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Mother's mental health after childbirth: does the delivery method matter?

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Abstract

The dramatic increase in the utilization of caesarean section has raised concerns on its impact on public expenditure and health. While the financial costs associated with this surgical procedure are well recognized, less is known on the intangible health costs borne by mothers and their families. We contribute to the debate by investigating the effect of unplanned caesarean deliveries on mothers' mental health in the first nine months after the delivery. Differently from previous studies, we account for the unobserved heterogeneity due to the fact that mothers who give birth through an unplanned caesarean delivery may be different than mothers who give birth with a natural delivery. Identification is achieved exploiting exogenous variation in the position of the baby in the womb at the time of delivery while controlling for hospital unobserved factors. We find that mothers having an unplanned caesarean section are at higher risk of developing postnatal depression and this result is robust to alternative specifications.

Keywords: Caesarean Section, Instrumental Variables, Maternal Health, Millennium Cohort Study, Postnatal Depression.

JEL codes: I12, I18

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1 Introduction

Over the past few decades, a dramatic growth in the caesarean section (CS) rate has been recorded in many developed countries, regardless of the type of healthcare system (and relative incentives for physicians) and women's health needs (Bragg et al., 2010; Gibbons et al., 2010). In England, for example, the overall rate was about nine per cent during the 1980s, while nowadays more than one-fourth of women gives birth through caesarean delivery (Health and Social Care Information Centre, 2012; OECD, 2017). This implies that the incidence of this surgical procedure has almost tripled over the last 30 years. Similar patterns have been experienced by other OECD countries (Declercq et al., 2006; Macfarlane et al., 2015; OECD, 2015), raising questions regarding the economic implications of alternative delivery methods.

Concerns about the increase in caesarean section utilisation are justified by the higher economic and health costs associated with this procedure compared to a normal delivery (Koechlin et al., 2010). Indeed, while it is undeniable that caesarean deliveries have life-saving effects for mothers and children, especially for those who have concurrent health conditions (Gholitabar et al., 2011), it is also recognised that this procedure is very expensive, being the cost of a caesarean delivery between 66 and 88 percent higher than the cost of a natural delivery (Gruber and Owings, 1996; Petrou et al., 2002; Epstein and Nicholson, 2009). Besides the financial impact, the World Health Organization (WHO) has highlighted the association of this procedure with short- and long-term health risks for the mother (WHO, 2015).

This paper aims to contribute to the debate by analysing the causal impact of unplanned caesarean sections on first-time mothers' mental health after childbirth. While the negative effects for mothers' physical health in terms of longer postpartum recovery and prolonged pain are well-known (Lydon-Rochelle et al., 2001; Jensen and Wüst, 2015), less evidence is available on the effect on their psychological well-being. Mental health issues in general, and postnatal depression in particular, have been found to largely impact the mother's life, as well as being associated with a deterioration of her physical well-being and the relationship with her partner (Mutryn, 1993). Previous studies have also shown a strong link between maternal mental health and child development (Minkovitz et al., 2005; Propper et al., 2007; Kiernan and Mensah, 2009; Coneus and Spiess, 2012), rates of infections, hospital admissions and completion of recommended schedules of immunization for children (WHO, 2015), child health (Perry, 2008), long term child educational, labour market and criminal outcomes (Johnston et al., 2013).

For identification, we focus on unplanned deliveries. This is justified by two reasons. First, elective and unplanned caesarean deliveries may have different impacts on mother's mental health. Indeed, unplanned caesareans are unexpected, usually mentally and physically stressful, and associated with a loss of control and unmatched expectations (Soet et al., 2003, Lobel and DeLuca, 2007). On the contrary, planned caesareans are scheduled in advance, allowing for the possibility for women to adjust (at least partially) their expectations for this event. The second motivation concerns a limitation of the data employed in the analysis. We cannot distinguish among planned caesarean deliveries, those that have been scheduled because of the mothers' or babies' health needs and those requested by mothers for other reasons (the so-called *caesarean delivery on request*). Distinguishing between the two cases may be important because a different psychological impact of this procedure is expected depending on the reason why it has been implemented.[1]

Most of the medical studies investigating the relationship between the delivery method and maternal mental health find that caesarean deliveries are expected to carry higher risks for mothers' mental health compared to natural deliveries. Indeed, women who have a caesarean delivery are more likely to suffer from physical pain after childbirth and have longer and more difficult postnatal recovery (Lydon-Rochelle et al., 2001,Cooklin et al., 2015), both conditions that also affect their psychological well-being. Additionally, caesarean deliveries may have a direct effect on mothers' mental health due to separation of mothers and their babies in the instants after the delivery (Mutryn, 1993). However, previous literature investigating this topic has not reached a unanimous consensus on whether having a caesarean delivery increases the risk of postnatal depression. This may depend on the limitations that characterise some of these studies, such as the small sample usually restricted to a particular geographic location or a population cohort, which does not allow to generalise the results to the entire population (Fisher et al., 1997; Koo et al., 2003). Failure to distinguish between elective (i.e. planned) and unplanned caesarean deliveries might also represent an issue, given that people tend to adjust better to traumatic events when they can predict or prepare for them (Clement, 2001). Additionally, the variability in the source of information on mothers' mental health (e.g. medical visits, self-completion questionnaires) and in the length of the postnatal period during which mothers develop depression (from a few weeks to one year after childbirth), can contribute to explain such heterogeneity (Robertson et al., 2004; Patel et al., 2005; Carter et al., 2006).

In general, these studies are characterised by the common assumption that the treatment (i.e. giving birth through an unplanned caesarean delivery) is randomly assigned. In other words, they implicitly assume that women who have an unplanned caesarean do not differ from those who give birth naturally except through observable characteristics for which we can control.[2] However, because of data limitations and the multiplicity of factors that can have an impact on both the delivery method and the mothers' mental health, it is very unlikely to be the case. As a result, the estimates reported in these studies may be (downward) biased.

[1]Results when considering both elective and emergency caesarean delivery are available on request from the author.

[2]This is equivalent to what Imbens and Wooldridge (2008) call *unconfoundedness assumption*, which assumes that adjusting for differences in observed pretreatment variables removes biases from comparisons between treated (mothers who give birth through unplanned caesarean deliveries) and control units (mothers who have a natural delivery).

This paper builds on the previous research by addressing some of these issues. It investigates the effect of caesarean deliveries on the risk of postnatal depression by employing a nationally-representative sample of mothers during their first pregnancy experience, obtained from the first sweep of the UK Millennium Cohort Study. We use a medium-term measure of maternal postnatal depression, which captures a period of sadness in the first nine months after childbirth. More importantly, this study represents the first attempt to identify the *causal* link between unplanned caesarean deliveries and mothers' mental health, by accounting for unobserved differences between mothers who give birth through different delivery methods (endogeneity). While other papers in the economic literature have dealt with this issue when analysing the causal effect of the delivery method on mothers' (Halla et al., 2016) and children's outcomes (Jensen and Wüst, 2015; Costa-Ramon et al., 2018), none of them have looked at the psychological consequences for mothers, yet the econometric methods they have employed are different from those used in this study.

We identify two main sources of endogeneity. One is due to the unobserved hospital characteristics that can both affect the choice of the delivery method as well as the risk of developing postnatal depression. For example, the level of resources available in a hospital in terms of staff and operating rooms may affect the level and standard of care. More specifically, in a hospital with a low nurse-to-patient ratio, women may receive less attention both during the labor and after the delivery. This may translate into (a) more compilations during labor, and therefore, into a higher risk of having an unplanned caesarean and (b) less psychological support after the delivery. At the same time, because the caesarean section is a surgical procedure, which requires it to be performed in operating rooms by surgeons, medical staff may decide to opt for this delivery method only in extreme cases and they may prefer to perform a natural (or instrumental) delivery whenever possible.

The second potential source of endogeneity is related to the fact that mothers who have an unplanned caesarean section might be systematically different from mothers who give birth naturally, in terms of their own health and of the health of their babies. While we can control for some characteristics (e.g. maternal age and baby's health at birth) which the literature has identified as driving the risk of having an unplanned caesarean delivery, there may be other factors we cannot observe due to data limitations, such as the mother's mental and physical health before and during the pregnancy. Also, we do not have detailed information on what occurred during the delivery and whether pain relief was used. However, epidural anesthesia has been found to increase the risk of unplanned caesarean delivery, and it is also associated with a reduction of pain during labour, which turns into a lower psychological impact from this event. As a result, failing to account for this factor can affect the estimation results.

In order to overcome these problems, we adopt an instrumental variable approach combined with hospital fixed effects, the latter being used to control for time-invariant characteristics at hospital level. As source of exogenous variation we exploit, for the first time in the literature, the position of the baby in the womb at the time of delivery. It has been shown that, conditional on the mother's observable characteristics, the probability of having babies in an abnormal position (i.e. with shoulders or feet first) is random[3] and mothers cannot affect it with their behavior (Impey et al., 2017).

Our results show that having an unplanned caesarean delivery increases the risk of postnatal depression. Without accounting for endogeneity, we find that a woman who gives birth through this procedure is 2.5 percentage points more likely to experience postnatal depression. The sign of this effect is confirmed by the IV estimates, even if in this case marginal effects are larger (15.1 percentage points). Results are robust to a number of specifications.

The rest of the paper is organized as follows. Section 2 summarises previous literature on this topic. Data are described in Section 3, while Section 4 presents our empirical strategies. Section 5 shows the main results and discusses the validity of the instruments employed in the analysis. Section 6 provides some sensitivity checks, while Section 7 concludes.

2 Related Literature

The worldwide increase in the utilisation of caesarean sections has attracted the attention of researchers to this phenomenon. Economists and health scientists have extensively investigated the medical and economic factors explaining this trend, together with its economic consequences for healthcare systems. Until now, however, only few papers exist that have focused on the impact of caesarean deliveries on mothers' health and even less have focused on their psychological well-being.

Most of the available evidence on the relationship between mode of delivery and maternal mental health after childbirth comes from the medical literature and shows mixed findings, making it difficult to draw useful conclusions from a policy perspective. The most robust evidence is provided by Patel et al. (2005), who employ a rich dataset, the Avon Longitudinal Study of Parent And Children, to analyse whether there are different incidence rates of postnatal depression among women who gave birth through different modes of delivery (elective caesarean, unplanned caesarean and natural deliveries). They measure postnatal depression eight weeks after childbirth and find no differences in the probability of experiencing postnatal depression among these groups of women. However, while this study relies on good-quality data, it fails to account for unobserved differences in these groups of women.

Fisher et al. (1997) employed a prospective study of 272 voluntary women and found that having a caesarean section does increase the risk of postnatal depression. However, because voluntary women are

[3]For a more discussion, see Section 4.

a selected group, this sample cannot be considered random and results cannot be generalised to the entire population.

Similar results were found by Koo et al. (2003), who used a retrospective comparative cohort study of 250 Malaysian women. They were interviewed at least six weeks after childbirth and found that, with respect to women having a non-emergency delivery, those who gave birth through caesarean section had about twice the risk of developing postnatal depression.

The meta-analysis by Carter et al. (2006) examined the association between caesarean section and postnatal depression, measured between 10 days and one year after delivery. The authors mentioned methodological weaknesses and the possibility that having a caesarean is a weak risk factor for postnatal depression as an explanation for the absence of clear evidence, suggesting that only high-quality studies may be able to identify such an effect.

Finally, in their review of the risk factors for postnatal depression, Robertson et al. (2004) classified caesarean section as a weak determinant. They drew this conclusion because of the mixed evidence from previous research with Warner et al. (1996), Forman et al. (2000) and Johnston et al. (2013), failing to find any relevant link. However, Boyce and Todd (1992) and Hannah et al. (2002) found a highly significant association between this delivery method and postnatal depression after three months and six weeks, respectively.

Economic studies analysing the health consequences of caesarean section have instead focused mostly on the baby's health (e.g. Jensen and Wüst, 2015; Costa-Ramon et al., 2018) and the mother's fertility and labour decisions (Halla et al., 2016; Card et al., 2018).

3 Data

The data comes from the UK Millennium Cohort Study (MCS), a multidisciplinary longitudinal data set on a cohort of children born between September 2000 and January 2002. This data set covers several topics, such as parenting, childcare, child behaviour and cognitive development, child's and parental health, pregnancy and delivery, parents' employment and education, as well as income and poverty. Information is derived from the parents' interviews in six sweeps, when children are 9-11 months, 3, 5, 7, 11 and 14 years old. For the purpose of this study, we use only the first sweep, which contains detailed information on circumstances of pregnancy and birth, as well as socio-economic background and the health conditions of the family where children were born.[4]

[4] For full details of the study, see Plewis et al. (2007).

3.1 Sample selection

The initial sample is characterised by 18,818 children, born from 18,552 women. We focus on natural mothers (99.9% of the sample) and we exclude women who had a multiple delivery (256) because they are more likely to have had health complications after childbirth and their babies are systematically different in terms of (lower) birth weight, gestational age at birth and other birth characteristics in comparison to singletons. In addition, since we use information on the place of the delivery and particularly hospital identifiers, we exclude deliveries that occurred at home or in unknown hospitals (384). We also drop observations with missing or incomplete information on the delivery method, mother's health, pregnancy, demographic characteristics and baby's health (leaving us with 84.51% of the original sample). We drop observations if the baby was delivered through a planned caesarean delivery or pre-term[5] (1,458) and the woman had previous pregnancies (7,472). Our final sample includes 5,896 women.

3.2 Variables

The outcome variable is a binary indicator that takes a value equal to one if the mother reports to have experienced a period of sadness lasting two weeks or more after childbirth. Previous literature focusing on the effect of caesarean delivery on mother's mental health shows a high degree of heterogeneity in the definition of postnatal depression[6]. In particular, while there is a general agreement in the medical community on the symptoms that identify postnatal depression (e.g. low mood, loss of enjoyment and pleasure, anxiety) and the length of the period after delivery[7], the time of onset that defines postnatal depression is less clear.[8] In this paper, we follow the definition of postnatal depression suggested by Mcintosh (1993), by considering postnatal depression as the experience of a depressed mood for a period of at least two weeks at some stage during the first nine months after delivery. Compared to other measures, this can be considered a medium- to long-term indicator of maternal postnatal depression. However, MCS does not provide details on the severity of this condition; therefore, mothers reporting symptoms of postpartum depression may be affected by this condition differently.

A potential limit of this measure is that it is built using self-reported information. The general concern about this type of health outcome is that it can measure individuals' health with error, being affected by unintentional (e.g. recall bias) and intentional bias (stigma associated with mental disorders may lead mothers to under-report mental illnesses). Nonetheless, more 'objective' measures, such as postnatal

[5]We define pre-term births if they occurred before the 37th week of gestation.

[6]For example, Patel et al. (2005) measured postnatal depression about two months after the delivery. In their meta-analysis, Carter et al. (2006) reviewed studies that measured postnatal depression between 10 days and one year after the delivery.

[7]To be classified as postnatal depression the condition should last at least two weeks (Gavin et al., 2005).

[8]Some experts in the field define postpartum depression as a condition characterised by low mood and anxiety that occur anytime within the first year postpartum irrespective of the time of onset (Stuart-Parrigon and Stuart, 2014).

depression diagnosed by doctors, are not necessarily more appropriate. A report from the Royal College of Obstetricians and Gynaecologists shows that about half of the mothers who experienced mental health problems were not referred to services or offered any further information about where to go for support. Additionally, the probability of being diagnosed with depression depends on the frequency of the contacts with her GP. If the woman tends not to attend GP visits, there exists a risk of underestimating the incidence of this condition.

In the MCS, the mode of delivery is initially coded in ten categories (including missing and refused responses). We reclassify this measure into three mutually exclusive groups: natural, elective caesarean and unplanned caesarean delivery. Natural deliveries are defined as those that can be classified as medical procedures according to the Healthcare Resource Groups (HRG) system (therefore, this category also includes instrumented deliveries). Caesarean sections are distinguished as elective and unplanned, with the latter usually associated with unexpected complications at the time of delivery. Following Essex et al. (2013), for those women who reported more than one mode of delivery, we combine responses by coding the most invasive as the primary delivery method.[9] Since the analysis focuses on the effect of unplanned caesarean deliveries compared to natural births, we drop from the sample elective caesareans and we define a binary variable, CS_m, taking a value equal to one if the woman had an unplanned caesarean delivery and zero in the case of a natural delivery.

There exists a variety of factors that may be associated with both the probability of experiencing postnatal depression and giving birth through unplanned caesarean delivery. We classify them in the following categories: (i) socio-economic factors, (ii) pregnancy-related attitude, (iii) maternal health, and (iv) baby's health at birth.

Among the socio-economic factors, mother's age is one of the most important. Teenagers are, on average, more likely to experience postnatal depression (Brown, 1996; Deal and Holt, 1998; Robertson et al., 2004). A set of dummies defining the mother's ethnicity are included to account for the heterogeneous composition of the UK population. In particular, we distinguish between (a) white mothers (either British or non-British), (b) black, (c) Pakistani, Bangladeshi and Indian, (d) other ethnicities (in particular Chinese and other Asian groups).[10] Some ethnicity groups have been found to be less likely to be affected by anxiety and/or depression, probably because of their propensity to under-report health problems (Fiscella et al., 2002; Harris et al., 2005). Household income and the mothers' level of education have been identified by the economic literature as strong predictors of psychological wellbeing. They are also positively associated with unplanned caesarean sections, even after controlling for standard covariates

[9] We consider unplanned caesarean sections as the most invasive procedure, while natural births as the less invasive.

[10] This classification follows the Office for National Statistics (ONS) recommendation on how to classify ethnicity in the UK. The residual category includes Chinese and mixed ethnicity women. I cannot further split the residual category because of the small numbers of women belonging to these ethnicity groups in the sample.

(Gresenz et al., 2001; Segre et al., 2007). We measure the mother's highest level of education with a set of dummies that indicate her highest national vocational qualification. Marital status is included as a proxy for perceived social support. A married woman is expected to have psychological support from her husband in taking care of the child, which, in turn, reduces her likelihood of becoming depressed (Stewart et al., 2003).

We include an indicator measuring if the pregnancy was planned, as this may be correlated with the psychological impact of the delivery method. Physical and mental health before pregnancy are strong predictors of postnatal depression. Unfortunately, being that the MCS is a child-focused dataset, it does not include any direct information on maternal health before the child was born. To proxy her physical health before pregnancy, we use information about the mother's body mass index (including both a linear and a quadratic term to allow for non-linearities in the effect). Admission to hospitals and whether she had a paid job during pregnancy are included to control for the mother's health during childbearing. Furthermore, we include dummies to measure whether she has ever suffered from diabetes, gestational hypertension or kidney diseases.[11]

According to the literature (e.g. McLennan et al., 2001), mothers of unhealthy children are negatively affected by their babies' health and, as a consequence, they are more likely to report a depression status. We account for this association by including binary indicators for underweight and overweight babies at birth and gestational age (in weeks) as measures of the baby's health.

Finally, our empirical approach exploits the exogenous variation in the position of the baby at birth. The instrument we derive is a binary variable, Pos, which takes the value of one if the baby was in a breech position or in another abnormal position requiring a surgical intervention.

Table 1 provides some descriptive statistics of the variables included in the analysis. 32.5 per cent of the women in the sample have experienced a period of sadness lasting at least two weeks after delivery. This percentage is above the documented prevalence rate for postnatal depression in the U.K., estimated to be around 15 per cent. However, this difference could be ascribed to variability in the severity of the symptoms[12] and in the length of the postnatal period considered. Additionally, previous literature has shown that higher rates of incidence are observed when employing a non-clinical definition of depression (e.g. self-reported measures as the one employed in this study), compared to the case in which standard instruments for the detection of depression are used[13].

[11] For this last set of conditions, we only know whether the mother has ever suffered from these conditions. In other words, we do not have information on the time of the onset (if ever).

[12] Stuart-Parrigon and Stuart (2014) argued that depressive symptoms after the baby's birth affect more than 25% of new mothers, while the rates of major depressive disorders during the perinatal period range from 10-15%.

[13] A recent study used self-reported information and established that the incidence of postnatal depression in the UK is likely to be higher than previously estimated, with around 3 out of 10 mothers experiencing this condition, (NICE 2011).

The proportion of mothers who had an unplanned CS is 19.05 per cent, while 7.06 per cent had a baby in a breech position.[14]

On average, mothers are 25 years old and half of them are married. In terms of their health during pregnancy, 19 per cent were hospitalized and 9 per cent suffered from pre-eclampsia. The average gestational age is 40 weeks and the baby's birth weight is 3.4 kilos.

4 Empirical Strategies

We study the effect of the mode of delivery on the mother's mental health after childbirth. In particular, the empirical model explaining the risk of postnatal depression is specified following the standard health capital models as theorized by Grossman (1972) and firstly estimated by Rosenzweig and Schultz (1983). We adapt such a framework by defining a maternal mental health production function that includes medical, as well as socio-economic factors associated with the risk of postnatal depression.

$$PD_m = f(CS_m,\ \mathbf{SES_m},\ \mathbf{X_m},\ \mathbf{H_m}^H,\ \mathbf{H_m}^C) \tag{1}$$

The outcome variable is PD_m, a binary variable denoting whether mother m suffered from postnatal depression in the first nine months after childbirth. CS_m represents the causal variable of interest and indicates whether the mother gave birth through an unplanned caesarean delivery (as compared to a natural delivery). SES_m is a vector including all socio-economic variables that may be related to the mother's mental health, such as age, marital status, income, ethnicity and level of education. X_m includes information on whether the pregnancy was planned. Measures of the mother's physical health, H_m^M, which refers to different points of time, are added to control for pre-existing health conditions. Finally, H_m^B represents the baby's health at birth, proxied by birth weight and gestation age.[15]

The health production function (Equation 1) is assumed to be additive separable and linear in its inputs:

$$PD_m = \beta_0 + \beta_1 CS_m + \mathbf{SES_m}\beta_2 + \mathbf{X_m}\beta_3 + \mathbf{H_m^M}\beta_4 + \mathbf{H_m^C}\beta_5 + \epsilon_m \tag{2}$$

where ϵ_m denotes the mother-specific idiosyncratic error.

[14]This proportion is larger than the national statistics because the sample we use includes first time mothers only. As mentioned above, the frequency of breech decreases with increasing parity because after the first pregnancy the womb tend to be larger, allowing the baby to move. When using the full sample, the proportion of breech babies decreases to 5 per cent.

[15]Gestational age at birth and birth weight may be endogenous as they are potentially affected by the mode of delivery. For this reason, as a sensitivity, we estimate the model excluding these variables from the vector of covariates. Results are reported in Section 6.

As previously noted, because the delivery method is not randomly assigned, a simple regression of CS_m on the indicator of postnatal depression is likely to lead to inconsistent estimates of the effect of the mode of delivery on the mother's mental health. This is also supported by the evidence provided in Table 2 where we compare mothers' characteristics by treatment (i.e. mode of delivery). The difference in socio-economic and medical characteristics of mothers who gave birth naturally compared to those who had an unplanned CS suggests that the two groups of mothers differ substantially and are likely to differ in unobservable characteristics as well.

In order to overcome these issues and obtain consistent estimates we combine two econometric approaches: hospital fixed effect models and instrumental variables.

4.1 Hospital fixed effects model

Hospital characteristics, such as internal organisation, resources availability (e.g. medical staff and operating rooms) and quality of care might affect both the probability of giving birth through an unplanned CS and the risk of developing postnatal depression. We control for these (time invariant) unobservable factors at hospital level by including hospital fixed effects into the model.

Equation 2 is rewritten to include hospital fixed effects:

$$PD_{mj} = \beta_0 + \beta_1 CS_{mj} + \mathbf{SES_{mj}}\beta_2 + \mathbf{X_{mj}}\beta_3 + \mathbf{H^M_{mj}}\beta_4 + \mathbf{H^B_{mj}}\beta_5 + \mu_j + \xi_{mj} \tag{3}$$

where PD_{mj} indicates whether mother m who gave birth in hospital j has suffered from postnatal depression in the first nine months after the baby's birth. This equation differs from Equation 2 because the error term is split into two components, an idiosyncratic mother-level component, ξ_{mj}, and an unobserved heterogeneity component at the hospital level, μ_j. By estimating this model, we get rid of the time-invariant unobserved heterogeneity at hospital level.

4.2 Instrumental variable approach

While the inclusion of hospital fixed effects accounts for differences in (time invariant) hospital characteristics, there may still be mother-specific unobservable characteristics correlated with the mode of delivery and their mental health (e.g. mother's health status during pregnancy and delivery experience), which would bias the results. We account for this issue by adopting an instrumental variable approach that exploits, as source of variation, the position of the baby in the womb before the delivery.

We define a binary variable, POS_m, equal to one if the baby presents feet or shoulders first, head at the back or other abnormal positions at birth, a situation called *breech position*. Full breech position at term means that the baby has not turned head down in the womb by week 37 of the pregnancy. If the baby is in a breech position at the end of week 36, the mother can be offered an external cephalic version (ECV). This is when a healthcare professional tries to turn the baby into a head-down position by applying pressure on the abdomen. The choice of performing this procedure depends on some health conditions of the mother (that we control for in the model).

If the baby remains in a breech position, the mother is given the option of a caesarean section or a natural delivery. Thus, the caesarean section can be either planned or unplanned, the latter case occurring in case of an emergency before she goes into labour (or before the planned CS). According to NICE statistics, 40% of women planning a natural breech birth end up needing an emergency caesarean section.

While breech presentation is very common in early pregnancy, by 36-37 weeks of pregnancy most babies turn into the head-first position, with 3-4% of babies being in the breech position (Royal College of Obstetricians and Gynaecologists, 2006) at the time of birth.

We define the first stage regression as:

$$CS_m = \alpha_0 + \alpha_1 Pos_m + \mathbf{SES_m}\alpha_2 + \mathbf{X_m}\alpha_3 + \mathbf{H_m^M}\alpha_4 + \mathbf{H_m^B}\alpha_5 + \epsilon_m \quad (4)$$

The instrumental variable approach requires two conditions to be met.

The first consists of the instrument being uncorrelated with ϵ_m, the error term (exclusion restriction or validity condition). In other words, having a baby in a breech position at the time of delivery must be uncorrelated with unobserved characteristics of the mother (and her pregnancy) that can also have an effect on her mental health. Tharin et al. (2011) argue that breech babies can be considered as a good random subgroup of all babies since there is no clear evidence of maternal or baby's characteristics that can predict the probability of a breech position. This is also supported by Jensen and Wüst (2015), who show that breech and non-breech mothers are similar in a range of observable characteristics, such as level of education and pregnancy conditions unrelated to breech (e.g. pre-eclampsia and diabetes). As well, the Royal College of Obstetricians and Gynaecologists states that, while persistent breech presentation may be associated with biological factors (such as amniotic fluid volume, the placental localisation and the uterus), it may be due to chance as well (Royal College of Obstetricians and Gynaecologists, 2006). This result is also generally confirmed by the medical literature, although there is some evidence of a weak association between the position of the baby and some predictors of postnatal depression, such as parity[16], age and birth weight (Rayl et al., 1996; Fruscalzo et al., 2014).

[16]Parity is likely to be a predictor of breech position because after the first pregnancy, the womb tends to be larger, allowing the baby to move, and thus, reducing the risk of a breech position. In this study, we control for parity by focusing on first-time mothers. Controlling for the number of previous pregnancies in the model rather than restricting the analysis on first-time mothers would not solve this problem, as we would not be able to account for the heterogeneity in previous

While the validity condition cannot be tested, we provide some evidence in support of using breech position as an excluded instrument.

We first regress the baby's position on a full set of the mothers' and baby's covariates to identify factors predicting the position of the baby. The idea is that if the we find no association between these factors and the baby's position, we have an argument in favour of the validity (exogeneity) of the instrument. Results show that none of the factors considered predicts the probability of having a baby in a breech position except the mother's BMI. This means that, once we control for BMI, the baby's position in the womb is exogenous. Supportive evidence of the baby's position is confirmed by the F-statistic for the joint significance of all the coefficients being very small (Table 3).

We also perform a balance test comparing the covariates of women whose babies were in a breech position with those of women whose babies were not in such a position. Table 4 reports the means for each variable by breech position. The majority of the variables considered do not differ in the two groups, in particular the baby's health at birth (proxied by birth weight and gestational age) and the mother's previous health conditions (e.g. diabetes, hypertension, eclampsia, etc.) are not associated with the baby's position in the womb. Consistently with the previous literature (e.g. Fruscalzo et al., 2014), we find that age is associated with the breech position. Similarly, income and education seem to increase the probability of having a baby in a breech position. However, these variables are likely to capture the age effect; indeed, we find that they are all strongly correlated with maternal age (for example, the correlation between age and income is 0.57, and its associated p-value is below 0.001). Being Pakistani, Bangladeshi or Indian is associated with a lower chance of having a baby in a breech position. This again can be explained by the fact that mothers belonging to this ethnic group are on average younger when they have the first child. Finally, we find some slight differences for BMI and being employed during the pregnancy. However, these differences are very small in magnitude. Therefore, all together this seems to suggest that breech position is random, once we control for the mother's age at birth.

So far, we have shown that there is no substantial evidence of selection on observables. However, what we really worry about is that women with breech and non-breech babies are different in terms of unobservable characteristics. We show that this is not the case by using the residuals obtained from a model that predicts the probability of having a baby in a breech position on the covariates included in the main model

pregnancy experiences (e.g. mode of delivery, number of previous pregnancies, etc.). The delivery method in previous pregnancies, for example, is an important factor that we cannot control for, because of data limitations. However, we know that the mode of delivery in previous pregnancies affects the delivery mode in subsequent deliveries (once a woman has had a caesarean section, the probability of having another caesarean is higher). Additionally, the impact of an unplanned delivery on the mothers' mental health can be different for women who had previous pregnancies because of the additional information they may already have on the birth experience. In Section 6, we show that results do not differ when we focus on all mothers, regardless of their previous pregnancy experiences. However, to guarantee the validity of the instrument, in the paper we focus on the case of first-time mothers.

to analyse whether the variation captured by the residuals is associated with unobservable characteristics of the mother. As a proxy for such unobservables we use information on the mother's smoking behaviour, which the literature has found to be strongly correlated with measures of human and social capital (Scheffler et al., 2010). We measure the mother's smoking behavior before the pregnancy, both in terms of the number of cigarettes (a measure for intensity), as well as whether the mother was a smoker. Table 5 shows that there is no statistically significant association between the residuals and our measures of unobserved skills and health, suggesting that the variation of our instrument is exogenous.

Another potential concern for the validity of the identification strategy employed in this study would be if mothers can affect the position of her baby (e.g. if mothers who know their babies are in a breech position try to change the position of the baby) and such behaviour is correlated with unobservables, which also affect the mothers' psychological well-being. We have already shown that there is no empirical evidence of a correlation between breech position and the mother's (observed and unobserved) characteristics. Additionally, the Royal College of Obstetricians and Gynaecologists has established that there is no scientific evidence to support the effectiveness of exercises performed by mothers to change the position of their baby in the womb (Impey et al., 2017). This means that, even if mothers try to change their baby's position by lying or sitting in a particular position, this behaviour does not actually change the probability of giving birth to a baby in a breech position. As a result, this is not a threat to the identification strategy.

The second condition to satisfy is the relevance of the instrument (i.e. baby's position in the womb), which must be a strong predictor of the mode of delivery (the endogenous variable). The National Institute of Clinical Excellence (NICE) encourages resorting to the caesarean delivery if a breech position occurs at the end of the gestational period in other to reduce the risk of perinatal mortality and neonatal morbidity (Gholitabar et al., 2011). Similar guidelines have been issued in other countries, especially after the publication of the results from the Term Breech Trial, the largest randomized control trial evaluating adequate modes of delivery for breech babies (Hannah et al., 2002; Whyte et al., 2004; Goffinet et al., 2006). As a result, a large proportion of breech babies are born through a caesarean delivery in the United Kingdom every year (Bragg et al., 2010), and similar rates are observed in other countries, e.g. U.S.A. (Lee et al., 2008), Sweden (Alexandersson et al., 2005), Denmark (Jensen and Wüst, 2015) and the Netherlands (Rietberg et al., 2005).[17] The strong compliance with these guidelines that have been observed in many countries (including the United Kingdom) guarantees that the relevance condition is satisfied.

[17] However there are still countries, such as Belgium and France, where it is still common practice to perform natural deliveries even in case of breech babies. Goffinet et al. (2006) shows that in those countries, this is still a valid option, as the risk of complications for babies is very low.

4.3 Estimation methods

We implement an instrumental variable approach by adopting a two-stage least squares estimation using Pos_m as an instrument and including hospital fixed effects in the model.

The main advantages of using linear IV methods concerns the possibility of testing the relevance of the instrument and to interpret the coefficients in terms of marginal effects. However this specification ignores the binary nature of the health outcome and the endogenous variable. As a robustness check, we estimate bivariate probit models (Heckman, 1978; Nichols, 2011) and we adopt a two-stage residual inclusion approach (Terza et al., 2008). Results are shown and discussed in Section 6.

5 Results

Equation 2 is initially estimated with Ordinary Least Squares (OLS), treating the mode of delivery (CS) as exogenous. This specification can be viewed as a descriptive regression which sheds light on whether the effect of unplanned caesarean delivery persists after controlling for other observed factors. Also, it provides a benchmark against which to compare the results from fixed effects and IV models.[18] Table 6 presents OLS estimates obtained by adding gradually different sets of covariates in the regression equation. The first column shows results when the mode of delivery and the socio-economic variables are included. In Column 2, we also include information on maternal health conditions and pregnancy. Finally, we add measures of the baby's health at birth to account for the negative impact of the poor baby's health on maternal mental health (Column 3).

In all the specifications, we find a positive and significant association between unplanned caesarean delivery and postnatal depression. When including measures of maternal health and pregnancy experience, the magnitude of the coefficient slightly decreases (moving from 0.029 to 0.025) and becomes less statistically significant, suggesting that part of the association is captured by the poorer levels of health of the mothers who gave birth through this procedure. The inclusion of measures of the baby's health at birth does not reduce the magnitude. Overall, when controlling for the full set of regressors, we find that having an unplanned caesarean delivery is associated with an increase in the likelihood of postnatal depression by 2.5 percentage points.

As discussed above, OLS estimates may be biased if there are omitted variables at the mother or hospital level. We first control for time-invariant hospital factors by including the hospital fixed effects in the model. Results, reported in Column 4 of Table 6, are not statistically different from those obtained in

[18] From a theoretical point of view, the linear probability model is not the appropriate specification, given the binary nature of the outcome variable. To account for this, we also estimate Equation 2 by adopting a probit model specification. Results, available from the author, confirm the OLS estimates.

the OLS specifications. This has at least two interpretations. First, it may be that unobservable hospital characteristics affecting both the delivery method and the risk of developing postnatal depression are not an issue in this context. Another explanation is that what matters to explain the risk of developing postnatal depression is the relationship of the mother with the nurse that follows her during and after the pregnancy, rather than factors at the hospital level, such as quality of care and resources available. Under the second scenario, hospital FE would not solve the endogeneity issue, being that this method is only able to account for hospital characteristics that do not vary over time and across mothers. However, the IV strategy can represent a solution, accounting for any source of endogeneity, provided that the instruments employed are valid.

5.1 First stage results

The first stage of linear IV models (Columns 1 and 3 of Table 7) estimated using Pos_m as an exclusion restriction, shows that the partial correlation between the baby's position in the womb and an unplanned CS is equal to 0.310 (0.314 when hospital fixed effects are included), and it is strongly statistically significant. This is in line with what obtained when comparing the proportion of breech babies born through an unplanned caesarean section with those who are born naturally, which are 0.197 and 0.048, respectively. Further evidence of the instrument relevance is provided in the bottom panel of Table 7. The F-statistic testing for the significance of the excluding restriction is equal to 163 (167.3 when hospital fixed effects are included)[19] and the test on the weak identification of the IV model (robust Kleibergen-Paap Wald rk F statistic) suggest that the position of the baby in the womb is a strong predictor of the mode of delivery.

Interestingly, the estimated effects of the covariates are in line with other studies (Halla et al., 2016). Ethnicity is the most important socio-economic predictor, with black and Pakistani, Bangladeshi and Indian women being at higher risk of having an unplanned caesarean delivery. There is also a negative educational gradient, with more educated mothers being less likely to have an unplanned CS. Most of the measures of the mother's health before and during the pregnancy also have predictive power. For example, hospitalisation during pregnancy or having suffered from diabetes increases the risk of an unplanned caesarean delivery. We also find that underweight and overweight babies are more likely to be born through an unplanned CS. This is explained by the fact that an underweight baby may suffer from health conditions that affect their development and require a medical intervention. Instead, overweight babies are usually associated with post-term deliveries, which are more likely to be affected

[19] Stock and Yogo (2005) suggest 10 as a rule of thumb. Under such value, the relevance of the instrument(s) is not guaranteed.

by complications. Similar findings are obtained when we include hospital fixed effects to the model (see Column 3 in Table 7).

5.2 Second stage results

Column 2 and 4 of Table 7 report the second-stage results. We find that an unplanned caesarean delivery increases the risk of developing postnatal depression by 15.1 (18.8) percentage points when we include (exclude) hospital fixed effects. The effect is not negligible, given the underlying risk of postnatal depression of 32.5 per cent.

When focusing on the coefficients associated with the covariates included in the model, we find that most of them behave as expected. For example, married women have 5 percentage points lower of a chance of being affected by postnatal depression than unmarried women. Income also shows a strong negative association with the probability of experiencing postnatal depression (negative coefficient equal to 0.003). This result is consistent with the *family stress model*, as defined by Conger et al. (2000), which states how economic hardship and pressure negatively impact parents' mental health.

Among the health and pregnancy variables, we find that poor physical health, measured by hospitalization during pregnancy, strongly predicts postnatal depression and, coherently with previous studies that show a strong association between physical and mental health (Canadian Mental Health Association, 2008). Along the same lines, we find that working during pregnancy is negatively associated with the probability of developing depression after childbirth (negative coefficient equal to 0.044). On the contrary, diabetes and hypertension are not significantly associated with postnatal depression.

Results also show that having planned the pregnancy in advance is associated with a decrease in the probability of postnatal depression by 6.1 percentage points. Finally, poor baby's health (proxied by birth weight and gestational age) does not appear to have an effect on the probability of developing postnatal depression.[20]

5.3 Interpretations of the results and analysis of the effect for low-risk pregnancies

Overall, we find that failing to account for selection into the delivery method leads to an underestimation of the impact of unplanned caesareans on maternal mental health. But, is this really the case? An explanation for our results may be that the linear IV model produces upward biased results because the instrument employed in the analysis does not satisfy the exclusion validity assumption. However, as we

[20] It is worth remembering that we have dropped from the sample pre-term births, meaning that the most severe cases (babies born before the 37th week) are not included.

discussed in Section 4, this is unlikely to be the case, as the tests we performed supports the validity of the instruments, so we rule out this hypothesis. Another explanation is that, if treatment effects are heterogeneous across the population of first-time mothers, what we obtain when exploiting the exogenous variation in the position of the baby in the womb is a local average treatment effect (LATE), i.e. the average treatment effect for a defined *subgroup* of women who had an unplanned caesarean delivery as a consequence of the position in the womb of their baby at birth (the so-called compliers, see Angrist and Pischke, 2008). That said, the effect would still be interesting and policy relevant, since breech babies account for around 4 percent of all births, which translates into about 30,000 babies born every year just in the UK alone. Similar proportions are observed in other countries (e.g. Denmark, see Jensen and Wüst, 2015).

If the effect we identify applies to mothers with breech babies only, a group of high risk deliveries, we may further wonder about the impact of an unplanned CS on mothers who had a low-risk delivery. We have tried to answer this question by following two approaches.

The first consists in identifying low-risk deliveries by excluding any cases whether the mother suffered (before or during the pregnancy) from medical conditions, which may affect her health or the health of her baby during the pregnancy and increase the risk of complications (such as diabetes, pre-eclampsia, kidney diseases) and pre-term deliveries. We also exclude mothers whose babies were in a breech position at the time of birth. By focusing on non-breech babies, we cannot implement the instrumental variable approach. Therefore, we estimate a hospital fixed effect model, similar to the one described in Equation 3. Results, reported in Table 8, do not differ from those obtained using the full sample (Column 4 in Table 6), suggesting that the effect of unplanned caesareans on mother's mental health is the same for high- and low- risk deliveries.

An alternative approach to identify the effect of unplanned CS on the mother's mental health in the case of low-risk CS would be to use the time of the day when the delivery occurred as an excluded instrument. Costa-Ramon et al. (2018) argued that "while nature distributes births and associated problems uniformly, time-dependent variables related to physicians' demand for leisure are significant predictors of unplanned c-sections". The idea is that, if the proportion of unplanned CS varies during the day (for example, if the rate of caesarean deliveries is higher during the early hours of the night) that would suggest that these procedures are performed following physicians preferences, and therefore cannot be classified as real emergencies. We test whether this is the case in our paper by estimating the first stage of a linear IV model using the time of the delivery (measured in hours) as an instrument. A strong correlation between the probability of having an unplanned CS and the time of the day would imply that we can identify low-risk (unnecessary) unplanned CS. Instead, we find a very weak association between the time of the delivery and the probability of having an unplanned caesarean, both when time is defined as a continuous measure and as a set of dummies (Table 9). These results indicate that these unplanned caesareans were medically-indicated, i.e. there was no physician's discretion on the choice of the mode of delivery and they had to be performed independently of the time of day.

Finally, we are interested in understanding whether the effect we observe is specific for first-time mothers or it can be also generalised to mothers who had previous pregnancies. We investigate this issue comparing our main results (reported in Table 7) with those obtained using a sample that includes first-time mothers as well as multiple-time mothers. We find no statistically significant differences in the impact of unplanned caesarean deliveries for the two groups (Table 10). Therefore, we conclude that having an unplanned caesarean delivery carries a lot of stress, regardless of the previous delivery experience.

6 Sensitivity checks and heterogeneity analysis

6.1 Model specification

Linear IV models (estimating by 2SLS) may not be the most appropriate model specification because they assume that the outcome and the endogenous regressor are continuous, while both CS_m and PD_m are binary indicators. We account for this issue by estimating the model using alternative approaches such as (a) a bivariate probit model and (b) two-stage residual inclusion (2SRI). Both these approaches account for the fact that the treatment (CS) and the outcome variables are binary.

The bivariate probit model assumes that the outcome and treatment are each determined by latent linear index models with jointly normal error terms. The two-stage residual inclusion (2SRI) estimation is a semi-parametric approach that uses the residuals from the first stage to control for endogeneity in the second stage (Terza et al., 2008; Basu et al., 2018). The estimates derived from a bivariate probit are interpreted as average treatment effects (ATE), as bivariate probit and other models of this sort can be used to estimate unconditional average causal effects and/or effects on the treated.

It is an open question whether we should rely on the linear IV model, the bivariate probit model, the 2SRI or other approaches. The existing literature offers conflicting advice. For example, Angrist and Pischke (2008) argue that "the hard part of the empirical problem is finding a good instrument and that the difficulties with endogenous variables in nonlinear limited dependent variables models are usually more apparent than real". Chiburis et al. (2011) provided some evidence based on Monte Carlo simulations and concluded that the choice of the model depends on different factors, an important one being the normality assumption of the error terms. They found that a violation of the normality assumption can lead to a severe bias in the bivariate probit estimates. Instead, Bhattacharya et al. (2006)'s simulations suggest that bivariate probit is slightly more robust than IV to non-normality of the error terms. In this paper, the normality assumption is not satisfied, so we prefer to show the results from the bivariate probit model as a robustness check only.

When choosing between linear IV and 2SRI, Terza et al. (2008) argued that in cases of binary dependent variables, we should rely on nonlinear 2SRI as these are the only ones that produce consistent estimates of ATE. Basu et al. (2018) analysed the case of binary outcome, a binary treatment and binary instrument and found that the 2SLS method with binary IV produce consistent estimates of LATE, while 2SRI estimate of ATE and LATE are generally bias. Among 2SRI the type of residual form that minimises the bias for the ATE are the generalised residuals.

We compare the results obtained from these approaches as a sensitivity exercise to test whether (and how much) our results are affected by the empirical approach we adopt. We find that the marginal effects obtained with the 2SLS and the bivariate probit model do not differ substantially (Table 11). This can be interpreted as evidence that relying on a linear specification of the model is acceptable. On the contrary, when comparing the results obtained with 2SLS and 2SRI, we find that the estimates are very different. In particular, in the latter case, the estimated effect is 0.41, but it is not statistically significant.

6.2 Robustness check: baby's health measures

Gestational age at birth and birth weight may be endogenous because they are potentially affected by the mode of delivery. This may be the case if, for example, women with low birth weight babies and women at high risk of giving birth before their due date are more likely to receive intensive care before the birth of their child and are also more likely to end up with an unplanned caesarean. For this reason, as a sensitivity, we estimate linear IV models excluding these variables from the vector of covariates. As Table 12 shows, results do not change significantly compared to a model with the full set of regressors. This is not surprising as baby's health at birth (proxied by birth weight and gestational age) is not associated to mother's mental health (Table 7). However, because the delivery method may be correlated with the baby's health at birth, we prefer to include these controls in the models.[21]

[21] As a robustness check, we replace birth weight and gestational age with an alternative measure indicating whether the baby was hospitalised in the first 9 months after birth. In this case, we find that the coefficient is positive and statistically significant, suggesting that having a baby hospitalised increases the risk of postnatal depression (Table 12). However, an issue related to this measure, as opposed to birth weight (or other proxies measured at birth) is that it may be capturing the effect of the mother's mental health after childbirth. For example, Perry (2008) shows that psychologically distressed mothers tend to be less able to take care of their children, in particular, in terms of adherence to health regimes. If this is the case, baby hospitalisation after birth would not only capture the effect of the baby's health but also the mother's mental health after the delivery (and its effect on the motherâĂŹs behaviour). For this reason, we prefer to include birth weight and gestational age in the model main specification.

6.3 Heterogeneity by mother's education

Women with greater resources or knowledge may be more capable of mitigating the negative events they experience. We test this assumption by splitting the sample into two groups of mothers: those with a university degree and those with a lower qualification (if any). When estimating the linear IV model for the two groups, we find no differences in the relationship between unplanned caesarean delivery and maternal mental health, although the coefficients become not significant (Table 13).

7 Discussion and Conclusions

This study contributes to the growing economic literature on the determinants and consequences of the increased utilisation of surgical procedures such as caesarean deliveries. It represents the first attempt to identify the causal effect of unplanned caesarean sections on the mothers' mental health, looking at whether this procedure is associated with an increase in the mothers' risk of developing postnatal depression in the first nine months after childbirth.

Results show that unplanned caesarean deliveries carry significant psychological risks, with women who give birth through this procedure being more vulnerable to depression (by 15 percentage points when estimated using linear IV models combined with hospital fixed effects). These findings are important for a number of reasons. First, caesarean deliveries have spread remarkably fast in recent years, becoming one of the most frequent surgical procedures, with 165,000 deliveries performed every year in England (among these, about 25,000 are unplanned caesarean deliveries). Second, depression can be a very severe condition, limiting the mothers' everyday life and their ability to take care of their children. Because mothers are usually the main childcare givers, the mother's poor mental health is likely to negatively affect their baby's health and development. Additionally, postnatal depression is likely to become a chronic health condition, associated with high costs for families as well as for society (e.g. inability to work, see (Schultz et al., 2013)).

This paper also explains the effect of caesarean deliveries on women's subsequent fertility decisions. Halla et al. (2016) find that mothers who give birth through a caesarean section are less likely to have other children and they mention psychological problems after childbirth as a possible explanation. While we cannot argue that this is necessarily the case, this paper shows evidence of the existence of a negative psychological impact of unplanned caesarean deliveries, which can explain their findings.

A limitation of this study concerns the data employed, more particularly, the limited information on the mother's mental health status during the pregnancy, together with the impossibility to distinguish between planned caesareans due to the mothers' or baby's health and those scheduled because of the mother's request. A longitudinal administrative dataset with detailed information on the mothers' previous pregnancy experiences and their health conditions before and after the pregnancy would allow for the identification of the causal effect of unplanned caesarean deliveries using alternative econometric approaches and fewer assumptions. In addition, it would allow the comparison of results from this study with those obtained using objective measures of the mother's mental health. Reaching these goals would require a link of hospital records on maternity events to other data sources containing information on primary care visits, being that depression is usually diagnosed by general practitioners (at least in a first instance), and census data providing details on mothers' income, education, working condition and other socio-economic variables. However, such linkages are not currently available, at least for English data.

The analysis of the effect of elective caesarean deliveries on the mother's mental health after childbirth is left to further research. As discussed in the paper, from a theoretical point of view, we may expect elective caesarean deliveries to have a smaller impact compared to unplanned caesarean deliveries, being planned in advance and giving mothers the opportunity to adjust their expectations. However, they can still have a negative impact on their body, and as a consequence, make their post-partum recovery more difficult. Looking also to elective caesareans would provide a more complete picture of this phenomenon.

From a policy perspective, this study highlights the importance of accounting for the psychological costs of unplanned caesarean deliveries when evaluating the costs and benefits of this procedure. Failing to account for these factors would lead to inaccurate evaluations of this procedure and, as a consequence, to the implementation of inappropriate health policies (Drummond, 2005). Additionally, it suggests the importance of providing appropriate services, such as professionally-based home visits and peer-based telephone support, to prevent the development of postnatal depression (Royal College of Obstetricians and Gynaecologists, 2017).

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Table 1: Descriptive Statistics

	Mean	Std. Dev.	Min	Max
Breech position	0.070	0.266	0	1
Postpartum depression	0.325	0.468	0	1
Mother's age	25.936	5.913	14	48
Married	0.493	0.500	0	1
Household income	16.979	10.919	1.21	66.70
GCSE/O-level (or equivalent)	0.386	0.487	0	1
A-level or higher (but no university)	0.178	0.382	0	1
University qualification	0.335	0.472	0	1
White	0.889	0.314	0	1
Black	0.024	0.153	0	1
Pakistani, Bangladeshi, Indian	0.059	0.236	0	1
Other ethinicity	0.028	0.164	0	1
Hospitalisation (pregnancy)	0.192	0.394	0	1
BMI (before pregnancy)	23.174	4.223	12.1	47.7
Planned pregnancy	0.528	0.499	0	1
Employed (pregnancy)	0.803	0.397	0	1
Diabetes (ever)	0.014	0.116	0	1
Hypertension (ever)	0.003	0.052	0	1
Kidney disease (ever)	0.009	0.095	0	1
Pre-eclampia (pregnancy)	0.089	0.285	0	1
Birth weight	3.372	0.474	0.67	4.89
Gestational age at birth	40.139	1.306	37	42

Notes. Mother's age is measured in years, while baby's gestational age at birth is measured in weeks. Income is measured in thousands of GB pounds. Statistics obtained using a sample of 5,896 first-time mothers. *** $p<0.01$, ** $p<0.05$ and * $p<0.10$.

Table 2: Mother's and baby's characteristics by delivery mode

	Natural delivery	Unplanned CS	P-value
Mother's age	25.43	28.09	0.000
Married	0.476	0.567	0.000
Household income	16.52	18.91	0.000
GCSE/O-level (or equivalent)	0.391	0.362	0.077
A-level or higher (but no university)	0.181	0.166	0.231
University qualification	0.324	0.383	0.000
White	0.891	0.882	0.384
Black	0.021	0.038	0.001
Pakistani, Bangladeshi, Indian	0.060	0.055	0.513
Other ethinicity	0.028	0.025	0.538
Hospitalisation (pregnancy)	0.188	0.210	0.092
BMI (before pregnancy)	22.87	24.46	0.000
Planned pregnancy	0.513	0.590	0.000
Employed (pregnancy)	0.792	0.850	0.000
Diabetes (ever)	0.011	0.023	0.002
Hypertension (ever)	0.002	0.007	0.002
Kidney disease (ever)	0.010	0.006	0.253
Pre-eclampia (pregnancy)	0.080	0.127	0.000
Birth weight	3.347	3.476	0.000
Gestational age at birth	40.10	40.29	0.000

Notes. The table reports the mean of the variables identifying mother's and baby's characteristics by delivery mode. Mother's age is measured in years, while baby's gestational age at birth is measured in weeks. Income is measured in thousands of GB pounds. All the other figures indicate percentages. Differences between groups are tested by means of 2-independent-sample t tests. Statistics obtained using a sample of 5,896 first-time mothers. *** $p<0.01$, ** $p<0.05$ and * $p<0.10$.

Table 3: Validity test: Predictors of breech position

	Outcome variable: Breech position
Age	0.003
	(0.005)
Age sq.	-0.000
	(0.000)
Married	-0.014
	(0.009)
Income	0.000
	(0.000)
GCSE/O-level or eq.	-0.006
	(0.013)
A level or more (no uni)	-0.002
	(0.013)
University qualification	0.002
	(0.013)
Black	-0.010
	(0.021)
Pakistani, Bangladeshi, Indian	-0.014
	(0.013)
Other ethnicity (Asian)	-0.024
	(0.020)
Hospitalisations during pregnancy	0.019*
	(0.011)
BMI	0.017***
	(0.004)
BMI sq.	-0.000***
	(0.000)
Planned pregnancy	0.002
	(0.009)
Employed during pregnancy	0.006
	(0.009)
Diabetes	-0.022
	(0.028)
Hypertension	0.091
	(0.094)
Kidney disease	0.025
	(0.043)
Eclampsia	-0.015
	(0.014)
Under weight (b)	0.001
	(0.021)
Over weight (b)	0.018
	(0.013)
Gestational age (38)	0.005
	(0.020)
Gestational age (39)	0.005
	(0.020)
Gestational age (40)	-0.006
	(0.018)
Gestational age (41)	-0.006
	(0.017)
Gestational age (42)	-0.023
	(0.020)
Constant	-0.218**
	(0.085)
No. Observations	5,896

Notes. Robust standard errors clustered at hospital level in parentheses. Linear probability models estimated using OLS. *** p<0.01, ** p<0.05 and * p<0.10.

Table 4: Validy test: Mean comparison

	No Breech	Breech	P-value
Age (m)	25.85	27.03	0.000
Married	0.492	0.508	0.52
Income	16.86	18.46	0.003
GCSE/O-level or eq.	0.388	0.357	0.195
A level or more (no uni)	0.178	0.175	0.874
University Qualification	0.331	0.386	0.018
Black	0.0242	0.0222	0.783
Pakistani, Bangladeshi, Indian	0.0612	0.0377	0.043
Hospitalisation	0.19	0.222	0.099
BMI	23.14	23.58	0.032
Planned pregnancy	0.524	0.57	0.063
Employed during pregnancy	0.799	0.854	0.005
Diabetes	0.0138	0.0111	0.635
Hypertension	0.0024	0.0067	0.094
Kidney diseases	0.0088	0.0133	0.336
Eclampsia	0.0885	0.0931	0.741
Birth weight	3.369	3.407	0.103
Gestational age (weeks)	40.15	40.05	0.135

Notes. The table reports the mean of the variables employed in the analysis by position of the baby in the womb before birth (breech and normal position). Mother's age is measured in years, while baby's gestational age at birth is measured in weeks. Income is measured in thousands of GB pounds. All the other figures indicate percentages. Differences between groups are tested by means of 2-independent-sample t tests. *** $p<0.01$, ** $p<0.05$ and * $p<0.10$.

Table 5: Validity test: Analysis of the unobservables

	Outcome Variable: Residuals from Breech Model
N. cigarettes	0.001
	(0.001)
Smoker (dummy)	-0.011
	(0.012)
Constant	0.001
	(0.004)
No. Observations	5,896
F statistic	0.49

Notes. Robust standard errors clustered at hospital level in parentheses. Linear probability models estimated using OLS. The residuals employed as dependent variable are obtained from a model that predicts the probability of having a baby in a breech position on the covariates included in the main model (Table 3). Mother's smoking behavior refers to the period before the pregnancy. F statistic of joint significance of the independent variables. *** p<0.01, ** p<0.05 and * p<0.10.

Table 6: Linear probability (LPM) and hospital FE models

	Outcome Variable: Postnatal Depression			
	LPM	LPM	LPM	LPM with hospital FE
	(1)	(2)	(3)	(4)
Unplanned CS	0.029**	0.025*	0.025*	0.026*
	(0.014)	(0.015)	(0.015)	(0.015)
Mother's age	-0.013	-0.001	-0.002	0.001
	(0.009)	(0.009)	(0.009)	(0.009)
Mother's age sq.	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Married	-0.069***	-0.052***	-0.052***	-0.050***
	(0.015)	(0.016)	(0.016)	(0.016)
Household Income	-0.003***	-0.003***	-0.003***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Black	0.080	0.075	0.074	0.062
	(0.050)	(0.050)	(0.050)	(0.057)
Pakistani, Bangladeshi, Indian	0.085***	0.079***	0.077***	0.056*
	(0.023)	(0.023)	(0.023)	(0.030)
Other ethnicity	-0.016	-0.025	-0.027	-0.018
	(0.039)	(0.039)	(0.040)	(0.038)
GCSE/O-level (or equivalent)	0.013	0.022	0.022	0.016
	(0.022)	(0.022)	(0.022)	(0.021)
A-level or higher (but no university)	-0.009	0.006	0.006	-0.004
	(0.026)	(0.025)	(0.025)	(0.024)
University qualification	-0.013	-0.001	-0.002	-0.010
	(0.026)	(0.026)	(0.026)	(0.024)
BMI		0.003	0.003	0.002
		(0.010)	(0.010)	(0.010)
BMI sq.		-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)
Planned pregnancy		-0.056***	-0.056***	-0.062***
		(0.013)	(0.013)	(0.014)
Hospitalisation (pregnancy)		0.111***	0.112***	0.112***
		(0.017)	(0.017)	(0.018)
Employed (pregnancy)		-0.048**	-0.048**	-0.043**
		(0.019)	(0.019)	(0.020)
Diabetes (ever)		-0.033	-0.031	-0.028
		(0.050)	(0.050)	(0.054)
Hypertension (ever)		-0.039	-0.037	-0.039
		(0.115)	(0.115)	(0.127)
Kidney diseases (ever)		0.059	0.061	0.060
		(0.062)	(0.062)	(0.064)
Unweight baby			0.017	0.019
			(0.035)	(0.036)
Overweight baby			-0.006	-0.007
			(0.019)	(0.020)
38th week (gestation)			0.004	0.009
			(0.037)	(0.039)
39th week (gestation)			0.040	0.037
			(0.037)	(0.039)
40th week (gestation)			0.022	0.016
			(0.033)	(0.035)
41th week (gestation)			0.017	0.014
			(0.035)	(0.036)
42th week or more (gestation)			0.041	0.040
			(0.033)	(0.035)
Constant	0.563***	0.367**	0.345**	0.326**
	(0.115)	(0.147)	(0.147)	(0.144)
No. Observations	5,896	5,896	5,896	5,896

Notes. Robust standard errors clustered at hospital level in parentheses. Linear probability models estimated using OLS. Column 4 reports results obtained including hospital fixed effects (FE). *** p<0.01, ** p<0.05 and * p<0.10.

Table 7: Linear instrumental variable (IV) models

	Linear IV model without FE		Linear IV model with FE	
	First stage	Second stage	First stage	Second stage
	(1)	(2)	(3)	(4)
Breech baby	0.310***		0.314***	
	(0.024)		(0.024)	
Unplanned CS		0.188***		0.151**
		(0.069)		(0.069)
Mother's age	-0.006	-0.001	-0.005	0.002
	(0.008)	(0.009)	(0.008)	(0.009)
Mother's age sq.	0.000**	0.000	0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.001	-0.051***	-0.005	-0.049***
	(0.013)	(0.016)	(0.013)	(0.016)
Household Income	0.000	-0.003***	0.000	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Black	0.106***	0.057	0.108**	0.049
	(0.040)	(0.054)	(0.046)	(0.060)
Pakistani, Bangladeshi, Indian	0.046**	0.070***	0.028	0.054*
	(0.023)	(0.023)	(0.028)	(0.030)
Other ethnicity	0.006	-0.027	0.010	-0.019
	(0.028)	(0.040)	(0.033)	(0.038)
GCSE/O-level (or equivalent)	-0.026	0.027	-0.024	0.019
	(0.017)	(0.023)	(0.017)	(0.022)
A-level or higher (but no university)	-0.043**	0.013	-0.037*	0.001
	(0.019)	(0.026)	(0.019)	(0.025)
University qualification	-0.051**	0.006	-0.046**	-0.004
	(0.020)	(0.026)	(0.021)	(0.025)
BMI	-0.009	0.003	-0.006	0.002
	(0.008)	(0.010)	(0.008)	(0.010)
BMI sq.	0.000**	-0.000	0.000**	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Planned pregnancy	-0.014	-0.053***	-0.011	-0.061***
	(0.013)	(0.014)	(0.013)	(0.014)
Hospitalisation (pregnancy)	0.023*	0.107***	0.023*	0.109***
	(0.013)	(0.018)	(0.013)	(0.018)
Employed (pregnancy)	0.005	-0.049**	0.011	-0.044**
	(0.013)	(0.019)	(0.014)	(0.020)
Diabetes (ever)	0.089*	-0.045	0.116**	-0.040
	(0.049)	(0.051)	(0.051)	(0.054)
Hypertension (ever)	0.201	-0.074	0.188	-0.066
	(0.127)	(0.112)	(0.132)	(0.126)
Kidney diseases (ever)	-0.066	0.071	-0.068	0.067
	(0.047)	(0.062)	(0.049)	(0.063)
Unweight baby	0.079***	0.004	0.086***	0.008
	(0.029)	(0.037)	(0.029)	(0.037)
Overweight baby	0.145***	-0.031	0.151***	-0.026
	(0.019)	(0.020)	(0.020)	(0.021)
38th week (gestation)	-0.016	0.007	-0.019	0.011
	(0.030)	(0.038)	(0.031)	(0.039)
39th week (gestation)	-0.019	0.043	-0.028	0.041
	(0.026)	(0.037)	(0.027)	(0.039)
40th week (gestation)	-0.019	0.025	-0.022	0.019
	(0.027)	(0.033)	(0.028)	(0.035)
41th week (gestation)	0.018	0.014	0.016	0.013
	(0.026)	(0.034)	(0.027)	(0.036)
42th week or more (gestation)	0.046	0.035	0.043	0.035
	(0.028)	(0.033)	(0.029)	(0.036)
Constant	0.091	0.341**		
	(0.136)	(0.145)		
No. Observations	5,896		5,864	
F-stat (first stage)	163.6		167.3	
Weak identification test	163.6¿16.38		167.3¿16.38	
Endogeneity Test (p-value)	0.0134		0.0583	

Notes. Robust standard errors clustered at hospital level in parentheses. For the weak identification test we report Stock-Yogo critical values, allowing for 10% of IV maximum distortion with respect to OLS. *** $p<0.01$, ** $p<0.05$ and * $p<0.10$.

Table 8: FE models for low-risk deliveries

	Outcome Variable: Postnatal Depression
Unplanned CS	0.042**
	(0.019)
Mother's age	0.003
	(0.011)
Mother's age sq.	0.000
	(0.000)
Married	-0.039**
	(0.020)
Household Income	-0.002*
	(0.001)
Black	0.087
	(0.056)
Pakistani, Bangladeshi, Indian	0.033
	(0.039)
Other ethnicity	0.021
	(0.042)
GCSE/O-level (or equivalent)	0.013
	(0.024)
A-level or higher (but no university)	0.003
	(0.030)
University qualification	-0.013
	(0.029)
BMI	-0.003
	(0.011)
BMI sq.	0.000
	(0.000)
Planned pregnancy	-0.080***
	(0.015)
Employed (pregnancy)	-0.054**
	(0.022)
Unweight baby	0.056
	(0.045)
Overweight baby	-0.022
	(0.023)
38th week (gestation)	-0.017
	(0.053)
39th week (gestation)	0.007
	(0.044)
40th week (gestation)	-0.032
	(0.043)
41th week (gestation)	-0.028
	(0.043)
42th week or more (gestation)	0.006
	(0.045)
Constant	0.377**
	(0.172)
No. Observations	4,205

Notes. Robust standard errors clustered at hospital level in parentheses. The sample includes mother who did not suffered from diabetes, hypertension, kidney diseases or pre-eclampsia. *** p<0.01, ** p<0.05 and * p<0.10.

Table 9: First stage of linear IV models using time of the delivery as IV

	Outcome Variable: Unplanned CS	
	(1)	(2)
Midnight		0.040
		(0.037)
1am		-0.038
		(0.034)
2am		-0.015
		(0.030)
3am		-0.062**
		(0.031)
4am		-0.073**
		(0.031)
5am		-0.095***
		(0.030)
6am		-0.050
		(0.033)
7am		-0.022
		(0.035)
8am		-0.040
		(0.033)
9am		-0.055
		(0.033)
10am		-0.031
		(0.034)
11am		0.005
		(0.032)
midday		-0.045
		(0.030)
1pm		-0.040
		(0.036)
2pm		-0.041
		(0.033)
3pm		-0.036
		(0.033)
4pm		-0.068**
		(0.034)
5pm		-0.009
		(0.033)
6pm		-0.077**
		(0.031)
7pm		-0.059*
		(0.032)
8pm		-0.017
		(0.034)
9pm		-0.019
		(0.034)
10pm		-0.008
		(0.032)
hour of the day	0.000	
	(0.001)	
No. Observations	5,896	5,896
F statistic (first stage)	0.32	2.41

Notes. Robust standard errors clustered at hospital level in parentheses. All model specifications include information on socio-economic status, pregnancy, mother's health and baby's health as in Column (3) of Table 6. Time is defined as a continuous measure (Column 1) and as a set of dummies (Column 2) capturing the time in a day when the baby was born. F statistic of the joint significance of the exclusion restrictions. *** p<0.01, ** p<0.05 and * p<0.10.

Table 10: Effect of unplanned CS on mother's mental health for first-time and multiple-time mothers

	Linear IV model without FE		Linear IV model with FE	
	First stage	Second stage	First stage	Second stage
	(1)	(2)	(3)	(4)
Breech baby	0.314***		0.317***	
	(0.020)		(0.020)	
Unplanned CS		0.180***		0.146***
		(0.055)		(0.055)
Mother's age	0.009**	0.002	0.009**	0.004
	(0.004)	(0.006)	(0.004)	(0.006)
Mother's age sq.	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Married	-0.004	-0.056***	-0.004	-0.057***
	(0.007)	(0.010)	(0.007)	(0.011)
Household Income	0.001	-0.004***	0.001	-0.003***
	(0.000)	(0.001)	(0.000)	(0.001)
Black	0.075***	-0.023	0.062***	-0.013
	(0.018)	(0.036)	(0.022)	(0.038)
Pakistani, Bangladeshi, Indian	0.019*	-0.013	0.011	-0.002
	(0.012)	(0.017)	(0.015)	(0.023)
Other ethnicity	0.019	-0.050*	0.007	-0.035
	(0.022)	(0.029)	(0.025)	(0.028)
GCSE/O-level (or equivalent)	-0.005	0.016	-0.002	0.017
	(0.007)	(0.016)	(0.007)	(0.016)
A-level or higher (but no university)	-0.018*	0.008	-0.015	0.007
	(0.010)	(0.017)	(0.010)	(0.016)
University qualification	-0.015	0.003	-0.013	0.004
	(0.010)	(0.019)	(0.010)	(0.018)
BMI	0.004	-0.005	0.004	-0.005
	(0.005)	(0.006)	(0.005)	(0.006)
BMI sq.	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
First child (parity)	0.135***	-0.046***	0.133***	-0.041***
	(0.007)	(0.013)	(0.007)	(0.013)
Planned pregnancy	-0.001	-0.044***	-0.001	-0.044***
	(0.006)	(0.008)	(0.006)	(0.008)
Hospitalisation (pregnancy)	0.022**	0.091***	0.021**	0.089***
	(0.009)	(0.011)	(0.009)	(0.011)
Employed (pregnancy)	0.003	-0.040***	0.005	-0.040***
	(0.006)	(0.011)	(0.006)	(0.010)
Diabetes (ever)	0.061**	-0.025	0.061**	-0.021
	(0.026)	(0.030)	(0.026)	(0.029)
Hypertension (ever)	0.057	0.044	0.057	0.045
	(0.057)	(0.074)	(0.057)	(0.074)
Kidney diseases (ever)	-0.000	0.083*	-0.005	0.077*
	(0.031)	(0.045)	(0.032)	(0.043)
Unweight baby	0.092***	0.032	0.091***	0.034
	(0.021)	(0.025)	(0.021)	(0.025)
Overweight baby	0.066***	-0.040***	0.067***	-0.041***
	(0.009)	(0.013)	(0.009)	(0.014)
38th week (gestation)	-0.046**	-0.013	-0.050***	-0.011
	(0.019)	(0.023)	(0.019)	(0.024)
39th week (gestation)	-0.064***	0.016	-0.072***	0.016
	(0.016)	(0.024)	(0.016)	(0.024)
40th week (gestation)	-0.066***	0.003	-0.070***	0.002
	(0.016)	(0.022)	(0.017)	(0.022)
41th week (gestation)	-0.052***	-0.002	-0.056***	-0.002
	(0.017)	(0.022)	(0.017)	(0.023)
42th week or more (gestation)	-0.025	-0.006	-0.030*	-0.005
	(0.017)	(0.023)	(0.017)	(0.024)
Constant	-0.243***	0.502***		
	(0.081)	(0.113)		
No. Observations	13,368		13,340	
F-stat	254.1		262.4	
Endogeneity Test (p-value)	0.00590		0.0348	

Notes. Robust standard errors clustered at hospital level in parentheses. Results obtained using a sample of first-time and mulitple-time mothers. *** p<0.01, ** p<0.05 and * p<0.10.

Table 11: Alternative model specifications

	Outcome Variable: Postnatal Depression		
	Linear IV model (1)	Bivariate probit model (2)	2SRI (3)
Unplanned CS	0.188***	0.116*	0.406
	(0.069)	(0.006)	(0.253)
N.observations	5,896	5,896	5,896

Notes. Standard errors in parentheses. In all the models, we use breech position as exclusion restriction. Linear IV models estimated using two-stages least squares (2SLS). Standard errors from the two-stage residual inclusion (2SRI) specification are obtained using bootstrapping. Column 2 reports the average marginal effects estimated from the bivariate probit model using the Stata command margins. Standard errors in the bivariate probit models are estimated using the delta-method. All model specifications include information on socio-economic status, pregnancy, mother's health and baby's health as in column (3) of Table 6.*** p<0.01, ** p<0.05 and * p<0.10.

Table 12: Robustness check: Baby's health measures

	Outcome Variable: Postnatal Depression			
	Linear IV model excluding baby's health measures		Linear IV model using alternative baby's health measures	
	without FE (1)	with FE (2)	without FE (3)	with FE (4)
Unplanned CS	0.186***	0.149**	0.186***	0.149**
	(0.069)	(0.068)	(0.068)	(0.068)
Hospitalisation			0.045**	0.049**
			(0.021)	(0.021)
No. Observations	5,896	5,864	5,896	5,864
F-test (first stage)	160.6	163.7	161.1	163.9
Endogeneity Test (p-value)	0.0137	0.0614	0.0124	0.0568

Notes. Robust standard errors clustered at hospital level in parentheses. All model specifications include information on socio-economic status, pregnancy and mother's health as in column (2) of Table 6. The alternative measure of baby's health is a dummy indicating whether the baby was hospitalised in the first 9 months after birth. *** p<0.01, ** p<0.05 and * p<0.10.

Table 13: Heterogeneity by mother's level of education

	Outcome Variable: Postnatal Depression	
	Linear IV model	
	without FE	with FE
	(1)	(2)
Effect of unplanned CS for:		
High educated mothers	0.232*	0.207
	(0.131)	(0.135)
Low educated mothers	0.164	0.121
	(0.102)	(0.100)
No. Observations	5,896	5,864
F-stat	25.82	27.29
Endogeneity Test p-value	0.0343	0.131

Notes. Robust standard errors clustered at hospital level in parentheses. All model specifications include information on socio-economic status, pregnancy and mother's and baby's as in column (3) of Table 6. High-educated mothers have a university qualification, while low-educated mothers have lower education (if any). *** p<0.01, ** p<0.05 and * p<0.10.