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HIGH RATE OF C-SECTION AND ITS CONSEQUENCES FOR THE TIMING OF BIRTH

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High Rate of C-section and Its Consequences for the Timing of Birth

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Abstract

In 2013 in Iran, almost half of all infants were born by caesarian section (c-section) in public hospitals, even more within the non-public sector, a figure which represented one of the highest rates in the world. In 2014, the Ministry of Health commenced major health care reform to break this prevalence. It was designed to alter both the demand and supply side incentives for cesarean surgery in public hospitals and by 2015 was shown to have reduced the rate by six percentage points. Our analysis indicates that changing the financial incentives for doctors had a role in the effectiveness of the programme but that the greater part of the change resulted from a strict cap on the maximum c-section rate for each doctor. We cannot find any effect on infantile health measures in terms of Apgar score, hospitalisation and mortality rate; however, gestation length and birth weight have significantly increased.

Keywords: c-section, health policy, birth timing
JEL Classification: I12, I18, J13

1 Introduction

There is a long-standing body of literature on the causal effect of cesarean delivery on infants' health, most of which focuses on developed countries with relatively low or moderate c-section rates. However, there are a number of countries where the c-section rate is as high as 50% and little is known about the consequences of such prevalence. According to a WHO Statement on cesarean section, the optimal rate in the population is 10%-15%; "there is a negative correlation between c-section rate and infant mortality up to the c-section rate of 10% and there is no gain from increased c-section rate beyond 10% and up to 30%". Furthermore, the statement declares that current data does not allow researchers to assess the link between infant mortality and c-section rates above 30% (WHO, 2015). This study intends to fill this gap and provides evidence relating to Iran in which the national average c-section rate was as high as 55% in 2014. For that purpose, we take advantage of a quasi-experimental variation following a major health care reform in 2014 which was designed to reduce the rate (see table A1 for more details).

Having a c-section rate above the WHO-suggested optimal rate is a worldwide phenomenon. In the past 30 years, a rise in the share of cesarean delivery has been observed in almost all countries. For example, in the USA, the rate increased from 20% in 1995 to 32% in 2007 (Martin et al., 2018). Furthermore, there is a large variation in the c-section rates between countries, ranging from 0.4%-58% (see Althabe et al., 2006;

Cavallaro et al., 2013), and within countries (see Hanley et al., 2010; Li et al., 2017; Martin et al., 2018).

Although a c-section can be a life-saving technique if medically indicated, as any other surgery, it can lead to complications, especially in settings that lack the facilities to properly conduct safe surgery. At the same time, many developing countries (e.g. Iran, Turkey, Brazil and Egypt) have very high rates of non-medically indicated c-section cases in which the proper facilities might be missing. In 2014, Iran had one of the highest c-section rates in the world, which was what motivated the Ministry of Health to implement a country-wide programme for reduction.

The programme started on 5th May 2014 in all public hospitals in the country. The c-section rate in public hospitals was lower than the national average, although still lay as high as 47%. As a result of the programme, vaginal deliveries became free of charge, and doctors received bonus payments for vaginal delivery as well as being subject to an annual quota for the maximum number of cesarean deliveries[1]. Nearly five months later, on 23rd September 2014, the system of national relative payments[2] was revised so that doctors are paid more for vaginal delivery than c-sections under the new scheme. Since this new payment scheme satisfied the goal of providing financial incentives for doctors to perform vaginal delivery and also due to the high cost of the reform, the original bonus payments in public hospitals were cancelled. The new payment scheme affected the financial incentives of doctors within both public and non-public hospitals[3]. We consider this September 2014 scheme as the second phase of the intervention although it was not officially part of the reform.

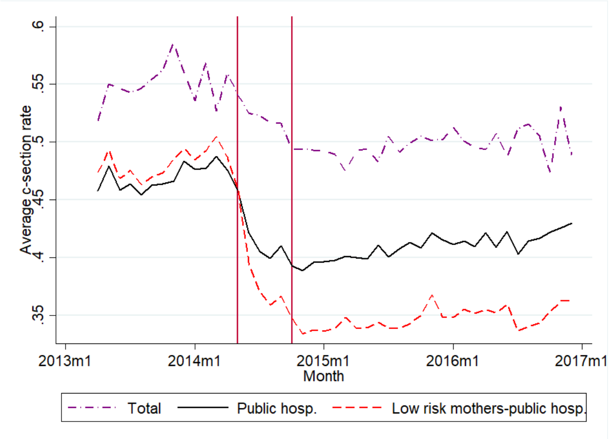
As shown in figure 1, the c-section rate declined sharply after the first phase of the programme in May 2014. This reduction is higher in public hospitals, which were the main target of the reform. Furthermore, first birth low risk mothers are the main complier group as the c-section rate among this group decreased at a higher rate than the average. The absolute magnitude of reduction is 5, 6 and 13 percentage points for the total, sample of public hospitals and first birth sample in public hospitals, respectively. Since the c-section is a very persistent procedure and many medical guidelines recommend or allow

[1]If they perform c-sections above their quota, they would not be paid for the extra surgery and their rank would reduce in the national ranking system of physicians.

[2]doctors are reimbursed based on pay-for-performance scheme. The relative values medical procedures are set nationally based on "Relative Value Units (RVU)"; however, the absolute value of reimbursement varies significantly across public and non-public sector. We discuss about this system in more details in Background section

[3]Non-public hospitals include private hospitals, charity hospitals and special organisation hospitals (for example military hospitals). These are not owned or managed by the government. The pricing of health care services in this sector vary widely, for example the prices in military hospitals are relatively high for people not affiliated with armed forces but are free for military employees and their families.

Figure 1: C-section, 2013-2016



Note: Graph shows the monthly rate of c-section. Purple dashed line shows the rate in the full sample, black line shows the rate in public hospitals and red dashed line shows the rate in first birth low risk sample in public hospitals . The two vertical lines show the two phases of the programme.

women to choose repeated c-sections after a prior birth using this method, reducing the rate among first birth mothers is expected to reduce the total rate further in the long term.

We show that a high c-section rate is due to the frequent use of elective (planned) cesarean surgery [4] and in order to plan the procedure with certainty, many infants are born early term i.e. in the 38th week of gestation. After the programme, by decreasing the number of early term deliveries, on average, gestation length increased by 0.12 weeks which resulted in a 21 gram increase in birth weight. If we calculate the results for the compliers, i.e. 13% out of the sample of first birth mothers, we conclude that c-section unnecessarily brought the birth of some infants forward by 1 week which reduced their weight by an estimated 160 grams.

The novelty of our research is not restricted to the health outcomes of the infants. The structure of the programme enables us to disentangle different demand and supply side incentives for c-section surgery. We show that financial incentives of doctors play a minor role in increasing the c-section rate; however, other incentives such as leisure time (c-section is a very quick and certain procedure in comparison to vaginal delivery) as well as parental demand for c-sections are very strong in a country with very high rates. The quota was shown to have played a major role in the effectiveness of the programme. Furthermore, although our research is not based on specific information about doctors,

[4] Zhang et al. (2010) shows that 9.6% of total c-sections in the US are "truly elective" without being based on medical indication. We show that in Iran, 15.9% of total c-sections and 13% of first birth c-sections were performed because of maternal request (see table A3).

we demonstrate that doctors who are mostly working in public hospitals have a major role in creating such a high rate and that behaviour has changed substantially since the programme. Based on the Iranian health care code of conduct, registrars work for four years as part of their training in public hospitals. Apart from registrars, studies show that other doctors who mainly work in public hospitals are either recent university graduates with a low level of experience or relatively low ability doctors who could not attract enough patients to their private offices (Alijanzadeh et al., 2016).

Our paper contributes to the literature of physician-induced demand, in which physicians manipulate the demand of patients according to their own self-interest (McGuire, 2000). In the case of childbirth, Gruber and Owings (1994), in a seminal paper, show that American gynaecologists compensated their income shock which resulted from the decline in fertility by substituting vaginal delivery with the highly-reimbursed c-section. Other studies discuss other channels such as leisure incentives (Brown III, 1996; Costa-Ramón et al., 2016; Halla et al., 2016), fear of malpractice claims (Dubay et al., 1999) and tort reforms (Currie and MacLeod, 2008). The programme in Iran, by targeting the financial incentives of doctors, helps us to discuss the relative importance of different channels for demand inducement.

This study is also related to the literature of causal effect of c-section on infants' health outcomes. Most papers in this area have used the instrumental variable approach to identify the marginal infant who could have been born vaginally but ended up being born by c-section (Card et al., 2018; Costa-Ramón et al., 2016; Jachetta, 2014); while we benefit from an exogenous shock to access to c-sections which was produced by the 2014 reform. Apart from methodological differences, our paper is distinguished from previous studies because first, we focus on a developing country with a very high rate of c-section; and second, we estimate the total effect on both planned and unplanned c-sections (and in fact our variation is largely a result of the change in the frequency of planned c-sections) while all other studies have only focused on emergency c-sections in order to maintain the relevance of the instrumental variable.

Finally, our results are in line with the literature on birth timing manipulation and its consequences for the health of newborns. Most studies have exploited the temporary birth scheduling near the cut-off of a policy change on baby bonus or child tax benefits (Borra et al., 2019; Brunner and Kuhn, 2014; Neugart and Ohlsson, 2013; Schulkind and Shapiro, 2014). The results of our study in terms of the effect of one week's shorter gestation length on birth weight is similar to others; however, we focus on a vast birth timing manipulation at all year round in the population resulted from high rate of c-section.

The paper is organised as follows: section 2 talks about the background of this specific health care reform in Iran. Section 3 discuss general patterns in the data. Section 4 presents our empirical analysis and section 5 concludes.

2 Background

The programme started on 5th May 2014 in public hospitals. The primary budget allocated for the first year of the programme was 71.5 million dollars. The optimal c-section rate was considered to be 25%-30% (the average rate in developed economies) and all public hospitals were required to reduce their cesarean rate by 10% (approximately 5 percentage points from the average rate) by the end of the first year (Aghajani et al., 2014; Behzadifar et al., 2019). Two distinct driving forces were designed to drive the effectiveness of the programme: increasing the demand of mothers for vaginal delivery and reducing the supply of c-section by doctors.

On the demand side, following the programme, vaginal delivery in all public hospitals became free and the out-of-pocket cost was compensated by the special fund related to the programme.

On the supply side, the programme was designed to give incentives to doctors to perform vaginal delivery instead of unnecessary c-sections. According to the national "Relative Value Unites (RVU) in Medical Practice[5]" in 2013, which determines the relative payment to doctors for different health care services and procedures, doctors earned 10% less for each vaginal delivery in comparison to the performance of a c-section. Policy-makers wanted to increase the relative payment for vaginal delivery in order to make this more financially appealing for doctors. Following the programme, doctors have been offered bonus payments for performing vaginal deliveries in public hospitals which earned them 2.5 times more for vaginal deliveries in comparison to c-section.

In addition, the Ministry of Health imposed a 45% quota for each doctor on the annual rate of c-section performed in public hospitals. If a doctor exceeded the quota, she would not be paid for the extra procedure performed (Aghajani et al., 2014; Ministry of Health Guidelines, 2016) and might also be sanctioned by losing points in the national point-based ranking system of doctors if shown to be persistently working above the quota. Table 1 summarises the interventions which occurred in terms of supply and de-

[5] RVU is a reimbursement formula used in many health care settings such as United States Medicare and the Iranian health care system. In our setting, RVU determines relative payments, although absolute reimbursement might vary substantially by the type and location of the hospital. For example, before the programme, doctors received 15 and 17 units for vaginal and cesarean deliveries respectively. Each unit was worth $3 in all public hospitals; however, this might have been as high as $30 in some private hospitals. The RVU of Iran is obtained from the Ministry of Health website: http://darman.umsha.ac.ir.

mand as at 5th May 2014 and the analogous variables before the start of the programme. The table also provides absolute value of costs of different methods of delivery for mothers and payments to doctors.

Table 1: Timing of the reform

		t_0	t_1	t_2
Demand		Before	5th May 2014	23rd Sept. 2014
	Cesarean price	$237	$237	$237
	Vaginal Price	$135	0	0
Supply	Doctors Absolute Earning for Vaginal delivery	15u	15u +30u	50u
	Doctors Absolute Earning for Caesarean delivery	17u	17u	40u
	Doctors Relative Earning for Vaginal delivery	0.9	2.5	1.25
	Doctors' Quota in Public Hospitals	-	45%	45%

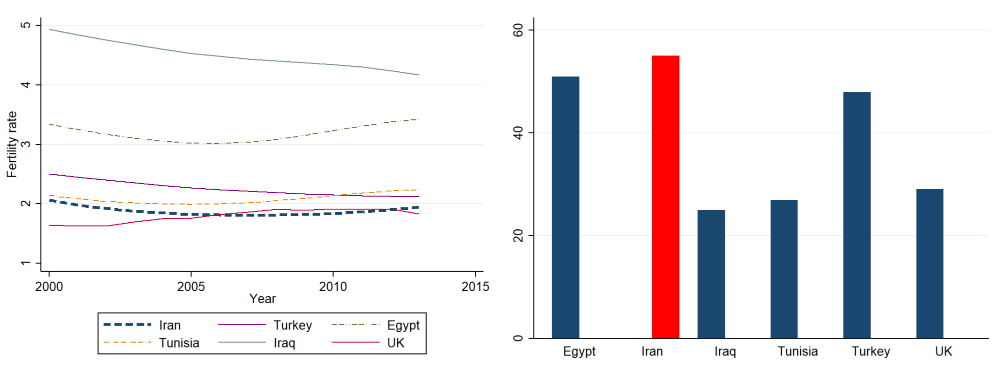
Note: Prices are obtained from the case study by Piroozi et al. (2016). Prices are heavily regulated by the government and are the same across all public hospitals. Relative Value Units are obtained fro the RVU book of Iran available at the Ministry of Health website (http://darman.umsha.ac.ir). Quota is obtained from Aghajani et al. (2014).

It is worth mentioning that the out-of-pocket cost of neither c-section nor vaginal birth was high before the implementation of the programme, considering the fact that 95% of individuals had some form of insurance and the insurance companies paid 80%-85% of bills. The out-of-pocket cost of vaginal delivery, on average, for an insured individual was $27. This cost was $35 for a c-section, a price difference of eight dollars. After the programme, the cost of vaginal delivery was zero which increased the price difference to $35. On the supply side, the absolute value of the bonus payment was $90 which tripled the earnings of doctors for performing a vaginal delivery.

Five months later, on 23rd September 2014, RVU was revised and in the new version, payment for both procedures increased. In addition, the relative payment was 1.25 times more for vaginal rather than cesarean birth, and therefore, the bonus payment for vaginal delivery was abolished since the new relative values satisfied the objective of the policy-makers to incentivise vaginal birth. The RVU is used across both public and non-public hospitals; therefore, relative payments in non-public hospitals was also affected by the new reforms on 23rd September. We consider this date as the second phase of the programme.

It is worth pointing out that policy-makers did not observe any abnormal health con-

Figure 2: Fertility and c-section rates in Iran and other selected countries.



(a) Fertility rate (b) C-section rate

Note: Fertility rates are obtained from the World Bank. C-section rates are obtained from WHO and are illustrated for the most recent year available.

ditions among neonates born by cesarean procedures or their mothers and the goal was not to improve health outcomes. The main objective of the policy was to increase the fertility rate Aghajani et al. (2014). Neither maternal nor neonatal health were alarming prior to the reforms and it is not surprising that we do not find major health improvement after the programme. The policy-makers were concerned about the low population growth rate in Iran since the fertility rate had reduced consistently over the past decades and a high c-section rate is considered to be a hindrance to population growth. There are a number of studies showing the negative effect of c-section on subsequent chance of conception (Hemminki, 1986; Kjerulff et al., 2013; Zdeb et al., 1984). Furthermore, international comparisons supported the policy-makers' beliefs about the role of the c-section rate in reducing the fertility rate. Iran experienced a sharp drop in fertility rate and a substantial rise in the c-section rate over the past few decades. Figure 2 shows that the fertility rate in the country dropped to below the reproduction rate after 2005; in addition, Iran has one of the highest c-section rates in the world.

3 Data

We have access to all birth records in Iran from March 2013 to March 2015. This data contains detailed information on the health outcomes of newborns such as birth weight, height, head circumference, Apgar score after 1 and 5 minutes[6], hospitalisation, death,

[6]Apgar score is a 0-10 measure which attributes a score of 10 to a baby with perfect health and 0 to death. It is constructed based on skin colour, heart rate, Grimace response (reflexes), muscle tone, breathing rate and effort. It is recorded 1 minute after birth to determine how well

respiratory and heart morbidity and any congenital disorder. Furthermore, the data includes information about demographic characteristics and the health status of the mothers such as age, level of education, nationality, place of residency, number of previous pregnancies, number of abortions and any type of pregnancy complications or risks. We also have general information about the delivery, for example, delivery method, gestation length, reason for having a c-section, doctor's identifier and the name of the hospital.

Throughout the paper we mostly focus on the results from first birth low risk women (around 40% of all births in both public and non-public sector). This is a standard assumption in the literature (Card et al., 2018). More precisely, we only consider first birth babies whose mothers are 17-35 years-old, the peak fertility period for a woman (Balasch, 2010), and who are not preterm (have gestation length above 37 weeks (WHO, 2018)). Older women who have had multiple pregnancies and those who have a preterm baby may receive c-sections for extreme emergency reasons without any vaginal alternative. Furthermore, if the c-section has any adverse health effects, we should observe that on the least risky individuals with few confounding risk factors.

Furthermore, we concentrate on observations from public hospitals (60% of total births) since they were the main target of the programme (although we also report some evidence on change within non-public hospitals). In addition, pricing and payments at public hospitals are quite homogeneous across the country which makes the analysis more accurate. It should be mentioned that health care services in the non-public sector are not necessarily too expensive which is why they have a great share (around 46%) of total observations, however, they are very diverse in terms of pricing for patients and payments to doctors. Table 2 reports the summary statistics of the demographic characteristics of pregnant women in public and non-public hospitals.

Comparing panels A and B shows that women in public hospitals tend to be from lower socioeconomic backgrounds. A great proportion of women who birthed in the non-public healthcare sector live in urban areas, approximately 95%, while only 68% of women using public sector hospitals live in urban areas; this may be due to lower access to non-public sector health care in many rural areas and small towns. In non-public hospitals, 44% of women have a college education and 61% use employment insurance schemes, whereas in public hospitals these shares are 18% and 30% respectively. The programme was originally therefore targeting poorer individuals relative to the average population and this may have intensified the effect of the programme from the demand side.

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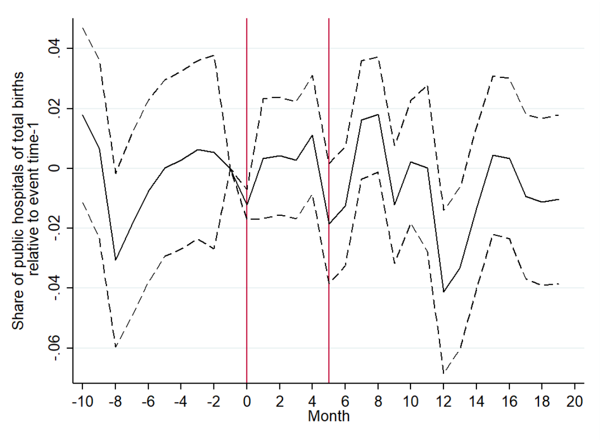
the baby tolerated the birth process and 5 minutes after birth to determine how well the baby thrives outside the womb .

Table 2: Demographic variables-Summary statistics

	Mean	SD	Min	Max
Panel A: in non-public hospitals				
% in urban areas	94.53	2.10	91.60	96.33
% College edu.	44.52	4.90	37.53	48.06
% High school edu.	39.08	1.31	37.32	40.46
% Primary/secondary edu.	16.40	4.82	11.49	22.97
% Government insurance	13.79	6.88	3.52	17.74
% Employment insurance	60.97	29.19	17.21	76.87
% Not insured	5.95	2.55	2.16	7.64
% Migrant	1.63	0.08	1.52	1.71
Observations	583,632			
Panel B: in public hospitals				
% in urban areas	67.91	3.10	65.06	71.13
% College edu.	17.74	1.71	15.19	18.79
% High school edu.	38.93	2.83	36.77	42.98
% Primary/secondary edu.	43.33	4.02	38.40	48.05
% Government insurance	45.97	21.89	13.49	60.69
% Employment insurance	30.30	13.83	10.01	40.44
% Not insured	4.88	2.58	1.09	6.88
% Migrant	3.56	0.60	2.81	4.27
Observations	690,020			

Note: Table shows the average and standard deviation of each demographic variables for low risk mothers in period 2013-2015. Min and Max shows the annual minimum and maximum levels.

Figure 3: Change in the share of public hospitals of total births



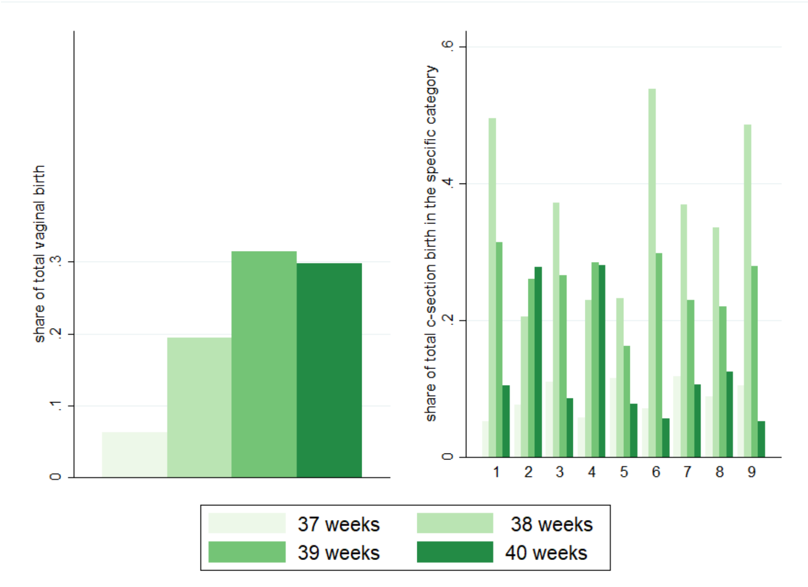
Note: The vertical axis shows the share of public hospitals of total births relative to one month before the start of the programme. The horizontal axis shows 10 months before and 20 months after the start of the programme. Solid lines show the changes, dashed lines show 95% confidence intervals. The two vertical lines indicate the first and second phases of the programme. Each point shows θ_k from estimating the following event study: $Y_{ijm} = \sum_{k=-10}^{20} \theta_k.\mathbb{1}(k = m) + \gamma X_{ijm} + h_j + \nu_{ijm}$. Mother's age, education indicator, insurance type, urban/rural residency, pregnancy and delivery risk factors (X_{ijm}) and hospital fixed effects (h_j) are controlled.

However, limiting observations to public hospitals may be problematic if the composition of women attending public hospitals changes after the programme. Women who otherwise would go to the non-public sector may have switched to public hospitals in order to benefit from free services. Conversely, some may have switched to the non-public sector in order to receive c-sections, which became harder to receive in public hospitals after the programme.

Figure 3 shows an event study for the share of births in public hospitals for 10 months before and 20 months after the first phase of the programme. The two vertical lines indicate the first and second phases of the programme, respectively. The figure indicates that the average use of public hospitals did not significantly change after the programme. Thus, we assume that people did not switch from public to non-public (see also table A2 for composition of demographic characteristics before and after the programme). As discussed in the background section above, the change in out-of-pocket price of vaginal delivery was minor; hence, it is not surprising that public hospitals did not become more appealing following the intervention. In addition, figure 3 shows that the choice of the type of hospital occurred prior to the choice of method of delivery.

One important feature of the data that helps us to investigate the effect of c-sections on birth timing is the variation of gestation length across different categories of cesarean and vaginal delivery. Figure 4 shows the share of most prevalent gestation lengths i.e.

Figure 4: Share of 37-40 weeks of gestation length among vaginal deliveries and each category of medical indication for c-section delivery.



Note: The numbering in the right hand panel corresponds to: 1. cephalopervic disproportion, 2. fetal distress, 3. impaired fetal presentation, 4. labour dystocia, 5. mother's high blood pressure, 6. mother's request, 7. other reasons, 8. placenta and umbilical cord problems, 9. previous cesarean or uterine scarring.

37-40 weeks of total births. The left hand side panel displays the distribution of gestation length for vaginal delivery. This panel shows that most babies are born in the 39th and 40th week of pregnancy (full term neonates). The right hand side panel shows the same result for each category of reasoning for the choice of c-section (medical indication for the c-section). In most categories, the share of the 38th week of gestation is higher than the 39th or 40th week except for fetal distress and labour dystocia which follow the same pattern as vaginal delivery; these two complications cannot be known prior to the start of the process of labour. It is especially interesting to note that the distribution is highly skewed towards the 38th week for category 6, "mother's request". Therefore, infants born by c-section are not inherently early term but their deliveries are planned early.

Furthermore, when we consider the change in the share of each category of medical indication out of total birth after the programme in table 3, we see that those categories which were skewed toward 38 week gestation length are those which experience a drop after the programme. We can say that a lot of unnecessary c-sections were categorised as "cephalopervic disproportion[7]", "mother's request" and "other rea-

[7]According to Danforth's obstetrics and gynecology, cephalopervic disproportion is as rare as 1 out of 250 pregnancies Gibbs et al. (2008); however, it was stated as a reason for about 5% of

sons". Births recorded under these categories have an important role in reducing gestation length since other categories of medical indication for c-section delivery are either not planned by definition (labour dystocia and fetal distress) or are very rare events (see also A4 for changes in gestation length after the programme). In total, the frequency of these three categories decreased by 13 percentage points after the programme, which is equal to the total reduction in c-section rate among first birth mothers in public hospitals.

Table 3: Share of each each medical indication for c-section out of total birth, one year before and one year after the programme.

	Before	After	Difference
cephalopervic disproportion	0.058	0.013	-0.045
	(0.0015)	(0.0022)	(0.0026)
fetal distress	0.12	0.13	-0.01
	(0.0022)	(0.0064)	(0.007)
impaired fetal presentation	0.046	0.042	-0.004
	(0.0014)	(0.0038)	(0.004)
labor dystocia	0.076	0.080	0.004
	(0.0017)	(0.0052)	(0.0055)
mother's high blood pressure	0.014	0.0080	-0.006
	(0.0076)	(0.0017)	(0.008)
mother's request	0.067	0.0077	-0.059
	(0.0016)	(0.0017)	(0.0023)
placenta and umbilical cord problems	0.015	0.012	-0.003
	(0.00079)	(0.0021)	(0.0022)
previous cesarean or uterine scarring	0.012	0.012	0
	(0.00072)	(0.0020)	(0.0021)
other reasons	0.081	0.050	-0.031
	(0.0018)	(0.0042)	(0.0046)
Observations	267,014	270,284	

Note: Table shows the means; standard errors are in parentheses. Column "Before" shows the averages in 2013 and column "After" in 2015.

Finally, we show the changes in some outcome variables before and after the programme. Table 4 shows the c-section rate, average birth weight, average Apgar score after 1 and 5 minutes, gestation length in weeks, respiratory morbidity rate (a common condition among newborns), hospitalisation rate and mortality rate.

The changes in gestation length and birth weight are significant even when comparing the averages. The average weight of the infants studied and their gestation length increased by 13 grams and 0.14 weeks, respectively. It is worth pointing out that respiratory morbidity rate, hospitalisation rate and mortality rates are high in comparison to high income countries but no significant change was observed, at least in the average rate.

all pregnancies in our data before the programme which is over 10 times higher than the expected rate. This could be reduced considerably by about 70%. Therefore, it seems that cephalopervic disproportion was an unnecessary reason for c-section surgery in many cases.

Table 4: Summary statistics of outcome variables.

	Before	After	Difference
C-section rate	0.49	0.34	-0.15
	(0.003)	(0.003)	(0.004)
Birth weight	3175.2	3188.7	13.5
	(2.86)	(2.93)	(3.41)
Apgar score	8.852	8.842	0.01
(1 min)	(0.004)	(0.004)	(0.005)
Apgar score	9.88	9.86	0.02
(5 mins)	(0.004)	(0.004)	(0.05)
Gestation Length	39.02	39.16	0.14
	(0.007)	(0.007)	(0.01)
Respiratory morbidity	0.0558	0.0558	0
	(0.002)	(0.002)	(0.003)
Hospitalization rate	0.058	0.0540	-0.004
	(0.002)	(0.002)	(0.003)
Mortality rate	0.0097	0.0086	-0.0011
	(0.0007)	(0.0006)	(0.0009)
Observations	270,765	274,105	

Note: Table shows the means. SE is in parenthesis. Birth weight is reported in grams, gestation length is in weeks. Apgar score is 0-10 measure which attributes score of 10 to a baby with perfect health and 0 to death. It is constructed based on skin color, heart rate, Grimace response (reflexes), muscle ton, breathing rate and effort. It is recorded 1 minutes after birth to determine how well the baby tolerated the birth process and 5 minutes after to determine how well the baby does outside the womb.

4 Empirical Analysis

First, we show that the programme actually had a significant effect on the rate of c-sections of first birth mothers. We estimate the following regression to track the changes in the c-section rate for 10 months before and 20 months after the first phase of the programme.

$$Y_{ijm} = \sum_{k=-10}^{20} \theta_k . \mathbb{1}(k = m) + \gamma X_{ijm} + h_j + \nu_{ijm} \tag{1}$$

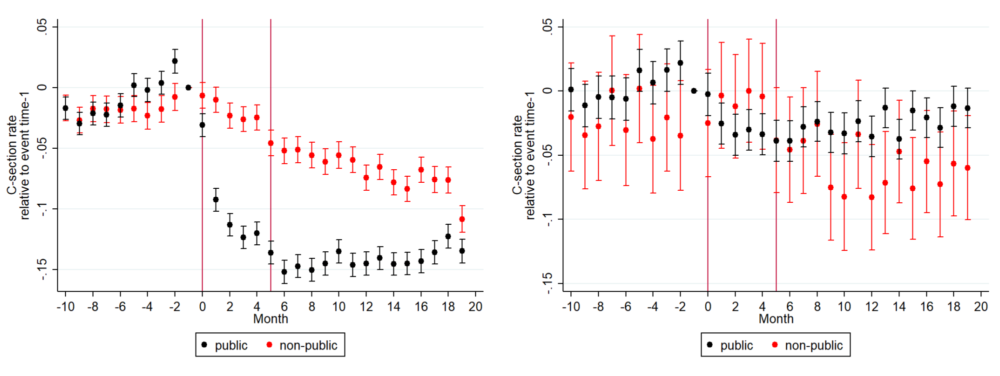
where Y_{ijm} is the outcome of interest for infant-mother i in hospital j in month m. X_{ijm} is a set of control variables including the mother's age, education level, insurance type, urban/rural residency, pregnancy and delivery risk factors; h_j is the hospital fixed effect.

Figure 5, panel a, shows the changes in the c-section rate in public hospitals as well as non-public hospitals for first birth mothers. The c-section rate in public hospitals dropped sharply after the implementation of the first phase of the programme, while the same did not happen in the non-public sample. Non-public hospitals also experienced a reduction in the c-section rate after the second phase of the programme since the new version of the RVU affected payments to doctors in the non-public sector; nevertheless, the absolute magnitude of change in public hospitals is three times higher than in non-public settings (see also table A1 for more details). Furthermore, comparing panel a and b shows that first birth mothers were actually the target of the programme. The doctors were more willing to reduce the number of c-sections performed for the least risky pregnancies in order to maintain their quota for high risk individuals. A higher degree of freedom is also given to first birth mothers to choose among different delivery methods – options are not always as wide for later pregnancies; almost all the mothers in our sample received a repeated c-section after a first c-section delivery.

There is a potential for concern that the programme limited access to c-sections for those in genuine medical need. In the previous graph, we showed that the programme mostly affected first pregnancies rather than higher order births. In addition, we showed that the programme had a greater impact among groups with higher rates of c-section. Panel a of figure 6 shows the effect of the programme in two different provinces: Mazandaran province which had an average rate of 71% one year before the programme and Sistan and Balouchestan province which is the most deprived region in Iran with a c-section rate of 24% prior to the programme (see figure A1 for provincial average c-section rates). In Mazandaran, the c-section rate after the programme reduced by more than 20 percentage points while the change in Sistan and Balouchestan was negligible.

Figure 5: Change in c-section rate in public and non-public hospitals

(a) First birth (b) Second birth



Note: The vertical axis is the c-section rate relative to one month before the start of the programme. The horizontal axis shows 10 months before and 20 months after the start of the programme. The two vertical lines indicate the first and second phases of the programme. Each point shows θ_k from estimating the event study.

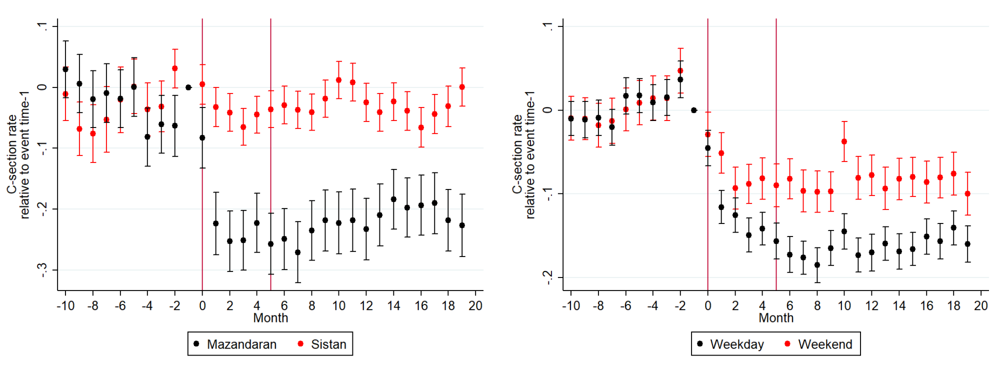
Panel b shows similar patterns in which we divided the sample based on the day of the week. Before the programme, the c-section rate on the first day of the week (Saturday in the Iranian calendar) was the highest in comparison to other days, on average 58%; while the c-section rate at weekends (Thursdays in this graph) was the lowest, at 39%. A large difference between different days reflects a high rate of elective c-section as the procedure is usually planned for the working days rather than weekends. Again, the response to the programme is sharper on weekdays when there were previously many planned c-sections which were not medically indicated. We could not therefore find evidence that the programme was harmful to groups in need of medically indicated c-section since the intensity of the impact of the programme was very low in places where most c-sections were necessary (and therefore, the baseline rate was very low); although, we cannot rule out the possibility of harmful effect for some people either.

In order to identify the effect of the programme on health measures of the infants (birth weight, Apgar score, hospitalisation and mortality) we report the intention-to-treat results using model 1.

The only health outcome that changed significantly after the programme in figure 7 is birth weight, all other measures, such as the Apgar score, mortality and hospitalisation rate at birth were not significantly different from rates in the months before the programme. Other papers which examined the effect of an exogenous variation in access to c-section on the immediate health outcomes of the infant in the US (Card et al., 2018; Currie and MacLeod, 2008) and the UK (Amaral Garcia et al., 2019) find sim-

Figure 6: Change in c-section rate in different provinces and different days of the week

(a) High vs. low rate province (b) Weekday vs. weekend



Note: The vertical axis is the c-section rate relative to one month before the start of the programme. The horizontal axis shows 10 months before and 20 months after the start of the programme. The two vertical lines indicate the first and second phases of the programme. Each point shows θ_k from estimating the event study. Before the programme, Mazandaran province had a c-section rate of 71% and Sistan and Balouchestan province had a c-section rate of 24%. The weekday here represents Saturdays (which is the first day of the week in the Iranian calendar) and the weekend represents Thursdays. The average c-section rate before the programme on Saturdays was 58% and on Thursdays was 39%.

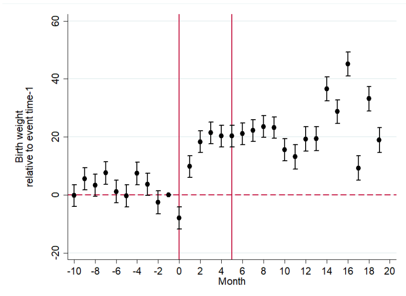
ilar results. Note that, here, the magnitude of change in access to c-section is much higher than other studies and still we fail to observe any significant result in terms of Apgar score, mortality and hospitalisation. However, we do observe significant change in the birth weight which guides us to the next step of exploring how the programme intervened in terms of the behaviour of doctors regarding delivery procedure.

We first identify the driving forces of the programme. In order to disentangle supply side incentives, we focus on two groups of doctors with different propensities to perform a c-section. In figure 8, we can see the changes in the monthly rate of c-section surgery for two groups of doctors: those whose rate in public hospitals was above the programme quota i.e. 45% before the intervention (high rate) and those with a rate below 45% (low rate). The two vertical lines show the first and second phases of the programme and the dashed line shows the quota (see also figure A2 for the change in the distribution of doctors' c-section rates).

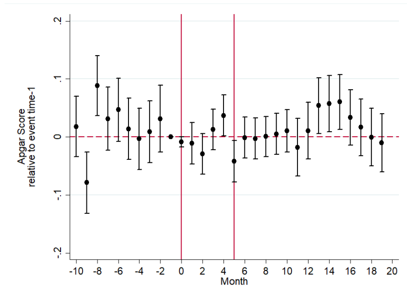
The doctors with a previously high rate of c-section immediately responded to the programme and decreased their rate in less than four months to below the quota while the doctors who were working below the quota did not respond to any great extent. Therefore, it seems that the quota had a great role in reducing the c-section rate. It is also worth pointing out that the gap between c-section rates of doctors above 45% and

Figure 7: Health outcomes-event study

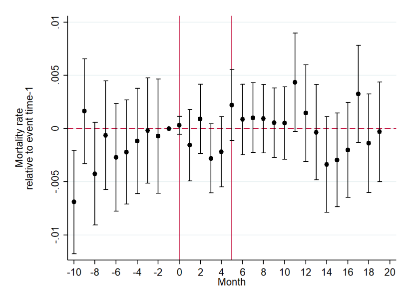
(a) Birth weight



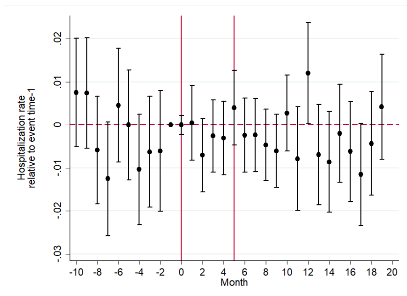
(b) Apgar Score



(c) Mortality rate

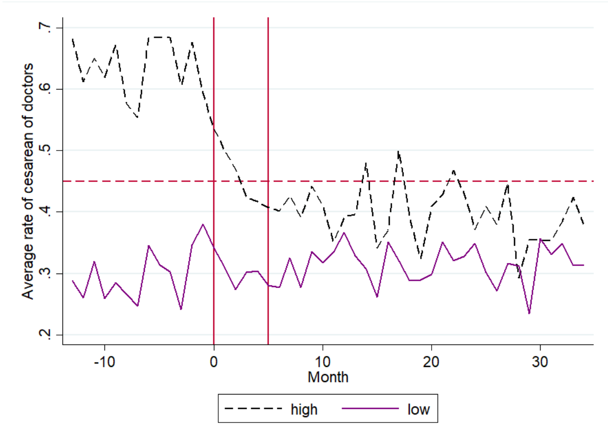


(d) Hospitalization rate



Note: The two vertical lines indicate the first and second phases of the programme. Each point shows θ_k from estimating the event study. Birth weight is in grams, the Apgar score is a 0-10 measure which attributes a score of 10 to a baby with perfect health and 0 to death. Hospitalisation shows admission to NICU right after birth.

Figure 8: Change in the doctor's monthly rate of performing a c-section for two groups of doctors



Note: The figure shows the average monthly c-section rate of each doctor. The black dashed line shows the trend for those doctors who, prior to the intervention, were performing c-sections above the quota set by the programme. The purple line shows the result for doctors who performed c-sections below the quota before intervention. Two vertical lines show the first and second phases of the programme. The horizontal dashed line shows the quota i.e. 45%.

those who were below this rate before the regulation was substantial. On average, the gap was about 26 percentage points. This large gap between these two groups shows that different doctors with different experiences and working backgrounds are working at quite different margins.

Table 5: Doctors performance in public and non-public hospitals

	Low Rate			High Rate		
	Before	After	Diff.	Before	After	Diff.
C-section rate in public hosp.	0.32	0.27	-0.05	0.58	0.42	-0.16
	(0.0052)	(0.0041)	(0.0066)	(0.0041)	(0.0049)	(0.0064)
C-section rate in non-public hosp.	0.71	0.63	-0.08	0.80	0.71	-0.09
	(0.0036)	(0.0038)	(0.0052)	(0.0076)	(0.0080)	(0.011)
Share of public hosp. deliveries	0.39	0.49	0.10	0.87	0.81	-0.06
	(0.0020)	(0.0018)	(0.0027)	(0.0016)	(0.0020)	(0.0027)
Observations	323,952	466,560		922,776	845,640	

Note: mean coefficients; SE in parentheses. High rate doctors are those whose rate of c-section was above 45% before the programme, low rate are those whose rate is below 45%.

Table 5 shows the performance of the two groups of doctors in public and non-public hospitals for one year before and one year after the intervention. Before the programme, the c-section rate of high rate doctors in public hospitals (58%) was approximately double the rate of low rate doctors (32%). Both groups work at higher margin in non-public hospitals. Furthermore, high rate doctors were mostly working within the public sector.

87% of all the deliveries they performed took place in public hospitals − this share is 39% for low rate doctors. After the programme, both groups of doctors reduced their c-section rate in both the public and non-public sectors, although the absolute value of change in public hospitals is three times greater for high rate doctors in comparison to low rate ones. The magnitude of reduction in non-public hospitals is similar. In non-public hospitals, a financial incentive was introduced in the second phase of the reforms and no quota was set; therefore, it is not surprising that the reaction was similar. Finally, low rate doctors tended to increase the amount of work they did in public hospitals by 10 percentage points while high rate doctors tended to shift to non-public hospitals where they had more freedom about the choice of delivery method.

In order to disentangle different aspects of the intervention, we estimate the following regression model:

$$Y_{ijy} = \beta_0 + \beta_1 DR_{ij0} + \beta_2 t_1 + \beta_3 DR_{ij0} \times t_1 + \beta_4 t_2 + \beta_5 DR_{ij0} \times t_2 + X_{ijy} + h_j + a_y + \varepsilon_{ijy} \quad (2)$$

where Y_{ijy} is the outcome of the programme. DR_{ij0} is a dummy variable which takes the value of one if the doctor's rate of c-section is higher than 45% in public hospitals at the start of the programme. t_1 and t_2 are the first and second phases of the programme, respectively. X_{ijy} is a set of mother and child's controls such as mother's age, education level and urban/rural residency, insurance type as well as pregnancy risk indicators. h_j is the hospital fixed effect, a_y is the year fixed effect and ε_{ijy} is the error term.

If we evaluate regression 2 for a dummy variable for c-section as the dependent variable, we expect to identify the differential change between the probability of receiving a cesarean for those whose delivery is performed by a high rate doctor and those with low rate doctors. β_1 captures this difference before the programme and we expect it to be positive.

β_2 and β_4 capture the change in the probability of c-section for mothers with low rate doctors in the first and second phase of the programme, respectively. We expect β_2 to be negative if demand side incentives and financial incentives had any effect. In this study, we cannot distinguish between the change in demand and change in the demand inducement from the supply side as the two interventions occurred at the same time. However, change in doctors' reimbursement was much higher than the price change for mothers. The payment to doctors increased by $90 in the first phase while the price reduced by $27 for mothers; plus, it is a one-off payment for mothers. Hence, we expect that the supply side incentives are stronger than demand changes. In the second phase, only the payment to doctors changed. Therefore, by comparing β_2 and β_4, we can compare the relative response of the demand to price changes with the supply response. Furthermore, we expect β_4 to be negative if doctors care about their absolute earnings. Conversely, it should be positive if the relative payment is more important (the relative payment decreased in the second phase relative to the first phase although the absolute earnings for both procedures increased. See table 1).

β_3 and β_5 capture the differential effect of first and second phase for high rate doctors. We expect the effect of the programme to be more striking for those whose c-section rate is bound by the quota.

Table 6 shows the results of the estimation of equation 2 for c-section probability in public hospitals. Column 1 shows the results for the full sample and other columns show the results for the sample of first birth low risk mothers. The probability of receiving a c-section if the delivery is performed by a high rate doctor is 14-15 percentage points higher at the baseline. The probability of c-section significantly reduced after both phases; however, the response of the first birth sample to the programme is stronger than the full sample, showing a high rate of unnecessary c-sections among this group. Approximately 41% of the total reasons for c-sections are repeated c-sections, first birth mothers by definition cannot have repeated c-section although their c-section rate is still as high as the full sample. Therefore, it is not surprising that doctors reduced the number of unnecessary c-sections for the first birth group in order to reserve their quota for repeated c-sections (in many medical guidelines, elective repeated c-section should be discussed with mothers who had a previous c-section [NICE, 2019]. In our data set, all subsequent birth mothers repeated delivery by c-section since Vaginal Birth After Cesarean (VBAC) is not available in most hospitals).

Comparing first and second phase reactions for low rate doctors, either among the full sample or the sample of first birth mothers, shows that first, in the second phase the c-section rate continued to decline and second, the absolute magnitude of reduction was five times greater in the first phase than the second phase. Therefore, first, doctors care more about their absolute earnings than their relative earning s; second, since the magnitude of change in the absolute reimbursement of doctors was stronger in the first than the second phase, we could expect the demand response to be very minor and most of the changes in the first phase to be due to supply side incentives.

The reaction of high rate doctors is at least twice as strong as that of low rate doctors in both phases. After the two phases, the difference between the probability of c-section between high and low rate doctors at the baseline almost disappears and the two groups of doctors work at similar rates. Thus, the quota can be seen to have a significant role in reducing the c-section rate – targeting the heterogeneity of the surgery by doctors was a specific aim of the programme..

Table 6: Change in c-section rate in public hospitals

	(1)	(2)	(3)	(4)
	All	First birth low risk		
		All first births	2014 Obs. only	Doctors Only in public
DR_0	0.137	0.150	0.170	0.127
	(0.0028)	(0.0048)	(0.0049)	(0.0060)
t_1	-0.0263	-0.0550	-0.0362	-0.0662
	(0.0024)	(0.0042)	(0.0043)	(0.0049)
$DR_0 \times t_1$	-0.0540	-0.0699	-0.0957	-0.0668
	(0.0032)	(0.0054)	(0.0055)	(0.0068)
t_2	-0.00425	-0.0126	-0.0123	-0.00976
	(0.0016)	(0.0025)	(0.0023)	(0.0030)
$DR_0 \times t_2$	-0.0107	-0.0298	-0.0297	-0.0207
	(0.002)	(0.0033)	(0.0038)	(0.0043)
Baseline c-section rate	0.47	0.49	0.49	0.56
Observations	2,122,248	690,020	285,009	309,287
Controls	yes	yes	yes	yes
Hospital FE	yes	yes	yes	yes
Year FE	yes	yes	no	yes

Note: Table shows the linear probability model of c-section in public hospitals. Column 1 contains the observation of the full sample, in the remaining three columns the sample is limited to first birth mothers, 17-35 years old whose infant is not preterm (gestation length of 37 weeks or above). In column three the observations are limited to 2014. In column 4 the observations are limited to doctors who are only working in public hospitals.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In order to ensure that we are capturing within-hospital variation and that different groups of doctors do not work in different types of hospitals, in column 3, we limit the observations to the year that the intervention took place, 2014. The results are similar to column 2 except that the reduction for those with low rate doctors is milder and those with high rate doctors is stronger. This again highlights the importance of the quota for doctors in public hospitals.

Furthermore, as mentioned in table 5, that doctors may switch from public to private, we limit the observations to those doctors who only work in public hospitals[8]. The

[8]It is mandatory for Iranian doctors to work in public hospitals after graduation from medical school until they have accrued enough quality and experience points in the national point-based ranking system of doctors. It takes five years on average for a doctor to achieve a license for

response of low rate doctors in the first phase is stronger in the limited sample while the response of high rate doctors is similar to the full sample. As we have seen in table 5 high rate doctors mostly work in the public sector, therefore limiting the sample to those who only work in the public hospitals include most of the sample. On the other hand, low rate doctors mostly work in private hospitals, therefore, the limited sample contains a smaller share of low rate doctors and those who remain respond more strongly to the regulations in public hospitals in comparison to other low rate doctors who were excluded.

Table 7 shows the same results within non-public hospitals. The non-public hospitals were only subject to regulations in the second phase of the programme and hence we only observe a reduction in the second phase in all columns of table 7. Furthermore, there is no difference initially between the two types of doctors at private hospitals and the reaction of both is similar since no specific quota was introduced for performance in the non-public sector. The magnitude of reduction is about one third that of the public hospitals.

It is possible that the results of the estimation of equation 2 might be biased if women switched from one type of doctor to another after the programme. Since both types of doctor had a higher incentive to perform vaginal delivery after the intervention, it is unlikely that mothers switched to vaginal delivery from the other type of doctor; however, some might switch from high rate to low rate doctors to receive a c-section because it is more likely that the latter are able to perform a c-section. To test these scenarios, we performed some falsification tests by running the same regression of equation 2 for the various reasons given for the choice of a c-section and the educational composition of mothers.

In table 8, column one is the estimation of probability of having labour dystocia or fetal distress (there are the two types of c-section that cannot be planned in advance). High rate doctors with higher probability of promoting c-sections tend to work with mothers with labour dystocia/fetal distress. These doctors might be more conservative regarding the delivery risks and therefore report a higher number of dystocia/distress. However, the probability of dystocia/distress did not change after the programme among either low or high rate doctors. On the other hand, in column 2, the probability of performing a c-section as a result of the mother's request significantly reduced after the programme and followed the same pattern of the total probability of c-section. In column 3, the dependent variable is a dummy variable which takes the value of one if the mother has a college education. There is no evidence of change in this composition

working privately. However, some doctors prefer to stay fully within the public sector because they are not well-known enough to work on their own.

Table 7: Change in c-section rate in non-public hospitals

	(1)	(2)	(3)
	All	First birth low risk	
		All first births	2014 Obs. only
DR_0	0.000716	0.00762	0.00685
	(0.00492)	(0.00649)	(0.00649)
t_1	0.000813	-0.0193	-0.0193
	(0.00728)	(0.0141)	(0.0141)
$DR_0 \times t_1$	-0.00127	-0.0138	-0.0129
	(0.0186)	(0.0248)	(0.0249)
t_2	-0.0395	-0.0386	-0.0381
	(0.00924)	(0.0130)	(0.0133)
$DR_0 \times t_2$	-0.00547	0.0187	0.0178
	(0.0217)	(0.0293)	(0.0320)
Baseline c-section rate	0.67	0.69	0.69
Observations	1,408,002	583,632	248,415
Controls	yes	yes	yes
Hospital FE	yes	yes	yes
Year FE	yes	yes	no

Note: Table shows the linear probability model of c-section in non-public hospitals. Column 1 contains the observation of the full sample, in the remaining two columns the sample is limited to first birth mothers, 17-35 years old whose infant is not preterm (gestation length of 37 weeks or above). In column three the observations are limited to 2014. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

of mothers for whom a doctor performs the delivery.

Table 8: Falsification tests

	(1)	(2)	(3)
	dystocia/distress	mother's request	College edu.
DR_0	0.0908	0.0640	0.00846
	(0.00567)	(0.00386)	(0.00694)
t_1	-0.00334	-0.0191	0.00288
	(0.0135)	(0.00679)	(0.0179)
$DR_0 * t_1$	-0.0233	-0.0513	0.0219
	(0.0178)	(0.0106)	(0.0223)
t_2	0.0281	-0.00772	0.0150
	(0.0173)	(0.00817)	(0.0222)
$DR_0 * t_2$	-0.0161	-0.0436	0.000200
	(0.0214)	(0.0116)	(0.0265)
Baseline rates	0.22	0.07	0.10
Observations	690,020	690,020	690,020
Controls	yes	yes	yes
Hospital FE	yes	yes	yes
Year FE	yes	yes	yes

Note: Table shows the linear probability models in public hospitals for the sample of first birth mothers, 17-35 years old whose infant is not preterm (gestation length of 37 weeks or above). Column 1 is the regression for labor dystocia or fetal distress, column 2 is the regression for c-section because of mother's request and column 3 is the regression for mother's college education.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

To estimate the effect of a planned c-section on the timing of birth, we estimate the previous model for gestation length. We also report the change in birth weight which is directly related to the gestation age but cannot be affected by the delivery method or doctors' skills. Table 9 reports the results for first birth low risk infants in public hospitals. The first three columns use gestation length as the dependent variable, columns 4 and 5 show the linear probability model of having a gestation length of 38 and 39 weeks, respectively.

The gestation length of infants who are born by high rate doctors is approximately 0.13 weeks shorter at the baseline. After the programme, the gestation length increases for this group and there remains no difference after the two phases. The gestation length of those with low rate doctors also slightly increases in the first phase but the change is not significant in the second phase. In the next two columns, we divide the observations based on the method of delivery to show that shorter gestation length is actually due to scheduling the delivery early by c-section and not because of different types of mothers with different risk factors visiting different types of doctors.

Table 9: Change in gestation length (public hospitals)

	(1)	(2)	(3)	(4)	(5)
	Gestation length			38th week of	39th week of
	All	CS	Vaginal	gestation age	gestation age
DR_0	-0.126	-0.161	-0.00834	0.0520	-0.00351
	(0.0105)	(0.0177)	(0.0136)	(0.00426)	(0.00718)
t_1	0.0229	0.0217	0.0177	-0.00937	0.0183
	(0.00946)	(0.0179)	(0.0110)	(0.00370)	(0.0181)
$DR_0 \times t_1$	0.0690	0.0776	0.00678	-0.0308	-0.00936
	(0.0121)	(0.0207)	(0.0154)	(0.00487)	(0.022)
t_2	0.00727	0.0510	-0.0149	-0.00522	0.00564
	(0.00611)	(0.0120)	(0.0703)	(0.00237)	(0.0212)
$DR_0 \times t_2$	0.0377	0.0436	0.00629	-0.00951	0.00807
	(0.00774)	(0.0140)	(0.00939)	(0.00303)	(0.0257)
Observations	690,020	250,427	439,593	690,020	690,020
Controls	yes	yes	yes	yes	yes
Hospital FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes

Note: Table shows the results for the sample of first birth mothers, 17-35 years old whose infant is not preterm (gestation length of 37 weeks or above) in public hospitals. First three columns use gestation length in weeks as dependant variable, in column 2 the sample is limited to cesarean deliveries, in column 3 the sample is limited to vaginal deliveries. Column 4 and 5 report the LPM of having a gestation length of 38 and 39 weeks, respectively. Column report the results for the birth weight in grams.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Column 4 shows that if the procedure is performed by a high rate doctor, there is a five percentage point higher chance that the infant is born in the 38th week of gestation age. This probability reduced after the programme and the difference disappeared after the second phase. On the other hand, there is no significant relationship between the chance of being born in the 39th week and the doctor's type or programme cut-offs. This indicates that if the birth is scheduled, it is scheduled for the 38th week and no later. Therefore, the gestation length is shortened by 2-3 weeks if the due date is in the 40th or 41st gestation week – in fact the due date of 40% of children is at or after week 40 (see figure 4).

Table 10: Chang in birth weight

	(1) BW	(2) BW<2500	(3) BW<1500
DR_0	-3.861	-0.00100	-0.000180
	(4.302)	(0.00242)	(0.000470)
t_1	2.036	0.00149	0.000154
	(3.892)	(0.00229)	(0.000449)
$DR_0 \times t_1$	14.39	-0.00247	-0.000360
	(4.960)	(0.00280)	(0.000545)
t_2	-5.037	0.00266	0.000757
	(3.171)	(0.00176)	(0.000335)
$DR_0 \times t_2$	7.741	-0.00335	-0.000773
	(2.526)	(0.00146)	(0.000281)
Observations	690,020	690,020	690,020
Controls	yes	yes	yes
Hospital FE	yes	yes	yes
Year FE	yes	yes	yes

Standard errors in parentheses

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

Table 10, column 1, shows the change in birth weight. The average birth weight significantly increased after the programme by 21 grams on average, which is mainly due to the change in the birth weight of those who are birthed by high rate doctors. Considering the fact that 13% of the sample of first birth mothers in public hospitals switched from planned c-section to vaginal in the period of the study, we can assert that a scheduled c-section shortens the gestation length by 1 week on average and reduces birth weight by 160 grams. Columns 2 and 3 show the probability of very low birth weight, below 2,500 and 1,500 grams, respectively. This also reduced significantly after the second phase, among babies born by high rate doctors.

Gestational age is very important for the long-term psychological development of infants. There are a number of studies showing that early term neonates (37-38 weeks) are at higher risk of poor developmental and educational outcomes than full term (39-41 weeks) infants (Lindström et al., 2009; MacKay et al., 2010). Early term children also have higher rates of hospital admission in the long run (Boyle et al., 2012).

If there is no medical guidance preventing doctors from scheduling the birth at a later gestational age, they have an incentive to plan the procedure very early. In order to secure the date of planned surgery, it must be scheduled for a date which lies before the due date, with a high degree of certainty. Approximately 95% of infants are born after the 37th week of gestation (see figure 4), therefore, immediately after this gestation age is a good estimate for scheduling the delivery. In fact, it is hard to reach a c-section rate of above 50% if deliveries are not scheduled early since more than 50% of mothers go through the natural process of labour at 38 or 39 weeks of gestation. Many clinical guidelines in developed countries have changed in the past decade in order to reduce the occurrence of non-medically-indicated c-section delivery and labour induction prior to 39 weeks (see for example ACOG, 2007).

5 Conclusion

We have evaluated the effect of a specific policy of health care reform on the c-section rate in Iran. The 2014 programme altered the demand and supply side incentives for mothers and doctors, mainly in public hospitals, in order to reduce the use of the c-section procedure which was, at the time, one of the highest in the world. The c-section rate reduced by six percentage points in public hospitals from an initial rate of 47%. This was mainly driven by first birth mothers whose rate decreased by 13 percentage points from an initial rate of 48%. During the period of the study, national payment schemes changed which affected the financial incentives of doctors in private hospitals as well as public hospitals. We have considered the time of this change as the second phase of the programme and show that c-section rates in private hospitals also dropped by four percentage points as a result.

In terms of demand, after the programme, the price of vaginal delivery reduced to zero. We cannot find any evidence of demand shift since insurance coverage is relatively high in the country and consequently, price change was not substantial. Furthermore, on the supply side, payment to doctors increased considerably after the programme and a quota of the total c-section rate of doctors in public hospitals was set. We show that financial incentive played a minor role in the reduction of unnecessary c-sections but the quota was much more effective. The quota was only two percentage points lower than the average rate in the public hospitals; however, since doctors were working at quite different margins, those for whom the quota was binding responded strongly to the programme.

Nevertheless, even after the programme and even among first birth mothers, the c-section rate is still higher than in OECD countries (for example, the first birth c-section rate in the UK is 22.5%, seeAmaral Garcia et al., 2019). This may be because the incentives introduced to doctors by the programme were not strong enough to compensate for other incentives they have for preferring c-section procedures. In addition, medical guidelines might be more conservative in Iran and demand for c-sections might have very low elasticity .

We have shown that in order to reach such a high rate of c-section births, many were scheduled for early term births, in the 38th week of pregnancy, and therefore, there was a vast birth timing manipulation in terms of unnecessary c-sections. The implementation of the programme in 2014 reduced the number of these non-medically indicated cases which led to a higher average gestation length and consequently higher birth weights . Apart from changing the timing of birth, we cannot find any significant effects on health of these policy changes. Therefore, we can say that the programme was not harmful and did not limit the access of those in need to c-section procedures; in fact, it was beneficial in terms of gestation age and thus birth weight for those who complied with the programme. The magnitude of birth gain for just one more gestation week was sizable and was estimated to be approximately 160 grams, i.e. 5% weight gain from an initial average of 3,175 grams.

The programme eliminated approximately 45,575 cesarean procedures in a year. If we assume that the cost of a c-section is only the cost that is paid to the hospital by the patient, the programme saved 10.8 million dollars for mothers and insurance companies. On the other hand, the total cost of the first year of the programme was around 71.5 million dollars. However, if we consider the long term welfare gain from higher birth weight as well as any health gain that might appear in the long term, the programme would be closer to cost effectiveness.

The initial goal of the programme was to increase the fertility rate in Iran. It is too early to evaluate the effectiveness of the programme in this regard since many women who were exposed to the programme are still in their fertile age. However, there is evidence that undergoing a c-section shifts the distribution of number of children to left (see figure A3); hence, it is expected that the programme has had a positive effect on fertility in the long run if the fertility decision remains the same over time.

Finally, this paper could be extended to identify long term effects of the programme on health outcomes of both the mother and the baby. Some consequences of c-section for the child, for example, appear immediately after the surgery, especially if the procedure was conducted using anaesthetic drugs. Furthermore, it is interesting to investigate how an exogenous shock to health care guidelines affects the fertility decision of women in terms of number of children and age gaps, which can ultimately affect labour market decisions.

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A Appendix

Table A1 shows the average c-section rate and the use of public hospitals among different education groups, rural/urban residency and insurance types for one year before (2013) and one year after (2015) the start of the programme; we also used Household Income and Consumption Survey (HICS) to identify 5 provinces with the lowest and 3 provinces with the highest average income and comparable population. we then reported the average shares in these two regions in table A1.

Column 1 indicates that the c-section rate is unequally distributed among different groups of women and in different regions. Even for the period after the programme, cesarean is more prevalent among women from higher socioeconomic backgrounds. C-section rate among women who have a college degree is 30 percentage point higher than women with primary education. The same pattern is observed when comparing women living in high income districts with women in low income regions, in urban areas with those in rural areas and comparing women with government insurance to those with employment insurance. C-section rate significantly reduced after the programme among all groups except for the not insured people which might partially be due to the lack of adequate observation for this group.

Column 2 shows the c-section rates in public hospitals. First, the c-section rate in public hospitals in absolute value is lower than the average rates. The changes in the rates in public hospitals for most groups are more than the changes in average rates.

Column 3 shows the c-section rates for low risk mothers. First, before the start of the programme, among women in high income districts, with a college degree, living in urban areas and those who had an employment insurance, the c-section rate for the first births is even higher than the average rates which caused the increasing trend in c-section rate in the country. Second, high SES women experienced a sharp drop in the use of cesarean as they were the main demand for the cesarean and the least at risk. Third, low SES women did not experience the same drop as higher SES women (look for example to women in rural areas), this may be due to the fact that even prior to the intervention, they mostly received emergency cesarean.

Column 4 shows the change in use of public hospitals. Low SES women highly use public health care services. For example, women with primary education, on average, use public hospitals by 50 percentage point more than women with a college degree. The change in the use of public hospitals is either not statistically significant for most groups or very minor.

Column 5 and 6 shows the share of public hospitals among vaginal deliveries and c-section, respectively. The table indicates a preference for having a cesarean in non-public sector. However, the difference between the two varies across various groups. The share of public hospitals among vaginal births is 20 percentage point more than the average share of public for women with a college degree; while this difference is only about 3 percentage point and not statistically significant for women with primary education. This indicates that high SES women easily switch between public and non-public hospitals based on the mode of delivery while the same is not true for low SES women.

Table A1: Changes in c-section and use of public hospitals before and after the start of the programme

		(1)	(2)	(3)	(4)	(5)	(6)
		C-section rate	C-section rate in public	C-section rate in public (first births)	Share of public (total births)	Share of public (total vaginal)	Share of public (total vaginal first births)
Province income group	High income-Before	0.73	0.61	0.65	0.40	0.50	0.48
		(0.010)	(0.016)	(0.027)	(0.011)	(0.019)	(0.0291)
	High income-After	0.67	0.54	0.48	0.39	0.48	0.44
		(0.009)	(0.015)	(0.027)	(0.009)	(0.016)	(0.0288)
	Difference	-0.06	-0.07	-0.17	-0.01	-0.02	-0.04
		(0.013)	(0.022)	(0.038)	(0.014)	(0.025)	(0.0410)
	Low income-Before	0.41	0.38	0.4	0.94	0.94	0.92
		(0.012)	(0.012)	(0.029)	(0.005)	(0.011)	(0.015)
	Low income-After	0.37	0.30	0.31	0.96	0.97	0.92
		(0.010)	(0.012)	(0.025)	(0.007)	(0.005)	(0.016)
	Difference	-0.04	-0.08	-0.09	0.02	0.03	0
		(0.015)	(0.017)	(0.038)	(0.009)	(0.012)	(0.023)
Education	College-Before	0.73	0.55	0.59	0.32	0.54	0.59
		(0.008)	(0.016)	(0.023)	(0.008)	(0.017)	(0.0230)
	College-After	0.66	0.47	0.38	0.36	0.57	0.53
		(0.008)	(0.016)	(0.022)	(0.009)	(0.015)	(0.0203)
	Difference	-0.07	-0.08	-0.21	0.04	0.03	-0.06
		(0.012)	(0.023)	(0.032)	(0.012)	(0.023)	(0.0307)
	High school-Before	0.61	0.55	0.52	0.51	0.59	0.63
		(0.007)	(0.009)	(0.017)	(0.009)	(0.010)	(0.017)
	High school-After	0.53	0.45	0.42	0.54	0.63	0.60
		(0.007)	(0.009)	(0.016)	(0.008)	(0.009)	(0.017)

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Table A1 – continued from previous page

		(1) C-section rate	(2) C-section rate in public	(3) C-section rate in public (first births)	(4) Share of public (total births)	(5) Share of public (total vaginal)	(6) Share of public (total vaginal first births)
	Difference	-0.08	-0.10	-0.10	0.03	0.04	-0.03
		(0.009)	(0.013)	(0.022)	(0.012)	(0.013)	(0.023)
	Primary edu.-Before	0.41	0.38	0.44	0.81	0.84	0.89
		(0.008)	(0.009)	(0.022)	(0.006)	(0.008)	(0.017)
	Primary edu.-After	0.34	0.31	0.31	0.83	0.87	0.93
		(0.008)	(0.009)	(0.019)	(0.007)	(0.008)	(0.019)
	Difference	-0.07	-0.07	-0.13	0.02	0.03	0.04
		(0.012)	(0.012)	(0.029)	(0.009)	(0.011)	(0.023)
Residency	Urban-Before	0.60	0.50	0.55	0.50	0.62	0.63
		(0.005)	(0.007)	(0.012)	(0.005)	(0.007)	(0.012)
	Urban-After	0.54	0.43	0.38	0.51	0.063	0.58
		(0.005)	(0.007)	(0.013)	(0.005)	(0.007)	(0.012)
	Difference	-0.06	-0.07	-0.17	0.01	0.01	-0.05
		(0.006)	(0.010)	(0.017)	(0.006)	(0.009)	(0.017)
	Rural-Before	0.43	0.42	0.39	0.84	0.86	0.89
		(0.008)	(0.009)	(0.018)	(0.005)	(0.007)	(0.013)
	Rural-After	0.35	0.33	0.33	0.88	0.91	0.89
		(0.008)	(0.008)	(0.018)	(0.006)	(0.006)	(0.013)
	Difference	-0.08	-0.09	-0.06	0.04	0.05	0
		(0.011)	(0.012)	(0.024)	(0.008)	(0.009)	(0.018)
Insurance	Employment-Before	0.63	0.53	0.56	0.41	0.52	0.53
		(0.005)	(0.009)	(0.015)	(0.006)	(0.009)	(0.015)
	Employment-After	0.57	0.47	0.42	0.45	0.56	0.52
		(0.005)	(0.008)	(0.015)	(0.005)	(0.02)	(0.016)
	Difference	-0.06	-0.06	-0.14	0.04	0.04	-0.01
		(0.007)	(0.012)	(0.022)	(0.008)	(0.021)	(0.024)
	Government-Before	0.46	0.44	0.46	0.84	0.87	0.89
		(0.006)	(0.007)	(0.014)	(0.005)	(0.006)	(0.012)
	Government-After	0.35	0.30	0.33	0.85	0.91	0.87
		(0.007)	(0.007)	(0.013)	(0.005)	(0.006)	(0.011)
	Difference	-0.11	-0.14	-0.13	0.01	0.04	-0.02

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Table A1 – continued from previous page

	(1) C-section rate	(2) C-section rate in public	(3) C-section rate in public (first births)	(4) Share of public (total births)	(5) Share of public (total vaginal)	(6) Share of public (total vaginal first births)
	(0.009)	(0.010)	(0.019)	(0.007)	(0.008)	(0.016)
Not insured-Before	0.53	0.37	0.52	0.65	0.86	0.73
	(0.014)	(0.017)	(0.039)	(0.014)	(0.013)	(0.036)
Not insured-After	0.48	0.25	0.36	0.60	0.73	0.63
	(0.04)	(0.05)	(0.040)	(0.04)	(0.05)	(0.04)
Difference	-0.05	-0.12	-0.16	-0.05	-0.13	-0.10
	(0.04)	(0.052)	(0.056)	(0.04)	(0.051)	(0.054)

Note: Mean coefficients, SE in parenthesis. Column 1 shows the total c-section rate. Column 2 is the share of births in public hospitals out of total births. Column 3 is similar to the column 3 among those baby who are born by vaginal delivery. Column 4 is the c-section rate in public hospitals. Column 5 is c-section rate in public hospitals for first birth mothers, 17-35 years old.

Table A2: Demographics in public hospitals (One month before and one month after)

	Before	After	Diff.
Age	23.95	23.99	0.04
	(0.0435)	(0.0375)	(0.0574)
Urban	65.47	66.01	0.54
	(0.482)	(0.420)	(0.639)
% College edu.	16.53	16.86	0.33
	(0.376)	(0.332)	(0.502)
% High school edu.	37.35	36.41	-0.94
	(0.490)	(0.427)	(0.650)
% Primary/secondary edu.	46.11	46.73	0.62
	(0.505)	(0.442)	(0.671)
% Government ins.	50.83	51.45	0.62
	(0.506)	(0.443)	(0.673)
% Employment ins.	41.54	40.67	-0.87
	(0.499)	(0.435)	(0.662)
% Not insured	7.63	7.88	0.25
	(0.269)	(0.239)	(0.360)
% Migrant	4.02	3.41	-0.61
	(0.199)	(0.161)	(0.256)
Observations	22475		

mean coefficients; SE in parentheses

Table A3: Cesarean Reasons out of total cesareans-first birth

	Before	After	Difference
cephalopervic disproportion	0.114	0.0344	-0.0796
	(0.00949)	(0.00639)	(0.01144)
fetal distress	0.234	0.337	0.103
	(0.0126)	(0.0166)	(0.0208)
impaired fetal presentation	0.114	0.127	0.013
	(0.00949)	(0.0117)	(0.0151)
labor dystocia	0.126	0.211	0.085
	(0.00989)	(0.0143)	(0.0174)
mother's high blood pressure	0.0285	0.0381	0.0096
	(0.00497)	(0.00671)	(0.0084)
mother's request	0.131	0.0209	-0.1101
	(0.0101)	(0.00502)	(0.0113)
other reasons	0.188	0.162	-0.026
	(0.0117)	(0.0129)	(0.0174)
placenta and umbilical cord problems	0.0338	0.0405	0.0067
	(0.00540)	(0.00692)	(0.0088)
previous cesarean or uterine scarring	0.0312	0.0295	-0.0017
	(0.00519)	(0.00593)	(0.00788)
Observations	130,274	95,071	

Table shows the averages; SE are in parentheses

Table A4: Share of each category of gestation length of total cesareans for one year before and one year after the programme

Gestation length	Before	After	Difference
37 weeks	0.0841	0.0737	-0.0104
	(0.000827)	(0.000915)	(0.0012)
38 weeks	0.301	0.217	-0.084
	(0.00137)	(0.00144)	(0.0019)
39 weeks	0.266	0.257	-0.009
	(0.00132)	(0.00153)	(0.002)
40 weeks	0.201	0.246	0.045
	(0.00119)	(0.00151)	(0.0019)
41 weeks	0.0457	0.0802	0.0345
	(0.000623)	(0.000951)	(0.00113)
Observations	130,274	95,071	

Table shows the averages; SE are in parentheses

Figure A1: Average c-section rate by province in 2013

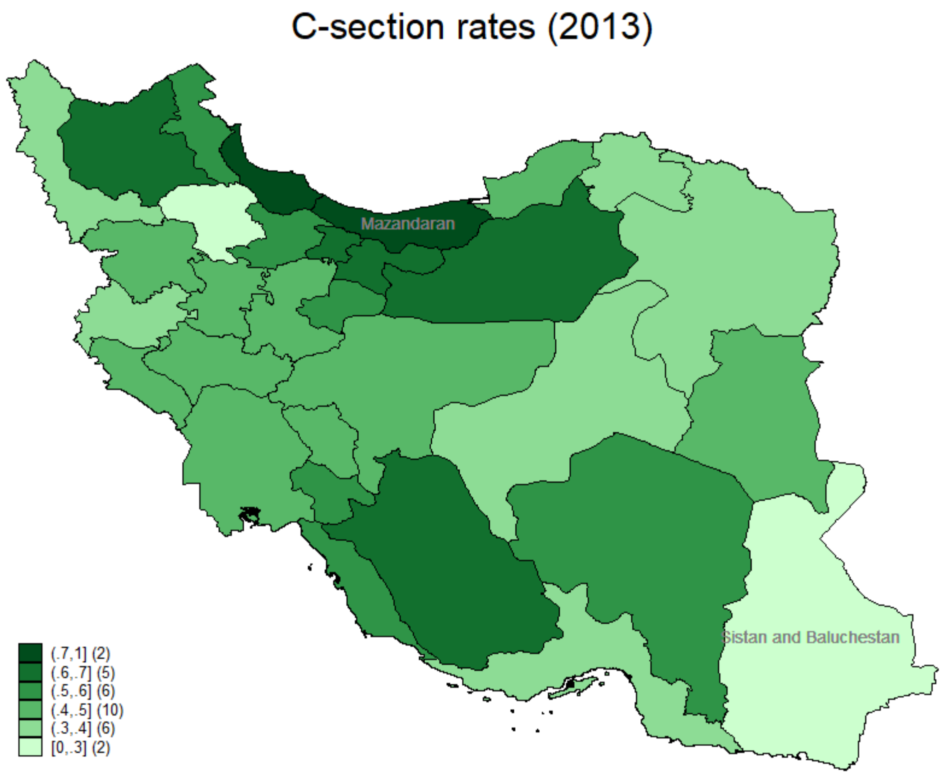
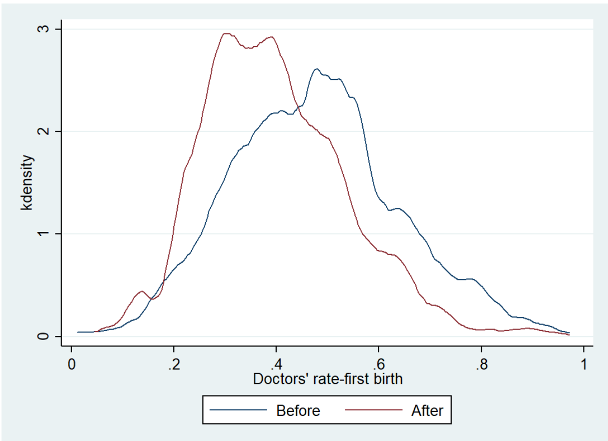


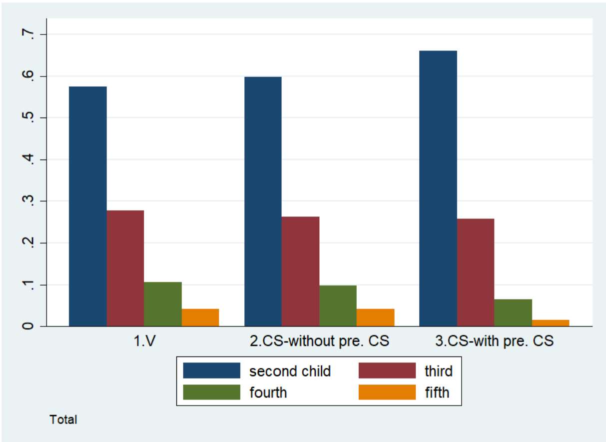
Figure A2: Change in the distribution of doctors' c-section rate



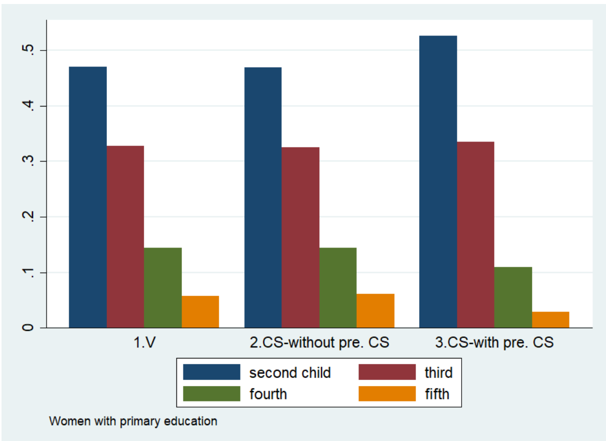
Note: Distribution of doctors rate of c-section for the year before and one year after the start of the programme.

Figure A3: Child order distribution

(a) Total



(b) Primary education



Note: Distribution of number of children for women who have vaginal delivery, cesarean with previous cesarean and cesarean without previous cesarean in their current delivery.