Congestion in the maternity ward:

Keep calm and call the surgeon

Gabriel Facchini*

February 15, 2016
WORK IN PROGRESS

Abstract

Over the past decades an increasing number of maternity wards have been shut down in developed countries due to the supposed lack of sufficient resources to provide appropriate care to parturient women. Congestion in the remaining maternity wards is thus expected to increase, raising questions over its effects on the quality of the services provided. Through an innovative natural experiment, this paper estimates the causal effects of congestion on patient treatment. Results suggest that, among women who attempt a vaginal delivery, those facing a ratio of patients to midwives higher than 1.25 (5 patients for every 4 midwives) experience a 21% rise in the probability of delivering by C-section. This is likely because C-sections are performed by gynecologists, which releases the workload of midwives in the delivery room. The fact that the increase in C-sections is only present in the morning and afternoon shifts when more surgeons are on call corroborates this hypothesis. Additionally, it is interesting to note that the effect of congestion is only present in single women, less education women, and first-time mothers.

1 Introduction

In both Europe and North America the number of maternity units has diminished regularly since the 1970s. This wave of closures affects mostly small maternity units that are deemed to be less safe. Centralization is expected to increase the number of medical facilities with multiple full-time obstetricians and ensure safe childbearing care. However, problems may arise if the units that remain open start seeing a demand higher than what they are capable of managing and situations of congestion start to emerge. According to a 2013 report by the National Audit Office in England, "28% of units [maternity wards] reported that they closed for half a day or more between April and September 2012, and mentioned lack of either physical capacity or midwives as the main reason behind these closures"[1]. It is still uncertain how much can, available resources, be overstretched before congestion starts affecting the quality of service.

---

*Department of Economics, European University Institute, Florence, Italy; e-mail: gabriel.facchini@eui.eu. I would like to extend my gratitude to Andrea Ichino, without whom this project would not have been possible, and Jérôme Adda for their invaluable support and advice throughout this research project. I am extremely grateful to Carlo Dani, Simone Pratesi, Federico Mecacci, Franca Rusconi and Luigi Gagliardi for their clinical expertise, to Tommaso Lanis for performing the confidential merge, and to Francesca Superbi for her assistance in accessing the data. I also thank seminar participants at the EUI Micro-Econometrics Working Group. All errors remain my own.

[1] National Audit Office (2013).

Studies focusing on the causal link between hospital congestion and patients' health have rose in the past 10 years. This literature finds none or very small effect when using census discharge data (Evans and Kim, 2006; Cook et al., 2012), but there seems to be an impact when focusing on congestion in the Emergency Department (ED) (de Araujo et al., 2013). Evans and Kim (2006) use the census of hospital discharges in California over the 1996-2000 period to estimate the impact of a large influx of patients on outcomes. Using a measure of unexpected admissions on some days of the week as an indicator of congestion, they find that congestion tends to reduce the length of stay and increase the chance of subsequent readmission (although both effects are very small) but has no impact on mortality rates. A more recent work by Cook et al. (2012) uses similar data for California to evaluate the impact of the California Assembly Bill 394 which mandated maximum levels of patients per nurse in hospitals. They use the difference between the required nurse staffing level and hospital staffing level in 2000 as an instrumental variable for the change in the ratio of patients to nurses between 2005-2006 and 2001-2002 (before and after the mandate was implemented)[2]. Their findings suggest that the AB394 had the intended effect of increasing the nurse staffing ratio, but fail to find any improvements in measured patient safety in affected hospitals. de Araujo et al. (2013), on the other hand, analyze the impact of ED overcrowding on wait times (time between admission and seeing a doctor) and patient outcomes. Because wait times is most likely endogenous, the authors use as instrumental variable the average number of patients in the ED at the time the patient checks in. They find evidence that longer waits at an ED increases the likelihood of negative outcomes for all patients.

The empirical evidence for the case of births is, however, much more limited. In particular, there is no study looking at the effect of congestion in maternity wards using a casual approach. The one that comes closest to this is Balakrishnan and Soderstrom (2000), using data from 225,473 maternity admissions at 30 hospitals in the state of Washington. The authors identify congested days using a percentile cut-off from the distribution of patients' admissions for each hospital-year combination and use the rate of C-sections as a proxy for the cost of congestion. They find a positive and significant effect only for those pregnancies that are classified as at-risk of C-section -where there is more room for physicians' discretion in the decision to operate. Although most C-sections are planned in advance and hospitals adjust their resources accordingly, the authors use the whole sample of births in their analysis because they cannot differentiate between scheduled and unscheduled surgeries in their data. Hence it could be the case that doctors plan more C-sections in some days than others without necessarily having any effect on patients' health, in which case there would be a problem of reverse causality in their identification strategy. Their study is silent with respect to other outcomes measuring patients' health more directly.

This study contributes to the existing literature by exploiting a natural experiment that allows for a causal interpretation of the potential effects of congestion on patients' health in the maternity ward setting. It exploits the fact that, for a large sample of births, the precise day and time of admission is independent from the quality of pregnancy. Most pregnancies follow a natural course where parturient women only go to the hospital once labor has already started and/or their water has broken -and this cannot be precisely predicted by the physician.

The data used corresponds to a census of births from the Azienda Ospedaliero Universitaria Careggi for the period 2011-2014. This is the biggest hospital in the Province of Florence (Italy) with more than 3,000 deliveries per year. Birth certificates contain information on mother and pregnancy characteristics, as well

---

[2] The Bill 394 was passed by the California legislature in 1999, but it was not implemented until January 1, 2004.

as indicators for quality of the delivery. More importantly, it allows to differentiate between scheduled and unscheduled births. Using patient ID, certificates are merged with hospital administrative data containing the exact time of admission, time of birth, and time of discharge. This information makes it possible to obtain the exact number of patients in the maternity unit at each point in time. Furthermore, this data is complemented with information on the number of midwives scheduled by month, day of the week and shift.

Congestion is measured as the ratio of patients to midwives. More precisely, the numerator computes how many patients are already in the maternity ward waiting to deliver at the time the indexed patient is admitted. The implicit assumption here is that the level of congestion at the moment of admission is orthogonal to patient characteristics in the sub-sample of pregnancies without a planned delivery date. Because the staff level at the hospital is not constant, adjusting by the number of midwives scheduled to the delivery room at the moment the indexed patient is admitted allows for a more precise measure of congestion.

Maternity wards have very few options to deal with surges in the ratio of patients to midwives. One possibility is the reduction of the number of patients in the ward. As explained in Balakrishnan and Soderstrom (2000), once a patient is referred to deliver by C-section, she is moved out to a surgical ward, thus reducing the congestion in the delivery room and the burden on midwives. In fact, for the data in hand, ratio of patients to midwives higher than 1.25 (more than 5 patients for every 4 midwives) produces a 21% increase in the likelihood of newly admitted patients delivering by C-section. Because elective C-sections are mainly performed during the morning and afternoon, the number of surgeons present in these shifts is much higher than at night (sometimes threefold). Consistent with this, regressions comparing the effect by shift find that that congestion rises the probability of an in-labour C-section only in the morning and afternoon shifts and has no effect at night.

It could be the case that by transferring patients to surgeons, midwives can take better care of patients remaining in the labor and delivery room. This does not seem to be the case for the data in hand, at least not for the afternoon shift. When looking at the effect of congestion on other measures of interventions and health, congestion only seems to diminish the probability delivering by operative birth and the probability of infants needing intensive care (maybe because midwives are more attentive) during the morning shift. At night, when there is no rise in C-sections, congestion shows no statistically significant effect on other outcomes.

Moreover, findings show that only first-time mothers, women without a university degree and single women see a rise in the probability of C-section during congested times. This poses the question of whether this is due to physicians finding it easier to convince these groups to have a C-section, or if it is simplu the case these women have a higher preference for C-section. Because the decision is made on the spot once the woman is already attempting to deliver vaginally, it is more likely that physician induced demand (PID) rather than taste drives these results. Indeed, there is a growing literature showing that factors dissociated with the medical status of the mother or fetus can determine the decision to operate. Economic research on this has mainly focused on doctors' monetary rewards to choose C-sections over vaginal delivery although there is evidence that non pecuniary incentives (e.g. leisure) also have an effect[3]. This study contributes to this last branch by adding a non-monetary incentive -workload release- to the reasons why physicians opt for C-sections (beyond medical reasons).

---

[3] For a literature review see Allin et al. (2015)

Although results suggest that there is little direct impact of congestion on patients' health, the fact that it increases the rate of C-section deliveries should be a reason for concern. According to the World Health Organization (WHO), C-sections can effectively prevent maternal and perinatal mortality and morbidity when medically justified. However, in cases where a C-section is not required, there is no evidence showing any benefit resulting from it[4]. On the contrary, since it is considered a major surgery, C-sections can cause complications that may affect the health of the woman, her child, and future pregnancies. In addition, entities responsible for the hospitals' budget should also take an interest in the rise of C-sections given that they are more costly than vaginal deliveries.

2 Clinical and Institutional Setting

There is a wide consensus regarding under supply of maternity services across developed countries. In a 2010 report, the WHO stated that "It is widely recognized throughout the WHO European Region that there are serious problems ensuring a sufficient number of well-qualified nurses and midwives..." (Büscher et al., 2010).

Beyond midwives shortage, the maternity ward setting has specific characteristics that make it specially well suited for issues of congestion to emerge. Following Balakrishnan and Soderstrom (2000) these characteristics are: (i) maternity wards are usually self-contained (in particular the labor and delivery room); (ii) these are expensive rooms and limited in number; (iii) their use varies significantly over time given the random nature of the beginning of labor and the fact that a woman in labor cannot be denied access.

This study focuses on women who follow the natural course of birth (unscheduled deliveries), for whom the arrival to the hospital is random and have a higher potential to create congestion. For these patients the process starts with frequent contractions and/or because they believe their water has broken. Once the mother arrives to the hospital she is evaluated and if she is indeed in active labor, she is admitted into a labor and delivery room and she is assigned a gynecologist and a midwife. If everything goes as plan and the woman is able to have a vaginal delivery, the midwife will be the one helping her through out the whole process. Nevertheless, during labor there are several medical conditions that can emerge and make necessary a cesarean delivery. More importantly, the actual presence of some of these medical conditions depend heavily on the subjective opinion of the gynecologist[5].

Under these conditions, C-sections may constitute a good proxy for system congestion. First, because a patient that is transferred to the operative theater is no longer followed so closely by the midwife but now she is in the hands of the gynecologist that will perform the surgery. This releases the midwives workload, and could allow them to better follow the patients who remain in the labor and delivery room. Second, due to the existence of the gray area mentioned before about when C-sections are indeed absolutely necessary. This circumstance gives the gynecologist more room to suggest surgery, even when not medically needed. Finally, the method of delivery is easy to measure and, unlike other information, whether the mother delivered vaginally or by C-section is always registered.

In a 2015 report, the World Health Organization (WHO) recognized that "governments and clinicians have

---

[4] World Health Organization (2015).

[5] Two of these conditions are dystocia (abnormally slow labor) and fetal distress

expressed concern about the rise in the numbers of cesarean section births and the potential negative consequences for maternal and infant health" (World Health Organization, 2015). One one side, the risk of postpartum death has been found to be several times higher after cesarean than after vaginal delivery (Deneux-Tharaux et al., 2006; Clark et al., 2008). Being a major surgery, the recovery times are larger for C-sections. In addition, trial of labor after prior C-section is associated with greater perinatal risk compared to repeated C-section (Landon et al., 2004) and serious maternal morbidity increases progressively with a higher number of C-sections (Silver et al., 2006). Hence physicians are rarely likely to recommend vaginal delivery for subsequent pregnancies after a C-section.

Finally, entities responsible for the hospitals' budget should also take an interest in the rise of C-sections given that they are more costly than vaginal deliveries. According to the Rates of hospital care for acute interventions published in 2013 by the Italian National Health Ministry[6], for uncomplicated deliveries a C-section costs €820 more than a vaginal delivery (€1,163 for complicated cases). These numbers are even larger for the case of the US[7]. Nevertheless all these risks and costs have to be weighed against the possible health problems that may arise in a congested maternity ward where midwives cannot help patients effectively.

3 Empirical Methodology

3.1 A natural experiment

An ideal experiment to test for any effect of congestion in the maternity ward on patients' health would imply assigning women in labor randomly between two different hospital types: a first one operating at its capacity limits and a second type with spare resources ready to focus entirely on the coming patient. For obvious reasons this is not possible to implement in practice. One possibility is then to test a model where the health outcomes of a birth depend on the number of deliveries that occur in the same hospital and day as the indexed birth. This strategy has the problem of reverse causation: if physicians schedule more C-sections when hospital resources (staff level) are higher[8] then the effect of congestion on C-section outcomes would be biased towards zero because those births will most likely show better health outcomes.

However, for a relatively large sample of the population of births, the time of arrival is unknown to the hospital beforehand. In the same way, the level of capacity utilization of the maternity ward in a given point in time is unknown for future patients until they reach the hospital. Hence for this sample of women one can assume that the variation in the number of patients waiting at the moment of arrival to the hospital is exogenous. This is the natural experiment exploited here to identify the impact of congestion on outcomes.

The study sample includes all births that, up to the point of arriving to the hospital, followed the "natural" course of pregnancy and, more importantly, labor. This means leaving out all planned deliveries where the physician decided, together with the pregnant woman, the date when the birth should take place. The first type of births that are excluded from the sample are all elective C-sections since they are programmed

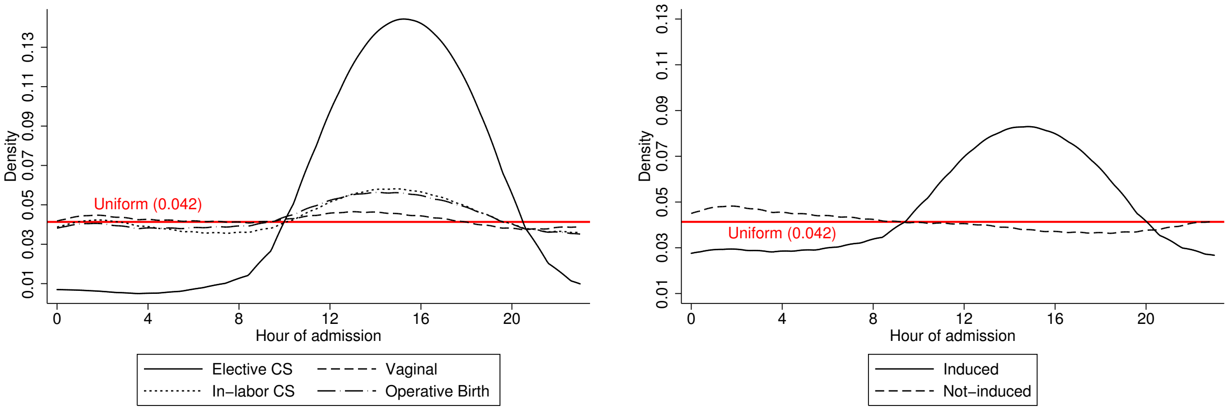
---

[6] Italian Health Ministry (2013).

[7] See Podulka et al. (2011).

[8] For example, in the data in hand, all planned C-sections are scheduled in the morning and resources are allocated accordingly.

Figure 1: Distribution of births by time of admission


(a) By delivery method

(b) By use of inducement

Note: Emergency C–sections are excluded, as well as all multiple pregnancies.

Note: Elective and Emergency C–sections are excluded, as well as all multiple pregnancies.

well in advance. Figure 1a shows how the distribution of elective C-sections by time of admission is not at all uniform across the day, but instead highly concentrated in the afternoon. This is because the hospital procedure prescribes that women who will follow an elective C-section will arrive the afternoon of the day before the surgery. Instead, for the remaining births, the distribution by time of admission is close to being uniform. This group includes all births that were planned vaginal deliveries (meaning that doctors and patients agreed on following the "natural" course for labor).

Furthermore, all births that were induced have to also be excluded from the study sample. Induced deliveries are in many cases planned in advance (e.g. when gestation is longer than usual). Similar to the case of elective C-sections, Figure 1b shows that women who are induced to deliver are more likely to be admitted at the hospital during the afternoon. For the remaining births the time of admission seems to be rather uniformly distributed across the day[9].

3.2 Data

Previous studies looking at newborns' health tend to use anonymous birth certificates since they are publicly available for many countries and for long periods of time. Nevertheless these datasets commonly lack information on key variables needed for a rigorous study of congestion, namely, the exact date and time of admission of patients, indispensable to quantify the demand for service at each point in time. Additionally, for a precise measure of congestion one needs to control for capacity utilization of the hospitals (supply side).

This study utilizes data from the Maternity Department of the Azienda Ospedaliero Universitaria Careggi (AOUC) for the years 2011 through 2014. This is the biggest hospital in the Province of Florence with

---

[9] It should be noted though that there are slightly less arrivals during the hours of pick admission for planned deliveries. This might have to do with a misclassification of unplanned births as planned. Because the data has no information on whether induced births were planned or not (some are, some are not), they are all classified as planned in order to keep a clean unexpected sample.

more than 3,000 deliveries per year. The primary databases used are two: (i) birth certificates[10]; and (ii) hospital admissions[11]. The birth certificates constitute a census of all births that took place in the hospital in this period. It contains information on mother characteristics (e.g. community of residence, education, civil status, age, previous deliveries, etc.), pregnancy characteristics (e.g. weeks of gestation, controls, assisted reproduction, etc.), birth characteristics (e.g. time of birth, type of labor, attendant, place, etc.) and indicators on health of the newborn (e.g. weight, height, APGAR score, death, etc.). The administrative hospital admission data provides information on the time of admission and time of discharge for each patient. Using unique mother-pregnancy identifiers, both databases can be merge together.

The aforementioned data on patients is complemented with information on the level of staff scheduled to be present at each month, day of the week and shift at the Maternity Department of the AOUC. Note that this is not the real level of staff present at each point in time but the schedule that the personnel should follow. Anecdotal evidence suggests that deviations from the planned level are rare, even because the hospital calls in someone else when an employee misses her/his shift. The information on staff shifts comes disaggregated by type of health worker (e.g. midwife, gynecologist, anesthetist and physician) and by sector within the ward (e.g. reception, delivery room, maternity ward, intensive care unit) which allows for a more precise measure of congestion.

However the richness of this dataset comes at a cost: because the information available corresponds only to one hospital in a four year period the sample size is relatively small. There are approximately 14,000 births for the period under study. From this about 1,900 observations are plural births and/or delivered by Emergency C-sections which will not be taken into account in the analysis because of their particular characteristics and handling within the hospital. Then further restricting the sample to non-induced planned-vaginal deliveries (leaving out elective C-sections) the number of observations goes down to around 8,100. Finally excluding observations with missing time of admission, maternal age, education, birth order, weight and prenatal visits the number of observations in the working sample is 7,988. The models described below are fitted to this sample of observations for which one can presume orthogonality between pregnancy characteristics and congestion upon admission to the hospital.

3.3 Defining congestion

When measuring congestion in the provision of a specific good or service, information on both demand and supply levels is needed. For the maternity ward service, this study uses a very intuitive measure of demand, namely, the number of patients waiting to deliver when the indexed patient is admitted at the hospital. The richness of the data in hand allows to construct a very precise measure of the number of parturient women in the maternity ward at any point in time and to differentiate between those waiting to deliver and those in postpartum. An implicit assumption in using this measure is that the number of patients waiting in the moment that the indexed patient arrives is orthogonal to her characteristics. As mentioned before, this is obtained by restricting the analysis to the sample of unexpected patients.

For the supply side the number of midwives scheduled to be on duty in the delivery room is used. Table 3.1

---

[10] Certificato di assistenza al parto (CEDAP).

[11] Scheda di Dimissione Ospedaliera (SDO).

Table 3.1: Number of midwives by sector, day of the week and shift.

Day	Shift	Sector Admission	Delivery Room	In-patient ward 1	In-patient ward 2
Weekday	Morning (7am - 1pm)	**1**	5	2	6
	Afternoon (1pm - 19pm)	**1**	4	2	5
	Night (19pm - 7am)	**1**	3	1	3
Saturday	Mattina (7am - 1pm)	**1**	4	2	5
	Pomeriggio (1pm - 19pm)	**1**	4	2	5
	Notte (19pm - 7am)	**1**	3	1	3
Sunday & holidays	Mattina (7am - 1pm)	**1**	3	2	5
	Pomeriggio (1pm - 19pm)	**1**	3	2	5
	Notte (19pm - 7am)	**1**	3	1	3

shows the number of midwives that should be present in each sector of the maternity ward by day of the week and shift. For the measure of congestion used here only the staff scheduled to be in the delivery room will be used since those are the ones dealing with the patient in labor. The number of midwives in this sector is highest in the morning shift (5), and lowest at nights, Sundays and holidays (3)[12].

Table 3.2 shows the distribution of the ratio of patients to midwives disaggregated by shift of admission. At the median, there are 5 patients waiting for every 3 midwives in the delivery room. The distribution is right-skewed hence the mean is slightly higher. Note that shifts later in the day have higher values of the ratio, meaning, higher congestion. Remember that the distribution of patients is rather uniform across the day, hence this upward shift in congestion comes exclusively from a lower supply (less midwives present).

Table 3.2: Descriptive statistics for ratio of patients to midwives by shift of admission.

	All	Morning (7am - 1pm)	Afternoon (1pm - 7pm)	Night (7pm - 7am)
p1	0.33	0.20	0.50	0.33
p5	0.67	0.50	0.75	0.67
p25	1.25	1.00	1.25	1.33
p50	1.67	1.33	1.67	2.00
p75	2.33	1.80	2.25	2.67
p95	3.33	2.67	3.00	3.67
p99	4.33	3.67	4.00	4.67
mean	1.86	1.42	1.74	2.11
sd	0.87	0.68	0.77	0.90
Ratio>1.25 (%)	0.73	0.52	0.67	0.87
N	7,988	1,988	1,818	4,182

---

[12] In Figure 2 one can see how the average ratio of patients to midwives by hour of admission shows a discrete jump up with each change in shift due to one less midwife being present.

3.4 Econometric specification

The first estimates are obtain from an OLS regression of a binary indicator for in-labor C-section on the treatment variable along with demographic and clinical controls. In contrast to previous literature in this area -that exploits daily within hospital variation in the number of patients- this paper adds hourly variation and controls for the level of staff scheduled to be in the delivery room. For the initial analysis a linear specification of congestion is used, where treatment is the ratio of patients to midwives. A simple reduced-form linear probability model of the following type is used[13]:

$$\mathrm{y}_{it} = \alpha + \beta\,\mathrm{R}_{it} + \mathbf{x}_{it}^{'}\,\theta + \gamma_t + \epsilon_{it} \tag{1}$$

where y_{it} is a dummy variable indicating whether birth i admitted at time t had an in-labor C-section, and R_{it} is the ratio of patients-to-midwives observed at admission. and $\mathbf{x}_{it}$ contains individual-level control variables of mother and pregnancy characteristics: a dummy for whether the mother is above 34 years old, a dummy for whether the mother has a university degree, a dummy for whether this is her first pregnancy, a dummy for whether the infant is a male, a dummy for whether is a pre-term birth (below 37 weeks of gestation), a dummy for whether the baby is born with low weight (less than 2,500 grams), and a dummy for whether the mother had at least one emergency check up during pregnancy. Time fixed effects γ include year, month, day of the week and shift of admission. β is the coefficient of interest. As discussed above, if physicians are more likely to perform a C-section when the ratio of patients to midwives is high, then β should be positive.

Because there can be non linear effects of congestion on the probability of C-section, patients were classified in two groups according to the level of congestion observed: a first (or control) group includes al patients that saw a ratio of patients to midwives below or equal to 1.25 (which coincides with the upper limit of the 25^{th} percentile of the distribution of congestion); all remaining patients with a higher ratio are in the second (or treatment) group. In a second model a dummy variable for being in the last group is used as treatment instead of the ratio of patients to midwives[14]. Following the literature on experiments, once observations have been classified in either treatment ($ratio > 1.25$) or control ($ratio \leq 1.25$), it is possible to check whether these groups are balanced in terms of pre-treatment characteristics. The first 2 columns of Table A.3 show the mean for each variable for each group. The last column reports the difference between the means of the two groups. The fact that none of these differences is statistically significantly different from zero reinforces the confidence on the quasi-natural experiment.

To test whether treatment varies with the availability of surgeons, the next set or regressions compare different shifts of the personnel. The estimated OLS regressions are:

$$\mathrm{y}_{it} = \alpha + \beta_1\,\mathrm{R}_{it} + \sum_{s=2}^{3}\left[\beta_s\,\mathrm{R}_{it} \times \mathrm{Shift}_{it}^{s}\right] + \mathbf{x}_{it}^{'}\,\theta + \gamma_t + \epsilon_{it} \tag{2}$$

where Shift_{it}^{s} is a variable indicating whether the mother was admitted during shift s (baseline is morning

---

[13] A probit model was also estimated assuming a normal distribution of the error term and results remain unchanged. Results for the probit regressions are available upon request.

[14] A model including dummy variables for each quartile of the ratio of patient to midwives was also tested. Results were similar, but the analysis of heterogeneity on treatment is more straight forward with a dummy.

shift=1). Since there are more surgeons on call during the morning shift than at night, one should expect β_1 to be positive and β_3 negative. This would imply that the transferring of patients from midwives to gynecologists is more likely to occur when there are more gynecologists available -all else equal-.

The next set of regressions uses the same model specification as in Eq. 2 but now y_{it} is an indicator variable for health outcomes or other interventions that were performed on pregnancy i -either the mother or the infant-. Because some of these outcomes are rare and the linear probability model performs poorly under such conditions, logit regressions were also estimated. Results are not different from the OLS estimates.

The final set of regressions explores heterogeneity effect of treatment between demographic groups for which the information asymmetry between the physician and the mother may be assume to be higher, and hence, easier for the physician to recommend a C-section without a medical reason for it. Starting from Eq. 1, now four dummy variables depicting some demographic characteristic of the mother are interacted with the variable of treatment ($R = Ratio > 1.25$). The four dummy variables are: whether the mother is primipara, whether she is younger than 35, whether she is not married, and whether she does not have a university degree. If indeed women in these groups have a lower bargaining power when deciding to perform a surgery, then the marginal effects of congestion should be higher for them.

4 Results

The first column of Table 4.1 presents the results of Eq. 1. To save space, only the coefficients of treatment are included, but results for other covariates are comparable to previous studies. The numbers in parentheses in the table are standard errors. The average value of each dependent variable is included at the bottom of each panel to help understand whether coefficients are economically important.

Panel (A) of the table reports results for the Ratio of patients to midwives as a linear variable, and Panel (B) reports results using a dummy variable for whether the patient experienced a ratio of patients to midwives above 1.25 (5 patients waiting for every 4 midwives) to test for non-linearities. Although the coefficient for the linear specification is not statistically significant, in the second one the probability of having an in-labor C-section is 22% higher for the treated group. Given that 1.25 is the percentile 25^{th} of the distribution, this means that three quarters of the sample are affected.

This effect would imply a 3.5% rise in total C-sections (scheduled and unscheduled), which seems reasonable and economically important when compared with previous studies looking at all C-sections and changes in monetary compensation. Allin et al. (2015) find that doubling the compensation for a C-section relative to a vaginal delivery increases the likelihood that a physician opts for the former by just more than 5 percentage points, all else equal. Gruber et al. (1999) suggests that cesarean delivery rates would rise by 3.9% in response to each $100 increase in the compensation received for a C-section, all else equal.

Under the hypothesis that some patients are transferred to follow a C-section in order to release some of the midwives' workload, the effect of congestion should only be present (or relatively higher) in times when there are gynecologists that can perform the surgery. The personnel schedule of gynecologists in the maternity ward presents a good set up to test this hypothesis. Because most elective C-sections are performed during

Table 4.1: Impact of congestion on In-labour C-sections

	All	Morning (7am - 1pm)	Afternoon (1pm - 7pm)	Night (7pm - 7am)
Panel (A)				
Ratio patients to midwives	0.0051	0.0116	0.0073	0.0028
	(0.0038)	(0.0083)	(0.0088)	(0.0046)
Panel (B)				
Ratio > 1.25	0.0179**	0.0260**	0.0249*	0.0043
	(0.0073)	(0.0118)	(0.0141)	(0.0120)
Observations	7,988	1,988	1,818	4,182
Mean Dep.	0.082	0.0734	0.0979	0.0791

Robust standard errors in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$
Reported coefficients are marginal effects of congestion for each shift.

the morning (and some in the afternoon) the presence of gynecologists is the highest in the morning shifts and the lowest at night. Given that the time of admission of patients in the study sample is uniformly distributed across the day, whether the patient is admitted while a surgeon is available or not is exogenous to her characteristics. Table A.4 shows that most pre-treatment characteristics are balanced across shifts[15].

The last three columns of Table 4.1 show the average marginal effect of congestion for each shift from estimates of Eq. 2. The positive effect of congestion on the probability of in-labor C-section is only present during the morning and afternoon shifts. The point estimate of the night shift is 6 times smaller, and not statistically different from zero. This confirms the hypothesis that the change in patients' delivery method occurs only when there is a surgeon ready to perform the C-section.

4.1 Are these extra cesarean sections necessary?

The estimates above show that women who are admitted during congested times are more likely to give birth through a C-section instead of a vaginal delivery. There are two possible hypotheses that can explain this. The first is that these "extra" cesarean sections are necessary to maximize the health outcomes of all the patients of the hospital because, without the possibility of transferring patients to surgeons, midwives would not do as good of a job. Under this scenario one should observe that during the night shift -when less surgeons are available- congestion has a negative impact on patients' health. The second possibility is that congestion, within the measures of this study, has no consequences on patients' health and these "extra" C-sections are unnecessary from a purely health point of view -although they do release the midwives' workload by using a surgeon's free time. In this case one should observe an effect of congestion on the probability of C-sections in the busiest shifts, but no effect of congestion on health. And this seems to be the case here.

In the economics literature the most commonly studied health outcomes for births are: weight, fetal mortality and maternal mortality. Nevertheless both maternal and fetal deaths are extremely rare events (4 per 100,000

---

[15] With the exception of gender. In this hospital inducements are more likely to happen during the afternoon and male newborns tend to have a more prolonged pregnancy (Divon et al. (2002)). At the same time, longer pregnancies are more likely to be induced. Since all induced births (both planned and unplanned) are excluded from the analysis, some not planned induced births taking place in the afternoon are also dropped, and this diminishes the share of male.

births and 2.7 per 1,000 births respectively for Italy). In the case of weight-at-birth, because treatment here is defined at the moment of admission to the hospital, it is considered a pre-defined outcome (not affected by treatment)[16].

The restricted-use version of the birth certificates in hand contains, however, some other measures of health and registers of medical interventions that are associated with health outcomes. The measures that occur in at least 1% of births are: Post-partum hemorrhage, having an operative birth[17], whether the newborn was transferred to a neonatal intensive care unit (NICU), no skin-to-skin contact, and lack of exclusive breastfeeding. A higher probability of needing NICU, having an operative birth[18], or a post-partum hemorrhage during congested moments could be signals of lower quality. Similarly, if human resources are scarce, physicians may decide to skip some steps of the service considered important but not essential. For example, they may decide that helping the newly mother achieve skin-to-skin contact with her newborn is not as important as helping another parturient woman to deliver. The same reasoning applies for not giving exclusive breast-feeding.

While it is clear why a post-partum hemorrhage or a higher probability of going to NICU are not desirable, there are also compelling arguments regarding the importance of the remaining set of outcomes. In a systematic review, Ip et al. (2007) finds that breastfeeding is associated with both decreased risk for many early-life diseases and conditions as well as with health benefits to women[19]. At the same time, skin-to-skin contact has been shown to increase the probability and length of exclusive breastfeeding (Moore et al., 2007), as well as substantially reducing neonatal mortality amongst preterm babies in hospital(Lawn et al., 2010). In the case of operative births, even though it is still widely used, this delivery method is becoming less popular due to some evidence showing that instrumental deliveries increase maternal morbidity and can cause significant fetal morbidity (Ali and Norwitz, 2009; Murphy et al., 2011; Towner et al., 1999).

The last five columns Table 4.2 show the effect of congestion on these measures of health and other medical interventions. In both linear and non-linear specifications congestion has a negative impact on the probability of needing intensive care during the morning shift. Since this shift also showed a rise in the probability of C-section due to treatment, this result main imply that transferring patients to surgeons indeed helps diminishing the likelihood of bad health outcomes that end up in the need for intensive care. Nevertheless the afternoon shifts shows a similar effect of congestion on the probability of C-section, but no effect on the health outcomes used here. Finally there is almost no effect of congestion on these health outcomes during the night shift. The only statistically significant effect of congestion during the night shift is a rise on the probability that the newborn does not get skin-to-skin contact -though the size of effect is relatively small. The lack of important negative effects of congestion at night agrees with the hypothesis of unnecessary C-sections.

---

[16] Low weight at birth is one of the variables used to assess the balancing of the sample between treatment and control groups.

[17] Operative vaginal delivery refers to a delivery in which the midwife uses forceps or a vacuum device to assist the mother in transitioning the fetus to extra-uterine life.

[18] A higher likelihood for operative birth has been linked to scarce or absent midwifery care and the presence of obstetrician or physicians instead (Hatem et al. (2008)).

[19] "Breastfeeding and Maternal and Infant Health Outcomes in Developed Countries", AHRQ Publication No. 07-E007, April 2007.

Table 4.2: Other interventions and health outcomes

	Post-partum hemorrhage	Operative Birth	NICU§	No s2s‡	Non-exclusive Breastfeeding
Ratio Patients to Midwives					
Morning (7am - 1pm)	-0.0101	0.0169*	-0.0113*	0.0047	0.0156
	(0.0091)	(0.0094)	(0.0060)	(0.0109)	(0.0166)
Afternoon (1pm - 7pm)	0.0034	0.0053	-0.0012	-0.0063	-0.0171
	(0.0099)	(0.0077)	(0.0055)	(0.0102)	(0.0144)
Night (7pm - 7am)	-0.0083	0.0049	-0.0017	0.0109*	0.0128
	(0.0053)	(0.0044)	(0.0035)	(0.0060)	(0.0083)
Ratio > 1.25					
Morning (7am - 1pm)	-0.0094	0.0045	-0.0193**	-0.0031	0.0160
	(0.0133)	(0.0113)	(0.0089)	(0.0155)	(0.0220)
Afternoon (1pm - 7pm)	-0.0004	-0.0011	0.0000	0.0004	-0.0238
	(0.0148)	(0.0131)	(0.0092)	(0.0176)	(0.0248)
Night (7pm - 7am)	-0.0163	0.0065	-0.0052	0.0068	0.0154
	(0.0140)	(0.0111)	(0.0094)	(0.0157)	(0.0212)
Observations	7,242	7,988	7,976	6,914	6,467
Mean Dep.	0.0855	0.0704	0.0583	0.149	0.274

Robust standard errors in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

§NICU: Neonatal Intensive Care Unit; ‡No s2s: No skin-to-skin contact.

Reported coefficients are marginal effects of congestion for each shift/outcome combination.

4.2 Is everyone as likely to get surgery during congested times?

This part of the study digs deeper into the effect of congestion on the rate of in-labor C-sections and tries to disentangle if there are specific demographic groups of women who are more likely to be passed to the operational theater. Using data from the state of New Jersey (US), Currie and MacLeod (2014) observe that, conditional on C-section risk, African-American and Hispanic women are more likely to have C-sections, as are less educated women, single women, older mothers, and mothers of first born children. Nevertheless they do not comment on what is causing this gap in probabilities. On one hand, it could be the result of differences in patients preferences with these women having a higher utility from C-sections than other women. But it can also be an outcome of an agency issue where physicians find it easier to convince women form the some demographic groups to change treatment and get surgery.

The set up of this paper offers a better setting for analyzing these options. Because the focus is exclusively on in-labor C-sections, the above estimates correspond to women who have already agreed on attempting labor in the process to have a vaginal delivery. Hence the effect is more likely to arise from decisions made in the delivery room regarding when to stop labor and change treatment than from maternal preferences for elective C-sections. Nevertheless, because data comes from a public hospital, if there is no medical reason for having a C-section patients may be denied that treatment even when preferred. Hence it is not possible to totally rule out that some demographic groups may be more inclined towards having a C-section and physicians internalize this when deciding which patient gets sent to surgery.

In order to check this a new set of regressions is run with interactions between the dummy of treatment and

Table 4.3: Average marginal effect of congestion on the probability of in-labor C-section by groups

	By pregnancy #		By age	
	Primipara	Not Primipara	Young ($\leq$ 34)	Old (>34)
Ratio > 1.25	0.0431***	0.0012	0.0167**	0.0197
	(0.0111)	(0.0089)	(0.0083)	(0.0122)
Observations	7,988	7,988	7,988	7,988

	By civil status		By education	
	Not married	Married	Without University	With University
Ratio > 1.25	0.0325**	0.0012	0.0275***	-0.0012
	(0.0128)	(0.0093)	(0.0087)	(0.0118)
Observations	6,984	6,984	7,988	7,988

Robust standard errors in parentheses.
$***p < 0.01, **p < 0.05, *p < 0.1$

four different covariates of interest -one at a time-: whether the woman is first-time mother, whether she is older than 34, whether she is married[20] and whether she has a university degree. Table 4.3 summarizes the results from this regressions showing only the coefficients of treatment for each group of interest.

The coefficients for women who are first-time mothers, as for single women and women without a university degree are consistently higher than those of women with previous pregnancies, married women and women with a degree. In fact, the effect of congestion does not seem to be present at all for these later women. The effect of congestion on the probability of in-labor C-section does not seem to vary with age.

5 Conclusions

Given the increasing number of maternity wards being closed in developed countries (either temporarily or permanently) it is extremely important to know whether congestion has an impact on patients' health. This study explores whether congestion in the delivery room, as measured by the ratio of patients to midwives, has an impact on the effective treatment received by the future mothers. The contribution is threefold. First it proposes an innovative empirical approach that rests on a quasi-natural experiment that assigns women randomly between treatment and control groups that allows for a causal interpretation of results. Second, while previous studies have measured congestion using exclusively data on patients, the richness of the dataset in hand allows to control for the level of health workers scheduled to be on duty. Lastly, it provides suggestive evidence that the costs of congestion, when existing, do not affect all patients equally.

---

[20] This variable is constructed only with married and single women. For the sake of clarity all women outside these two categories (divorced, separated and widows) are not considered.

Focusing exclusively on patients attempting labor and vaginal delivery, this study finds that during congested times the probability of delivering by C-section rises. Women that, at admission, see a ratio of patients to midwives higher than 1.25 are about 21% more likely to change delivery method. Because C-sections have to be performed by a gynecologist, this evidence is understood as a hospital's strategy to diminish the pressure on midwives. Results by shift of admission confirm that this effect is only present in the morning and afternoon shifts -when there are more surgeons on call- and not at night.

In order to disentangle whether this "extra" treatment is at the same time aiming at maximizing the health of the patients, the effect of congestion on other measures of treatment and health were analyzed. The absent of an effect of congestion on any of these measures during the night shift (when transferring patients to gynecologists is not possible) suggests that such a change in treatment is not necessary medically justified. Furthermore, this practice seems to be used only on first-time mothers, as for women without a university degree and single women. Following the literature on supplier induced demand, it may be easier for the physician to convince these demographic groups about the need for a C-section.

This paper demonstrates that approximately 15% of in-labor C-sections are unnecessary from a medical point of view. This comes down to about 3.5% of all C-sections (both scheduled and unscheduled). In the absence of congestion hospital expenditures could be reduced by at least €35,000 a year per hospital[21].

It should be mentioned that some of these results are not estimated precisely due to the small sample size of the database in hand. More importantly, critical measures of health (like mother and newborn death, and the probability of having a low APGAR score) could not be used because of small sample size. Therefore it remains an open question whether these outcomes are affected by congestion.

References

Ali, U. A. and Norwitz, E. R. (2009), 'Vacuum-assisted vaginal delivery', *Reviews in Obstetrics and Gynecology* **2**(1), 5.

Allin, S., Baker, M., Isabelle, M. and Stabile, M. (2015), Physician incentives and the rise in c-sections: Evidence from canada, Technical report, National Bureau of Economic Research.

Balakrishnan, R. and Soderstrom, N. S. (2000), 'The cost of system congestion: Evidence from the healthcare sector', *Journal of Management Accounting Research* **12**(1), 97–114.

Büscher, A., Sivertsen, B., White, J. et al. (2010), 'Nurses and midwives: a force for health', *Copenhagen: World Health Organization (WHO)* .

Clark, S. L., Belfort, M. A., Dildy, G. A., Herbst, M. A., Meyers, J. A. and Hankins, G. D. (2008), 'Maternal death in the 21st century: causes, prevention, and relationship to cesarean delivery', *American journal of obstetrics and gynecology* **199**(1), 36–e1.

---

[21] Back of the envelope calculations suggest that there are about 43 "extra" C-sections per year due to congestion. According to the prices on acute interventions published by the Italian Ministry of Health, a vaginal delivery without complication is rated at €1,272, while a C-section costs €2,092. Hence the difference (€820time the number of extra C-sections (43) gives €35,260.

Cook, A., Gaynor, M., Stephens Jr, M. and Taylor, L. (2012), 'The effect of a hospital nurse staffing mandate on patient health outcomes: Evidence from california's minimum staffing regulation', *Journal of Health Economics* **31**(2), 340–348.

Currie, J. M. and MacLeod, W. B. (2014), 'Diagnosing expertise: A two factor model of physician skill'.

de Araujo, P., Khraiche, M. and Tukan, A. (2013), 'Does overcrowding and health insurance type impact patient outcomes in emergency departments?', *Health Economics Review* **3**(1), 1–7.

Deneux-Tharaux, C., Carmona, E., Bouvier-Colle, M.-H. and Bréart, G. (2006), 'Postpartum maternal mortality and cesarean delivery', *Obstetrics & Gynecology* **108**(3, Part 1), 541–548.

Divon, M. Y., Ferber, A., Nisell, H. and Westgren, M. (2002), 'Male gender predisposes to prolongation of pregnancy', *American journal of obstetrics and gynecology* **187**(4), 1081–1083.

Evans, W. N. and Kim, B. (2006), 'Patient outcomes when hospitals experience a surge in admissions', *Journal of Health Economics* **25**(2), 365–388.

Gruber, J., Kim, J. and Mayzlin, D. (1999), 'Physician fees and procedure intensity: the case of cesarean delivery', *Journal of Health Economics* **18**(4), 473–490.

Hatem, M., Sandall, J., Devane, D., Soltani, H. and Gates, S. (2008), 'Midwife-led versus other models of care for childbearing women', *The Cochrane Library* .

Ip, S., Chung, M., Raman, G., Chew, P., Magula, N., DeVine, D., Trikalinos, T. and Lau, J. (2007), 'Breastfeeding and maternal and infant health outcomes in developed countries.', *Evidence report/technology assessment* pp. 1–186.

Italian Health Ministry (2013), Tariffe delle prestazioni di assistenza ospedaliera per acuti (sistema drg), Technical report.
URL: *http://www.salute.gov.it/portale/temi/p2_6.jsp?id=3662&area=programmazioneSanitariaLea&menu=vuoto*

Landon, M. B., Hauth, J. C., Leveno, K. J., Spong, C. Y., Leindecker, S., Varner, M. W., Moawad, A. H., Caritis, S. N., Harper, M., Wapner, R. J. et al. (2004), 'Maternal and perinatal outcomes associated with a trial of labor after prior cesarean delivery', *New England Journal of Medicine* **351**(25), 2581–2589.

Lawn, J. E., Mwansa-Kambafwile, J., Horta, B. L., Barros, F. C. and Cousens, S. (2010), 'kangaroo mother careto prevent neonatal deaths due to preterm birth complications', *International Journal of Epidemiology* **39**(suppl 1), i144–i154.

Moore, E. R., Anderson, G. C., Bergman, N. et al. (2007), 'Early skin-to-skin contact for mothers and their healthy newborn infants', *Cochrane Database Syst Rev* **3**.

Murphy, D. J., Macleod, M., Bahl, R. and Strachan, B. (2011), 'A cohort study of maternal and neonatal morbidity in relation to use of sequential instruments at operative vaginal delivery', *European Journal of Obstetrics & Gynecology and Reproductive Biology* **156**(1), 41–45.

National Audit Office (2013), NAO maternity services in england, Technical report.
URL: *https://www.nao.org.uk/report/maternity-services-england-2/*

Podulka, J., Stranges, E. and Steiner, C. (2011), 'Hospitalizations related to childbirth, 2008'.

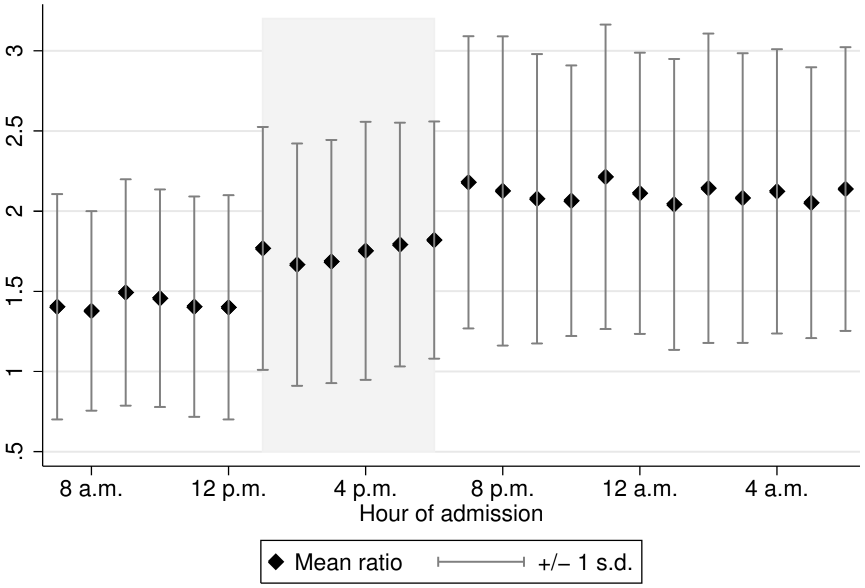
Silver, R. M., Landon, M. B., Rouse, D. J., Leveno, K. J., Spong, C. Y., Thom, E. A., Moawad, A. H., Caritis, S. N., Harper, M., Wapner, R. J. et al. (2006), 'Maternal morbidity associated with multiple repeat cesarean deliveries', *Obstetrics & Gynecology* **107**(6), 1226–1232.

Towner, D., Castro, M. A., Eby-Wilkens, E. and Gilbert, W. M. (1999), 'Effect of mode of delivery in nulliparous women on neonatal intracranial injury', *New England Journal of Medicine* **341**(23), 1709–1714.

World Health Organization (2015), WHO statement on caesarean section rates, Technical report.
URL: *http://www.who.int/reproductivehealth/publications/maternal_perinatal_health/cs-statement/en/*

A Other Graphs and Tables

Figure 2: Ratio of Patients to Midwives by time of admission



Note: Shaded area marks the afternoon shift (1 pm – 7 pm)

Table A.1: OLS estimates - Linear specification of congestion

	All	Morning (7am - 1pm)	Afternoon (1pm - 7pm)	Night (7pm - 7am)
Ratio patients/midwifes	0.0051	0.0080	0.0139	0.0029
	(0.0038)	(0.0092)	(0.0097)	(0.0047)
University degree	-0.0212***	-0.0197	-0.0232	-0.0194**
	(0.0064)	(0.0123)	(0.0148)	(0.0088)
Old (>34 years old)	0.0423***	0.0259**	0.0690***	0.0383***
	(0.0067)	(0.0125)	(0.0154)	(0.0092)
Primipara	0.0351***	0.0144	0.0553***	0.0343***
	(0.0065)	(0.0121)	(0.0153)	(0.0088)
Male	0.0195***	0.0235**	0.0187	0.0189**
	(0.0061)	(0.0116)	(0.0139)	(0.0082)
Preterm (<37 wofg)	0.0294	0.0141	0.0026	0.0580*
	(0.0214)	(0.0409)	(0.0441)	(0.0308)
Low weight at birth (< 2.5kg)	0.1062***	0.0737	0.1565***	0.0890**
	(0.0259)	(0.0504)	(0.0540)	(0.0360)
ER visit	0.0353***	0.0502**	0.0369	0.0295*
	(0.0115)	(0.0233)	(0.0237)	(0.0158)
Observations	7,988	1,988	1,818	4,182
Mean Dep.	0.0820	0.0734	0.0979	0.0791

$***p < 0.01, **p < 0.05, *p < 0.1$

Table A.2: OLS estimates - Non-linear specification of congestion

	All	Morning (7am - 1pm)	Afternoon (1pm - 7pm)	Night (7pm - 7am)
Ratio > 1.25	0.0179**	0.0224*	0.0327**	0.0041
	(0.0073)	(0.0123)	(0.0145)	(0.0120)
University degree	-0.0210***	-0.0193	-0.0226	-0.0194**
	(0.0064)	(0.0123)	(0.0148)	(0.0087)
Old (>34 years old)	0.0422***	0.0261**	0.0681***	0.0383***
	(0.0067)	(0.0125)	(0.0153)	(0.0092)
Primipara	0.0348***	0.0146	0.0535***	0.0342***
	(0.0064)	(0.0121)	(0.0152)	(0.0088)
Male	0.0197***	0.0240**	0.0183	0.0190**
	(0.0061)	(0.0116)	(0.0139)	(0.0082)
Preterm (<37 wofg)	0.0292	0.0136	0.0033	0.0579*
	(0.0214)	(0.0408)	(0.0440)	(0.0308)
Low weight at birth (< 2.5kg)	0.1066***	0.0754	0.1558***	0.0892**
	(0.0259)	(0.0502)	(0.0539)	(0.0361)
ER visit	0.0351***	0.0493**	0.0369	0.0294*
	(0.0115)	(0.0232)	(0.0237)	(0.0158)
Observations	7,988	1,988	1,818	4,182
Mean Dep.	0.0820	0.0734	0.0979	0.0791

$***p < 0.01, **p < 0.05, *p < 0.1$

Table A.3: Pre-treatment variables balanced across treatment and control.

	Control Ratio ≤ 1.25	**Treatment** Ratio > 1.25	**Difference**
Mother's characteristics			
% of mothers above 34 years old	0.39	0.39	0.00
	(0.01)	(0.01)	(0.01)
% of mother's with university degree	0.34	0.33	0.01
	(0.01)	(0.01)	(0.01)
% of first-time mothers	0.40	0.42	-0.02
	(0.01)	(0.01)	(0.01)
Pregnancy's characteristics			
% of births before 37 weeks of gestation	0.05	0.05	0.00
	(0.00)	(0.00)	(0.01)
% of pregnancies with at least 1 ER visit	0.11	0.11	-0.00
	(0.01)	(0.00)	(0.01)
Newborn's characteristics			
% of male newborns	0.52	0.50	0.02
	(0.01)	(0.01)	(0.01)
% of newborns weighting less than 2,500 grams	0.04	0.04	0.00
	(0.00)	(0.00)	(0.01)
Observations	2,132	5,856	

$***p < 0.01, **p < 0.05, *p < 0.1$

Table A.4: Pre-treatment variables balanced across shifts.

	Means			**Differences**	
	Shift 1	Shift 2	Shift 3	S1-S2	S1-S3
Mother's characteristics					
% of mothers above 34 years old	0.38	0.40	0.39	-0.02	-0.01
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
% of mother's with university degree	0.34	0.31	0.34	0.02	-0.00
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
% of first-time mothers	0.42	0.42	0.41	-0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Pregnancy's characteristics					
% of births before 37 weeks of gestation	0.05	0.05	0.04	0.00	0.01
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
% of pregnancies with at least 1 ER visit	0.11	0.12	0.10	-0.02	0.01
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Newborns's characteristics					
% of male newborns	0.52	0.49	0.51	0.04*	0.01
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
% of newborns weighting less than 2,500 grams	0.04	0.05	0.04	-0.01	0.01
	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)
Observations	1,988	1,818	4,182		

Shift 1: Morning (7am-1pm); Shift 2:Afternoon (1pm-7pm); Shift 3: Night (7pm-7am).
$***p < 0.01, **p < 0.05, *p < 0.1$

Table A.5: LPM of the probability of In-labour C-section with interactions

	By birth order	By age	By civil status	By education
Treatment (Ratio > 1.25)	0.0012	0.0197	0.0012	-0.0012
	(0.0089)	(0.0122)	(0.0093)	(0.0118)
Treatment x Non-primipara	0.0419***			
	(0.0135)			
Treatment x Old (above 34)		-0.0030		
		(0.0141)		
Treatment x Married			0.0313**	
			(0.0151)	
Treatment x University				0.0287**
				(0.0139)
Non-primipara	0.0348***	0.0351***	0.0285**	0.0352***
	(0.0115)	(0.0115)	(0.0119)	(0.0115)
Old (above 34)	0.0426***	0.0401***	0.0410***	0.0424***
	(0.0067)	(0.0118)	(0.0072)	(0.0067)
University	-0.0206***	-0.0210***	-0.0154**	-0.0001
	(0.0064)	(0.0064)	(0.0069)	(0.0118)
Preterm (<37 wofg)	0.0292	0.0292	0.0293	0.0295
	(0.0213)	(0.0214)	(0.0237)	(0.0213)
Low weight at birth (< 2.5kg)	0.1065***	0.1066***	0.1068***	0.1066***
	(0.0258)	(0.0259)	(0.0283)	(0.0259)
ER visit	0.0348***	0.0351***	0.0285**	0.0352***
	(0.0115)	(0.0115)	(0.0119)	(0.0115)
Married			-0.0068	
			(0.0126)	
Observations	7,988	7,988	6,984	7,988

Robust standard errors in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

All regressions include fixed effects by year, month and day of the week of birth and shift of admission.