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Mother's health after childbirth: does 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 in the 1980s, while nowadays more than one-fourth of women gives birth through caesarean delivery (Health and Social Care Information Centre, 2009, 2012), implying 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 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, 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 mother's life, being associated with a deterioration of her physical well-being and the relationship with her partner. 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. 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 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]

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, 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. 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 variability (Robertson et al., 2004; Patel et al., 2005; Carter et al., 2006).

These studies are in general 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 which can have an impact on both the delivery method and mothers' mental health, it is very unlikely to be the case. As a result, the estimates reported in these studies may be (downward) biased.

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 British children (and mothers) obtained from the first sweep of the UK Millennium Cohort Study. We

[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).

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., 2017), none of them have looked to psychological consequences for mothers and the econometric methods they have employed are different from those employed 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 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 child'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 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 were used. However, epidural anesthesia has been found to increase the risk of unplanned caesarean delivery, and it is also associated to 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 to control for time-invariant characteristics at hospital level. As main source of exogenous variation we exploit, for the fist time in the literature, the position of the baby in the womb at the time of delivery. It has been shown that, conditional on mother's observable characteristics, the probability of having babies in abnormal position (i.e. with shoulders or feet first) is random and mothers cannot affect it with their behavior.[3] We control for mothers' health conditions which may be associated to the position of the baby and we argue that the variation left is exogenous. As an additional source of variation we use information on whether the mother suffered by pre-eclampsia during pregnancy. This is a health condition which may affect mothers after the 34th week of gestation and it is associated with some chronic conditions, such as diabetes and kidney diseases. While we control for these health problems, we cannot rule out completely that pre-eclampsia is uncorrelated with mother mental health after childbirth. As a result, we decide to rely on baby position in the womb and to use information on pre-eclampsia as a sensitivity only.

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 3 percentage points more likely to experience postnatal depression. The sign and statistical significance of this effect is confirmed by IV estimates, even if in this case marginal effects are larger (15.3 percentage points). Results are robust to a number of specifications.

The rest of the paper is organized as follows. Section 2 presents our empirical strategies while data are described in Section 3. Section 4 shows the main results and discusses the validity of the instruments employed in the analysis. Section 5 provides some sensitivity checks and Section 6 concludes.

2 Empirical Strategies

We study the effect of the mode of delivery on 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 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.

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

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 mother's mental health, such as age, marital status, income, ethnicity and level of education. X_m includes

[3] After the 34th week, in case the baby is in an abnormal position the mother may be asked to do some physical exercises in order to try to change the position of the baby. We assume that mothers who comply with this do not differ from mothers who ignore their doctor's suggestion, except for observable characteristics we can control for.

information on whether the pregnancy was planned and whether the mother had previous deliveries. Measures of mother's physical health, H_m^M, which refer to different points of time, are added to control for pre-existing health conditions. Finally, H_m^B, represents child's health at birth, proxied by birth weigh and gestation age.[4]

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

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

where ϵ_m denotes the mother-specific idiosyncratic error.

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 mother's mental health. This is also supported by the evidence provided in Table 1 where we compare mothers' characteristics by treatment (i.e. mode of delivery). The difference in socio-economic and medical characteristics of mothers who give birth naturally compared to those who have an unplanned CS suggests that the two groups of mothers differ substantially and they 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.

2.1 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:

$$PD_{mj} = \beta_0 + \beta_1 CS_{mj} + \mathbf{SES_{mj}}\beta_2 + \mathbf{X_{mj}}\beta_3 + \mathbf{H_{mj}^M}\beta_4 + \mathbf{H_{mj}^B}\beta_5 + \mu_j + \xi_{mj} \qquad (3)$$

where PD_{mj} indicates whether mother m who gave birth in hospital j has suffered from postnatal depression in the first nine months after child'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

[4]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 5.

heterogeneity component at the hospital level, μ_j. By estimating this model we get rid of the time-invariant unobserved heterogeneity at hospital level.

2.2 Instrumental variable approach

While the inclusion of hospital fixed effects accounts for differences in (time invariant) hospital characteristics, there may still be mothers-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 which exploits two sources of variation: (a) the position of the baby in the womb before the delivery and (b) mother's health status during the pregnancy, namely whether she suffered from pre-eclampsia.

2.2.1 Baby's position in the womb

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. Among babies at term, breech position is present in three to four per cent of all births (Royal College of Obstetricians and Gynaecologists, 2006).

We define the first stage regression as:

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

This approach requires two conditions to be met. The first is that Pos_m must not be correlated with ϵ_m (exclusion restriction). In other words, having a baby in a breech position at the time of delivery is uncorrelated with unobserved characteristics of the mother (and her pregnancy). 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 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, pregnancy conditions unrelated to breech (e.g. pre-eclampsia and diabetes). Also 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 mother's age, parity, health behaviors and birth weight (Rayl et al., 1996;

Fruscalzo et al., 2014). When using our sample to compare characteristics of mothers with breech and not-breech babies, we also find some differences in maternal characteristics (parity, ethnicity, socio-economic status) and in child health at birth. The latter result is not surprising since breech babies are more likely to be underweight and preterm (Cammu et al., 2014). However, when we regress baby's position on the full set of covariates (including unplanned CS), we find that apart from the mode of delivery, only parity, baby's health at birth and mother's ethnicity are significantly associated with the position of the baby. Nonetheless, to make sure the instrument is actually exogenous, we control for these factors in the model. In Section 4 we provide further evidence of the validity of the instrument computing an over-identification test after estimating linear IV models.

The second condition to satisfy is the relevance of the instrument, i.e. Pos_m must be a strong predictor of the mode of delivery. The National Institute of Clinical Excellence (NICE) guidelines encourage resorting to a caesarean delivery if a breech position occurs at the end of the gestational period 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 the adequate mode of delivery for breech babies that has shown the superiority of planned caesarean delivery with respect to a planned natural delivery (Hannah et al., 2002). 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). Given the strong compliance with guidelines, we expect α_1 in Equation 4 to be positive and strongly significant.

2.2.2 Pre-eclampsia during pregnancy

Our additional instrument exploits variation in the probability of experiencing pre-eclampsia during the pregnancy. This health condition is mainly characterised by high blood pressure (hypertension) and it usually occurs after the 34th week of gestation. We define a binary variable, Ecl_m, equal to one if the mother suffered from this condition during the pregnancy. The first stage regression becomes:

$$CS_m = \alpha_0 + \alpha_1 Ecl_m + \mathbf{SES_m}\alpha_2 + \mathbf{X_m}\alpha_3 + \mathbf{H_m^M}\alpha_4 + \mathbf{H_m^B}\alpha_5 + \epsilon_m \tag{5}$$

To satisfy the relevance condition, Ecl_m must be associated with CS_m, i.e. α_1 must be strongly significant. We expect this to be the case as women with pre-eclampsia are at higher risk of stroke and heart attack, and since a natural delivery is a very stressful event with a strong impact on the woman's body, physicians tend to opt for a (unplanned) caesarean delivery to avoid such risk.

This approach also requires that unobserved characteristics do not affect jointly the probability of suffering from pre-eclampsia and the mode of the delivery. As in the case of breech position, women cannot directly affect their probability of experiencing this condition. However, differently from the previous case, there are some biological and behavioral factors that the medical literature has identified as strong predictors of this condition. These include parity, obesity, multiple deliveries and antenatal visits.[5] Moreover, women with existing long-term medical problems, such as diabetes, kidney diseases or high blood pressure, are at higher risk of pre-eclampsia. While we can easily control for the first set of covariates, this is not completely possible for the others. Indeed, our data report only whether the woman has ever been affected by these long-term illnesses during her life, but no information is available on the onset of such conditions. As a result, even if the woman reports that she suffers (or has suffered) from such health conditions, we are not able to determine whether this happened during the pregnancy. While imperfect, we include these measures in the model to isolate the exogenous variation in mothers' probability of suffering from pre-eclampsia. However, because of the limitations discussed above, our preferred specification is the one exploiting variation in the position of the baby at the womb. We use Ecl_m, in combination with Pos_m, as a robustness check in order to obtain an over-identified model and be able to test formally the validity of the instruments.

2.3 Estimation methods

First we implement an instrumental variable approach by adopting a two-stage least squares estimation using Pos_m as the main instrument and including hospital fixed effects in the model. Then we re-estimate the model adding Ecl_m to the vector of instruments to obtain an over-identified model, which allows testing the validity of the instrument using a Sargan test.

The main advantages of using linear IV methods concern the possibility to test the validity and relevance of the instruments and to interpret the coefficients in terms of marginal effects. However, as in the OLS case, this specification ignores the binary nature of the health outcome and the endogenous variable. As a robustness check, in addition to linear IV models, we also estimate bivariate probit models (Heckman, 1978), following the approach suggested by Nichols (2011). The bivariate probit model is defined for two binary responses, postnatal depression (PD_m) and unplanned caesarean section (CS):

$$CS_m^* = 1(\mathbf{SES_m}\gamma_1 + \mathbf{X_m}\gamma_2 + \mathbf{H_m^M}\gamma_3 + \mathbf{H_m^B}\gamma_4 + \phi_1 Pos_m + \nu_m > 0) \tag{6}$$

$$PD_m = 1(\lambda_1 CS_m + \mathbf{SES_m}\delta_1 + \mathbf{X_m}\delta_2 + \mathbf{H_m^M}\delta_3 + \mathbf{H_m^B}\delta_4 + \zeta_m > 0) \tag{7}$$

[5] Since pre-eclampsia symptoms are usually picked up during routine antenatal visits, there may be a correlation between antenatal care and this health condition.

where $1(\bullet)$ is the indicator function which takes value of one if its argument is true and zero otherwise. Errors ν_m and ζ_m are assumed to be jointly normal with unit variance, but unknown correlation, ρ. If ρ is different from zero then single-equation models produce inconsistent estimates. Although theoretically the identification of bivariate probit models does not require exclusion restrictions, empirical identification and testing can be quite difficult without the use of instrumental variables (Monfardini and Radice, 2008). Therefore, in Section 4 we present results based on the same exclusion restrictions used in the linear models. When comparing results across different models, it is important to bear in mind that in the case of bivariate probit, not only exclusion restrictions, but also functional form assumptions, concur to the identification of the parameters of the model. Additionally, while with the 2SLS we obtain estimates of the local average treatment effect (LATE), in the case of the bivariate probit what we get are estimates of the average treatment effects.

3 Data

The data come 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, income and poverty. Information is derived from 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 health conditions of the family where children were born.[6]

3.1 Sample selection

The initial sample is characterised by 18,818 children, born from 18,552 women. We exclude women who had a multiple delivery (two or more babies) because they are more likely to have 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 single-pregnancy babies. We also drop observations with missing or incomplete information on the delivery method, postnatal mental health, mother's health conditions that occurred before and during the pregnancy, socio-economic status and baby's health. In addition, since we use information on the place of the delivery and particularly hospital identifiers, we exclude deliveries occurred at home or in unknown hospitals. Finally, we drop observations if information on the identifying instruments we require for the IV strategy (i.e. baby's position before

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

delivery and pre-eclampsia during pregnancy) is not available. This lead us with a final sample of 14,221 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 mother's postnatal depression shows a high degree of heterogeneity in the definition of this condition. 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), the length of the period after delivery[7] and the time of onset[8] that should be taken into account are less clear. 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. 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 outcomes 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 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 to not 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

[7] For example, the NICE and the Scottish Intercollegiate Guideline Network define postnatal depression as any non-psychotic depressive illnesses occurring during the first postnatal year.

[8] In some women, postpartum blues - a transient condition that mothers could experience shortly after childbirth (Stewart et al., 2003) - simply continue and become more severe. In others, a period of well-being after delivery is followed by a gradual onset of depression.

includes instrumented deliveries), while caesarean sections are distinguished in elective and unplanned, 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 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) child 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 dummy defining mother's ethnicity is included to account for the heterogeneous composition of the UK population. Ethnic minorities are 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 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 (Gresenz et al., 2001; Segre et al., 2007). We measure mother's highest level of education with a set of dummies that indicate her highest national vocational qualification (defined in three categories). 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).

As covariates related to the pregnancy, we include an indicator that measures if the pregnancy was planned and a measure of parity (i.e. whether the cohort member is the first child of the woman).[10]

Physical and mental health before pregnancy are strong predictors of postnatal depression. Unfortunately, being the MCS 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 smoking behaviour and her 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 mother's health during childbearing. Furthermore, we include

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

[10] This information is not directly available in the dataset. We derive it using the algorithm developed by Dr. Fiona Mensah, who combined different information from MCS (see Kiernan and Mensah, 2009).

dummies to measure whether she suffers/has suffered in the past from diabetes, gestational hypertension or kidney diseases.

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 baby at birth and gestational age (in weeks) as measures of baby's health. However, these variables may be endogenous if affected by the mode of delivery. In Section 5 we report the results when we exclude these variables from the model.

Finally, our empirical approach exploits the exogenous variation in the position of the baby at birth and whether the mother suffered from pre-eclampsia during the pregnancy. The instruments we derive are two binary variables, Pos and Ecl. The former takes the value of one if the baby was in a breech position or in another abnormal position requiring a surgical intervention. Pre-eclampsia, hereafter called Ecl, measures whether the mother has suffered from this hypertension disorder during the pregnancy and/or at the time of delivery.

3.3 Descriptive statistics

Table 1 provides some descriptive statistics of the variables used in the analysis for the full sample and by treatment status (i.e. the delivery method). 34.5 per cent of the women in the sample have experienced a period of sadness lasting at least two weeks after delivery (PD=1). 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 definition of postnatal depression and in the length of the postnatal period considered. Additionally, previous literature has shown that higher rates of incidence are observed when employing 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.

Columns 2 and 3 of Table 1 show means and standard deviations by delivery method for all the covariates and the outcome measure. Comparing the incidence rate of postnatal depression across women who gave birth through an unplanned CS and those who had a natural delivery, we find that the rate is higher for the former group of mothers and the difference is statistically different from zero (Pearson chi-squared = 7.95, p-value = 0.005).

When looking at other predictors, we find a significant difference in mothers' health status during pregnancy, with CS mothers more likely to experience poor health (in terms of hospitalisation during pregnancy, diabetes and hypertension). Additionally, 64.4 per cent of the women who had an unplanned CS had no previous pregnancies, while only 39.4 per cent of those who had a natural delivery have no other children. This may suggest that a mechanism through which unplanned CS negatively affects mothers' mental health is the lack of information (or wrong expectations) they may have about the delivery experience.

4 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.[11] Table 2 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 child health at birth to account for the negative impact of 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 decreases (moving from 0.046 to 0.041), suggesting that part of the effect is due to the poorer level of health of mothers who gave birth through this procedure. The inclusion of measures of child health at birth further reduces the magnitude and such reduction is even larger. Overall, when controlling for the full set of regressors, we find that having an unplanned caesarean delivery increases the likelihood of postnatal depression by 3 percentage points and this effect is significant at the 5 per cent level.[12]

As discussed above, OLS estimates may be biased if there are omitted variables at mother or hospital level. We first control for time-invariant hospital factors by including hospital fixed effect in the model. Results, reported in column 4 of Table 2, are not statistically different from those obtained in 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

[11] 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 adopting a probit model specification (see Table A1 in the Appendix.) and results are consistent with those obtained in the linear probability model.

[12] In Table A2 we report the full list of coefficients for the control variables.

pregnancy, rather than factors at hospital level, such as quality of care and resources available. Under the second scenario, hospital FE would not solve the endogeneity issue, being this method only able to account for hospitals characteristics which 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.

4.1 First stage results

The first stage of linear IV models (top panel of Table 3) estimated using only Pos_m as an exclusion restriction, show that the partial correlation between baby's position in the womb and unplanned CS is equal to 0.316 (0.320 when hospital fixed effects are included), and it is strongly statistically significant (p-value = 0.000). This is in line with what obtained comparing the proportion of breech babies born through an unplanned caesarean section with those who are born naturally, which are 0.185 and 0.045 respectively. Further evidence of the instrument relevance is provided in the bottom panel of Table 3. The F-statistic testing for the significance of the excluding restriction equal to 324.1 (337.7 when hospital fixed effects are included)[13] 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). Maternal age and ethnicity are the most important socio-economic predictors with older women and women from minorities groups being at higher risk of having an unplanned caesarean delivery (see column 1 in Table A3 in the Appendix). Most of the measures of mother's health before and during the pregnancy have also predictive power. For example, hospitalisation during pregnancy, smoking before the pregnancy as well as having suffered from diabetes and hypertension also increase the risk of an unplanned caesarean delivery. A U-shape relationship between gestational age and the probability of unplanned caesarean is also found, with premature and post term babies more likely to born through this procedure. This is explained by the fact that a premature birth usually occurs because of the development of un expected health condition affecting either the mother or the baby. On the contrary, a post term delivery may come up to be an unplanned CS if an unexpected event occurred during the delivery, for example in case of delivery induction. Similar findings are obtained when we include hospital fixed effects to the model (see columns 2 in Table 3 and in Table A3).

Adding Ecl_m to the set of instruments (with or without hospital fixed effects) does not change the main conclusions. In terms of relevance of this instrument, we find that women suffering from pre-eclampsia

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

have a higher risk of giving birth through an unplanned caesarean (coefficient equal to 0.08) and the effect is strongly statistically significant. Also in this case, the tests confirm the strong relevance of the instruments.

4.2 Second stage results

Panel B of Table 3 reports the second-stage results. Using Pos_m as the only instrument we find that an unplanned caesarean delivery increases the risk of developing postnatal depression by 15.3 per cent (18.7 per cent) when we include (exclude) hospital fixed effects. The effect is not negligible, given the underlying risk of postnatal depression of 34.5 per cent. Same results are obtained when using both the instruments (columns 3 and 4 of Table 3).

When focusing on the coefficients associated with the covariates included in the model, we find that they behave as expected (see Table A4). For example, married women have a 3.9 percentage points lower 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 women who smoked before the pregnancy are at higher risk of developing postnatal depression (8.2 percentage points) compared to non-smoking mothers. Poor physical health, measured by hospitalization during pregnancy, strongly predicts postnatal depression, coherently with the literature that shows a strong association between physical and mental health (Canadian Mental Health Association, 2008). In the same line we find that working during pregnancy is negatively associated with the probability of developing depression after childbirth (negative coefficient equal to 0.035). On the contrary, diabetes and hypertension are not significantly associated with postnatal depression (and the negative effect of having kidney problems is significant at 10 per cent only). This result goes in the opposite direction with respect to what is highlighted by the descriptive statistics, suggesting that once accounting for other concurrent health issues, these conditions are no longer relevant in explaining mother's mental health.

Results also show that having planned the pregnancy in advance is associated with a decrease in the probability of postnatal depression by 3.5 percentage points. Finally, as expected, poor baby's health (proxied by birth weight and gestational age) are strong predictors of maternal postnatal depression.

Overall, when comparing the coefficient associated with the delivery method in the OLS model with those found in linear IV models, it seems that failing to account for selection into the delivery method leads to an underestimation of the impact of this procedure on maternal mental health. But, is it 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 do not satisfy the exclusion validity assumption. However, as we discussed in Section 2, this is unlikely to be the case and the Sargan-Hansen test (reported in Table 3) further supports the validity of the instruments, so we rule out this hypothesis. Another explanation is that what we obtain when exploiting the exogenous variation in the position of the baby in the womb (and mother's pre-eclampsia) 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 is still interesting and policy relevant being the number of breech babies born every year not negligible (about 3-4 per cent of all deliveries).

5 Sensitivity checks and heterogeneity analysis

5.1 Model specification

As discussed in Section 2, linear IV models may not be an appropriate model specification because of the binary nature of CS_m and PD_m. We account for this issue by estimating a bivariate probit model and comparing results from this model with those obtained using the linear IV specification. Because the coefficients of the bivariate probit model are not directly interpretable we report average marginal effects (AME) from the bivariate probit (reported in Table 4). When only breech position is excluded from the outcome equation, we find that having an unplanned delivery increases the probability of postnatal depression by 11.6 percentage points. Adding pre-eclampsia to the vector of exclusion restrictions does not significantly change the results (average marginal effect equal to 11.5 percentage points).

When interpreting the estimates in the two models, it is important to keep in mind the different source of identification that the two models exploit. The bivariate probit model depends, in addition to the exclusion restrictions, also on the functional form assumptions. The fact that in this case the magnitude of linear IV estimates and AME from the bivariate probit are similar suggests that the stricter assumption of joint normality of error terms in the bivariate probit is consistent with the data. More generally, these findings could be interpreted as evidence of the robustness of results, that do not depend on parametric assumptions.

5.2 Excluding baby health measures

Gestational age at birth and birth weight may be endogenous as 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 5 shows, results do not change significantly compared to the model with the full set of regressors. In particular, the instruments are still strongly associated with the endogenous variable, CS_m, suggesting that the relevance of the instruments is not affected by the exclusion of baby health measures. Similarly, the second stage estimates are not statistically different from those obtained including baby health measures. Finally, the Sargan Hansen test confirms the validity of the instruments (p-value equal to 0.9230). However, because breech position may be correlated with baby's health at birth, we prefer to include in the models these controls.

5.3 Heterogeneity

Women with more resources or knowledge may be more able to mitigate for 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 (or 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 (Table 6).

Similarly, we explore a mechanism which can explain the negative impact of unplanned caesarean deliveries on mothers' mental health, namely the difference between what women may expect or imagine to be the delivery and their actual experience. It may be that women who had previous pregnancies (regardless of the mode of delivery) have more information on the delivery process and, as a result, their expectations are more similar to the reality they experience. If this is the case, the psychological impact of having an unplanned caesarean would be smaller than the impact for women with no previous experience. However, when we test this hypothesis by splitting the sample by parity, we find no evidence of differences in the impact of unplanned caesarean deliveries. This may imply that having an unplanned caesarean delivery carries a lot of stress, regardless of the previous delivery experience.

6 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 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 post-traumatic distress and 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 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 mothers' everyday life and their ability to take care of their children. Because mothers are usually the main childcare givers, poor mother's 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 contributes also to explain 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, which opens the door to future research in this area, relates to the data used to shed light on this phenomenon. A longitudinal administrative dataset with detailed information on mothers' previous pregnancy experiences and their health conditions before and after the pregnancy would allow to identify 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 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 depression 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.

Another aspect left for the future is the extension of this study to elective caesarean deliveries. 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 more difficult their post-partum recovery. 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 to provide 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: Mother and child characteristics by mode of delivery

	Full sample	Natural delivery	Unplanned CS	Statistical difference
Breech position	0.053	0.032	0.185	***
Pre-eclampsia	0.072	0.061	0.144	***
Mother's age	28.10	27.92	29.20	***
Married	0.577	0.572	0.606	**
Household income (thousands)	15.37	15.03	17.48	***
No qualification	0.154	0.160	0.120	***
GCSE/O-level (or eq.)	0.394	0.398	0.367	**
A-level or higher (but no uni)	0.153	0.153	0.151	
University qualification	0.299	0.288	0.362	***
White	0.871	0.873	0.860	
Smoker (before pregnancy)	0.363	0.366	0.347	
BMI (before pregnancy)	23.59	23.43	24.57	***
Parity	0.443	0.411	0.644	***
Planned pregnancy	0.542	0.537	0.575	**
Hospitalisation (during pregnancy)	0.182	0.169	0.260	***
Employed (during pregnancy)	0.653	0.637	0.748	***
Diabetes	0.019	0.016	0.035	***
Hypertension	0.004	0.003	0.011	***
Kidney diseases	0.009	0.009	0.011	
Gestational age	39.69	39.793	39.043	***
Underweight baby	0.065	0.050	0.160	***
Overweight baby	0.121	0.114	0.161	***
Postpartum depression	0.345	0.341	0.370	*
No. Observation	14,221	12,249	1,972	

Notes. The table reports the mean of the variables employed in the analysis for the full sample and by mode of delivery (natural delivery and unplanned caesarean delivery). 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 * $p<0.10$. Data source: UK Millennium Cohort Study, sweep 1.

Table 2: Linear probability models (LPM) and hospital FE results

	Postnatal depression			
	LPM	LPM	LPM	Hospital FE
	(1)	(2)	(3)	(4)
Unplanned CS	0.046***	0.041***	0.030**	0.031***
	(0.011)	(0.011)	(0.012)	(0.012)
No. observations	14,221	14,221	14,221	14,221
Socio-economic variables	✓	✓	✓	✓
Pregnancy variables		✓	✓	✓
Mother's health variables	✓	✓	✓	✓
Child's health variables			✓	✓

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. Socio-economic variables include mother's age, ethnicity, marital status and household income. Pregnancy variables include parity and planned pregnancy. Mother's health include BMI, whether she was a smoker, employment status and hospitalisation during pregnancy, whether she ever suffered from diabetes, hypertension and kidney diseases. Child's health at birth include birth weight and gestational age.
Data source: UK Millennium Cohort Study, sweep 1.

Table 3: Linear Instrumental Variable (IV) models

Postnatal depression				
	IV: Breech position		IV: Breech position & Pre-eclampsia	
	without FE	with FE	without FE	with FE
	(1)	(2)	(3)	(4)
First stage				
Breech position	0.316***	0.320***	0.317***	0.321***
	(0.018)	(0.017)	(0.018)	(0.017)
Pre-eclampsia			0.077***	0.081***
			(0.016)	(0.016)
Second stage				
Unplanned CS	0.186***	0.153***	0.187***	0.152***
	(0.050)	(0.049)	(0.049)	(0.049)
No. observations	14,221	14,189	14,221	14,189
Post-estimation tests				
F-test (first stage)	324.1	337.7	178.0	178.0
Weak identification test	324.1>16.38	337.7>16.38	178.0>19.93	178.0>19.93
Endogeneity test of CS[a] (p-value)	0.0017	0.0135	0.0014	0.0125
Sargan Hansen test (p-value)	-	-	0.9829	0.9631

Notes. Robust standard errors clustered at hospital level in parentheses. Linear IV models. *** p<0.01, ** p<0.05 and * p<0.10. All model specifications include information on socio-economic status, pregnancy, mother's health and baby's health as in column (3) of Table 2. Column (2) and (4) include hospital fixed effects (FE).

For the weak identification test we report Stock-Yogo critical values in case of one or two exclusion restrictions, allowing for 10% of IV maximum distortion with respect to OLS.

a: Under the null hypothesis of exogeneity, the statistic is distributed as a chi-squared with 1 degree of freedom.

Data source: UK Millennium Cohort Study, sweep 1.

Table 4: Linear IV models and bivariate models

	Postnatal depression			
	IV: Breech position		IV: Breech position & Pre-eclampsia	
	Linear IV model	Bivariate model	Linear IV model	Bivariate model
	(1)	(2)	(3)	(4)
Estimated coefficients				
Unplanned CS	0.186***	0.328***	0.187***	0.326***
	(0.050)	(0.125)	(0.049)	(0.119)
Marginal effects[a]				
Unplanned CS	0.186***	0.116***	0.187***	0.115***
	(0.050)	(0.044)	(0.049)	(0.042)
No. observations	14,221	14,221	14,221	14,221

Notes. Standard errors in parentheses. Linear IV models and bivariate probit models. *** p<0.01, ** p<0.05 and * p<0.10. All model specifications include information on socio-economic status, pregnancy, mother's health and baby's health as in column (3) of Table 2. Average marginal effects estimated with the Stata command margins. Delta-method standard errors. Data source: UK Millennium Cohort Study, sweep 1.

Table 5: Linear IV models excluding baby measures

	Postnatal depression			
	IV: Breech position		IV: Breech position & Pre-eclampsia	
	without FE	with FE	without FE	with FE
	(1)	(2)	(3)	(4)
First stage				
Breech position	0.328***	0.332***	0.329***	0.332***
	(0.018)	(0.018)	(0.018)	(0.018)
Pre-eclampsia			0.086***	0.089***
			(0.016)	(0.016)
Second stage				
Unplanned CS	0.193***	0.161***	0.196***	0.162***
	(0.047)	(0.047)	(0.047)	(0.047)
No. observations	14,221	14,189	14,221	14,189
Post-estimation tests				
F-test (first stage)	335.3	347.8	184.5	190.5
Weak identification test	335.3>16.38	347.8>16.38	184.5>19.93	190.5>19.93
Endogeneity test of CS[a] (p-value)	0.0015	0.0120	0.0010	0.0098
Sargan test	-	-	0.8735	0.9230

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

All model specifications include information on socio-economic status, pregnancy and mother's health as in column (2) of Table 2. Column (2) and (4) include hospital fixed effects (FE).

For the weak identification test we report Stock-Yogo critical values in case of one or two exclusion restrictions, allowing for 10% of IV maximum distortion with respect to OLS.

a: Under the null hypothesis of exogeneity, the statistic is distributed as a chi-squared with 1 degree of freedom.

Data source: UK Millennium Cohort Study, sweep 1.

Table 6: Linear IV models by mother's education and by parity

	Postnatal depression	
	IV: Baby's position with FE (1)	IV: Baby's position & Eclampsia with FE (2)
Heterogeneity by mother's education		
High educated mothers	0.137	0.138
	(0.093)	(0.086)
Low educated mothers	0.126*	0.125*
	(0.073)	(0.073)
Heterogeneity by parity		
Mothers at first pregnancy	0.145**	0.139**
	(0.062)	(0.067)
Mothers with previous pregnancy experiences	0.143*	0.147*
	(0.085)	(0.082)
No. observations	14,189	14,189

Notes. Robust standard errors clustered at hospital level in parentheses. Effect of having an unplanned CS on postnatal depression estimated using linear IV models with hospital fixed effects. *** $p<0.01$, ** $p<0.05$ and * $p<0.10$.
All model specifications include information on socio-economic status, pregnancy and mother's health as in column (3) of Table 2. Data source: UK Millennium Cohort Study, sweep 1.

Appendix

Table A1: Probit model

	Postnatal depression
Unplanned CS	0.030**
	(0.012)
Mother's age	-0.000
	(0.001)
Married	-0.036***
	(0.010)
Household income	-0.004***
	(0.001)
GCSE/O-level (or eq.)	0.019
	(0.015)
A level or more but not uni	0.012
	(0.016)
University qualification	0.011
	(0.019)
White	-0.008
	(0.014)
Smoker	0.085***
	(0.009)
BMI	-0.001
	(0.005)
BMI (sq.)	0.000
	(0.000)
Parity	-0.026***
	(0.010)
Planned pregnancy	-0.035***
	(0.008)
Hospitalisation	0.085***
	(0.010)
Employed	-0.032***
	(0.010)
Diabetes	-0.011
	(0.028)
Hypertension	0.005
	(0.060)
Kidney diseases	0.069*
	(0.037)
Underweight baby	0.034*
	(0.018)
Overweight baby	-0.025*
	(0.014)
Gestational age	-0.101***
	(0.029)
Gestational age (sq.)	0.001***
	(0.000)
No. observation	14,221

Notes. Average marginal effects from probity model, computed with Stata command, margin. *** p<0.01, ** p<0.05 and * p<0.10. Data source: UK Millennium Cohort Study, sweep 1.

Table A2: OLS and hospital FE results - full set of estimates

	Postnatal depression			
	LPM	LPM	LPM	Hospital FE
	(1)	(2)	(3)	(4)
Unplanned CS	0.046***	0.041***	0.030**	0.031***
	(0.011)	(0.011)	(0.012)	(0.012)
Mother's age	-0.000	-0.000	-0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Married	-0.068***	-0.038***	-0.038***	-0.039***
	(0.009)	(0.010)	(0.010)	(0.010)
Household income	-0.005***	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
GCSE/O-level(or eq)	-0.004	0.016	0.018	0.019
	(0.016)	(0.016)	(0.015)	(0.015)
A level or more but no uni	-0.026	0.008	0.011	0.011
	(0.018)	(0.017)	(0.017)	(0.016)
University qualification	-0.033*	0.008	0.011	0.012
	(0.020)	(0.019)	(0.019)	(0.018)
White	0.007	-0.012	-0.007	-0.010
	(0.015)	(0.014)	(0.014)	(0.018)
Parity		-0.026***	-0.027***	-0.027***
		(0.010)	(0.010)	(0.010)
Planned pregnancy		-0.037***	-0.035***	-0.035***
		(0.008)	(0.008)	(0.008)
Smoker		0.091***	0.088***	0.084***
		(0.010)	(0.010)	(0.010)
BMI		-0.004	-0.002	-0.003
		(0.006)	(0.006)	(0.006)
BMI (sq.)		0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
Hospitalisation		0.097***	0.089***	0.086***
		(0.010)	(0.010)	(0.010)
Employed		-0.036***	-0.035***	-0.034***
		(0.010)	(0.010)	(0.010)
Diabetes		-0.011	-0.011	-0.013
		(0.029)	(0.028)	(0.028)
Hypertension		0.019	0.004	0.001
		(0.064)	(0.064)	(0.064)
Kidney diseases		0.078*	0.072*	0.068*
		(0.040)	(0.040)	(0.039)
Overweight baby			-0.025*	-0.029**
			(0.013)	(0.014)
Underweight baby			0.036*	0.035*
			(0.019)	(0.020)
Gestational age			-0.109***	-0.104***
			(0.029)	(0.030)
Gestational age (sq.)			0.001***	0.001***
			(0.000)	(0.000)
Constant	0.471***	0.449***	2.585***	2.504***
	(0.025)	(0.076)	(0.555)	(0.569)
No. Observations	14,221	14,221	14,221	14,221

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.
Data source: UK Millennium Cohort Study, sweep 1.

Table A3: Linear IV models: first stage results

Probability of giving birth through an unplanned CS				
	IV: Breech position		IV: Breech position & Pre-eclampsia	
	without FE	with FE	without FE	with FE
	(1)	(2)	(3)	(4)
Breech position	0.316***	0.320***	0.317***	0.321***
	(0.018)	(0.017)	(0.018)	(0.017)
Pre-eclampsia			0.077***	0.081***
			(0.016)	(0.016)
Mother's age	0.007***	0.007***	0.007***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
Married	0.000	0.003	-0.000	0.002
	(0.007)	(0.007)	(0.007)	(0.007)
Household income	0.001	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
GCSE/O-level(or eq)	0.001	0.002	0.000	0.001
	(0.008)	(0.008)	(0.008)	(0.008)
A level or more but no uni	-0.006	-0.006	-0.007	-0.007
	(0.010)	(0.010)	(0.010)	(0.010)
University qualification	0.000	-0.001	-0.000	-0.001
	(0.011)	(0.011)	(0.011)	(0.011)
White	-0.035***	-0.029**	-0.037***	-0.031**
	(0.009)	(0.014)	(0.009)	(0.014)
Smoker	0.020***	0.020***	0.021***	0.021***
	(0.007)	(0.007)	(0.007)	(0.007)
Parity	0.129***	0.128***	0.126***	0.125***
	(0.007)	(0.007)	(0.007)	(0.007)
Planned pregnancy	-0.002	-0.002	-0.002	-0.001
	(0.006)	(0.006)	(0.006)	(0.006)
BMI	0.006	0.006	0.005	0.006
	(0.005)	(0.005)	(0.005)	(0.005)
BMI (sq.)	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Hospitalisation	0.041***	0.038***	0.021**	0.018*
	(0.009)	(0.009)	(0.009)	(0.009)
Employed	0.004	0.005	0.004	0.004
	(0.006)	(0.006)	(0.006)	(0.006)
Diabetes	0.067***	0.066**	0.067***	0.066***
	(0.026)	(0.025)	(0.025)	(0.025)
Hypertension	0.122**	0.118**	0.081	0.076
	(0.052)	(0.052)	(0.052)	(0.053)
Kidney diseases	-0.016	-0.018	-0.016	-0.017
	(0.030)	(0.030)	(0.030)	(0.030)
Underweight baby	0.138***	0.140***	0.136***	0.138***
	(0.017)	(0.017)	(0.017)	(0.017)
Overweight baby	0.071***	0.072***	0.071***	0.072***
	(0.009)	(0.009)	(0.009)	(0.009)
Gestational age	-0.138***	-0.130***	-0.141***	-0.133***
	(0.034)	(0.035)	(0.034)	(0.034)
Gestational age (sq.)	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.543***		2.596***	
	(0.660)		(0.655)	
No. Observations	14,221	14,189	14,221	14,189

Notes. Robust standard errors clustered at hospital level in parentheses. Linear IV models, first stages. *** p<0.01, ** p<0.05 and * p<0.10. Data source: UK Millennium Cohort Study, sweep 1.

Table A4: Linear IV models: second stage results

	Postnatal depression			
	IV: Breech position		IV: Breech position & Pre-eclampsia	
	without FE	with FE	without FE	with FE
	(1)	(2)	(3)	(4)
Unplanned CS	0.186***	0.153***	0.187***	0.152***
	(0.050)	(0.049)	(0.049)	(0.049)
Mother's age	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Married	-0.038***	-0.039***	-0.038***	-0.039***
	(0.010)	(0.010)	(0.010)	(0.010)
Household income	-0.003***	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
GCSE/O-level(or eq)	0.018	0.019	0.018	0.019
	(0.015)	(0.015)	(0.015)	(0.015)
A level or more but no uni	0.012	0.012	0.012	0.012
	(0.017)	(0.016)	(0.017)	(0.016)
University qualification	0.011	0.012	0.011	0.012
	(0.019)	(0.018)	(0.019)	(0.018)
White	-0.003	-0.007	-0.003	-0.007
	(0.015)	(0.017)	(0.015)	(0.017)
Smoker	0.085***	0.082***	0.085***	0.082***
	(0.010)	(0.010)	(0.010)	(0.010)
Parity	-0.049***	-0.044***	-0.049***	-0.044***
	(0.012)	(0.012)	(0.013)	(0.013)
Planned pregnancy	-0.035***	-0.035***	-0.035***	-0.035***
	(0.008)	(0.008)	(0.008)	(0.008)
BMI	-0.003	-0.004	-0.003	-0.004
	(0.006)	(0.006)	(0.006)	(0.006)
BMI sq.	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Hospitalisation 0.082***	0.081***	0.082***	0.081***	
	(0.010)	(0.010)	(0.010)	(0.010)
Employed	-0.036***	-0.035***	-0.036***	-0.035***
	(0.010)	(0.010)	(0.010)	(0.010)
Diabities	-0.022	-0.021	-0.022	-0.021
	(0.029)	(0.029)	(0.029)	(0.029)
Hypertension	-0.016	-0.015	-0.016	-0.014
	(0.066)	(0.066)	(0.065)	(0.065)
Kidney diseases	0.074*	0.069*	0.074*	0.069*
	(0.040)	(0.039)	(0.040)	(0.039)
Underweight baby	0.014	0.018	0.014	0.018
	(0.021)	(0.021)	(0.021)	(0.021)
Overweight baby	-0.037***	-0.038***	-0.037***	-0.038***
	(0.013)	(0.014)	(0.013)	(0.013)
Gestational age	-0.085***	-0.086***	-0.085***	-0.087***
	(0.031)	(0.032)	(0.031)	(0.032)
Gestational age (sq.)	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.148***		2.147***	
	(0.592)		(0.593)	
No. Observations	14,221	14,189	14,221	14,189

Notes. Robust standard errors clustered at hospital level in parentheses. Linear IV models. *** p<0.01, ** p<0.05 and * p<0.10. Data source: UK Millennium Cohort Study, sweep 1.