h}_t^{V,s}}{\partial \pi} = (\bar{h}^{V} - z - (1+\pi)\bar{v} - (\theta + \pi\gamma)\bar{v})\bar{v}\frac{f(z+(1+\pi)\bar{v})}{1 - F(z+(1+\pi)\bar{v})} - \gamma\bar{v}. \tag{10}$$

As in equations (4) and (5), the first term on the right hand side of equation (9) and 10 will always be positive, as the mean health of those born via CS/vaginally will always be lower/higher than that of the individual at the threshold, given by $h_i = z+(1+\pi)v_t-(\theta-\pi\delta)v_t$ $[h_i = z+(1+\pi)v_t-(\theta+\pi\gamma)v_t]$. Given that in equation (9) the second term is also always positive, for a given level of obesity ($\bar{v}$), more specialization unambiguously increases the average health of those born through CS. This is not the case for vaginal births, where the last term in equation (10) is negative and could thus lead to worse health outcomes.

Additionally, when considering the health of the whole population, independent of the procedure, increases in obesity *without* specialization always lead to worse health outcomes, as:

$$\frac{\partial \bar{h}_t^{all}}{\partial v_t} = -\theta, \tag{11}$$

while *with* specialization, the effect on overall health is ambiguous and depends on the value of the specific parameters and on the level of obesity, v_t:

$$\frac{\partial \bar{h}_t^{all,s}}{\partial v_t} = -\theta + \pi[\delta F(z+(1+\pi)v_t) - \gamma(1 - F(z+(1+\pi)v_t))]. \tag{12}$$

Finally, for a given $\bar{v}$, the effect of obesity-driven specialization on overall health is given by:

$$\frac{\partial \bar{h}_t^{all,s}}{\partial \pi} = [\delta F(z+(1+\pi)\bar{v}) - \gamma(1 - F(z+(1+\pi)\bar{v}))]\bar{v}, \tag{13}$$

suggesting that overall health may improve with specialization (for a given obesity burden), but only for the case of delivery-related health outcomes. Note that for delivery-unrelated health outcomes, where $\delta = \gamma = 0$, specialization should have no effect (as compared to no specialization, or $\pi = 0$).

1.3 Testable predictions

By construction, the first prediction that arises from the model is that increases in the obesity burden lead to increases in the CS rate, with or without specialization (the increase would be larger with specialization). In addition, the model captures the different pathways through which an effect of hospital-level obesity on birth outcomes may operate. In particular, the direct effect of obesity on newborn health can be seen by comparing $\bar{h}^T(v,0)$ to $\bar{h}^T(0,0)$, while the model's predictions regarding to how $\bar{h}^T(v,0)$ and $\bar{h}^T(v,\pi v)$ compare, allow to test whether there is evidence of specialization.

It is worth noting that the model yields predictions on the average health of newborns (overall and by type) without requiring information on individual mothers' weight. The model's main predictions, for both delivery-related and unrelated health outcomes, are summarized below.

Considering delivery-related outcomes, by comparing cells A1 and D4, as obesity increases, a positive effect on overall newborn (delivery related) health may only be observed if there is obesity-driven specialization, for instance.

Delivery-related outcomes

	Baseline (B)					
	$\bar{h}^{all}(0,0)$	$\bar{h}^{CS}(0,0)$	$\bar{h}^{V}(0,0)$	$\bar{h}^{all}(v,0)$	$\bar{h}^{CS}(v,0)$	$\bar{h}^{V}(v,0)$
(x)	(1)	(2)	(3)	(4)	(5)	(6)
A. $\bar{h}^{all}(v,0)$	$x < B$			$=$		
B. $\bar{h}^{CS}(v,0)$		?			$=$	
C. $\bar{h}^{V}(v,0)$			?			$=$
D. $\bar{h}^{all}(v,\pi v)$	?			?		
E. $\bar{h}^{CS}(v,\pi v)$		?			$x > B$	
F. $\bar{h}^{V}(v,\pi v)$			?			?

Regarding delivery-unrelated outcomes, cell D4 would suggest a null effect from specialization for delivery unrelated health outcomes for overall newborn health with respect to the no-specialization case.

Delivery-unrelated outcomes

	Baseline (B)					
	$\bar{h}^{all}(0,0)$	$\bar{h}^{CS}(0,0)$	$\bar{h}^{V}(0,0)$	$\bar{h}^{all}(v,0)$	$\bar{h}^{CS}(v,0)$	$\bar{h}^{V}(v,0)$
(x)	(1)	(2)	(3)	(4)	(5)	(6)
A. $\bar{h}^{all}(v,0)$	$x < B$			=		
B. $\bar{h}^{CS}(v,0)$		?			=	
C. $\bar{h}^{V}(v,0)$			?			=
D. $\bar{h}^{all}(v,\pi v)$	?			=		
E. $\bar{h}^{CS}(v,\pi v)$		?			$x > B$	
F. $\bar{h}^{V}(v,\pi v)$			?			$x > B$

2 Data

This study uses two sources of data. The first data source comprises the administrative health data from the universe of public health hospitals managed by the Ministry of Health (SSA) in Mexico. These data include information on inpatient hospital discharges and diagnoses recorded using the ICD-10 codes for all SSA hospitals between 2008 and 2015,[6] as well as patients age, sex, and municipality of residence. The analysis considers all SSA public health facilities for which at least eight births were observed in every month between 2008 and 2015.[7,8] In addition, to alleviate concerns of endogenous selection, the study focus on a balanced panel of 226 hospitals which are the only public health facility in the municipality (as explained in Section 3).

The second data source is the Mexican Birth Certificate Data, a census of all the registries

[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). The data 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.

[8]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. Healthcare facilities are referred to as hospitals hereafter.

of live births.[9] While this census contains information on all births, our analysis focuses only on those public hospitals administered by the Ministry of Health. The birth certificate contains information related to the type of birth delivery (vaginal or cesarean), the newborns sex, birth weight, gestational age (in weeks), and Apgar score.[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). As birth certificates include a variable for any congenital anomaly, illness, or lesion of the newborn (also using ICD-10 codes), dummies for whether there was any birth injury or trauma are also included.[11] Finally, birth certificates include a variable indicating whether the mother survived after delivery, which we use as an outcome.

The study considers as women of reproductive age (WRA) those 15-45 years of age. Following Card et al. (2023), the analysis focuses on low-risk mothers given the variables available in our data. Although women who previously had a CS are generally more likely to undergo a CS in subsequent births, the sample is not restricted to first-time mothers. As there are no differences in the data on the likelihood of CS by birth order, the analysis considers all low-risk mothers.[12] The low-risk sample excludes women under 18 and over 35, multiple births, births under 37 weeks of gestation, and women with more than 20 prenatal visits. Selecting mothers on these criteria allows to exclude the women at a higher risk for CS (high-risk births are defined as those that do not satisfy any one of the aforementioned conditions), although it does not necessarily allow to focus on pregnancies that are at a very low-risk for a CS.[13]

Only live births are considered, as the data available for fetal deaths does not include a hospital identifier so it cannot be matched to the data. Excluding fetal deaths from the analysis may imply

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

[10] The Apgar score is a widely used diagnostic indicator of newborn health, ranging from 0 to 10 (Card et al., 2023). A higher score reflects a better health outcome.

[11] Birth trauma is defined as a dummy variable for any of the ICD-10 codes from P10 to P15, following the WHO definition. Birth injury is defined 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. The dummy variables for birth injury, birth trauma, and mother survival after birth delivery are multiplied by 1,000.

[12] There is no evidence in the data that higher order births are more likely to be CS (as compared to first births). In fact, there is evidence supporting the opposite: CS rates seem to be decreasing in birth order. In 2008 the CS rate was 33.3% for first time mothers, 32.7% for second births, 32.4% for third births and 31.1% for higher order births.

[13] Due to data limitations, it is not possible to 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. (2023).

a survival bias for our estimates, although the direction of the bias is *a priori* unclear. In particular, a direct (negative) effect of obesity on health leading to an increase in overall fetal deaths may lead to overstated health effects, while (positive) effects of specialization leading to a higher number of surviving newborns would likely bias our estimates downwards.

Since the administrative data on hospital inpatient discharges and from birth certificates do not include information on patients' individual weight and height, this study creates a measure of hospital-level obesity. It uses 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, it calculate the fraction of obesity-related discharges for WRA per month. The hospital obesity measure considers patient diagnoses for the following obesity-related diseases: pre-gestational hypertension (I10-I15, O10 and O11), pre-gestational 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). It also considers pregnancy complications associated with obesity such as preeclampsia, gestational diabetes, pre-gestational diabetes, and pre-gestational hypertension—though these may not be linked to specific births. Arguably, 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 weight data is not available.

The information on obesity prevalence is only available at the state level from national health surveys,[14] while the obesity index data come from the administrative inpatient hospital records. As a validation exercise, Appendix Table A1.1 shows that the aggregated index at the state level has a positive and statistically significant correlation with the state-level obesity and overweight rates, by regressing state obesity on the obesity index.[15] If the estimates were to be in levels, a coefficient closer to one would reveal that the index perfectly captures obesity rates. However, the empirical strategy uses changes in the index not levels. The raw correlation of the obesity index with state obesity (overweight and obesity) is 0.49 (0.35).

[14]The 2012 Encuesta Nacional de Salud y Nutrición (ENSANUT) is the latest available round of this survey overlapping with the study period. ENSANUT is representative at the state level.

[15]Different specifications of the obesity index are tested 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 A1.1.

Table 1 shows descriptive statistics of the main variables used in the empirical models in 2008, for high- and low-obesity hospitals, as measured by the obesity index. A hospital is classified as high-obesity if its average obesity index in 2008 is higher than the median of the sample. As mentioned earlier, the estimation sample includes all mothers who are at low-risk of having a CS birth as earlier defined. Regarding mothers' characteristics, there are small albeit statistically significant differences between high- and low-obesity hospitals in women's age and schooling, but not in 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, any selection concerns in the patient pool is addressed in our empirical strategy and the models control for 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 32% in high-obesity hospitals and 28% in low-obesity hospitals. There are no statistically significant differences between high- and low-obesity hospitals in delivery-related birth outcomes, such as average Apgar scores as well as a dummy variable for Apgar scores lower than 7, frequencies of birth injury, birth trauma, and mother survival. Similarly, differences in delivery-unrelated outcomes, such as low birth weight (LBW), are statistically indistinguishable between high- and low-obesity hospitals. Nevertheless, newborns are heavier in high-obesity hospitals, which is consistent with results linking heavier mothers to heavier newborns and fetal macrosomia (Khashan and Kenny, 2009). Finally, by construction, the obesity index is higher for hospitals with high obesity prevalence. As the empirical strategy exploits changes in the obesity index (and not levels), and time-invariant hospital characteristics are absorbed by hospital fixed effects, concerns about differences in both types of hospitals are limited.

During the study period, there is considerable variation in CS rates and obesity prevalence, both over time and across hospitals. Using the sample of hospitals, Figure 1 illustrates how CS rates and the hospital-level obesity measure varies over 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 the hospital-level obesity measure on a woman's probability of having a CS and her newborn's delivery-related birth outcomes.

3 Empirical strategy

The analysis start by considering the effect of hospital-level obesity prevalence on the likelihood of a woman having a cesarean birth. The identification comes from variation across time and hospitals in the obesity index, conditioning on mother, pregnancy, and newborn characteristics, using time and hospital-fixed effects. In order to mitigate concerns regarding endogenous selection into hospitals, the main analysis focuses on municipalities where there is only one SSA hospital. The following model is estimated:

$$Y_{itc} = \alpha + \beta Obesityindex_{t-1,c} + \gamma X_i + \delta_t + \theta_c + \epsilon_{itc} \tag{14}$$

where Y_{itc} is a dummy variable that captures whether birth i at time t (month) in hospital c was via CS. $Obesityindex_{t-1,c}$ is the standardized obesity index for clinic c at time $t-1$ (i.e., lagged one year).[16,17] X_i is a set of time-varying 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) that capture country-wide time trends and the seasonality of births during the period of analysis. θ_c are hospital fixed effects that control for all observed and unobserved time-invariant differences between hospitals. Standard errors are clustered at the hospital-month level.

As mentioned earlier, the main sample includes all low-risk mothers, defined as the sample of mothers 18-35 years of age, excluding multiple births, 37 or less gestation weeks, and with less than 20 prenatal visits. The analysis focuses on low-risk births, as they are less likely ex-ante to require a medically recommended CS. And, it is not limited to first-time mothers. The results of the obesity-index on CS are presented for all births, first-time mothers as well as low-risk first-time mothers.

The main threats to identification are endogenous patients selection into hospitals and differential changes in patient composition at high- versus low-obesity hospitals. Arguably, if women were to endogenously sort into high/low specialization hospitals according to their underlying health

[16] The obesity index is standardized by subtracting the 2008 mean level across hospitals and dividing by the 2008 standard deviation. Thus, all estimates can be interpreted in terms of an increase equivalent to one standard deviation at baseline.

[17] The lagged index is calculated as the average of the lagged calendar-year (i.e., if the birth occurred on February-2010, the average index for 2009 was assigned).

risks, such endogenous selection would be likely to bias our results against finding a positive effect of obesity on health outcomes. That is because women more at risk 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. Nevertheless, in order to mitigate concerns regarding endogenous selection, the analysis excludes hospitals in municipalities that have more than one public hospital and where maternal choice in terms of delivery place may be more concerning. Arguably, endogenous hospital choice is less likely to be present in municipalities with only one hospital. Additionally, these concerns are also alleviated as the study setting is limited to women delivering in public hospitals where women are assigned the clinic they must attend and therefore have limited choice. Hence, the analysis considers the panel of 226 hospitals for which births are observed for every time-period that are in municipalities served only by one hospital. The results are also robust to including the unbalanced panel sample of these hospitals across the period of interest.

Another threat to identification is related to hospitals patient composition. If the overall health or individual characteristics of a hospitals patient pool have different trends for hospitals with different obesity, the estimates from equation (14) could be biased. To present evidence of the validity of the design, the main models are estimated using a set of predetermined maternal characteristics as the dependent variable. In particular, changes in the hospitals measure of obesity are regressed against maternal age, marital status, and education as dependent variables. The estimates presented in Table 2 show that changes in the obesity index do not appear to predict mothers age, marital status, and education. Even without correcting for multiple hypotheses testing, the coefficients for these dependent variables are not significant at conventional levels. These findings mitigate potential concerns that the results might be driven by changes in the population within a hospital catchment area. Additionally, in Section 5, the preferred specification is estimated including state-level time trends to further alleviate concerns that the results might be driven by secular trends in the health of patients in the hospital catchment area.

Using the same specification as in equation (14), the study estimates the reduced form effects of hospital-level obesity prevalence on newborn health outcomes that could be affected by CS specialization during delivery: i) whether the Apgar is less than 7 (Apgar$<$ 7)[18]; ii) maternal

[18]The outcomes considered are: a dummy variable for whether the Apgar is less than 7 (Apgar$<$ 7), as the

survival; iii) whether there was birth trauma; and iv) whether there was birth injury. Any positive effects of high-obesity hospitals on birth outcomes are likely to be lower bounds of "true" effects, as in general, increases 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 overweight or obese 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.

The results on birth outcomes are presented for all births and separately for CS and vaginal births. Although presenting results by type of delivery is conditioned on an outcome, showing results separately may help depict a more complete picture of the mechanisms driving the results. Additionally, the model gives a theoretical framework with predictions regarding the average health of CS and vaginal births at the hospital-level (with and without specialization). As predicted in the theoretical model, while specialization should not affect birth outcomes for newborns delivered vaginally directly, selection may lead to observing better health outcomes for vaginal births as marginally risky mothers who would have otherwise delivered vaginally are induced to deliver via CS, and 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 or mother obesity is negatively correlated with newborn health. Hence the expected direction of specialization on delivery-related birth outcomes for vaginal births is *a priori* ambiguous, as predicted by the theoretical model.

The study also explores the effects of obesity on delivery-unrelated outcomes. The theoretical model predicts that these outcomes should not be affected by specialization, but could be affected by changes in mothers' health burden (e.g., obesity). For this, birth weight and dummies for LBW

American Academy of Pediatrics defines a 5-minute Apgar score of 7-10 as reassuring, a score of 4-6 as moderately abnormal, and a score of 0-3 as low in the term infant and late-preterm infant (American Academy of Pediatrics, 2015).

and macrosomia are used. It is worth noting that the literature suggests that there is no evidence of LBW being affected by mother's obesity when controlling for gestational age (McDonald et al., 2010) (in terms of the model, $\theta = 0$) while there is evidence of obesity being associated with a higher probability of macrosomia (Wollschlaeger et al., 1999). When estimating the models using these birth outcomes that are arguably not determined at time of delivery, one would expect to see no (positive) effects from specialization if the specialization hypothesis is correct (although a negative direct effects from increases in average mother's obesity in the case of macrosomia may be observed).

4 Results

Table 3 reports the effects of the hospital-level obesity measure on womens likelihood of having a CS. It shows the estimates for all low-risk mothers (column 1), all mothers (column 2), first-time low-risk mothers (column 3), and all first-time mothers (column 4). For all four samples, there is a positive and statistically significant relationship between changes in obesity at the hospital-level and changes in the individual probability that a woman delivers via CS. Considering all low-risk mothers, an increase of one standard deviation in hospital-level obesity (with respect to 2008, the baseline year) leads to a 0.3 percentage points (pp) increase in the probability of having a CS. Given the 2008 CS rates of 29%, this corresponds to an increase in CS of approximately 1%. This estimate is relevant as it corresponds to the sample of women who ex-ante have a lower risk of having a CS. For this reason, the main analysis considers the sample of all low-risk mothers, as this may present a complete picture of the potential effects of CS specialization.

Moreover, Appendix Table A1.2 explores whether the results vary according to whether deliveries happened during "Daytime" vs "Nighttime and weekends" CS birth delivery, as birth certificates do 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, one may think of CS as unplanned if it occurred during night hours (i.e. 8pm-8am) or weekends. The 8pm-8am range is used, as the data show a discontinuity in CS rates at these times (see Figure A1.2), that most likely are related to changes in medical staff shifts. There is no evidence showing that CS specialization might be driven by doctors working during the "Daytime." Although the coefficient for the "Daytime CS" is slightly larger than the effect for all births (column 1), it is only statistically significant at the 10 percent level and not statistically different from the coefficient for "Nighttime and Weekend," reported in column 3.

Next, the reduced form effects of our hospital-level obesity measure on newborn health for delivery-related and delivery-unrelated health outcomes are considered. The estimates in Table 4, Panel A, highlight a significant increase of mother survival for all births, as well as a decrease in the probability of experiencing birth injury or birth trauma, although the latter reduction is not statistically significant at conventional levels. No effects on Apgar scores were found. These results are 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. In particular, the results on the reduction of maternal mortality suggest remarkable returns of specialization in the Mexican context where maternal mortality is still a prevalent issue.

Panels B and C of Table 4 show the effects of the obesity measure on health outcomes by delivery type: CS births and vaginal births. As these analyses are conditioned on an outcome, they should be interpreted with caution and taking into account that selection into CS is not exogenous: as discussed above, increases in obesity are likely to increase the likelihood of a woman receiving a CS. Nevertheless, these estimates are presented by delivery types to get a clearer picture of the potential mechanisms driving the health effects on all births. Panel B, column 1, shows that the increase in the probability of mother survival after delivery is mostly driven by CS. Similarly, Panel B, column 2, indicates that the lower probability of birth injuries is driven by CS births. These effects are consistent with the hypothesis of specialization. Furthermore, Panel B, column 4, shows a decrease in the probability of having an Apgar score < 7 for CS births. Low Apgar scores are often the result of prolonged labor (Card et al., 2023; Altman et al., 2015), which is less likely for CS birth as they tend to be quicker (Costa-Ramón et al., 2018). Again, this finding supports the specialization hypothesis: a lower probability of a low Apgar in CS births can be explained by doctors becoming specialized in CS.

Furthermore, Panel C shows improvements in mother survival for vaginal births and although we find reductions in birth injury and birth trauma, these are not statistically significant. These findings could be interpreted as a selection effect: to the extent that specialization leads to marginally riskier women to deliver via CS, the average risk of women delivering vaginally falls—thus improving delivery-related health for newborns born vaginally as well.

In addition, Appendix Table A1.3 shows the reduced form for birth delivery outcomes for all CS births (Panel A), and separately for CS during the day (Panel B) and CS at night time and on weekends (Panel C). Arguably, the latter two categories may proxy for scheduled and unscheduled CS, respectively. A similar caveat to the one for Table 4 applies: although the time of delivery is plausibly exogenous, the estimates are conditional on having a CS birth, thus should be interpreted with caution. As shown in column 1, CS births increase the probability of mother survival regardless of the time of day. The estimates in Column 2 indicate a decrease in the probability of birth injury after delivery is stronger for "Daytime CS," and, even though it is not statistically significant for "Nighttime and Weekends CS," both coefficients have the same sign and are not statistically different. This finding is also consistent with a specialization hypothesis.

Next, Table 5 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. Columns 1 and 2 show that the obesity index does not have a statistically significant effect on birth weight and low birth weight. Column 3 reports 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). These results provide a falsification test for the specialization hypothesis, adding validity to the interpretation of the results as evidence of CS specialization. While one 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), one would not expect birth weight or the probability of low birth weight (conditional on gestational age) to be affected by our hospital-obesity index (McDonald et al., 2010).

4.1 Mechanisms

The findings support the hypothesis that an increase in hospital-level obesity prevalence increases a woman's probability of CS and affect newborns' delivery-related outcomes through the specialization channel. However, it is possible that other mechanisms might be at play, such as preferences over the type of birth delivery, supply driven changes, or hospital congestion.

Appendix Table A1.4, columns 2–4, analyzes differential effects by mothers age. Variation in the measure of facility-level obesity on CS is concentrated among women under 30—although there is also a positive effect, albeit not statistically significant, for women 30–35. This result suggests 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, Appendix Table A1.4, 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). Furthermore, Appendix Table A1.4, panel B, shows that the returns of CS specialization in maternal mortality reduction are found across maternal age cohorts and levels of education. Overall, estimates from Appendix Table A1.4 suggest that the results are unlikely to be driven by higher educated womens 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, the estimates could be driven by the supply side. However, this is unlikely in this context: physicians working at public hospitals are salaried workers who earn a monthly wage. They do not receive any additional benefits based on the number or type of deliveries they perform.

An alternative explanation could be that the results are 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). The specifications however, control for changes in the contemporaneous monthly volume of births at the hospital level, which would capture changes in congestion. Hence, the findings are not likely to be driven by congestion.

5 Robustness checks

The analysis first considers the effects of our hospital-level obesity measure on delivery-related birth outcomes for a subgroup of newborns that are most frequently (almost always) born via CS: preterm newborns. In these cases, the use of CS is more frequent and arguably would be less likely to be affected by the physicians choice. The models are estimated using two definitions of the sample preterm newborns. The first definition includes all infants born between 30 and 37 gestational weeks to first-time mothers 30 years old and older. The second definition includes babies with the same gestational age but conditions to low birth weight newborns from all mothers. Table 6 shows that, regardless of the definition used, the hospital-level obesity index is uncorrelated to the probability of a CS for this subset of births (and that the CS rate is in fact higher; i.e., 57-66% depending on the sample definition). However, when looking at delivery-related birth outcomes, Table 6 shows evidence consistent with a specialization hypothesis: there is a positive association between the obesity index and delivery-related birth outcomes for preterm newborns–where no effect on the probability of CS is observed. A higher obesity index at the hospital level is associated with a lower probability of birth trauma and maternal mortality for preterm newborns. These results would (only) be expected if higher obesity improves physicians CS skills through CS specialization.

Next, Appendix Table A1.5 shows that the results are robust to a series of alternative specifications. First, one might be concerned that the results are exclusively driven by the short-run fluctuation of the obesity index. The main analysis uses the previous year as the relevant measure for learning at time t as it allows for a long period for doctors to be specialized (and frequent enough to have sufficient variation in the data).[19] Nevertheless, to mitigate concerns that the time window choice is not driving the results, Appendix Table A1.5, Panel A, uses a moving average of the obesity index over 12 months instead of the lagged index. Estimates show that the main effects of the obesity index on CS, mother survival, birth injury, and birth trauma are overall robust to the measure used.

Second, the estimation sample is limited to the public hospitals that have at least eight births per month in every year of our study, and as such, it is a balanced panel of facilities. Panel B estimates the 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 every year over our study period, i.e. the unbalanced panel of hospitals. Appendix Table A1.5, Panel B, shows that the results remain robust to this specification.

Third, Panel C estimates model specifications that control for specific linear time trends to alleviate concerns that the results are driven by secular trends in the health of patients in the hospital catchment areas. As the estimates in Appendix Table A1.5 Panel C shows, the effects of the hospital-level obesity measure on the probability of having a CS are robust to adding state-

[19] Results remain mostly unchanged when using the previous quarter.

specific linear time trends. Therefore, there are no concerns that seasonal or omitted trends at the state level might be driving the results.

Fourth, Panel D explores the effects of the obesity index on high-risk births. In line with the model's predictions, one would expect to see a weak or null effect of obesity on the probability of CS for riskier pregnancies, whereas positive effects on this subgroup is likely to be evidence of specialization. Estimates show that there is only a marginally significant effect on CS for high-risk births, but a large and statistically significant improvement in maternal mortality. This result can be interpreted as further evidence of specialization.

As discussed previously, the exact relevant window for learning at time t for doctors is unknown. However, one would expect doctors to specialize in CS over time if they are exposed to riskier pregnancies (in this context, to more obese mothers). The empirical strategy captures both an increase in CS from treating more obese patients and a decrease in CS from treating less obese patients. In order to explore whether the results are being driven by increases or decreases in CS specialization (and in order to alleviate potential concerns regarding the definition of the learning period) the analysis presents the results from estimating a regression of the hospital-level CS time trend (over the entire study period) on its obesity index time trend. Intuitively, this analysis shows whether in the longer term, trends in obesity are correlated with trends in CS. Furthermore, this regression can be estimated separately for those clinics where the estimated linear time trend for obesity was positive (overall increase in obesity) or negative (overall decrease in obesity). By doing this, it is possible to present some evidence on whether the results are being driven by doctors specializing in CS when they treated a riskier patient pool or whether they are driven by doctors performing fewer CS as obesity falls. Arguably, if it is hard to de-specialize once a doctor becomes specialized, one should see a positive effect for hospitals with increasing obesity, and a smaller or null effect for hospitals with a decrease in obesity. The estimates from this analysis are reported in Appendix Table A1.6. Results show that a hospital's obesity time-trend is correlated with its CS time-trend: increases in obesity are positively correlated with increases in CS. Furthermore, columns 2 and 3, show that this association is positive and statistically significant only for hospitals with an upward obesity trend, while it is indistinguishable from zero for those hospitals in which obesity trended downwards. These findings suggest that treating more obesity cases is likely to lead to performing more CS overall.

Finally, to further mitigate concerns regarding patient selection, the analysis explores whether selection into *private* hospitals could affect the results. Using the certificate birth data one can calculate the share of births in a municipality that happened in private hospitals. As the analysis focuses on municipalities with only one public hospital, the share of births occurring at a private clinic is regressed on the obesity index of the (only) public hospital in a municipality (and municipality and year/month fixed effects are included to mimic the preferred specification). Appendix Table A1.7 shows that changes in obesity in the public hospital do not predict changes in private hospital share, suggesting that selection to/from the private sector is unlikely to be driving our results. Columns 1 and 2 include all municipalities in our sample (with column 2 including the total number of births as a control), while columns 3 and 4 focus on municipalities where the share of births in private facilities is nonzero. Coefficients are not significant across all specifications.

6 Conclusion

Over the past decades, CS rates have increased worldwide–particularly in middle and low-income countries. Similarly, obesity prevalence—a risk factor for CS—has also dramatically increased. The literature on the determinants and consequences of increasing CS rates mostly focuses on high-income countries. Hence, the evidence for low- and middle-income countries, where maternal and neonatal mortality are still high and health systems are resource constrained, is lacking.

This paper studies how variation in hospital practices induced by high obesity levels might affect hospital CS rates and whether that has an impact on maternal and neonatal delivery-related outcomes in Mexico, a country where CS rates are the second largest in Latin America, 70% of the population is obese, and maternal and infant mortality are still relatively high. The analysis uses a novel measure of hospital-level obesity by exploiting data from patient diagnoses. It leverages the obesity-index variation across time and hospitals to identify the effect of obesity on a woman's likelihood of having a CS.

The study finds that hospital-level obesity increases a womans probability of CS among a sample of mothers with low-risk of CS. 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. While other mechanisms might be at play, the findings are not consistent with demand-driven channels (e.g. higher educated womens 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. The results thus speak to how the use of intensive treatments may affect health outcomes (as in Doyle et al. (2015)) which is a key policy concern given the ample variation in treatment choice (i.e., CS) observed in Mexico and particularly relevant for resource-constrained settings.

Furthermore, CS specialization leads to better birth outcomes for all mothers with low-risk of CS, consistent with evidence on productivity spillovers in health care (Chandra and Staiger, 2007). Delivery-related birth outcomes improve for CS: there is a reduction in birth injuries, birth trauma, and an increase in mother survival. There is also a reduction in maternal mortality among mothers who deliver vaginally. The results might inform other low- and middle-income countries on the path of increasing CS and obesity rates.

To the extent that there are positive returns to specialization in CS, a policy recommendation derived from the results is that the need for CS increases as population health changes (e.g. obesity increases). Thus, having hospitals that are more/less specialized in performing CS and sorting women efficiently into these according to their pregnancy risk, could be welfare enhancing, particularly in resource-constrained settings.

While this study analyzes the immediate effects of CS on newborn and maternal health, it does not speak to the literature on long-term effects of CS on mothers (e.g., Halla et al. (2020)) or childrens health (e.g. Costa-Ramón et al. (2022)). While CS specialization may improve health outcomes in the very short term, improvements in some health outcomes, such as Apgar score, should be weighed against potential long-term costs associated with increased CS use. However, the benefits of increased mother survival from CS specialization are unlikely to be out weighted by other long-term costs associated with CS use.

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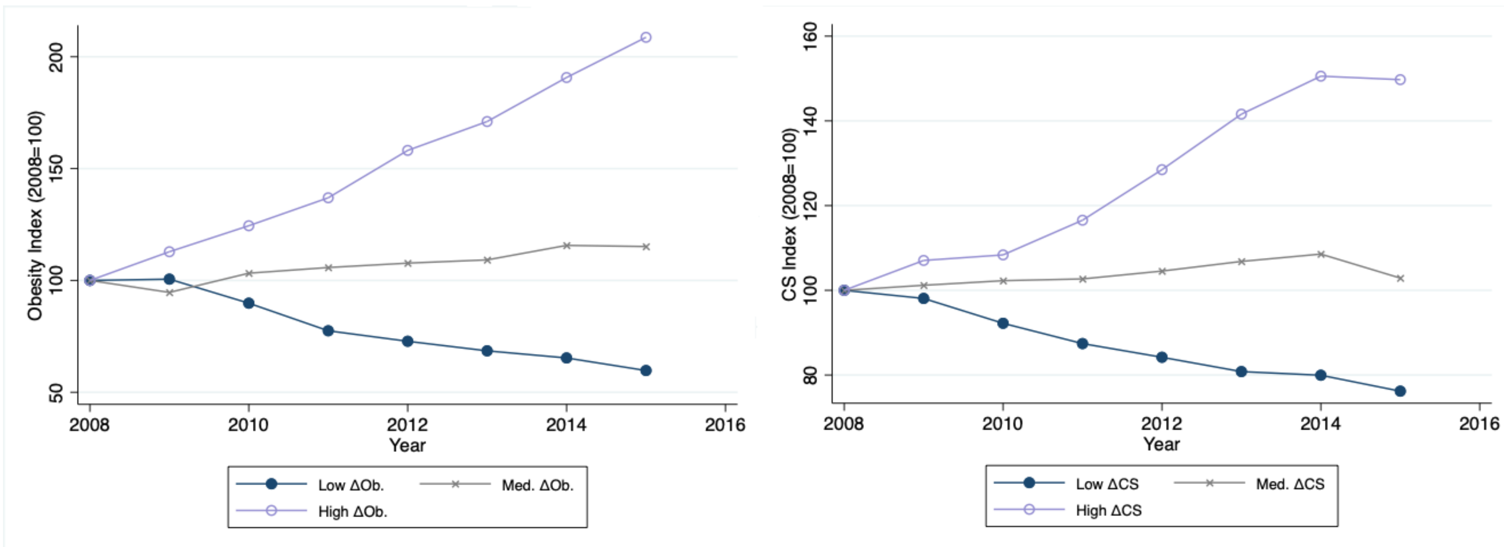
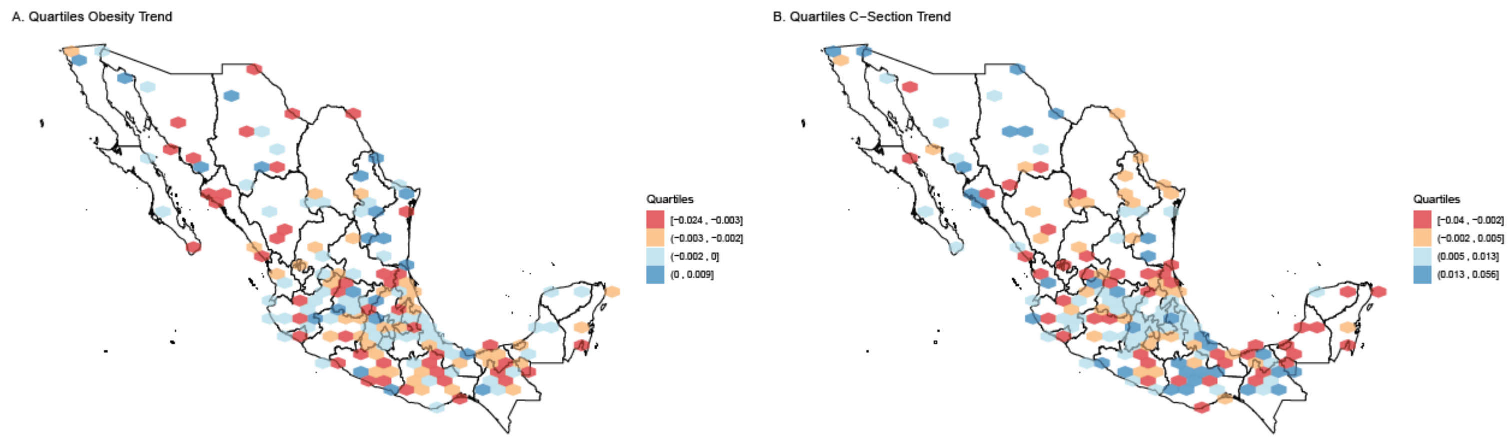
FIGURE 1: **Time variation in hospital-level CS and obesity rates**



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**

	High-obesity hospitals		Low-obesity hospitals			
	Mean	Std. Dev.	Mean	Std. Dev.	Diff	t-test
Panel A: Mother characteristics						
Age	24.26	0.40	24.45	0.42	0.19***	(3.47)
Schooling	8.73	0.75	8.38	0.77	-0.35***	(-3.44)
Married	0.35	0.14	0.35	0.14	0.00	(0.10)
Panel B: Birth outcomes						
Delivery related outcomes						
CS	0.32	0.10	0.28	0.10	-0.04***	(-3.07)
Apgar	8.91	0.11	8.92	0.13	0.01	(0.82)
Apgar < 7	0.01	0.00	0.01	0.01	0.00	(0.58)
Birth injury	5.91	8.70	6.28	8.87	0.37	(0.31)
Birth trauma	2.27	3.67	2.73	5.43	0.46	(0.75)
Mother survival	996.80	4.65	997.07	5.51	0.27	(0.40)
No. prenatal visits	6.32	0.69	6.27	0.74	-0.05	(-0.54)
Non-delivery related outcomes						
Deliveries	124.40	101.15	89.69	75.38	-34.71***	(-2.92)
Gestational weeks	39.37	0.14	39.40	0.15	0.03*	(1.80)
Low birth weight	0.01	0.00	0.01	0.00	-0.00	(-0.42)
Weight	3268.34	84.54	3248.54	83.78	-19.80*	(-1.77)
Obesity index	0.60	0.65	-0.47	0.31	-1.07***	(-15.99)
No. hospitals	113		113		226	

width=1

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

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. The sample consists of all low-risk mothers (i.e. mothers 18-35 years of age excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits) and only considers municipalities with one clinic. Schooling is defined as number of years of education. Married is an indicator equal to one if the mother is currently married. Apgar is based on a total score between 0 and 10, where a higher score reflects a better health outcome. Apgar< 7 is a dummy variable for whether the Apgar is less than 7. Birth injury is a dummy for the ICD-10 Codes: P10-15, P209-P221, P219-P221, P228, P229, P240, P285, P011, P032, P368, P369, P399, P545 and P914 multiplied by 1,000. Birth trauma is a dummy for the ICD-10 Codes: P10-15 multiplied by 1,000. Mother survival is a dummy for mother survival multiplied by 1,000. Low birth weight is a dummy variable for having low birth weight (lower than 2,500 gr). Obesity index: Standardized monthly obesity index lagged one year.

Table 2: **Reduced form evidence: the effect of obesity index on mother characteristics**

	Age	Age group	Schooling	Married
	(1)	(2)	(3)	(4)
Panel A: All births				
Obesity index	0.002	0.000	0.010	-0.001
(STD lagged one year)	(0.009)	(0.001)	(0.009)	(0.001)
Mean dep. variable (2008)	24.38	1.58	8.17	0.38
No. mothers	1,988,871	1,988,871	1,988,871	1,988,871
Panel B: CS births				
Obesity index	-0.015	-0.002	0.002	-0.001
(STD lagged one year)	(0.017)	(0.002)	(0.013)	(0.002)
Mean dep. variable (2008)	24.61	1.61	8.53	0.40
No. mothers	605,723	605,723	605,723	605,723
Panel C: Vaginal births				
Obesity index	0.008	0.001	0.010	-0.001
(STD lagged one year)	(0.011)	(0.002)	(0.010)	(0.001)
Mean dep. variable (2008)	24.28	1.56	8.02	0.37
No. mothers	1,383,148	1,383,148	1,383,148	1,383,148

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$. All models control for month and hospital fixed effects. Standard errors clustered at the hospital-month level. The sample consists of all low-risk mothers (i.e. mothers 18-35 years of age excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits) and only considers municipalities with one clinic. The age group variable is defined as 1 for mothers 18–24, as 2 for mothers 25–30, and as 3 for mothers 30–35. Schooling is defined as number of years of education. Married is an indicator equal to one if the mother is currently married. Obesity index: standardized monthly lagged one year.

Table 3: **Higher hospital obesity index increases the probability of CS**

	All mothers (low risk) (1)	All mothers (2)	FTM (low risk) (3)	FTM (4)
Obesity index	0.003**	0.003**	0.005**	0.004**
(STD one year lagged)	(0.001)	(0.001)	(0.002)	(0.002)
Mean dep. variable (2008)	0.29	0.31	0.34	0.33
No. mothers	1,988,871	2,805,181	641,290	1,029,699

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

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-month level. Low-risk mothers are defined as mothers between 18-35 years old excluding multiple births, 37 or less gestation weeks and with less than 20 prenatal visits. FTM denotes first-time mothers. Obesity index: Standardized monthly obesity index lagged one year.

Table 4: **Reduced form evidence: the effect of obesity index on delivery-related birth outcomes**

	Mother survival (1)	Birth injury (2)	Birth trauma (3)	Apgar< 7 (4)
Panel A: All births				
Obesity index	1.239***	-0.533*	-0.130	-0.000
(STD one year lagged)	(0.207)	(0.279)	(0.141)	(0.000)
Mean dep. variable (2008)	991.75	4.18	1.48	0.01
No. mothers	1,988,871	1,988,871	1,988,871	1,988,871
Panel B: CS births				
Obesity index	1.798***	-1.066**	-0.144	-0.001*
(STD one year lagged)	(0.315)	(0.427)	(0.141)	(0.000)
Mean dep. variable (2008)	989.27	5.45	1.18	0.01
No. mothers	605,723	605,723	605,723	605,723
Panel C: Vaginal births				
Obesity index	0.995***	-0.240	-0.118	-0.000
(STD one year lagged)	(0.183)	(0.285)	(0.177)	(0.000)
Mean dep. variable (2008)	992.77	3.65	1.60	0.01
No. mothers	1,383,148	1,383,148	1,383,148	1,383,148

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$. All models control for woman's age, schooling, marital status, birth weight, gestational weeks, number of births, number of prenatal consults, and month and hospital fixed effects. The sample consists of all low-risk mothers (i.e. mothers 18-35 years of age excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits) and only considers municipalities with one clinic. Standard errors clustered at the hospital-month level. Apgar is based on a total score between 0 and 10, where a higher score reflects a better health outcome. Apgar< 7 is a dummy variable for whether the Apgar is less than 7. Birth injury is a dummy for the ICD-10 Codes: P10-15, P209-P221, P219-P221, P228, P229, P240, P285, P011, P032, P368, P369, P399, P545 and P914 multiplied by 1,000. Birth trauma is a dummy for the ICD-10 Codes: P10-15 multiplied by 1,000. Mother survival is a dummy for mother survival multiplied by 1,000. The (monthly) obesity index is standardized and lagged one year.

Table 5: **The effect of the obesity index on delivery-unrelated birth outcome**

	Birth weight	Low birth weight	Macrosomia
	(1)	(2)	(3)
Panel A: All births			
Obesity index	-0.728	-0.309*	0.223***
(STD one year lagged)	(0.890)	(0.165)	(0.063)
Mean dep. variable (2008)	3,263.91	9.33	2.12
No. mothers	1,988,871	1,988,871	1,988,871
Panel B: CS births			
Obesity index	-2.159	-0.350	0.323**
(STD one year lagged)	(1.430)	(0.298)	(0.140)
Mean dep. variable (2008)	3,316.22	8.74	3.90
No. mothers	605,723	605,723	605,723
Panel C: Vaginal births			
Obesity index	-0.896	-0.262	0.176***
(STD one year lagged)	(1.006)	(0.192)	(0.058)
Mean dep. variable (2008)	3,242.39	9.58	1.38
No. mothers	1,383,148	1,383,148	1,383,148

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$. All models control for womans age, schooling, marital status, number of births, number of prenatal consults, gestational weeks and month and hospital fixed effects. Standard errors clustered at the hospital-month level. The sample consists of all low-risk mothers (i.e. mothers 18-35 years of age excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits) and only using municipalities with one clinic. Low birth weight is a dummy variable for having low birth weight (lower than 2,500 gr). Macrosomia is a dummy variable for having fetal macrosomia (birth weight higher than 4,500 gr). LBW and macrosomia are multiplied $\times 1,000$. Obesity index: standardized monthly lagged one year.

Table 6: **Robustness tests: Obesity index effect on delivery-related birth outcomes - Premature births**

	CS	Mother survival	Birth injury	Birth trauma	Apgar< 7
	(1)	(2)	(3)	(4)	(5)
Panel A: Premature birth def. 1					
Obesity index	0.000	1.241	-1.885	-3.907**	-0.002
(STD one year lagged)	(0.017)	(2.643)	(5.894)	(1.817)	(0.004)
Mean dep. variable (2008)	0.66	986.01	25.17	2.80	0.02
No. mothers	5,998	5,998	5,998	5,998	5,998
Panel B: Premature birth def. 2					
Obesity index	0.001	3.216***	-1.068	-0.196	0.001
(STD one year lagged)	(0.005)	(0.842)	(3.547)	(0.341)	(0.002)
Mean dep. variable (2008)	0.57	988.50	38.79	1.39	0.05
No. mothers	66,940	66,940	66,940	66,940	66,940

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: Significance levels: $^{*}p < 0.1,^{**}p < 0.05, p < 0.01$. All models control for womans age, schooling, marital status, gestational weeks, number of births, number of prenatal visits, and month and hospital fixed effects. For birth outcomes birth weight is included as a control. Two definitions of premature births are used. Premature birth definition 1: first time mothers (age > 30) gestational age between 30 and 37 weeks. Premature birth definition 2: All mothers, gestational age 30-37, and only low birth weight births.

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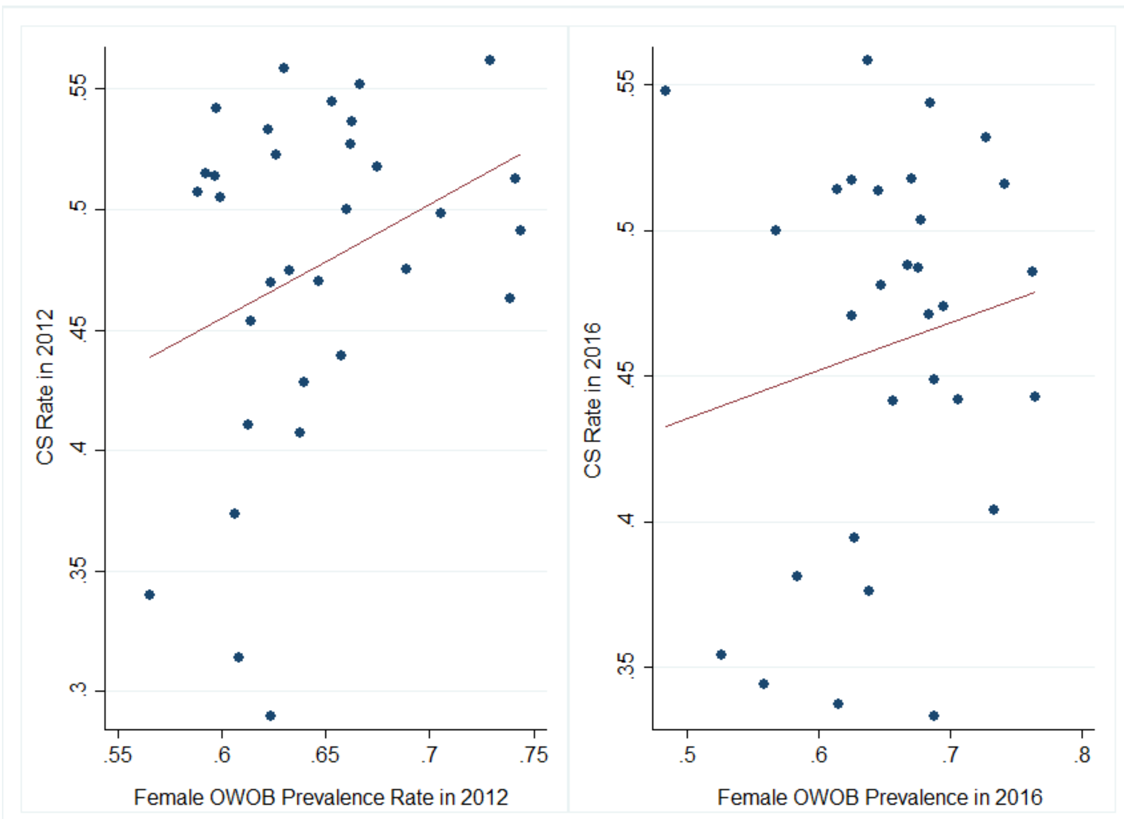
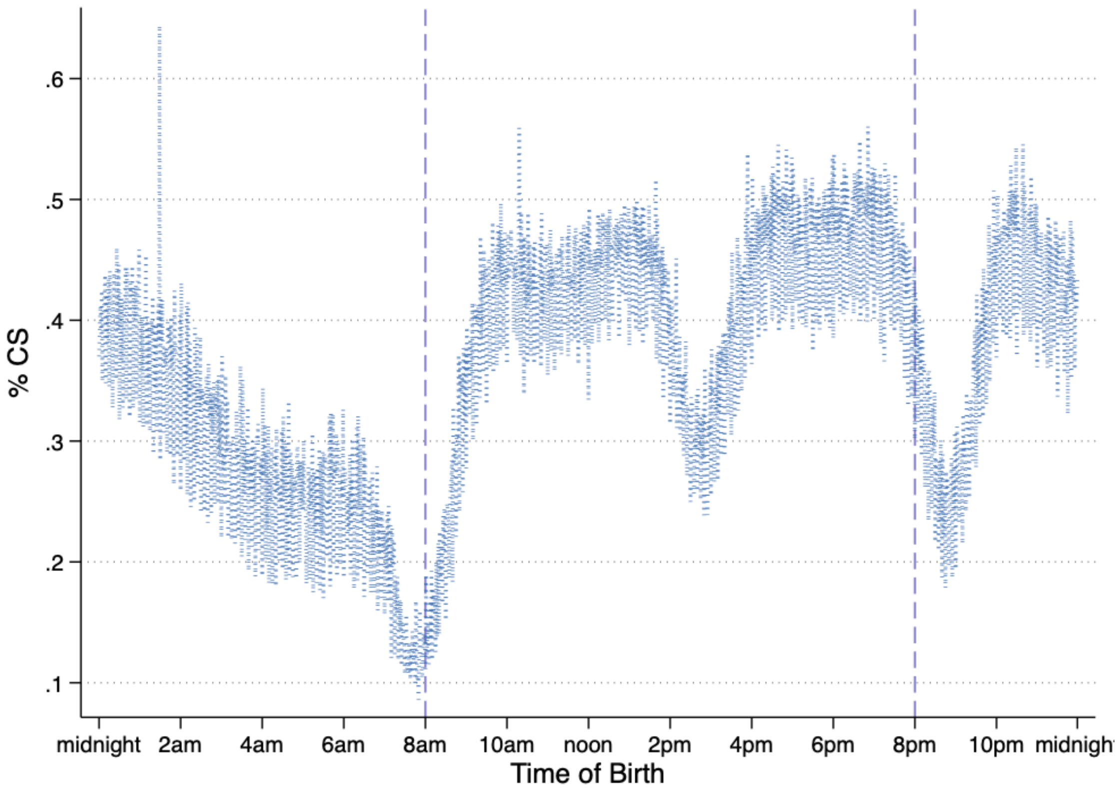
Online Appendix

Figure A1.1: **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 A1.2: **Time of day variation in CS rates**



Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

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

Table A1.1: **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
Observations	32	32	32	32	32	32
R^2	0.18	0.16	0.24	0.23	0.13	0.13

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC) and the National Survey of Health and Nutrition (ENSANUT).

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 bronchitis and stroke. State obesity index standardized.

Table A1.2: **Obesity index and CS: Heterogeneous effects by time of delivery**

	All births	Daytime	Nighttime + weekends
	CS	CS	CS
	(1)	(2)	(3)
Panel A: All births			
Obesity index	0.003**	0.004**	0.002
(STD one year lagged)	(0.001)	(0.002)	(0.002)
Mean dep. variable (2008)	0.29	0.37	0.24
No. mothers	1,988,871	846,512	1,142,359

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$. The dependent variable is whether a birth was via CS. 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-month level. The sample consists of all low-risk mothers (i.e. mothers 18-35 years of age excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits) and only considers municipalities with one clinic. The (monthly) obesity index is standardized and lagged one year. Nighttime is defined as if the birth occurred during the night hours (i.e. 8pm–8am).

Table A1.3: **Reduced form evidence: the effect of obesity index on delivery-related birth outcomes only for CS births and according to time of delivery**

	Mother survival (1)	Birth injury (2)	Birth trauma (3)	Apgar< 7 (4)
Panel A: All CS births				
Obesity index	1.798***	-1.066**	-0.144	-0.001*
(STD one year lagged)	(0.315)	(0.427)	(0.141)	(0.000)
Mean dep. variable (2008)	989.27	5.45	1.18	0.01
No. mothers	605,723	605,723	605,723	605,723
Panel B: Daytime CS births				
Obesity index	1.681***	-1.230**	-0.128	-0.001
(STD one year lagged)	(0.352)	(0.493)	(0.165)	(0.000)
Mean dep. variable (2008)	989.23	4.39	0.80	0.01
No. mothers	324,000	324,000	324,000	324,000
Panel C: Nighttime + weekends CS births				
Obesity index	1.909***	-0.834	-0.131	-0.001
(STD one year lagged)	(0.366)	(0.599)	(0.228)	(0.000)
Mean dep. variable (2008)	989.32	6.67	1.61	0.01
No. mothers	281,723	281,723	281,723	281,723

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: $^{*}p < 0.1$,$^{**} p < 0.05$,$^{***} p < 0.01$. All models control for woman's age, schooling, marital status, birth weight, gestational weeks, number of births, number of prenatal consults, and month and hospital fixed effects. Standard errors clustered at the hospital-month level. The sample consists of all CS births for low-risk mothers (i.e. mothers 18-35 years of age excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits) and only considers municipalities with one clinic. Apgar is based on a total score between 0 and 10, where a higher score reflects a better health outcome. Apgar< 7 is a dummy variable for whether the Apgar is less than 7. Birth injury is a dummy for the ICD-10 Codes: P10-15, P209-P221, P219-P221, P228, P229, P240, P285, P011, P032, P368, P369, P399, P545 and P914 multiplied by 1,000. Birth trauma is a dummy for the ICD-10 Codes: P10-15 multiplied by 1,000. Mother survival is a dummy for mother survival multiplied by 1,000. The (monthly) obesity index is standardized and lagged one year.

Table A1.4: **Heterogeneous effects on CS and maternal mortality by mothers' age and education**

	All births	18-24 years old	25-30 years old	30-35 years old	Low education	High education
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: CS						
Obesity index	0.003**	0.003**	0.003*	0.002	0.006***	0.002
(STD one year lagged)	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Mean dep. variable (2008)	0.29	0.28	0.30	0.32	0.27	0.31
No. mothers	1,988,871	1,151,129	584,278	253,464	684,102	1,304,769
Panel B: Mother survival						
Obesity index	1.239***	1.213***	1.376***	1.055***	1.106***	1.308***
(STD one year lagged)	(0.207)	(0.215)	(0.257)	(0.281)	(0.225)	(0.226)
Mean dep. variable (2008)	992.05	991.86	992.54	991.76	991.73	992.31
No. mothers	1,988,871	1,151,129	584,278	253,464	684,102	1,304,769

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: $^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$. All models control for marital status, gestational weeks, number of prenatal visits, number of births, and month and hospital fixed effects. Standard errors clustered at the hospital-month level. The sample consists of all low-risk mothers (i.e. mothers 18-35 years of age excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits) and only considers municipalities with one clinic. The (monthly) obesity index is standardized and lagged one year. Including linear time trends.

TABLE A1.5: **Robustness tests: Obesity index effect on delivery-related birth outcomes**

	CS	Mother survival	Birth injury	Birth trauma	Apgar< 7
	(1)	(2)	(3)	(4)	(5)
Panel A: Moving average index					
Moving average index	0.012***	0.075	-0.305	-0.351**	-0.000
	(0.002)	(0.236)	(0.225)	(0.139)	(0.000)
Mean dep. variable (2008)	0.30	992.26	3.60	1.30	0.01
No. mothers	1,521,076	1,521,076	1,521,076	1,521,076	1,521,076
Panel B: Unbalanced panel					
Obesity index	0.003***	0.590***	-1.104***	-0.881***	0.001**
(STD one year lagged)	(0.001)	(0.117)	(0.216)	(0.157)	(0.000)
Mean dep. variable	0.31	991.20	4.64	1.82	0.01
No. mothers	4,205,056	4,205,056	4,205,056	4,205,056	4,205,056
Panel C: Linear time trends					
Obesity index	0.003**	1.036***	-1.379***	-0.552***	0.000
(STD one year lagged)	(0.001)	(0.175)	(0.282)	(0.146)	(0.000)
Mean dep. variable	0.29	991.75	4.18	1.48	0.01
No. mothers	1,988,871	1,988,871	1,988,871	1,988,871	1,988,871
Panel D: High-risk mothers					
Obesity Proxy (STD	0.004*	1.737***	0.257	0.304	0.000
L1y)	(0.002)	(0.267)	(0.679)	(0.220)	(0.000)
Mean dep. variable	0.36	988.06	8.94	1.72	0.02
No. Mothers	824,986	824,986	824,986	824,986	824,986

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: Significance levels: $^{*}p < 0.1, ^{**}p < 0.05, p < 0.01$. All models control for womans age, schooling, marital status, gestational weeks, number of births, number of prenatal visits, and month and hospital-fixed effects. In addition, only Panel C controls by state-linear time trends. For the birth outcomes birth weight is included as a control. All models are estimated using the sample of all low-risk mothers (i.e. mothers 18-35 years of age excluding multiple births, 37 or less gestational weeks, and with less than 20 prenatal visits)—except for panel D which looks at high-risk births, defined as those under 18 or over 35, or with multiple births, or with gestational age < 37 weeks or with 20+ appointments. Only municipalities with one public clinic are considered except for Panel B where all clinics are included and are not restricted to those that had at least eight monthly births during each year over the study period. Apgar is based on a total score between 0 and 10, where a higher score reflects a better health outcome. Apgar< 7 is a dummy variable for whether the Apgar is less than 7. Birth injury is a dummy for the ICD-10 Codes: P10-15, P209-P221, P219-P221, P228, P229, P240, P285, P011, P032, P368, P369, P399, P545 and P914 multiplied by 1,000. Birth trauma is a dummy for the ICD-10 Codes: P10-15 multiplied by 1,000. Mother survival is a dummy for mother survival multiplied by 1,000. Obesity index: monthly standardized and lagged one year (Panel B, C, D); standardized moving average (Panel A).

TABLE A1.6: **Hospital-level Trends in obesity predict trends in CS**

	All hospitals (1)	Upward obesity trend hospitals (2)	Downward obesity trend hospitals (3)
$\beta_t^{Obesity}$	0.97***	1.09**	-1.79
	(0.37)	(0.54)	(1.25)
Observations	208	140	68
R-squared	0.03	0.03	0.03
Clinics	All	$\beta_t^{Obesity} > 0$	$\beta_t^{Obesity} < 0$

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: Significance levels: $^{*}p < 0.1,^{**} p < 0.05, p < 0.01$. The dependent variable is the hospital-level CS linear time trend, and the only explanatory variable is the obesity linear time trend ($\beta_t^{Obesity} > 0$). Regressions are weighted by the total number of births in a given hospital. The hospitals with the 1% largest and smallest obesity and CS trends are dropped from the estimation. Obesity linear time trends are calculated at the hospital level over the entire period.

Table A1.7: **No evidence of spillovers into private hospitals at municipal level**

	(1) % Private	(2) % Private	(3) % Private	(4) % Private
Obesity Proxy	0.004	0.003	0.006	0.006
(STD one year lagged)	(0.003)	(0.003)	(0.005)	(0.005)
Mean dep. variable	0.04	0.04	0.07	0.07
X: no. births	no	yes	no	yes
Sample	all	all	private> 0	private> 0
Clusters	226	226	129	129
Observations	18,834	18,834	10,719	10,719

Source: Authors' analysis based on data from birth/hospitalizations registries from Mexico's Ministry of Health (SSA/SINAC).

Notes: Significance levels: $^{*}p < 0.1,^{**}p < 0.05, p < 0.01$. Municipal level regressions. The dependent variable, % Private, is the share of births in a municipality that happened in private healthcare facilities, the main explanatory variable is the obesity index for the (only) SSA clinic in the municipality, lagged 1 year. All models include municipality-level fixed effects and year/month fixed effects. Some models control for the total number of births at the municipal level (X: no. births). Errors are clustered at the municipality level. Models 3 and 4 drop municipalities without private healthcare facilities over the entire period.