Health Care Regionalization and Birth Outcomes: Evidence from Maternity Clinic Closures*

Daniel Avdic† Petter Lundborg‡ Johan Vikström§

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Abstract

Regionalizing health care creates a potential trade-off between increased productivity and decreased access. We study how the regionalization of Swedish maternity clinics during the 1990s affected the quality of maternal care received by mothers and infants, using register data on all births in Sweden over two decades. To account for endogenous sorting to clinics we exploit closures of maternal clinics, which generates exogenous variation in distance to clinics and in their case volume. We find that closures had positive effects on the health of newborns but also increased the risk of maternal birth trauma. These results suggest the existence of a trade-off between infant and maternal health when regionalizing health care. Our results are robust to a number of sensitivity checks and are not driven by case-mix changes in the underlying patient population.

Keywords: Health care quality, regionalization, hospital closure, birth outcomes, maternal care

JEL Classifications: D24; I11; I18; J13; R41

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†CINCH and University of Duisburg-Essen. Corresponding Author: CINCH — Health Economics Research Center, Edmund-Körner Platz 2, DE-451 27 Essen, Germany. Phone: +49 (0)201 183 6326. E-mail: daniel.avdic@uni-due.de.

‡IZA and Department of Economics, Lund University.

§IFAU and UCLS, Uppsala.

1 Introduction

Most countries display large disparities in health at birth and a recent literature highlights the long-term economic implications of such disparities (see e.g., Heckman, 2007; Currie and Almond, 2011). Early life health interventions, such as improved prenatal and neonatal care, have shown effective in improving short and long-run outcomes (see e.g., Almond *et al.*, 2010; Bharadwaj *et al.*, 2013) but there is less evidence on how the organization of maternal care health in itself matters for early child and women health outcomes. Understanding the effect of organizational changes is important for policy, as an inefficient organization means that there are potentially unrealized gains in health that do not necessarily rely on investments in new and expensive technology.

In this paper, we study the effect of changes in the organization of maternity clinics on infant and maternal health outcomes. In particular, we study the effect of a wave of maternity clinic closures in Sweden that took place in Sweden 1990 and 2005, which led to increased regionalization and thereby to fewer but larger units. Using administrative data on all births in Sweden during two decades, we provide evidence on the effect of maternity clinic regionalization on babies and mothers' health, as well as on the mechanisms behind these effects.

Concentrating the number of maternity wards has two main, and potentially, offsetting effects. One the one hand, recent trends of regionalizing health care are often endorsed by the idea that hospitals with higher patient volumes perform better and are more efficient due to, for example, staff learning-by-doing, specialization and scale effects. Regionalizing health care could also mean that low-performing units are closed and that patients are instead referred to remaining units of higher quality.[1] On the other hand, regionalization policies also mean that the distance to the hospital increases for some patients. Longer travel times may be particularly acute for pregnant mothers and, thus, there exists a potential tradeoff between quality of and distance to maternal health care. Understanding the net effect of regionalizing policies is essential for health care policy.

The major challenge in estimating the effects of health care regionalizing, and the mechanisms behind the effects, is that women located close to a maternity ward, or to maternity

[1] Fewer health care units might also lead to crowding and reduced accessibility, which could affect health outcomes negatively.

wards with certain characteristics, may be different from those living at a greater distance from such facilities. Women who are more health conscientious, or who expect more complications at birth, might for instance locate close to maternity clinics in general or live closer to high-quality clinics. We tackle these problems by comparing changes in health outcomes of newborns and women living in areas where a birth clinic was closed to the corresponding changes in areas without any closures. This gives us the combined effect of increased distance to a clinic and of changes in the characteristics of the clinic, such as patient volume and medical practices.

The concentration of the number of clinics may also affect the outcomes of patients in areas where no closure took place but where the remaining clinics experienced an additional inflow of patients. These patients will now be exposed to higher-volume clinics but will not experience any change in the distance to the clinic. Women at wards may benefit from the higher volume and potentially greater specialization but may also suffer from increased crowding. We can estimate the effect of the regionalizing policy for this group by comparing changes in their outcomes with the corresponding changes in outcomes in areas that did not experience any inflow of new patients following from a nearby closure. By combining the estimates obtained for the patient in areas with and without closures, we are able to assess the net effect of the concentration of clinics.

We find that low birth weight babies born in areas where a birth clinic closed had significantly higher Apgar scores. Moreover, the risk of birth trauma decreased, also in areas without a closure but who faced an additional inflow of patients from closed nearby clinics. These results point to the value of concentrating the number of clinics and suggests that the positive effect of giving birth at a larger clinic may dominate any negative effect of reduced access.

We also find some negative effects for the mothers giving birth. Mothers exposed to a closure had an increased risk of maternal birth trauma. This suggests that effects of reduced access and larger clinics may be different for babies and mothers. The conflicting results for child and maternal outcomes also suggest a trade-off, where the positive effect of concentration the number of maternal clinics for babies should be weighted against the negative effects we find for mothers.

Our results have several important implications. While maternal and infant mortality have steadily decreased in the developed world over time, a surprisingly high rate of birth-related maternal complications and injuries still persist. Figure 1 illustrates trends of infant mortality (left panel) and the share of births in Sweden where a delivery was complicated by obstetric trauma, categorized by delivery type and birth weight (right panel). While the infant mortality rate declined from six to less than one child per 1,000, the share of patients with obstetric trauma actually increased during the 1990s and has since then remained at a higher level.

[Figure 1 about here]

Our paper relates to several strands of literature. A few papers have studied the effect of hospital closures on the health of patients, using quasi-experimental designs. For adult patients, Buchmueller *et al.* (2006) estimates the effect of hospital closures in Los Angeles county on deaths from heart attacks and injuries and finds that the increased distance following closures increase deaths. Similar findings following the closure of emergency rooms have been obtained in Sweden and Taiwan (cf., Avdic, 2015; Shen and Hsia, 2012). Avdic *et al.* (2014) report improvements in cancer surgery survival after closures of cancer surgery clinics. Joynt *et al.* (2015) report that hospital closures in the U.S. led to decreases in the use of inpatient care but did affect mortality or hospitalization rates.

To our knowledge, only two previous papers have estimated the effect of hospital or obstetric unit closures on birth outcomes and the findings are mixed. Studying the effect of local hospital closures in Norway, Grytten *et al.* (2014) found no significant effects on neonatal and infant mortality in Norway. Lorch *et al.* (2013) studied the effect of obstetric unit closures on neonatal and perinatal mortality in Philadelphia and found short-term adverse effects that faded out over time.

At a more general level, our paper relates to the literature on the returns to childbirth interventions (see e.g., Almond *et al.*, 2010; Bharadwaj *et al.*, 2013). These papers focus almost exclusively on high-risk births, such as babies born with low or very low birth weight. A few exceptions are Almond and Doyle Jr (2011) who study the effect of post-partum stays and Daysal *et al.* (2016) who study the effect of home births versus hospital births.

Our paper proceeds as follows. The next section describes the institutional setting in Sweden. Section 3 introduces our data and Section 4 describes the closure of maternity clinics that took place during our study period and that we exploit in our empirical design. Section 5, outlines our empirical specifications and Section 6 show results. Section 7 concludes.

2 Maternal care in Sweden

2.1 Institutional setting

The Swedish health care system is highly regulated and the vast majority of health care is owned, managed, and financed by the public sector. The Swedish public sector comprises three tiers; the national, the regional and the local level, and the responsibility for health care, regulated by the Swedish Health Services Act (1982:763), generally takes place on the regional level. The regional county councils are the major financiers and providers of Swedish health care. There are 21 county councils in all, and each council is obliged, by law, to provide its residents with equal access to health services and medical care. Each county council sets its own patient fees but a national ceiling limits the total amount that a patient has to pay out-of-pocket over a 12-month period. Hence, patient fees account for only around three percent of total health care revenues. There is free choice of health care provider but referral is required in some cases, in particular for specialized care or when patients seek care in another county. The county councils are allowed to contract with private providers, but most health care is performed by public agents. This institutional context implies that political representatives of the county councils and local bureaucrats, rather than competition among health care providers, determine the number, size, location and coverage of hospitals within each region.

The Swedish health care system is also characterized by that prospective patients have little discretion in the choice of hospital when they require specialized care. As health care in Sweden is mainly funded by direct taxes there exist no individual agreements between providers and recipients of inpatient care. Instead, place of residence largely determine which hospital patients will be admitted to when in need of health care, since each hospital

is responsible for all specialized care within their catchment area. This setting ensures that each patient always has a designated "home hospital", which can be identified by using hospital admission data linked to information on the patient's registered home.

During the 1990s, a large number of maternity clinic closures occurred in Sweden as a part of a more general reorganization of the health care system to consolidate resources in order to increase efficiency and to cut costs. During the time period studied in this paper, 1987-2004, 18 maternal clinics were closed all in all. This reorganization was mainly triggered by the economic crisis beginning in 1991 and was further strengthened by a new law stipulating that no county was allowed to run an annual deficit in the health care budgets. Accordingly, many counties explored new ways to cut costs and many specialized services were transferred to regional hospitals in the hope that they would improve productivity from economics of scale. Emergency health care was also reorganized so that a greater focus was put on ambulatory care rather than a high density of small and medium-size hospitals in rural areas.

2.2 Assisted births, cesarean sections and birth complications[2]

Assisted births are births delivered by the use of instruments, normally forceps or a ventuose suction cup, to help deliver the infant's head. There are many different reasons for the decision to assist the birth such as concerns about the infant's heart rate, if the infant is in an awkward position or if the patient is too exhausted or a first-time mother. A ventouse (vacuum extractor) is an instrument that is attached to the infant's head by suction. Forceps are smooth metal instruments that look like large spoons or tongs, curved to fit around the infant's head. With a contraction and the patient's pushing, the obstetrician can then use a suction device or the forceps' grip to help deliver the baby. Forceps are also sometimes used to turn the infant in the right position to be born. Forceps are more successful than ventouse in delivering the baby, but a ventouse is less likely to cause obstetric trauma.

If the obstetrician has any concerns and the infant cannot easily be delivered instrumentally, a cesarean section may instead be considered. In some cases, however, a smaller cut (episiotomy) to make the vaginal opening bigger may be enough for secure delivery as a ce-

[2]The text in this section is based on the NHS (http://www.nhs.uk/conditions/pregnancy-and-baby)

sarean section involves major invasive surgery and should therefore normally be chosen as a last resort. A cesarean section is performed by cutting through the patient's abdomen and then into the uterus. Emergency cesareans are needed when complications develop during pregnancy or labor and delivery needs to be quick, such as if the cervix doesn't dilate fully during labor, birth is not progressing properly or if the patient bleed substantially during labor. A cesarean is elective if it is planned in advance which happens when the responsible doctor believes that labor will be dangerous for the patient or the baby, such as when the baby is in the breech position. Most cesareans are performed under epidural or spinal anesthesia but also general anesthetic can be used if the baby needs to be delivered quickly.

Various complications could occur during childbirth. In this paper we focus mainly on perineal tears as they are a common indicator for health care quality in many countries (cf., OECD, 2011). Perineal tears are unintended lacerations (as opposed to episiotomy) of the skin and other soft tissue structures which separate the vagina from the anus in women, occurring as a result of childbirth straining the perineum. Tears may vary widely in severity and the majority are superficial and require no treatment but severe tears can cause significant bleeding, long-term pain or dysfunction. Tears are classified into four categories with respect to the severity of the laceration. According to the Agency for Health care Research and Quality (AHRQ), in 2011, first- and second-degree perineal tear was the most common complicating condition for vaginal deliveries in the U.S. among health insured women (cf., Moore *et al.*, 2014). The risk of perineal tear is reduced by the use of episiotomy and cesarean sections although these procedures are also traumatic. Epidural anesthesia and induction of labor also reduce the risk. The use of forceps or ventouse reduces the risk if the fetus is in the normal position.

3 Data

We use data from several Swedish administrative registers; the Intergenerational Register (IGR), containing information for the full Swedish population on the link between parents and their children for up to three generations; the Swedish National Patient Register (NPR), containing population-wide information on all in-patient care in Sweden; the Clinical Birth Registry (CBR), containing detailed health information on the mother and the newborn for

all Swedish births; and a population register called LOUISE, containing yearly information socio-economic background characteristics such as marital status, household characteristics (e.g. number of children), labor income and income from various insurance schemes (e.g. sickness and disability). The NPR contains individual-level data on the date and the hospital of admission and discharge, the nature of the admission, such as the length of stay and whether it was acute or planned, as well as detailed medical information including main and co-morbidities (through the International Classification of Diseases, ICD). It furthermore includes information about any medical procedures made in relation to the hospitalization, such as type of surgery and complementary treatments, through the National Classification of Surgical Procedures (NCSP13).[3] The CBR additionally includes information on the date, place and type of birth and, in addition, detailed characteristics of the health of the newborn, such as APGAR scores and birth weight.

We sample all births in Swedish hospitals over the period 1987–2004 from the data.[4] As Sweden is a country where mid-wives mainly operate in the hospitals and very few births occur in the home, the NPR essentially covers the full population of interest. Lindgren *et al.* (2008) finds that out of over 1.2 million births over the time period 1992–2004, only 1,600 births were planned home deliveries. The main reason for this is that home deliveries are neither recommended by health care authorities nor covered by the public health insurance and, hence, has to be paid out of pocket. Since health care is funded by taxes there is a strong economic disincentive for give birth at home.

Due to data restrictions we are not able to merge the NPR data with the CBR data. Instead we will use two different data sets. The first data set is based on the NPR register and is used to study maternal outcomes, such as cesarean sections and complications at birth. For this data set we also have information on the entire medical history of the mothers, which enables us to adjust for a large sample of pre-pregnancy health indicators. The second data set is based on the CBR, and focuses on child outcomes, such as Apgar scores and trauma during the delivery. This data set also contain information on the mothers, but unfortunately we do not have information on pre-pregnancy health. Instead we have some additional

[3] A major revision of the NCSP occurred in 1997, which complicated some comparisons of birth surgery procedures over time, but were in most cases straightforward. For diagnoses there was also a switch from ICD-9 to ICD-10 the same year but it did not affect the structure of the classification to any important extent.

[4] Specifically, until 1998 ICD-9-codes 650–669 and, from 1998 onwards, ICD-10 codes O60–O84.

information such maternal hight and weight.

Figure 2 shows the number of births in Sweden over the relevant time period by month of birth. In the beginning of the period between 10–13,000 children were born every year in Sweden. There was a significant drop in childbirths during the economic crisis years in the beginning of the 1990's which have since then stabilized on a permanently lower level with around 8,000 children per month until the end of the studied period. To validate our sample of births we compare the numbers to official births statistics. This is reported in Table 1 where the difference before and after adjustment in our sample of mothers in the last two columns refers to that it is taken from the intergenerational registry, which also contains foreign-born individuals. Once this is taken care of by linking the intergenerational data to inpatient data the sample corresponds very closely to official statistics.

Table 1 also reports the number of children in the sample based on the CBR data. We see that the number of children in the CBR data is somewhat lower than the official statistics. This is because not all birth clinics report to the CBR register each year. There are some variation over the years, but the fraction of births that are recorded in the CBR stays roughly the same. We have also examined how the fraction reported births vary by regions, but did not find any systematic patterns. Another issue is that the mothers identification number is not registered for all births in CBR, and we need this identification number in order to link the CBR data to population register information on place of residence that is used to construct, for instance, distance to the nearest birth clinic. The last column of Table 1 therefore reports the number of CBR observation for which we have the identification number of the mothers. We conclude that the fraction missing is rather constant over time.

3.1 Maternal outcomes

The main maternal outcomes we use in our estimations are indicators for whether the birth was assisted by instrumental or surgical means (i.e. cesarean sections or by using ventouse or forceps), and obstetric trauma according to the Patient Safety Indicators 18–19 from the Agency for Health care Research and Quality (AHRQ) capturing the severeness and prevalence of different complications at birth (see e.g., Iizuka, 2013). In particular, we look at perineal tears but also more serious conditions such as hemorrhages and shocks. These

outcomes will mainly capture short-run effects.[5,6] From our statistics we note that assisted births have become much more common over time, mainly due to an increase in cesarean sections.

3.2 Child outcomes

We also have several interesting child outcomes. One set of variables are based on the Apgar score after 1, 5 and 10 minutes. The Apgar score is mainly used to establish a simple and clear classification of newborn infants which, for instance, can be used to compare the results of obstetric practices. It is based on the heart rate, respiratory effort, reflex irritability, muscle tone and the color of the infant. For each sign the baby is given a rate of either 0,1 or 2 from worst to best, and taken together this gives an Apgar value from 0 to 10. One general rule is that scores of 7 and above are considered normal and that scores of 3 and below is considered critically low. We also study effects on child mortality and birth traumas, where the latter includes intracranial laceration and haemorrhage due to birth injuries, and injuries to the scalp, skeleton and the peripheral nervous system.

3.3 Background characteristics

In our regressions we include a rich set of covariates which are known to be related to birth outcomes and especially complications at birth. Using the inpatient data, we compute the medical history of all mothers in our sample back to 1987 and follow the convention used in e.g., Dubay *et al.* (1999, 2001); Currie and MacLeod (2006); Shurtz (2014) and dividing the medical information into part pre-existing conditions and part pregnancy-specific conditions. To validate this information we have compared our data with the descriptive information in Dubay *et al.* (2001) and with Swedish official records. Table 2 shows descriptive statistics of all variables we use in our analyses by sample.[7]

For our sample of mothers these variables include socioeconomic characteristics (e.g.

[5] We do not consider maternal mortality as it is an extremely uncommon outcome in Sweden during this time period.

[6] We also aim to analyze longer term economic and health-related outcomes of the mother and child by following them after birth; specifically re-admissions, subsequent fertility, parental leave and incomes.

[7] Around 5% of all births reported in Table 1 are discarded in the final estimation sample due to missing covariate information. Most of these relate to missing in-hospital records.

age, foreign born and marital status), medical history (e.g. tumors, obesity and heart diseases), pregnancy-specific conditions(e.g. diabetes, anemia and early onset birth) and delivery specific conditions (e.g. incorrect fetal position and prolonged delivery). In the sample based with child outcomes that is based on the CBR we have somewhat less information on the mothers.

[Table 2 about here]

4 Empirical framework

Our aim is to analyze the effects of regionalization of maternity clinics on birth outcomes for mothers and newborns. In particular, we study the effect of a wave of maternity clinic closures in Sweden that took place in Sweden 1990 and 2005, which led to increased regionalization and thereby to fewer but larger units. Using birth records closures of maternity clinics are easy to identify. Specifically, a ward is classified as closed if the yearly number of births at the ward decreases by more than 90 percent. During our sampling period (1987–2004) we observe a total of 18 closures.[8] These closures have also been validated using official documents, media coverage and research reports. Figure 3 describes where in Sweden the closure-affected municipalities are located. The maps in the figure show that the closures mainly affected rural areas, but that also that some maternity clinics were closed in the areas around the two largest cities in Sweden (Stockholm and Gothenburg).

[Figure 3 about here]

4.1 Closure of maternity clinics and health outcomes

Closures of maternity clinics can impact child and maternal health and human capital in several different ways.

Case volume. If a maternity clinic is closed this means that the number of births at nearby clinics increases, and this case volume increase might affect the quality of the obstet-

[8]The closed maternity wards are Avesta 1992, Köping 1994, Nacka 1996, Upplands Väsby 1996, Trelleborg 1996, Uddevalla 1997, Trollhättan 1997, Luleå 1998, Boden 1998, Katrineholm 1998, Bollnäs 1998, Ängelholm 1999, Kiruna 2000, Piteå 2001, Kalix 2001, Norrköping 2003, Motala 2003 and Lidköping 2003.

ric care in different ways. Learning-by-doing is one important channel if the increased case volume in nearby clinics lead to increased learning among the physicians and the midwives at nearby wards. The larger case volume might, for instance, mean that the physicians and midwives gain more experience about how to treat underweight children in the best way. Another potential effect of more concentrated care is that the remaining clinics might be able to exploit scale effects and invest in newer and more advanced technology. Larger clinics might also allow the physicians and midwives to specialize in different types of care, such as treatment of pre-mature and/or riskier births. All these channels suggest that a closure should improve the quality of the obstetric care at the remaining nearby clinics. However, if the number of births at the remaining wards increases too much, this might lead to organizational problems that could have detrimental crowding out effects, which might be important, at least in the short-run.

As a background to this discussion about case volume effects, Figure 4 and Figure 5 describe how the maternity ward closures affected the case volumes, measured as the annual number of births performed in a clinic. Figure 4 relates the decrease in the number of clinics to the average case volume size, by showing the yearly number of clinics and the average case volume for each year. We see that the average case volume increased as the number of birth clinics decreased. We next describe the distribution of the closure induced case volume changes. Panel (b) in Figure 5 shows the volume changes at the remaining nearby maternity clinics and panel (a) shows the volume changes that mothers in areas with a closed ward experience. These figures reveal substantial increases to the yearly case volume, and these increases are larger for mothers in closing areas than for mothers in the nearby areas.

[Figure 4 and Figure 5 about here]

Distance to the clinic. Closures of maternity clinics also mean that the average distance to the clinics increases for some mothers. Longer travel times may be particularly acute for pregnant mothers. In our empirical analyses we will use the distance to the individual's designated maternity clinic as distance measure. Place of residence determines which hospital an individual is referred to when in need of health care and can be identified by analyzing aggregate patient flows on the municipal level each year. The home hospital is selected using hospitalizations from the NPR and aggregated to the municipal level. Specifically, for

an individual residing in a given municipal a given year, the home hospital is defined as the modal hospital to which most of the inhabitants of the municipality were admitted in that particular year. Geographical coordinates for each individual's registered place of residence are added to the analysis sample by linking information from Statistics Sweden. The coordinates are used to compute the geographical distance from each patient's registered home to his or her home hospital each year. We explore three different distance measures. The first is simply the minimum distance between the two points, which is a proxy for the patient's actual travel distance. We also information on actual driving distance and travel time. These have been collected using geocoding software from STATA® and Google®.

Panel (a) of Figure 4 shows how the average distance to a maternity clinic increased as the number of clinics were reduced over time. Furthermore, panel (c) of Figure 5 shows the distribution of the distance changes for the affected women in closure regions. Overall we see that the distance changes cover a broad spectrum of the distance distribution. Some people living near the border of the catchment areas may actually have had a decrease in distance after the closure due to that the referral hospital was closer before the closure.[9]

Clinic quality and technology practices. Besides causal case volume and distance effects a closure of a maternity clinic could affect maternal and infant outcomes simply because the quality of the maternal care is better at the nearby remaining clinic compared to the closed clinic, so that mothers that would have given birth at the closed clinic now give birth at a clinic with maternal care of better quality. It might also be the case that the technological practices differ between the closed and the nearby remaining clinics, which could affect maternal and infant outcomes in different ways. In general, the expected direction of the this effect depends on the relative quality of the closed and nearby clinics. We intend to shed more light on this quality aspect by examining outcomes at the closed and remaining clinics before the closures. In particular, we will test for quality and technology practice differences before the closures with and without controlling for a detailed battery of patient characteristics.

[9]We analyze the impact of these individuals on our main results in a robustness check.

4.2 Empirical model

Initially, we estimate the reduced form average effect of a closure through a difference-in-differences type empirical design only including closure and control catchment areas unaffected by hospital closures (i.e. excluding catchment areas to which individuals from closing areas were referred to after the closure). Specifically, for individual i, in local area s in region r in year t we estimate:

$$y_{isrt} = \beta C_{st} + \lambda_s + \lambda_t + t \times \lambda_r + X_i'\gamma + \varepsilon_{isrt} \tag{1}$$

where y_{isrt} is the specific outcome (instrumental/surgical delivery, obstetric trauma, apgar score). C_{st} captures the effect of a closure, and is an indicator variable for whether the individual was affected by a in year t or before t. Specifically, for individuals affected by a closure j (indexed by $j = 1, 2, ..., J$), defined as living in a closure area s_{c_j} where a hospital closure occurred at time t_{c_j} ; i.e., $C_{st} = \mathbf{1}[t > t_{c_j}, s = s_{c_j}]$. This captures the average effect during the closure year and all subsequent years. Later on we will also analyze how the effect vary with time since the closure by replacing the closure dummy C with a set of time dummy variables by year from closure.

We control for local area fixed effects, λ_s, which controls for all time-invariant differences between mothers in areas where a maternity clinic was closed and mothers in areas unaffected by closures. We also adjust for general changes to maternal and infant health by including calender year fixed effects, λ_t. Our model also include a large set of pre-birth health characteristics, X_{it}'. The exact covariates are reported in Table 2. Finally, we control for regional time trends, $t \times \lambda_r$, which adjust for differential trends in health in regions with and without closures. In our baseline model we include linear trends, but also report results from models without these trends. In robustness analyses we also estimate models with quadratic trends.

The resulting parameter estimate $\hat{\beta}$ from estimation of model (1) will include both effects of distance, case volume and clinic quality. To analyze each effect separately, we will perform analyses using different sub samples. For instance, we will make use of the fact that some maternity clinics were entirely unaffected by a nearby clinic closure while other clinics acted

as the new referral clinics for patients living in closure catchment areas. Figure 6 illustrates the intuition behind the approach: Three types of catchment areas exist, which are made up by one or several municipalities: Closing catchment areas (A) which are subject to a closure of a maternity clinic, referral areas (B) which are subject to transferring patients from the closing catchment areas, and control areas (C) completely unaffected by closures. Individuals living in catchment areas of type A are affected in three ways by the closure; first, by experiencing an increase in the distance to the nearest maternity clinic; second, by a change in the case volume of the referral hospital; third, by a potential clinic quality effect by the fact that they now will be treated at hospital B instead of hospital A. For individuals in catchment areas of type B, the distance to the maternity clinic stays the same but inhabitants will experience a higher volume due to the new patients arriving from the closed hospital's catchment area. Finally, for individuals living in control areas C, neither volume nor distance will change. By exploiting spatial variation across regions and time variation before and after hospital closures, we are able to analyze each effect separately, as well as their net impact on the outcomes of interest.

[Figure 6 about here]

Finally, note that (1) will handle several important selection problems associated with studying effects from living further away from a maternity clinic and from being treated in a hospital with higher case volumes. The main empirical challenge is that both the distance to the hospital and the size of the hospital might be related to both observed and unobserved maternal characteristics. For that reason we closures of maternity clinics as plausible exogenous variation in hospital volume and distance to a hospital.

5 Results

5.1 Maternal outcomes

Figure 7 shows the unconditional changes in instrumental births by time from hospital closure divided into; (a) the share of cesarean sections; (b) the share of ventouse and forceps deliveries; (c) the share of obstetric trauma, categorized into perineal tears of degree 1–2

(d) and 3–4 (e) and (f) other traumas for the sample of individuals living in closure areas and unaffected areas. For women living in control regions there is, as expected, a smooth trend across the closure years for all outcome variables. In contrast, for closure-affected mothers there is a substantial reduction in the probability of having an assisted birth (ventouse/forceps). Furthermore, from panels (c)–(f) there is a similar, but reversed, pattern with respect to the risk of obstetric trauma; in particular for less severe trauma of the first and seconds degree the increase is substantial, but the pattern is consistent also for the other trauma outcomes.

[Figure 7 about here]

We next report estimate from model (1). Table 3 reports results from both models with linear regional trends (Panel A) and without trends (Panel B). The reason for this is that we wish to examine to what extent our results are robust with respect to different trend specifications. Let us first focus on the effects for mothers in closure areas. Similar to the descriptive pattern in Figure 7, the regression results imply that closure-affected women had a lower probability of having a assisted delivery and a higher probability of obstetric trauma, although the effect on obstetric trauma is insignificant in the model with regional trends. The parameter estimates suggest substantial effects with reductions of around 0.6 percentage points or about 10% in the probability of having ventuose/forceps assisted deliveries, and an increase of about 2.7 percentage points or 33% in the risk of obstetric trauma. The latter results for obstetric trauma is for a model without regional trends.

[Table 3 about here]

5.2 Child outcomes

Table 4 and Table 5 present estimates for our child outcomes. As for maternal outcomes we report both estimates with and without linear regional trends. We also report separate estimates for all children and the group of children with low birth weight (below 2500g). Two important reasons for low birth weight are a pre-mature delivery or other in-utero complications, which in both cases means that the delivery is associated with greater risks.

By examining effects on the sub sample of children with low birth weight we are, thus, able to study the effects of maternity clinic closures on high-risk deliveries, for which the case volume, distance and clinic quality effects by might be different than for low-risk deliveries.

Table 4 reports estimates for Apgar score after 1, 5 and 10 minutes. We mainly focus on the probability of having a low Apgar score (below 7) and the probability of having a very high Apgar score (above 8). For the full sample with all children we find no robust effects on any of the three apgar scores. For the low birth weight sample on the other hand we find robust and significant effects on the probability of having a Apgar 1 score above 8. This is explained by a significantly reduced probability of a Apgar score in the interval 7-8. There are also indications of decreased probability of having a Apgar score that could be classified as low (below 7), although the estimate is insignificant. But, we find no significant effects on Apgar 5 and Apgar 10.

[Table 4 and Table 5, about here]

In Table 5 we examine effects on infant mortality and traumas experienced during the delivery. For infants with low birth weight we find no significant effects, but for the full sample we find a significantly reduced probability of a birth trauma. The effect on birth trauma is sizeable and corresponds to an 0.27 percentage points or about 17%. This may reflect a decreased access to birth clinics, where increased travel time might lead to more emergency births, and/or crowding at the remaining clinics.

5.3 Referral regions

In order to learn more about the mechanisms we also examine effects for referral catchment areas. That is effects for mothers giving birth at clinics that experience a inflow of additional mothers from areas with closed clinics. Remember that this group only experience case volume and crowding effects. We estimate a similar models as (1), but replace the closure dummy with a referral dummy, which takes the value one for referral regions from the year of the inflow of new mothers and onwards, i.e. for the year that a nearby clinic is closed and onwards. From the results for the infants in Table 4 and Table 5 we find no effects that are significant in both the model with and without linear regional trends. This holds both for

the full sample of infants as well as for the low birth weight sample. For mothers, Table 3 reveals significant effects on obstetric trauma, and the estimate is of about the same size as for the closure-affected mothers. One possible explanation to this results is crowding effects at the remaining clinics as a result of the increased number of births.

6 Mechanism(s)

To be added.

7 Conclusions

This paper studies how the concentration of Swedish maternity clinics during the 1990s affected the quality of maternal care received by mothers and infants. To account for endogenous sorting to clinics we exploit closures of maternal clinics, which generates exogenous variation in distance to clinics and in their case volume. Our empirical design allows us to analyze the impact of both changes in distance and in maternity clinic characteristics, as well as the overall impact from both factors.

We find that concentrating the number of maternity clinics have positive health effects for babies in areas exposed to a closure. Although distance to the nearest maternity clinic increase, babies who were now born in farther away, but larger, clinics had significantly higher Apgar scores as well as a decreased risk of birth trauma. We found no offsetting negative health effects for babies born in areas that were not exposed to a closure but that were exposed to larger maternal clinics because of a nearby closure.

We also found some negative health effects for mothers exposed to a closure. Birth trauma increased both for mothers in areas exposed to a closure and for those in areas experiencing a nearby closure. This may reflect a decreased access to birth clinics, where increased travel time might lead to more emergency births, and/or crowding at the remaining clinics.

Concentrating health care creates a potential trade-off between increased productivity and decreased access. Our conflicting results for child and maternal outcomes suggest an additional trade-off, where the positive effect of concentration the number of maternal clinics for babies should be weighted against the negative effects we find for mothers. This

complicates the assessment of the net gains from concentration policies but should nevertheless be considered when designing policy. Further research should aim at increasing our understanding of the costs and benefits of concentration policies.

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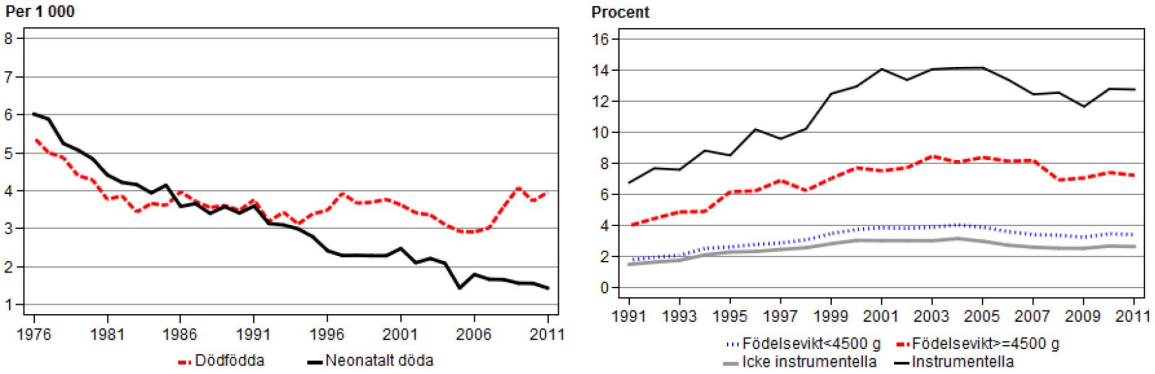
Tables and Figures

FIGURE 1.
Infant mortality and birth injuries in Sweden over time

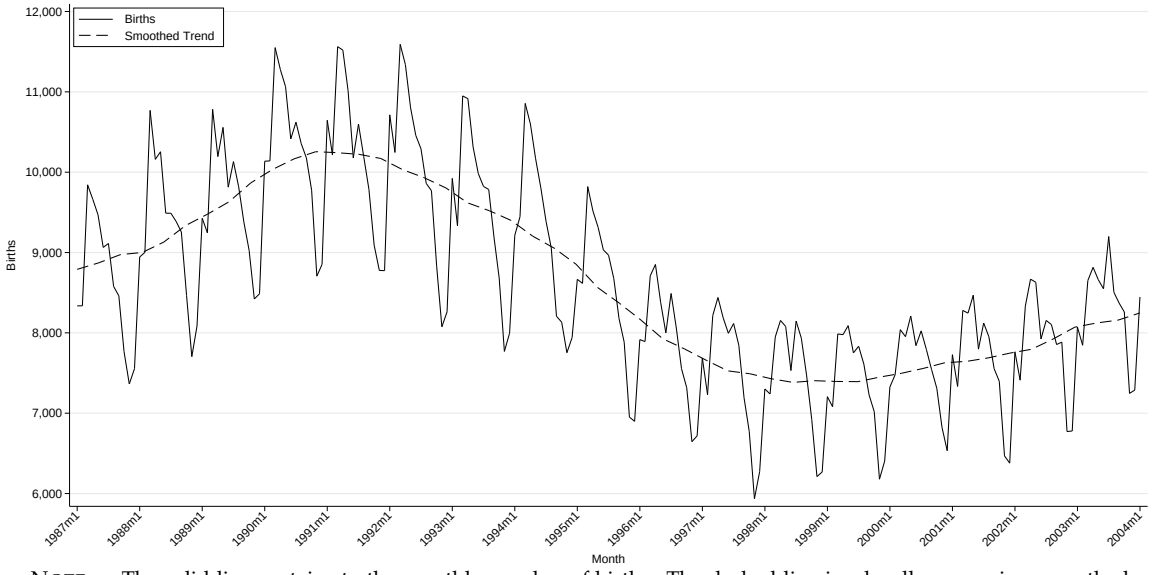


(a)
Infant mortality per 1,000 newborns

(b)
Share of births where the mother suffered from obstetric trauma

NOTE.— Official statistics from the Swedish National Board for Health and Welfare

FIGURE 2.
Births in Sweden 1987–2004



NOTE.— The solid line pertains to the monthly number of births. The dashed line is a locally regression smoothed trend.

TABLE 1.
Birth sample and official births

	Official records			Estimation sample mothers		Estimation sample children	
Year	Total	Boys	Girls	Before adjustment	After adjustment	Full sample	Observed mother id
1987	104,699	53,565	51,134	116,185	104,404	103,737	100,887
1988	112,080	57,821	54,259	124,187	111,875	111,097	106,803
1989	116,023	59,683	56,340	127,846	116,046	114,698	109,118
1990	123,938	63,572	60,366	135,626	123,992	122,245	114,591
1991	123,737	63,729	60,008	134,077	123,302	123,106	113,997
1992	122,848	63,193	59,655	131,492	121,033	122,378	110,997
1993	117,998	60,329	57,669	125,361	115,314	116,715	103,825
1994	112,257	57,329	54,928	120,205	110,864	110,661	97,941
1995	103,422	53,214	50,208	111,172	102,782	101,883	88,959
1996	95,297	48,660	46,637	102,800	94,754	94,409	82,089
1997	90,502	46,511	43,991	97,882	90,109	88,822	76,686
1998	89,028	45,940	43,088	96,484	89,388	85,343	73,316
1999	88,173	45,230	42,943	95,201	88,531	85,875	73,506
2000	90,441	46,620	43,821	97,224	90,966	89,337	76,336
2001	91,466	47,138	44,328	97,290	91,927	90,244	76,693
2002	95,815	49,187	46,628	101,169	96,226	94,807	80,134
2003	99,157	51,114	48,043	103,811	99,467	98,124	82,494
2004	100,928	51,975	48,953	105,309	101,364	101,925	84,953
Total	1,877,809	964,810	912,999	2,023,321	1,872,344	1,855,406	1,653,325

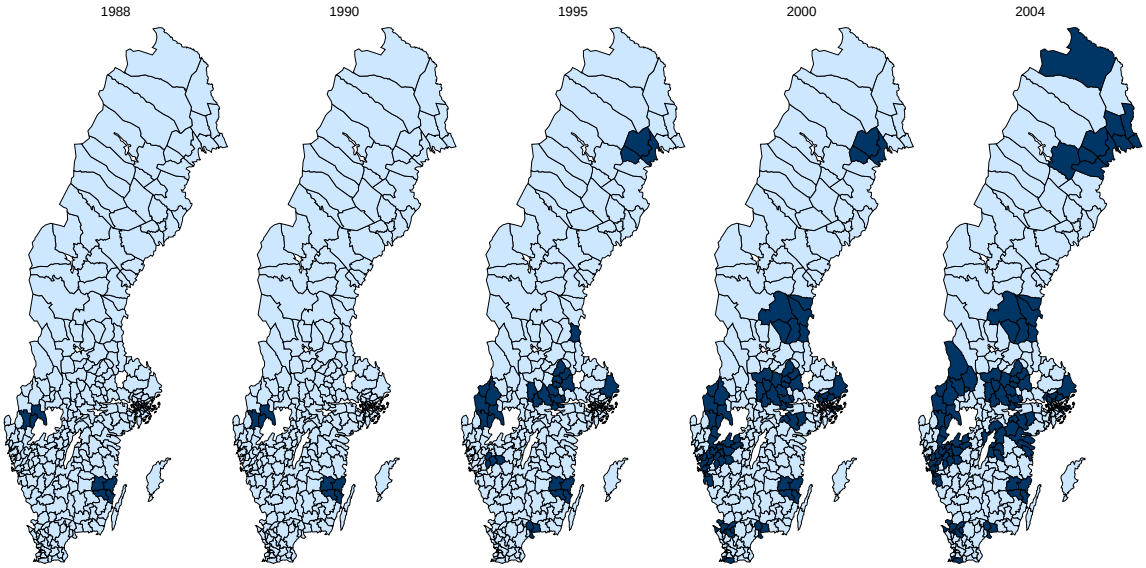
NOTE.— Official birth records are obtained from Statistics, Sweden. Before (after) adjustment refers to the numbers before (after) foreign-born are discarded from the sample.

TABLE 2.
Sample statistics

Variable	Sample			
	All	Control	Referral	Closure
Socioeconomic characteristics				
Age	29.39	29.18	29.74	29.12
Foreign Born	0.13	0.12	0.15	0.10
Number of Children	2.59	2.61	2.56	2.61
Primary Education	0.12	0.13	0.12	0.13
Secondary Education	0.39	0.41	0.36	0.42
Post-Secondary Education	0.20	0.18	0.22	0.17
Married	0.40	0.39	0.42	0.38
Unmarried	0.39	0.40	0.38	0.41
Employed	0.72	0.72	0.72	0.72
Earnings before tax	50,958	47,835	54,923	49,595
Medical History				
Tumor	0.00	0.00	0.00	0.00
Miscarriage	0.08	0.08	0.08	0.08
Substance Dependence	0.01	0.01	0.01	0.01
Obesity	0.00	0.00	0.00	0.00
Heart Disease	0.01	0.01	0.01	0.01
Respiratory Disease	0.04	0.04	0.03	0.04
Placenta	0.04	0.04	0.04	0.04
Hypertension	0.04	0.04	0.05	0.04
Pregnancy-specific conditions				
Early Onset	0.05	0.05	0.05	0.05
Prolonged Pregnancy	0.03	0.03	0.04	0.03
Illness	0.01	0.01	0.01	0.01
STD	0.00	0.00	0.00	0.00
Diabetes	0.01	0.01	0.01	0.01
Anemia	0.04	0.04	0.04	0.03
Other (Mother)	0.05	0.05	0.05	0.04
Other (Child)	0.09	0.08	0.10	0.09
Fetal Distress	0.07	0.06	0.07	0.06
Delivery-specific conditions				
Incorrect Fetal Position	0.05	0.06	0.06	0.05
Pelvis Abnormality	0.10	0.10	0.11	0.10
Membranes	0.06	0.05	0.07	0.06
Other Labor-specific	0.06	0.06	0.07	0.06
Labor Dystocia	0.11	0.09	0.14	0.12
Prolonged Delivery	0.01	0.01	0.01	0.01
Umbilical Cord	0.00	0.00	0.01	0.00
Treatment variables				
Distance after closure	19.95	19.43	14.98	33.60
Distance before closure	17.13	19.43	14.98	16.23
Volume after closure	3,247	3,196	3,362	3,100
Volume before closure	2,746	3,196	2,962	996
Maternal Outcomes				
Trauma during Delivery	0.08	0.07	0.09	0.07
1st Deg. Perineal	0.01	0.01	0.01	0.01
2st Deg. Perineal	0.03	0.03	0.04	0.02
3st Deg. Perineal	0.02	0.02	0.02	0.02
4st Deg. Perineal	0.00	0.00	0.00	0.00
Postpartum Hemorrhage	0.07	0.06	0.07	0.07
Retained Placenta	0.01	0.01	0.01	0.01
Anesthetic Problem	0.00	0.00	0.00	0.00
Other Delivery Problem	0.04	0.03	0.04	0.04
Post-partum Complications	0.03	0.03	0.03	0.02
Premature	0.01	0.01	0.01	0.01
Spontaneous	0.66	0.67	0.64	0.66
Induced	0.02	0.02	0.02	0.02
Other	0.14	0.13	0.15	0.13
Assisted	0.18	0.18	0.19	0.18
Unassisted	0.82	0.82	0.81	0.82
Ventouse/Forceps	0.06	0.06	0.06	0.06
Cesarean	0.12	0.12	0.12	0.12
Number of Births	1,745,098	763,356	698,732	283,010

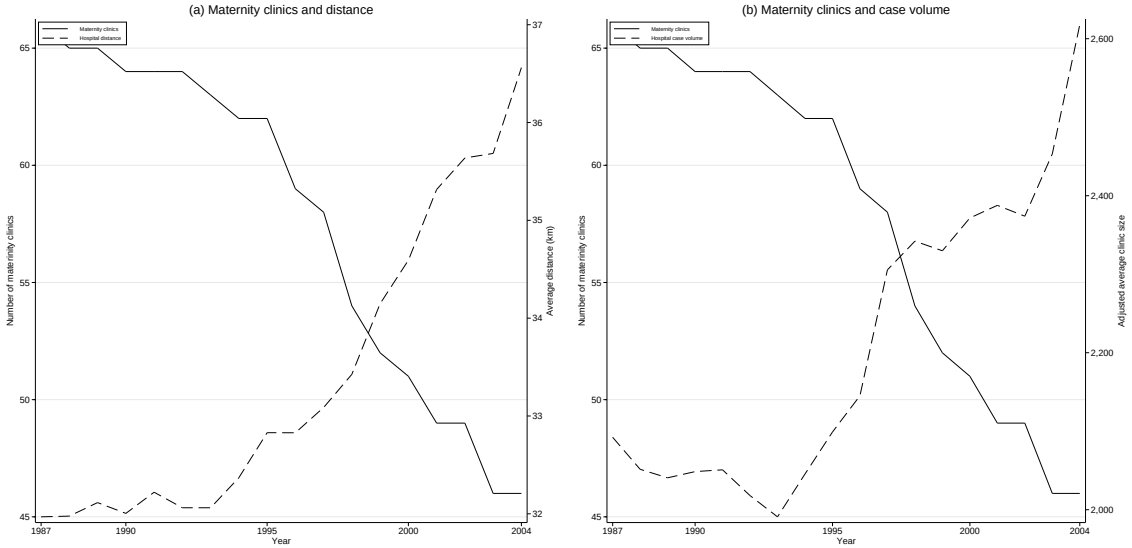
NOTE.— The table reports mean values for each variable by sample. See the text for variable and sample definitions. Earnings are measured in Swedish crowns (SEK). One crown corresponds to around 0.1 euro in 2015.

FIGURE 3.
Municipals affected by maternity clinic closures, 1987–2004



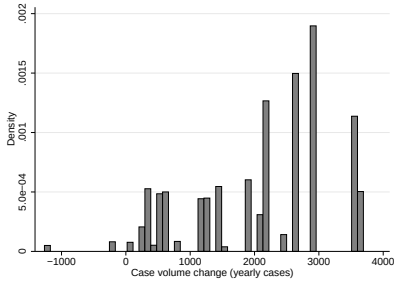
NOTE.— Dark blue areas correspond to municipals affected by a nearby maternal clinic closure.

FIGURE 4.
Maternity clinics, average case volume and distance, 1987–2004

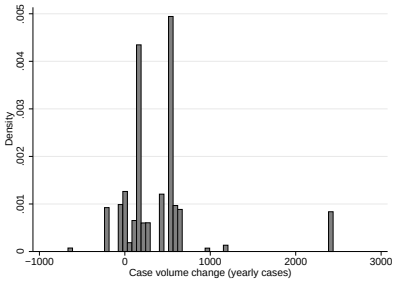


NOTE.— Distance is measured as the average distance for all individuals associated with a respective maternal clinic. Case volume is adjusted for time trends in fertility.

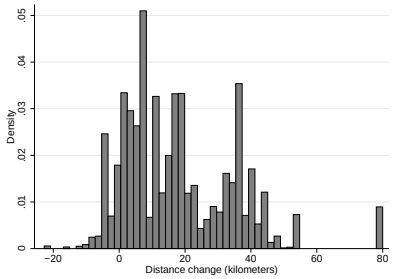
FIGURE 5.
Birth clinic closures and changes to case volume distance to the birth clinic



(a)
Volume changes for closure regions



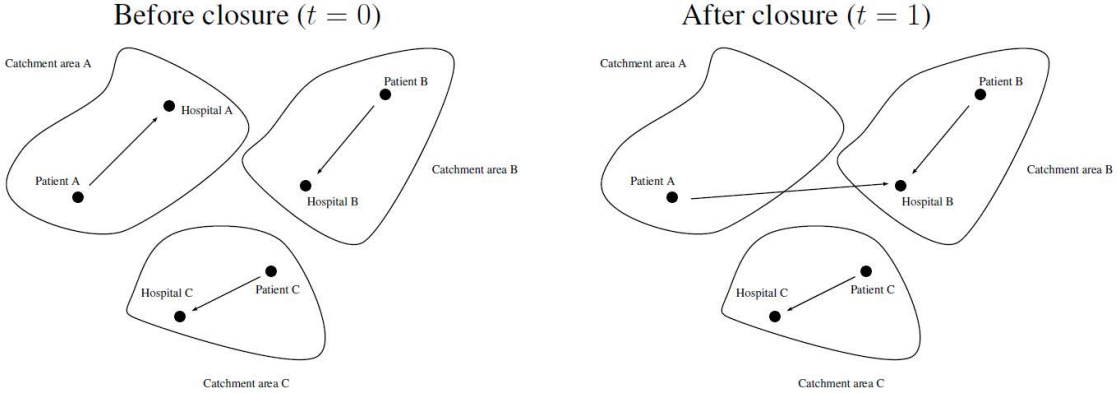
(b)
Volume changes for referral regions



(c)
Distance changes for closure regions

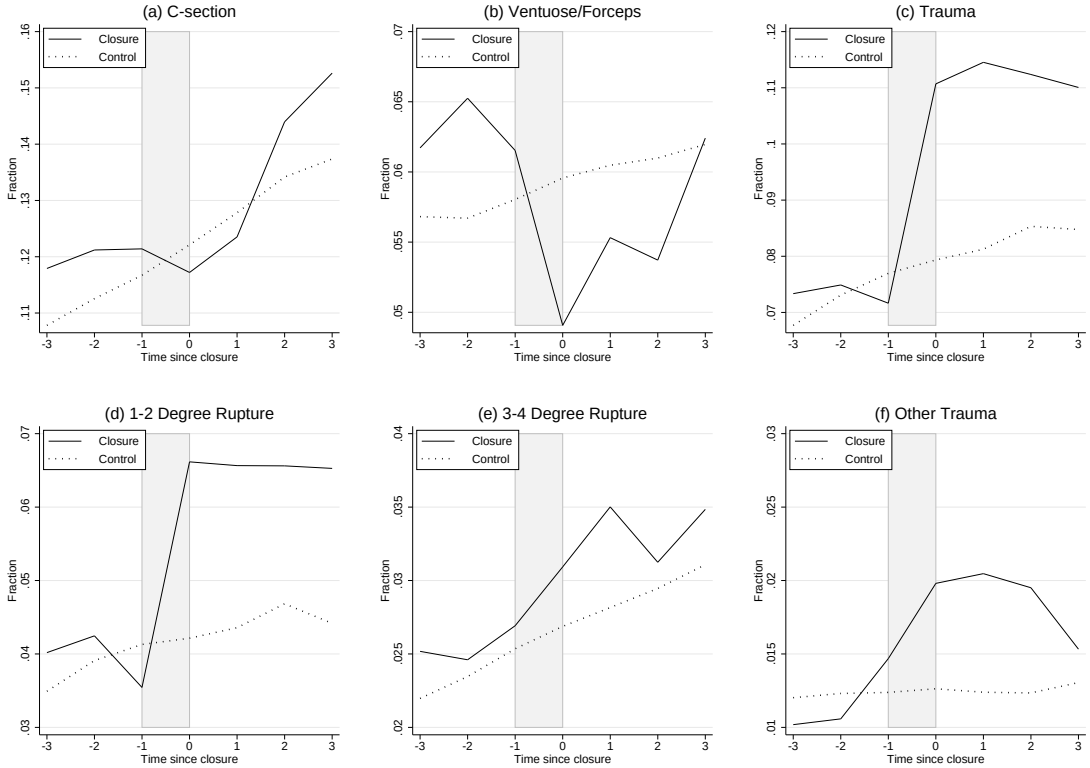
NOTE.—

FIGURE 6.
Closure, Referral and Control regions



NOTE.— (*A*) Closing areas: Areas subject to a closure of a birth clinic. (*B*) Referral areas: Areas subject to a transfer of patients from a closed area subsequent to the closure. (*C*) Control areas: Areas unaffected by closures.

FIGURE 7.
Descriptive results: All



NOTE.— The solid line corresponds to the closure areas where a maternal clinic occurred at time zero. The dotted line corresponds to the control areas unaffected by the closures.

TABLE 3.
Maternity ward closures, medical technology and maternal health

	Medical technology		Maternal health			
	C-section (1)	Ventuose/ Forceps (2)	Trauma (3)	1–2 deg. Rupture (4)	3–4 deg. Rupture (5)	Other Trauma (6)
Panel A: Models with regional trends						
Closure	-0.0049	-0.0068*	0.0084	0.0087	-0.0023	0.00074
	(0.0031)	(0.0026)	(0.0070)	(0.0061)	(0.0015)	(0.0012)
Referral	-0.0020	-0.0028	0.029**	0.025**	-0.00073	0.0055**
	(0.0024)	(0.0019)	(0.0078)	(0.0061)	(0.0010)	(0.0020)
Panel B: Models without regional trends						
Closure	-0.0014	-0.0052*	0.027**	0.024**	-0.00020	0.0040**
	(0.0028)	(0.0021)	(0.0073)	(0.0064)	(0.0013)	(0.0011)
Referral	0.0046*	-0.0016	0.037**	0.033**	-0.00033	0.0061**
	(0.0019)	(0.0015)	(0.0079)	(0.0066)	(0.00088)	(0.0015)

NOTE.— Swedish data for the period 1990-2004. All models include local area fixed effects, year fixed effects, linear regional trends, maternal socioeconomic characteristics and maternal pre-pregnancy health measures. Standard errors clustered at the parish level in parentheses. **p<0.05 ***p<0.01.

TABLE 4.
Maternity ward closures and Apgar scores

	Apgar 1			Apgar 5		Apgar 10	
	Low (< 7) (1)	7 or 8 (2)	High (> 9) (3)	Low (< 7) (4)	High (> 9) (5)	Low (< 7) (6)	High (> 9) (7)
Panel A: Models with regional trends							
All children							
Closures	-0.00070	-0.0029	0.0036	-0.0012	-0.010**	0.00038	0.00038
	(0.0016)	(0.0029)	(0.0034)	(0.00076)	(0.0037)	(0.00065)	(0.00065)
Referral	0.0010	0.0056**	-0.0066**	0.00088	-0.014**	0.00099	0.00099
	(0.0012)	(0.0020)	(0.0025)	(0.00063)	(0.0030)	(0.00051)	(0.00051)
Low birthweight ($\leq$ 2500g)							
Closures	-0.0089	-0.028*	0.037*	-0.0012	0.0048	-0.00072	-0.00072
	(0.015)	(0.014)	(0.017)	(0.0096)	(0.018)	(0.0062)	(0.0062)
Referral	-0.0019	-0.011	0.013	-0.0059	-0.0099	0.0014	0.0014
	(0.011)	(0.011)	(0.013)	(0.0065)	(0.014)	(0.0044)	(0.0044)
Panel B: Models without regional trends							
All children							
Closures	-0.0036*	-0.0070**	0.011**	-0.0011	-0.0068	0.00012	0.015
	(0.0015)	(0.0024)	(0.0029)	(0.00068)	(0.0037)	(0.00056)	(0.019)
Referral	-0.0017	-0.00039	0.0021	0.000031	-0.0045	0.00034	0.025
	(0.00090)	(0.0018)	(0.0022)	(0.00047)	(0.0032)	(0.00040)	(0.013)
Low birthweight ($\leq$ 2500g)							
Closures	-0.023	-0.028*	0.051**	-0.0077	0.0088	-0.0027	0.016
	(0.013)	(0.012)	(0.015)	(0.0087)	(0.016)	(0.0057)	(0.016)
Referral	-0.0055	-0.0089	0.014	-0.0077	-0.0026	-0.0015	0.017
	(0.0085)	(0.0082)	(0.010)	(0.0051)	(0.011)	(0.0036)	(0.014)

NOTE.— Swedish data for the period 1990-2004. All models include local area fixed effects, year fixed effects, linear regional trends, maternal socioeconomic characteristics and maternal pre-pregnancy health measures. Standard errors clustered at the parish level in parentheses. **p<0.05 ***p<0.01.

TABLE 5.
Maternity ward closures and child mortality, trauma and birth weight

	Mortality				
	First day	0–7 days	0–28 days	Trauma	Birthweight
	(1)	(2)	(3)	(4)	(5)
Panel A: Models with regional trends					
All children					
Closures	-0.000019	-0.00028	-0.00032	-0.0027**	9.51
	(0.00026)	(0.00039)	(0.00042)	(0.0010)	(5.42)
Referral	-0.000014	-0.000025	0.000021	-0.0013	6.17
	(0.00017)	(0.00025)	(0.00028)	(0.00082)	(3.36)
Low birthweight ($\leq$ 2500g)					
Closures	-0.0033	-0.0058	-0.0051	0.0026	19.1
	(0.0052)	(0.0065)	(0.0071)	(0.0015)	(19.7)
Referral	0.0019	-0.00076	0.00020	0.0018	11.7
	(0.0030)	(0.0043)	(0.0046)	(0.00097)	(12.8)
Panel B: Models without regional trends					
All children					
Closures	4.7e-06	-0.00048	-0.00054	-0.0037**	18.4**
	(0.00024)	(0.00036)	(0.00037)	(0.0011)	(4.18)
Referral	0.000064	-0.000029	-0.000035	-0.0017*	12.6**
	(0.00012)	(0.00020)	(0.00021)	(0.00065)	(3.28)
Low birthweight ($\leq$ 2500g)					
Closures	-0.00011	-0.0063	-0.0058	0.0013	22.4
	(0.0045)	(0.0060)	(0.0064)	(0.00098)	(17.2)
Referral	0.0029	0.0013	0.0024	0.00049	2.78
	(0.0022)	(0.0035)	(0.0036)	(0.00068)	(10.2)

NOTE.— Swedish data for the period 1990-2004. All models include local area fixed effects, year fixed effects, linear regional trends, maternal socioeconomic characteristics and maternal pre-pregnancy health measures. Standard errors clustered at the parish level in parentheses. **p<0.05 ***p<0.01.