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Food for Thought? Breastfeeding and Child Development

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Abstract

We show that children who are born at the weekend or just before are less likely to be breastfed, owing to poorer breastfeeding support services at weekends. We use this variation to estimate the effect of breastfeeding on children's development for a sample of uncomplicated births from low educated mothers. We find that breastfeeding has large effects on children's cognitive development, but not on non-cognitive development or health. Regarding mechanisms, we estimate how breastfeeding affects parental investments in the child and the quality of the mother-child relationship.

JEL classification: I14, I18, J13

Keywords: Breastfeeding; timing of birth; hospital support; instrumental variables; optimal instruments; cognitive and non-cognitive development; health.

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1. Introduction

There is little doubt that conditions in early childhood can have long-lasting effects on human capital, reinforcing the intergenerational transmission of wealth as well as human capital (see Almond and Currie 2011a and 2011b; Black and Devereux 2011; Case, Lubotsky and Paxson 2002; Cunha and Heckman 2007; Cunha, Heckman and Schennach 2010). However, much less is known about the key contributors to the intergenerational gap. Breastfeeding has the potential to play a key role both because of claims regarding its beneficial effects on child development and its stark socioeconomic gradient - 48% (53%) of college graduates in the UK (US) breastfeed at 6 months, compared to 13% (32%) of those with less than high school education. However, with the exception of one randomized controlled trial (Kramer et al. 2001, 2008), most of the claims about breastfeeding's beneficial effects on child development come from observational studies. The challenge is to define an empirical strategy that provides credible causal evidence, thus helping to understand its role in child development.

This paper estimates the causal effects of breastfeeding on child development at various ages up to age 7. To do so, it exploits the authors' observation that, in the UK, the timing of birth affects breastfeeding. In particular, breastfeeding rates are lower amongst mothers who give birth just before or early into the weekend. We argue that this is because the provision of infant feeding support in UK hospitals is lower at weekends than during the week. Without early hands-on support at the hospital, it is more difficult for successful breastfeeding to be established. Timing of delivery provides a source of exogenous variation that we use as an instrumental variable for breastfeeding. In focusing on exogenous shifts in breastfeeding support, our identification strategy shares common ground with the only randomized controlled trial in lactation, Kramer et al. (2001, 2008), which randomizes health care worker assistance for initiating breastfeeding and for post-natal breastfeeding support. So both the estimates of Kramer et al. (2001, 2008) and the ones in this paper relate to the returns to increasing breastfeeding through increasing the support that "marginal" mothers receive at hospital.

Our estimates, based on the UK Millennium Cohort Study, show that breastfeeding has large positive effects on cognitive development, of around 0.6 of a standard deviation. We detect no evidence of any benefits for health, though we note that health is measured for the first time at 9 months and so we cannot say if there are immediate/short-lived effects during early breastfeeding. Our estimates are robust to alternative sample selections and the inclusion or exclusion of hospital fixed effects. Whilst the effects on cognition are large, they are around half the size of estimates from the well-known randomized controlled trial of Kramer et al. (2008) in Belarus, and the 10-year follow-up of a randomized controlled trial of specially supplemented formula milk (Isaacs et al. 2011). Also consistent with our results, Kramer et al. (2001) find only weak effects on health.

A number of features of the UK health system contribute to the validity of our empirical strategy because they limit the ability of women to choose when they deliver. First, 98% of births are in public hospitals, which conform to guidelines of the National Institute of Clinical Excellence (NICE).[3] These guidelines allow for planned Caesarean sections (C-section) or labor inductions only if there are medically indicated reasons for them, as detailed in section 3. Second, expectant women do not have a pre-assigned midwife or obstetrician who is expected to be present at delivery, alleviating concerns that health care professionals schedule the delivery at convenient times (non-randomly). Both of these features are unlike the US, which are more flexible regarding elective C-sections and inductions (ACOG 2003, 2009) and where 50% of deliveries are covered by private insurance, rendering competition, choice and selection much more important.

Another important factor contributing to the validity of our empirical strategy concerns the availability and variability of core hospital services. We focus on “normal” deliveries - excluding C-sections and children who were placed in intensive care - for which post-natal hospital care is relatively straightforward and focused on maternal health, infant feeding and maintaining infant health (NICE Guidelines, 2006). We show that a comprehensive set of hospital services relating to labor and delivery do not differ by timing of birth. Furthermore, the finding that breastfeeding affects cognition but not health reinforces the claim that hospital services do not differ by timing of birth.

There is a vast literature on the importance of the early years for later outcomes (see Almond and Currie 2011a; Cunha and Heckman 2007; Cunha, Heckman and Schennach 2010). Our paper makes an important contribution to at least four strands of this literature. The first relates to the importance of hospitals and maternity care for later outcomes. Two studies

[3] NICE was set up in 1999 to reduce variation in the availability and quality of the National Health Service (NHS) treatments and care. It provides evidence-based guidance to resolve uncertainty about which medicines, treatments, procedures and devices represent the best quality care and the best value for money for the NHS.

consider the effects of medical treatments at birth for very low birth weight newborns, finding lower one-year mortality rates (Almond, Mazumder and van Ewijk 2011) and higher school test scores and grades (Bharadwaj, Loken and Nielson 2013). Other studies consider the length of hospital stay post-partum, finding no impacts on health (Almond and Doyle 2011), and the effects of improved hospital post-neonatal mortality rates and access to hospitals for blacks in the 1960s/70s, finding improvements in their academic and cognitive skills as teenagers (Chay, Guryan and Mazumder 2009). In contrast, we focus not on medical care but on maternal care in the form of breastfeeding. Moreover, our results are applicable to healthy newborns and not just to those with particular health risks.

A second contribution is to the literature on the optimal timing of interventions in the early years. We show that though breastfeeding is not a form of medical care, hospital policy - specifically, breastfeeding support - can influence it significantly. Given the evidence we provide on its importance for cognitive development, this raises the question as to how and when policy to increase breastfeeding rates should be targeted. Rather than focusing solely on the provision of infant feeding support in maternity wards, a more integrated approach to providing information on breastfeeding to expectant women would, in underpinning subsequent hospital support, be likely to be more effective. In this respect, our paper supports the view that pre-natal interventions are important (Almond and Currie 2011a, 2011b).

Third, our findings contribute to the literature that explores the pathways to improved long-term outcomes. Milligan and Stabile (2008) find that early cash transfers increase children's test scores, without improving health. This is consistent with Field, Robles and Torero (2009) who find that iodine supplementation in pregnancy increases schooling by a year and a half despite not improving health. This evidence suggests that improving health is not a prerequisite to improving cognition in the early years.[4] Our paper reinforces this by showing that cognitive development can increase considerably without commensurate improvements in health.

Finally, our paper contributes to understanding the importance of nutrition for later outcomes. Whilst links between nutrition and development have been documented, much of the

[4] Similarly, Currie (2009) finds that early health improves educational outcomes through the effect of early health on later health, rather than through a direct effect of early health on education (such as through improved cognition).

literature focuses on developing countries and/or on extreme shocks such as famines, making it difficult to extrapolate to everyday circumstances in developed countries.[5] The few studies in developed countries that consider the effects of margins more responsive to policy, point towards a positive effect of nutrition on later outcomes. For instance Dahl and Lochner (2005) and Milligan and Stabile (2008) find that increased economic resources *in utero* improve children's later cognition, most likely due to improved early nutrition. Hoynes, Schanzenbach and Almond (2012) find improvements of expanded nutritional resources *in utero* and in early childhood on adult health. Consistent with these studies, our findings suggest that the nutritional value of breast milk is a key factor in its importance for cognition.

The rest of the paper is as follows. Section 2 provides an overview of relevant background and of the literature specific to breastfeeding; in section 3 we discuss the institutional setting and in section 4 the data that we use. Section 5 discusses the identification strategy. Section 6 deals with estimation and section 7 presents the main results of the paper. Section 8 provides robustness tests and the paper is concluded in section 9. Note that throughout the paper, we also make extensive use of appendices, to provide more in-depth analysis of particular issues.

2. Background

In this section, we provide a brief discussion of the potential channels through which breastfeeding might improve child development, as well as an overview of some of the related literature.

2.1 Mechanisms

The literature has emphasized two main mechanisms with the potential to explain the effect of breastfeeding on child development: the first relates to the compositional superiority of breast milk over formula milk owing to the presence of particular fatty acids, and the second relates to mother-child interaction.

[5] For studies in developing countries see Maluccio et al.(2009), Martorell et al. (2010), Barham (2012), Maccini and Yang (2009), Field, Robles and Torero (2009), Behrman and Rosenzweig (2004), Barham, Macours and Maluccio (2013), Glewwe and King (2001). For studies on effects of exposure to extreme conditions such as famine on later outcomes such as test scores, employment and life expectancy see Almond et al.(2007), Scholte, Van der Berg and Lindeboom (2012) and Lindeboom, Portrait and Van der Berg (2010) and Ampaabeng and Min Tang (2012), Almond (2006) and Kelly (2009). Almond, Mazumder and Reyn van Ewijk (2011) find lower test scores for Pakistani and Bangladeshi students exposed to Ramadan in early pregnancy in England. Almond and Mazumder (2011) find that observance of fasting on Ramadan has long-term health effects.

The compositional superiority of breast milk over formula milk is mainly due to the presence of two long-chain polyunsaturated fatty acids, Docosahexaenoic Acid (DHA) and Arachidonic Acid (AA). Around one half of the brain is made up of lipid, much of which is DHA and AA (Grantham-McGregor et al. 1999; Gerber 2013). They are major parts of the neuron membranes, which are the core components of the nervous system, and their content affects membrane fluidity and the functioning of various membrane-associated proteins such as transporters, enzymes and receptors (Fernstrom 1999).

During the first year of life, infants require large quantities of DHA and AA for brain development (Clandinin et al. 1981). DHA and AA are naturally present in breast milk and are easily absorbed due to the particular triglyceride structure of breast milk. Since late 2001, most formula milks are supplemented with synthetic forms of DHA and AA. Though there is evidence from one randomized trial that the supplementation of formula milk with DHA increased IQ by 70% SD in pre-term non-breastfed babies (Isaacs et al. 2011), concerns remain regarding the absorption properties of synthetic DHA and AA (Clandinin et al. 1989).[6] Moreover, the majority of the children in our sample were not exposed to this supplemented formula.[7] Instead, the available formula milk required infants to produce DHA and AA from other components of the milk. This synthesis requires sufficient enzyme capacity, which young infants generally do not have (Uauy and Andraca 1995, Koletzko et al. 2008), resulting in lower absorption of DHA and AA from formula than from breast milk.

The second mechanism through which breast milk may be more beneficial for children's development than formula milk is due to increased mother-child interaction. First, breastfeeding increases skin-to-skin contact which might promote secure attachment (Britton et al. 2006). Second, breastfeeding triggers beneficial hormonal responses in mothers, potentially reducing stress and depression which might improve quality of care (Reynolds 2001; Uauy and Peirano 1999). Third, breastfeeding involves direct physical contact and

[6] A number of randomized controlled trials on the effect of DHA formula milk supplementation (blinded to mothers) on both cognition and visual function are inconclusive (Schulzke, Patole and Simmer 1996) but they are restricted to children below the age of 4 (and mostly below 2) for whom measurement of cognition is much more challenging. Isaacs et al. (2011) is the only one to consider older children. However the sample sizes of these studies are small (around 100 infants).

[7] On the basis of our analysis of market reports and advertisements in midwifery journals, one of the two largest producers of infant formula milk in the UK started DHA and AA supplementation only in August 2001, while the second largest producer started in 2002. Only 11% of children in our estimating sample were born in August 2001 or later.

interaction with the mother on a regular basis every day, which may stimulate cognitive development. However, it is also plausible to expect that the majority of bottle feeding is done by the mother. We will explore these mechanisms in greater detail in section 7.

2.2 Related Literature on Breastfeeding

There is just one study that uses experimental variation to identify the effects of breastfeeding on children's outcomes, that of Kramer et al. (2001). The intervention, the Promotion of Breastfeeding Intervention Trial (PROBIT) is based on the Baby Friendly Hospital Initiative (WHO, UNICEF). It provided health care worker assistance for initiating and maintaining breastfeeding, randomly across 31 hospitals in Belarus in the late 1990s. The effects on health - both in the first 12 months of life and the medium-term - are weak or non-existent (Kramer et al. 2001; 2007; 2009). On the other hand, there are very large effects, of one standard deviation or higher, on cognition at age 6.5 years (Kramer et al. 2008).[8]

Other studies that consider the relationship between breastfeeding and children's outcomes are observational and use different methods to control for selection bias - propensity score matching (Borra, Iacovou and Sevilla 2012; Rothstein 2013; Quigley et al. 2012; Belfield and Kelly 2010), mother fixed effects (Evenhouse and Reilly 2005; Der, Batty and Deary 2006), and instrumental variables (Baker and Milligan 2008 and 2010; Del Bono and Rabe 2012). The general consensus is that there is a small and significant positive association between breastfeeding and cognitive development, with often insignificant associations between breastfeeding and non-cognitive development and health.

3. Institutional Background

In this section we describe maternity care in the UK, which is notably different from the US system. The UK National Health Service (NHS) is a publicly funded, and by and large also publicly run, health care system. In 2000, which is the time the majority of our sample were born, 97.5% of deliveries occurred in NHS hospitals, 2% were home births, and only 0.5% were privately funded. Hospital choice is non-existent in practice and based on geo-

[8] They only report intention-to-treat estimates. The effect of one standard deviation on cognition is based on the authors' computations of the Wald estimator based on the data that they report for three months of exclusive breastfeeding.

proximity.[9] Moreover, expectant mothers register at the hospital at around 12 weeks of pregnancy and maternity records are kept there, which is where she ultimately delivers, dispelling any concerns that mothers choose hospitals depending on the day of onset of labor.

Unlike the US, most births in the UK are attended by midwives (70% in 1999) instead of obstetricians, who are usually only called upon only when an instrumental delivery or surgical birth is required. When women arrive to hospital to deliver, they are allocated one of the midwives available at the time of admission. Women do not have a pre-assigned obstetrician or midwife who might want to schedule the delivery at a convenient time.

Regarding delivery type, planned Caesarean sections and labor inductions are permitted only if there are medically indicated reasons for them, not at the request of the mother. For planned C-sections, at least one of the following medical conditions must be present: breech presentation, placenta praevia, HIV positive mother (2004 NICE Clinical Guidelines on Caesarean Section). Maternal request is not an indication for C-section and an individual clinician has the right to decline a request for C-section in the absence of an identifiable medical reason (this has changed in the most recent 2011 clinical guidelines). The 2001 NICE Clinical Guidelines on Induction of Labor specify that women should be offered a labor induction in the following situations: prolonged pregnancy (41 weeks or more), pregnancy complicated by diabetes, and pre-labor rupture of the membranes. In cases of uncomplicated pregnancies, induction of labor prior to 41 weeks gestation should be considered if (1) resources allow, (2) the woman has a favourable cervix and (3) there are compelling psychological or social reasons

The core care provided during the post-natal period centres on maternal health, infant feeding and maintaining infant health (NICE, 2006). For the newborn, care is relatively straightforward and involves a complete physical examination before discharge; all parents are offered vitamin K prophylaxis for their babies; advice is offered to parents on signs of jaundice, thrush, constipation and diarrhoea, care of the newborn's skin and nappy rash is also discussed. Regarding infant feeding, initiation of breastfeeding is encouraged as soon as

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[9] The Choice and Book system that introduced hospital choice to NHS patients started in 2005. Its precursor, the London Patient Choice Project, only started in October 2002.

possible after delivery, ideally within 1 hour, and continued support is provided thereafter.[10] After discharge, post-natal care is transferred to a community midwife/health worker who makes home visits in the early days.

4. Data

The main data used is the Millennium Cohort Study (MCS), a rich longitudinal study covering the four countries of the UK and which follows nearly 18,500 babies born at the beginning of the noughties.[11] We use data from each of the surveys conducted up to 7 years of age (9 months (2000/2001), 3 years (2004/05), 5 years (2006), 7 years (2008)). In our sample selection, we drop multiple births, those who were not born in a hospital and those born in Northern Ireland. To limit the potential for hospital confounders, and as explained more fully in section 5, we also drop children born through Caesarean sections and those that were placed in intensive care after delivery.

As part of the MCS, age-appropriate tests - the Bracken School Readiness and British Ability Scales - were administered by trained interviewers to children (at ages 3 and ages 3,5,7 respectively), offering a distinct advantage over parental-reported measures (Fernald et al. 2009). Children's behavioural (non-cognitive) development was measured using the Strengths and Difficulties Questionnaire (SDQ), a validated behavioural screening tool (ages 3,5,7). Children's health includes maternal-reported measures of morbidity and chronic conditions (ages 9 months, 3,5,7 years). Details on the measures are provided in Appendix I.

Within the above developmental domains - cognitive skills, non-cognitive skills and health - we aggregate multiple measures within and across ages into a summary index, following Anderson (2008). In this way, our results provide a statistical test for whether breastfeeding has a "general effect" on development which is robust to concerns about multiple inference (Hoynes, Schazenbach and Almond 2012; Kling et al. 2007; Liebman et al. 2004), that is, concerns that one null hypothesis is rejected simply because we have tested many null hypotheses. To create summary indices for cognition, we combine cognitive scores at age 3 (expressive language and school readiness), age 5 (expressive language, pictorial reasoning,

[10] Regarding maternal health, information is provided as to signs and symptoms of potentially life-threatening conditions such as postpartum haemorrhage or pre-eclampsia; other less urgent issues include the monitoring of urinary retention and the provision of advice on perineal care.

[11] Born between 1 September 2000 and 31 August 2001 in England and Wales, and between 22 November 2000 and 11 January 2002 in Scotland and Northern Ireland.

visuo-spatial) and age 7 (numerical, verbal and visuo-spatial) into a single cognitive index.[12] The index is a weighted mean of the standardized scores of each test, with the weights calculated to maximize the amount of information captured in the index by giving less weight to outcomes that are highly correlated with each other. For non-cognitive outcomes, we combine the standardized scores of the strength and difficulties test at ages 3, 5 and 7. For health, we combine 7 health indicators measured at each wave (including asthma, hayfever, eczema, wheezing, ear infections (age 3 only), obesity, long-standing health conditions).

Breastfeeding duration is measured using information on how old the child was when (s)he last had breast milk. So the measure relates to any breastfeeding, regardless of exclusivity.[13] Figure 1 shows spikes in the number of babies breastfed at discrete points in time - (at least) 30 days, 60 days and 90 days, with the largest spike at 90 days. So our measure of breastfeeding takes the value one if the infant was breastfed for at least 90 days, and zero otherwise. Note the recommendation in the UK at the time was to breastfeed exclusively for at least 16 weeks, or 112 days. However, if we took the cut-off to be 112 days, we would allocate zero to those who were breastfed for 90 days, which seems to be the more relevant empirical threshold.

[FIGURE 1 HERE]

5. Identification Strategy

In this section, we discuss five key components of our identification strategy. First, we discuss the importance of providing early, hands-on support to mothers to establish successful breastfeeding. Second, we show how differences in support, induced by timing of birth, affect breastfeeding. Third, we show that timing of birth is uncorrelated with a wide range of maternal characteristics, and fourth with labor and delivery and post-natal maternity services received. Finally, we provide graphical evidence on the relationship between timing of delivery and breastfeeding, as well as between timing of delivery and child development, which precedes the following sections where a more formal analysis is conducted.

[12] Note that like Anderson (2008) and Kling et al. (2007), the number of tests contributing to the index need not be constant across individuals. This means that we can still create the index even for individuals who attrit/have some missing test measures, an issue we return to in section 8.1.

[13] The MCS does not contain enough information to define exclusive breastfeeding because it does not ask mothers about the baby’s intake of water. According to another data source in the same year (2000 Infant Feeding Survey) the vast majority of babies who were breastfeed at 90 days were being exclusively breastfed.

5.1 Breastfeeding support matters

At the heart of our identification strategy is the fact that the support provided by hospital staff is crucial for successful breastfeeding. This is for two key reasons: (1) successful breastfeeding requires a sequence of quick yet skilful and coordinated movements by the mother, the majority of whom need to be guided and supported in their attempts several times before they master it. For instance, the mother needs to pull her baby towards her with pressure on the back - not on the baby's head - after she has stimulated the baby to open his/her mouth wide using various learned techniques. The pull must be done very quickly so that the mouth remains wide open and the nipple is positioned in the correct part of the baby's mouth. (2) If this sequence is not done correctly, serious damage to the nipples can easily occur right from the beginning, resulting in a very painful experience for the mother (including mastitis). Despite the nipples being damaged, the mother must still continue to breastfeed or else the milk supply ceases within a few days. If problems continue with the latch, damage to the nipples worsens. Eventually, the mother stops breastfeeding. A recent UNICEF report claims that "It is clear that putting resources into supporting women to breastfeed successfully would be hugely cost effective to the NHS, as well as preventing the distress and pain felt by a mother who has a bad experience of breastfeeding." (UNICEF 2012).

Many studies highlight the importance of hospital support and policies and procedures in the early post-partum as key determinants of breastfeeding success - for instance, skin-to-skin contact straight after birth (Renfrew et al. 2009; Bolling et al. 2005); increased "Baby-Friendly" hospital practices, and other maternity-care practices (Di Girolamo et al. 2008; Merten et al. 2005; Del Bono and Rabe 2012); whether or not formula milk was administered in hospital (McAllister et al. 2009); individualised breastfeeding support and consistency (Backstrom et al. 2010); extra professional support (Sikorski et al. 2002).

5.2 Breastfeeding support varies by timing of birth

At the time our sample of children was born, infant feeding support was provided by midwives, nurses and clinical support workers as part of their daily duties. We maintain that advice on and support for breastfeeding is worse at weekends, which adversely affects breastfeeding. This is because higher rates are paid to staff at weekends, and hence managers are more likely to limit staff responsibilities to the core services of delivery, labor, maternal and child health at the expense of infant feeding support. As the median length of hospital stay after a natural delivery is 48 hours (Figure 2), mothers most exposed to this reduced feeding support are those who give birth on Fridays, followed by those who give birth on Saturdays and, to a lesser extent, Sundays.[14] More generally, exposure to weekend feeding support increases as the week progresses (Figure 3).

[FIGURE 2 & 3 HERE]

We corroborate the claim that breastfeeding support is lower at weekends using the UK Maternity Users Survey (MUS, 2007). The MUS is a postal survey conducted on a sample of around 26,000 mothers three months after giving birth, and covers 148 NHS trusts in England. The survey covered the three stages in maternity care: antenatal care, labour and delivery, and post-natal care. Of particular relevance, it asked respondents "Thinking about feeding your baby, breast or bottle, did you feel that midwives and other carers gave you consistent advice/practical help/active support and encouragement?" Stark differences emerge when we split the sample by education status.[15] Columns 1-3 of Table 1 show that low educated mothers of children born on Friday or Saturday report being less satisfied with the infant feeding advice they obtained in hospital compared to mothers of Monday-borns. This pattern is broadly mirrored in breastfeeding rates, as measured in the MCS.[16] In particular, column 4 reports significantly lower breastfeeding rates for children born on Friday, Saturday and Sunday, which will be essential for our identification strategy. The difference on Sunday between columns 1-3 and column 4 may be due to the different time periods (columns 1-3 relate to 2007 (MUS); column 4 relates to 2000/01 (MCS)).

Interestingly, neither of these patterns - differences in support or in breastfeeding rates by day of the week - is present for high educated women (columns 5-8). Several reasons may underlie this: (1) facing time constraints, midwives target the high educated; (2) the high educated are more demanding and are more likely to seek out help from midwives; (3) the high educated can benefit more from the same level of support as they have more information before arriving to hospital, and (4) the high educated can afford to pay for support from

[14] We note that infant feeding support is also likely to be lower during the night, though exposure to mainly night-time services is very rare.

[15] In the MCS, we define low educated = 1 if NVQ level 2 or less, or NVQ level is unknown but left school before 17; high educated = 1 otherwise. In the MUS, as we do not observe highest qualification level, we define low educated=1 if left full-time education at or before age 16; high educated=1 if left full-time education after age 16. This might over-estimate (under-estimate) the true proportion of high (low) educated, as those who left full-time education after age 16 may have an NVQ Level 1 or 2 as their highest qualification level.

[16] Concerning breastfeeding, the MUS only asks if the child was ever put to the breast and how was the child fed in the first few days after birth.

private lactation consultants after discharge, or seek out peer community groups and access telephone advice hotlines, pamphlets and friends/relatives, and hence rely less on hospital-provided support.[17]

[TABLE 1 HERE]

Given the above evidence, from hereon we focus on the sample of low educated mothers, for whom hospital feeding support matters significantly for breastfeeding.

5.3 Types of mother do not vary by timing of birth

A potentially important concern is that mothers who give birth over the weekend (Fri-Sun) are somehow different from those who give birth during the week (Mon-Thurs). Given that the timing (within the week) of spontaneous vaginal deliveries is random, one would not expect this to be the case. Regarding labor inductions, they are only offered under specific circumstances (see section 3) and moreover the woman has little incentive to try to schedule them on a specific day because, unlike in the US, she does not have a pre-assigned midwife or obstetrician for delivery. Regarding scheduled c-sections, we exclude them because they are not scheduled over the weekend (and moreover they are only allowed under medical circumstances – section 3). We also exclude emergency c-sections as well as children who have been in intensive care, in order to restrict the sample to uncomplicated deliveries for which medical care is relatively straightforward, and in this way mitigate concerns that delivery complications varying by timing of birth might be affecting results.[18] Because we exclude emergency C-section and children who have been in intensive care from the sample, we test in Table 2 whether they vary by day of the week, and they do not. Moreover, in section 8 we show robustness to these choices..

The left panel of Table 3 contains a small but important subset of the variables considered in the more comprehensive balance analysis reported in Appendix II. It shows that certain characteristics of the mother and the child (newborn birth weight, maternal smoking and

[17] We can rule out that differences in reporting are due to selection effects (in particular, that the more educated go to better hospitals). We can control for hospital fixed effects in the main analysis that uses the MCS data, and when we do, we find the same pattern between breastfeeding rates and timing of birth as when we omit them.

[18] Note also that infants placed in intensive care are more likely to be different from the rest of the sample in terms of their development, and they may receive additional medical care that may affect their development. For instance, Bharadwaj et al.. (2013) show that infants who receive extra medical care at birth (surfactant therapy) go on to have lower mortality rates and higher test scores and grades in school. In the UK, surfactant therapy is administered in the Intensive Care Unit, where babies with neonatal respiratory distress syndrome are transferred.

drinking during pregnancy, mother's receipt of welfare benefits) are fully comparable between deliveries that take place at the weekend (Fri-Sun) and weekday (Mon-Thurs). Appendix II shows that this comparability extends to a wide range of maternal characteristics.

[TABLE 2 & 3 HERE]

5.4 Other hospital maternity services do not vary by timing of birth

It is crucial to assess whether other hospital services relevant for child development, apart from breastfeeding support, vary by timing of birth. For instance, a more complicated delivery could affect a child's development either through its effects on the child's health or on the mental health of the mother. Our hypothesis is that hospital managers protect all services relating to birth delivery, because of the major repercussions if mistakes occurred. In this section, we provide several pieces of evidence supporting this claim. First we show that a wide range of characteristics relating to labor, delivery, and post-natal care are extremely similar regardless of timing of birth. Then we discuss the potential for other unobserved hospital-related factors.

The right panel of Table 3 shows how a subset of characteristics associated with delivery and post-natal services vary across weekdays and weekends (see Appendix II for a more comprehensive list and analysis). The first thing to note is that we observe in the MCS an important and comprehensive set of characteristics, including whether the labor was induced, duration of labor, whether forceps were used, whether an epidural was administered (which requires an anaesthetist, and is a proxy for availability of core services), and whether complications occurred. Using data from the MUS, we can also explore post-natal care variables including whether the baby received a newborn health check and how staff treated the mother, as well as what she thought of the information she received. The values of all of these variables (and other more detailed variables shown in Appendix II) are markedly similar between weekdays and weekends, and no differences are statistically significant at the 5% level.

Whilst the above considers an extensive range of characteristics relating to hospital maternity services, the extent to which there may be unobserved characteristics varying by timing of birth must be addressed. Because our identification strategy relies on the fact that weekend delivery negatively affects breastfeeding, the particular threat to identification is that hospitals weekend services "harm" children's health, in which case we may be picking up that effect. We next discuss several reasons why we believe this not to be a concern.

First of all, we reiterate that we consider a sample of vaginal deliveries, and babies not placed in intensive care, for whom medical care is routine and relatively uncomplicated. Recent work has shown large effects of specialized medical care of children at serious health risk (Almond, Mazumder and van Ewijk 2011; Bharadwaj, Loken and Nielson 2013). Although lack of data prevents us from examining the distribution of such specialized medical care between weekday and weekends, this is not of concern for us as we exclude children who have been in intensive care units.

Second, we anticipate one of our key findings, which is that breastfeeding does not affect children's subsequent health (Figure 4d that follows below provides graphical evidence). This suggests strongly that there are no unobserved core hospital services that are simply better during the week than at the weekend and reinforces the view that other unobserved hospital services are not confounding estimated impacts.

Third, it is extremely unlikely that services which target directly child's cognitive development are being provided in maternity wards: according to the NICE 2006 guidelines ('Routine Post-natal Care of Women and Their Babies')[19], post-natal services are structured in three key areas (1) maternal health, (2) infant health, and (3) infant feeding. There is no indication in the extensive guidelines that hospitals implement programs or interventions (apart from infant feeding support) that could affect children's development apart from those that could operate through either the mother's and/or child's health. Indeed, it must be remembered that the median stay in hospital is just 48 hours, leaving little time for anything other than the most essential care; moreover the mother is tired and recovering and focused on her and the newborn baby's basic needs; hospitals are capacity constrained (and indeed the majority of mothers and newborns stay in communal post-natal labor wards rather than individual rooms) and hence it makes sense for hospital managers to focus resources on the key areas of maternal and infant health, as opposed to early childhood programs, for instance.

[19] 2006 is the first year that the guidelines were issued. We have no reason to believe that they represented a change from prior practice, but rather a formalization of existing practice.

Consistent with the assertion that post-natal services are centred on maternal and child health and infant feeding support, the MUS only covers infant feeding support, whether a newborn check-up was received, and general questions on information about recovery and whether staff treated them with respect. The fact that the survey does not include any questions about any other services, such as early childhood programs, strongly suggests that they are simply not taking place, in line with the NICE (2006) guidelines. Moreover, there is no statistically significant relationship at 5% between any of the above variables and whether the birth took place on a weekday or weekend (Appendix II).

5.5 Timing of birth, breastfeeding and child development

In this section we provide semi-parametric evidence on how both breastfeeding rates and child development relate to timing of birth, for our main sample - low educated mothers with normal deliveries and whose baby was not placed in intensive care - as a precursor to the more formal analysis we conduct in the following sections. Figure 4a shows the relationship between breastfeeding at 90 days and $hour_i$, which is the number of hours between Sunday 00:01am and the hour of child *i*'s birth (0 refers to the first hour of Sunday and 167 to the last of Saturday). More precisely, $hour_i$ is defined as

$$hour_i = 24 * DayBirth_i + TimeBirth_i \tag{1}$$

where $DayBirth_i$ is day of the week of birth of child *i* (Sunday is 0 and Saturday is 6), and $TimeBirth_i$ is the hour of birth of child *i* (in 24 hour format).

It is clear from Figure 4a that breastfeeding rates are quite low early on into Sunday but increase quite steeply at the beginning of the week, and then taper off right through to Saturday.[20] Although breastfeeding support is likely to be as good on Mondays as it is on Wednesdays, the later on in the week the child is born, the more likely it is that (s)he stays during the weekend (Figure 3) when the support will be worse.

[20] We plot the function f(*hour*) estimated within a partially linear model specified as $B = f(hour) + X\beta + \varepsilon$, where *B* is breastfeeding at 90 days, X are covariates, and ε an error term (Robinson 1988). The function f(*hour*) is estimated using Kernel regression with a Triangular Kernel and a bandwidth of 72. The same methods are used to plot the solid line of Figures 4b, 4c and 4d. The dotted line of Figures 4b, 4c and 4d are standard Triangular Kernel regression estimates of the scores predicted using a linear regression over X (bandwidth also 72).

Figure 4b plots on the right vertical axis the relationship between breastfeeding rates and *hour* (as in Figure 4a), and on the left vertical axis on solid line the relationship between the cognitive index and *hour*. It is clear that the relationship between the cognitive index and *hour* follows the same pattern as the relationship between breastfeeding and *hour*. They both peak around Monday night, and they both have their minimums between Friday noon and midnight. This similarity in the patterns pre-empts a strong effect of breastfeeding on child development when we estimate a formal IV model in section 6. In the dashed line, Figure 4b plots the prediction of cognitive development as a function of all the variables in Table II.1 and II.4 (upper panel) of Appendix II (R^2 =0.25 between the index and the covariates). The predicted index exhibits a flatter pattern than the actual one, and does not track either the actual cognitive index or breastfeeding rates, confirming the comprehensive sample balance that we showed in sections 5.3 and 5.4.

We repeat Figure 4b, but for the non-cognitive index (Figure 4c), and this shows a more divergent pattern as the non-cognitive index peaks at around midnight Wednesday (compared to midnight Monday when breastfeeding peaks). Also, the non-cognitive index is decreasing during Saturday rather than increasing as breastfeeding does. From this, we expect a null effect of breastfeeding on non-cognitive outcomes.

Finally, considering health, we see from Figure 4d that the health index hardly varies at all by *hour*. This will translate in a zero effect of breastfeeding on the child health index when we estimate a formal IV model. Moreover if there is any underlying trend, it in fact suggests that the health index is slightly higher over weekends and lower on weekdays, dispelling concerns that the strong effects on cognitive outcomes are due to hospital weekend services harming children's health.

[FIGURE 4 HERE]

6. Estimation

In this section we describe the empirical model that we estimate, show results from the first stage estimation, and perform a Monte Carlo simulation exercise with the data in order to understand the direction of potential biases.

6.1 Model

To establish the causal effects of breastfeeding on children's outcomes, we estimate the following linear model

$$Y_{ij} = \alpha_0 + \alpha_1 B_i + \alpha_2 X_i + h_j + \varepsilon_i\,, \qquad (2)$$

where Y_{ij} is the outcome variable of chid i (cognitive/non-cognitive development/health) who was born in hospital j, B_i is a binary variable that takes the value 1 if child i has been breastfed for at least the first 90 days of life and 0 otherwise, X_i is a vector of covariates (including all those shown in Table II.1 of Appendix II (antenatal care, characteristics at birth, maternal health/lifestyle/demographics, socioeconomic characteristics) and Table II.5 (delivery), and in addition month of birth, month of interview, and regional dummies), h_j denotes hospital fixed effects, and ε_i is an error term which includes unobserved characteristics relevant for the child's development. The parameter α_1 measures the effect of being breastfed for at least 90 days on child i's outcomes.

As discussed already, our identification strategy to estimate the effect of breastfeeding on child development exploits timing of birth within the week. As exclusion restrictions, we use either a third order polynomial in $hour_i$ as defined in section 5.5 and that captures well the different slopes of Figure 4a, or $exposure_i$, which is the share of hours falling in a weekend, in the interval between the infant's birth and 45 hours later (the average length of stay in hospital).[21] Both exclusion restrictions exploit the fact that some mothers are more exposed to the weekend than others.

For estimation, we follow Wooldridge (2002, p. 623) and Angrist and Pischke (2008, p. 191) and use a non-linear two-stage estimator (NTSLS hereon) where we first estimate a Probit model of breastfeeding, B_i, over X_i and $Exposure_i$ (equivalently for the cubic polynomial in $hour_i$). The underlying latent variable $\dot{B}_i$ measures the propensity for child i to be breastfed, and is given by:

$$\dot{B}_i = \beta_0 + \beta_1 Exposure_i + \beta_2 X_i + \vartheta_i\,, \qquad (3)$$

[21] Using potential rather than actual exposure circumvents problems of endogenous length of hospital stays (though note that women have little to no choice in this).

where $B_i = 1\ if\ \dot{B}_i \geq 0; B_i = 0\ if\ \dot{B}_i < 0$, ϑ_i is standardized normal, and $\beta_0,\ \beta_1,\ \beta_2$ are parameters to be estimated.[22] Next, we compute the fitted probabilities, $\hat{B}_i$, associated with the Probit model as:

$$\hat{B}_i = \Phi[\hat{\beta}_0 + \hat{\beta}_1 Exposure_i + \hat{\beta}_2 X_i],$$

where $\hat{\beta}_0, \hat{\beta}_1,$ and $\hat{\beta}_2$ are estimates from the model specified in (3) and $\Phi[.]$ is the cumulative distribution function of the standardized normal. Finally, we use Instrumental Variables to estimate the causal effect of breastfeeding on outcome Y_{ij} using X_i and $\hat{B}_i$ as instruments.[23]

There are several advantages to using NTSLS compared to the more standard Two Stage Least Squares (TSLS). The most important one is that if the predictions from the first-stage Probit model provide a better approximation to B_i than a linear model, the resulting IV estimates are more efficient than those that use a linear first stage model (Newey 1990; Wooldridge 2002; Angrist and Pischke 2008). This is expected because if the Probit model is correct, NTSLS is implicitly using the optimal instrument (the conditional mean of B_i).

A second advantage is that the consistency of the estimator does not depend on the Probit model being correct (Kelejian 1971) and the IV standard errors do not need to be corrected (Wooldridge 2002, p.623). Clearly, NTSLS implicitly uses the nonlinearities in the first stage as a source of identifying information (Angrist and Pischke 2008). However in our case, Figure 4b already showed that both cognitive development and breastfeeding jointly track *hour* quite closely. Moreover, as we will see, the NTSLS estimates of α_1 are very similar to those obtained using TSLS. Both pieces of evidence indicate that our exclusion restrictions provide meaningful variation for identification.

6.2 First Stage Estimation

Table 4 shows the results of Probit and OLS regressions of breastfeeding at 90 days, *B*, on either *Exposure* (columns 1-3) or a cubic polynomial in the *hour* variable (columns 4-6) and

[22] We do not include hospital fixed effects amongst the covariates we use to estimate the Probit model, as there are hundreds of them and B_i is constant in some of them.

[23] Indeed, this procedure is the same as using the propensity score as instrument in linear IV (see Carneiro, Heckman and Vytlacil 2011; and Heckman and Navarro-Lozano 2004). See also Windmeijer and Santos Silva (1997) in the context of Count Data models.

the set of covariates, X, estimated over our main sample (low educated mothers who delivered their babies through a vaginal birth and whose babies were not admitted to intensive care). Those who are fully exposed to the weekend are around 4.1 percentage points less likely to be breastfed for at least 90 days (marginal effect associated with column 1). The coefficients in *hour* imply that breastfeeding rates as predicted by the Probit model (column 4) follow the same pattern as the semi-parametric plot of Figure 4a - this is shown in Figure VII.1 of Appendix VII which is dedicated to additional Tables and Figures).

[TABLE 4]

Depending on the coefficients, they are significant at either the 1%, 5% or 10% levels. The F-test for the hypothesis that either the coefficient on *Exposure* or the terms of the polynomial are null are between 4.33 and 8.6, which lie below the critical values reported in Stock and Yogo (2005). While this requires careful scrutiny, which we do in Appendix III (see below), two points are worth emphasising. First, the critical values in Stock and Yogo (2005) are derived under the assumption of a linear endogenous regressor while the endogenous regressor is binary in our case.[24] Second, the use of the first stage F-statistic to assess the quality of the instruments has its limitations (Hahn and Hausman 2003; Cruz and Moreira 2005; Murray 2006; Angrist and Pischke 2008, p. 215). In general, Stock-Yogo tests are known to have low power (the critical values of the F-statistics are larger than required, and then the tests indicate that the instruments are weak too often).[25] In our case, we have included a rich set of covariates that will reduce the degree of endogeneity and improve the properties of the IV estimator (Hall, Rudebusch and Wilcox 1996; Shea 1997), but this reduction in the degree of endogeneity is ignored by Stock-Yogo F-based tests (Hall, Rudebusch and Wilcox 1996).

However, in order to assess fully the finite sample properties of our estimator, in Appendix III we describe an extensive Monte Carlo simulation in which the Data Generating Process uses the sample, covariates and estimated coefficients from the first stage regressions. In this way we assess the finite sample properties of our estimators using a Data Generating Process

[24] This is of relevance because TSLS implicitly uses the optimal linear instrument (the conditional mean) when the endogenous regressor is continuous but not when it is discrete. Intuitively, OLS will result in a relatively poor fit (and hence relatively "low" F-statistics) if the dependent variable is discrete.

[25] Stock and Yogo (2005) indicate in their footnote 6 that the critical values could be much lower (4.63 for their particular example) depending on the value of unknown parameters. Cruz and Moreira (2005) obtain meaningful estimates even when the first stage F-statistics are as low as 2 which suggests that the rule-of-thumb of F-statistic larger than 10 is far from conclusive (Murray 2006; Angrist and Pischke 2008).

that mirrors the main features of our data, including the strength of the instrument. We have three key findings: (1) both NTSLS and TSLS are consistent if the true effect of breastfeeding is relatively small (including zero), (2) both NTSLS and TSLS are biased towards zero if the true effect is large, (3) the standard errors are correctly estimated. This means that our estimates are conservative and that, if anything, our estimates will be lower bounds. We also find that NTSLS is far more precise than TSLS.

7. Results

In this section we first describe results for child development as measured using the summary indices. We then estimate quantile regressions to see whether the effects are concentrated in a particular part of the distribution. Finally, we consider mechanisms relating to maternal behaviour, including the home environment and maternal mental health.

7.1 Effects on Overall Child Development

We observe cognitive and non-cognitive development of the child at ages 3, 5 and 7. Measures of cognition are based on age-appropriate tests administered directly to the child, and non-cognitive skills are based on maternal reports (section 4 and Appendix I). We also observe child weight and maternal-reported measures of health and morbidity (at ages 9 months, 3,5,7 years). We consider as outcomes the indices summarizing cognitive skills, non-cognitive skills and health across all ages (created as described in section 4). All indices are coded so that larger values correspond to higher levels of development achieved.

The main results for the three summary indices are shown in Table 5. The key finding is that, irrespective of whether we use *Exposure* or the cubic polynomial in *hour* as exclusion restriction (columns 1 and 4), breastfeeding affects positively children's overall cognitive development (in line with Figure 4b), and the effect is significant at the 1% level. We also note that NTSLS and TSLS point estimates are extremely similar. This is very reassuring as it means that the identification of the parameter of interest is not driven by the non-linearities embedded in the first stage Probit model, but by the variation embedded in the exclusion restrictions (see again Figure 4b)

The key difference between NTSLS and TSLS is the precision of the estimates: the NTSLS standard errors are around half of the TSLS when we use the cubic polynomial in *Hour* and around a third when we use *Exposure*. The gain in precision of NTSLS (anticipated given its optimality as discussed in section 6.1) matches the results of the Monte Carlo simulations in Appendix III and is not unusual in other very recent work that uses non-linear predicted instruments. For instance, Løken et al. (2012) achieves reduction in standard errors of up to a half when using predicted instruments, as do Wooldridge (2002, p.624) and Attanasio et al. (2013). Recently, in the context of random coefficient models, Reynaert and Verboven (2013) report that standard errors can drop by a factor of 5 to 7, both using simulations and real data. [26] Moreover, our Monte Carlo results in Appendix III also showed that the estimated standard errors are correct.[27]

Another important result from Table 5 is that the effects of breastfeeding are limited to cognitive development: there is no evidence that it leads to improvements in either health or non-cognitive development (as had been anticipated from Figures 4c and 4d). Importantly to note, health is first measured at 9 months of age, when most mothers have ceased breastfeeding their children. Hence, our results could not capture a health effect if it is present only while the child is being breastfed.

Table 5 also reports OLS estimates, which are all positive and statistically significant throughout (the health one is significant at only 10%). The IV estimates are markedly larger than OLS ones (as it is the case in the returns to education literature). This might be for two non-exclusive reasons: misclassification error and heterogeneous treatment effects. Figure 1 showed that mothers' reported of breastfeeding durations are clustered around 30, 60, 90, 120, and 150 days which suggests that misclassification error might be an issue. In Appendix IV, we conduct a simulation exercise that shows that reasonably sized misclassification probabilities in the breastfeeding variable (probability of falsely reporting that the child was breasted for at least 90 days to be 0.16, and the probability of falsely reporting that the child was not breastfed for at least 90 days to be 0.11) are enough to almost fully explain the discrepancy between the OLS and the IV results. We also show that the IV estimation recovers correctly the treatment effect.

[26] It is outside the scope of this paper to study when the efficiency gains are more important. Still, we note that the linear first stage provides a poor fit among those with a low propensity to breastfeed according to Xs (those in the bottom 20%), amongst whom 33% have predicted probabilities of breastfeeding of less than zero.

[27] This is already emphasized by Wooldridge (2002, p. 623) who indicates that the IV standard errors already account for the uncertainty related to the estimation of the Probit model. Indeed, our estimates of the standard errors are the same as when we jointly bootstrap both the first (Probit) and second stage.

A complementary explanation as to why the IV estimates are larger than the OLS ones is that IV identifies a local average treatment effect parameter (LATE: Imbens and Angrist 2004) and that the group of compliers is one that particularly benefits from breastfeeding. In our case, the compliers are children whose mothers do not breastfeed them if they do not receive adequate support at the hospital, indicating that they would not substitute the hospital support with other alternatives (such as private lactation consultants) or use other support mechanisms (such as books, leaflets, telephone hotlines, community support groups). These compliers may also be less inclined to make future investments in their children, so the added value of breastfeeding will be relatively large (compared to children who receive many more investments). Consistent with this, we will report in section 7.3.1 that the compliers do not compensate for lack of breastfeeding with other investments.

[TABLE 5 HERE]

Appendix V reports the results by age and each different development measure. Regarding cognitive development, the results for ages 3 and 5 are all positive across the different measures of cognition and statistically significant in most of them. The magnitude of the effects are around 65% SD. At age 7, the estimates shrink towards zero and they are no longer significant. This seems to be due to a marked increased in attrition at age 7. Although attrition is uncorrelated with the instruments, the households that leave the sample tend to be more disadvantaged (section 8.1 and Appendix VI provide more detail on attrition). For reasons explained above, these households are likely to benefit most from breastfeeding, hence the reduction in the estimates. Evidencing this, the effects of breastfeeding at age 5 estimated on the sample available at age 7, are much smaller than the estimates based on the entire sample available at age 5 (Table VI.16 in Appendix VI). Appendices V and VI provide further details.

7.2 Quantile Regressions

We also use quantile regressions to estimate the effects of breastfeeding on different parts of the distribution (Bitler et al. 2006). We deal with the endogeneity of breastfeeding by using a control function approach (Lee 2007) and estimate the standard errors through bootstrapping. In Table 6, we report results using *Exposure* as the exclusion restriction (results using the cubic in hour are similar, and are shown in Table VII.1 of Appendix VII).

The quantile regressions in Table 6 provide evidence that breastfeeding has a significantly larger effect on cognitive development at the lower end of the distribution (quantiles 10 and 25). At higher quantiles, the effects are not statistically distinguishable from zero. This is consistent with the fact that breastfeeding benefits children from poorer socio-economic backgrounds more, because they receive fewer investments and hence breastfeeding is relatively more important. Consistent with our previous results, the estimates on non-cognitive development and health are not statistically significant at conventional levels.

[TABLE 6 HERE]

7.3 Mechanisms

The striking findings just shown raise the question as to the underlying mechanisms through which breastfeeding may be affecting children's cognition. In section 2, we discussed the two main ones put forward in the literature: (1) the compositional superiority of breast milk and (2) breastfeeding may improve the relationship between mother and child - due to hormonal responses in mothers that may reduce stress and depression, and/or breastfeeding resulting in the mother spending more time with the baby. Regarding the latter, an improved mother-child relationship may result in an increase in activities likely to increase cognitive development (such as reading/telling stories); any observed increase in such activities may also be due to the perceived returns to such activities being higher for breastfed children. Clearly however, the direction of the relationship could also go the other way, for instance if mothers invest more in these activities in an attempt to compensate for not having breastfed. In this section, we consider both the effect of breastfeeding on maternal activities with the child, as well as the effect on the quality of the relationship between mother and child (which could indirectly affect the maternal behaviors as the literature hypothesizes).[28] In so doing, we provide evidence that (2) is not the mechanism at play, suggesting that (1) has a potentially important role to play in improving brain development and hence cognition.

7.3.1 Maternal investments

We use the frequency of learning activities such as reading to the child, library visits, singing, painting (see Appendix I) to analyse whether mothers respond to breastfeeding by investing

[28] Breastfeeding could also affect children's outcomes if it is used as a contraceptive method, of which there is evidence in developing countries (Jayachandran and Kuziemko, 2011). However, this is unlikely to be the case in a developed country like the UK, where women have better access to modern contraception. Indeed, in our data, the average number of younger siblings is 0.44 for weekday born children and 0.436 for weekend ones.

more or less in their children. The list of activities comprises the Home Learning Environment (HLE) index, a composite measure of the quality and quantity of stimulation and support available to a child in the home (Bradley, 1995). Column 1 of Table 7 reports the overall summary index of the HLE indices at ages 3, 5 and 7 computed following Anderson (2008). The remaining columns focus on age 3. Columns 2-7 report the results for separate activities at age 3, and column 8 shows the result for the activities at age 3 combined into the HLE index. The results are quite unequivocal: there is no evidence that breastfeeding changes the learning activities that parents provide their children with (this is true also at ages 5 and 7 - see Tables VII.2 and VII.3 in Appendix VII). Results using the cubic polynomial in *hour* are similar and available upon request.

[TABLE 7 HERE]

7.3.2 Maternal mental health and mother-child relationship

In the first five columns of Table 8, we find no significant differences of breastfeeding on maternal mental health measured using the Malaise Inventory, either overall (column 1) or at separate waves (columns 2-5; note from column 2 it is also measured when the baby is 9 months old). - The last two columns of Table 8 estimate whether breastfeeding affects the quality of the mother-child relationship, measured via the Pianta Scales when the child is 3 years old. It captures both the warmth of the relationship and conflict within the relationship. We detect no effect of breastfeeding on either aspect of the relationship.

[TABLE 8 HERE]

8. Robustness

In this section we discuss attrition from the sample and also carry out a battery of robustness exercises.

8.1 Sample Attrition

Appendix VI is dedicated to a detailed analysis of attrition from the sample; we summarize its three key aspects here. First, attrition is uncorrelated with the variation we exploit for identification. Indeed, attrition at various waves is practically the same for children born at the weekend and those born on weekdays (the difference ranges between -0.9% and +0.8% depending on the wave, and is not statistically different from zero in any case, see Table VI.1). This balance also extends to the instruments of *Exposure* and *Hour* (Table VI.2).

Second, the rich set of characteristics that we observe are well balanced between those born in weekend and weekdays across waves 2, 3, and 4 (see Tables VI.3-VI.14, which effectively extend the balance analysis that we carried out in Appendix II to each single wave). Third, those who attrit are from more disadvantaged backgrounds (Table VI.15). Hence, our results are valid conditional on the sample available but the sample in later waves (and especially at age 7) is not representative of the initial one. As discussed at the end of section 7.2, this is probably the reason why the estimates at age 7 are much smaller than at Age 3 or 5 (see also Appendix V).

8.2 Robustness Exercises

In this section, we carry out a number of exercises to check robustness of our main findings to specification and sample selection. Column 1 of Table 9 reports our main results using *Expoure* as exclusion restriction (see Table VII.4 in Appendix VII for similar results using *hour*). In column 2, we remove labor inductions from the sample, in column 3 we include emergency C-sections, and in columns 4 and 5 we condition on time of birth within the day (using either a third order polynomial in the hour of birth defined between 0 and 23 or dummy variables for each hour of birth).[29] In all cases, the effect of breastfeeding on cognitive development remains large and statistically significant. In column 6, we impute missing values (due to attrition) in the cognitive outcomes based on the values of non-missing waves. In column 7, we drop hospital fixed effects and find that the effect of breastfeeding remains large and significant but its magnitude drops a little. This is interesting because it shows that if there is any hospital level omitted variable, it biases the estimates towards rather than away from zero.[30]

As an additional robustness check, we use cut-offs different from 90 days to define the breastfeeding binary variable. Rather than trying to estimate the optimal duration of breastfeeding (for which we would need exogenous variation in the cost of breastfeeding at different ages of the child), the aim of this exercise is to show that our results apply more generally and are not an artefact of the specific 90 day threshold used in the main analysis. While Table 10 shows that the effect of breastfeeding for at least 30 days is smaller (and not

[29] We do this because there is a within day cycle in inductions and epidurals. Inductions are more frequent in the morning and hence children are born later in the day (epidurals follow the same patter because induced deliveries tend to be more painful and hence epidurals are administered more frequently for induced deliveries). This is further discussed in Appendix II.

[30] Robustness results on non-cognitive skills and health are also in line with the main ones, see Tables VII.5-VII.8 in Appendix VII. Using *Hour* as exclusion restriction provides similar results to the ones using *Exposure*.

statistically significant) than the effect of breastfeeding for at least 90 days, the effects of breastfeeding for at least 60 or 120 days are extremely similar to that of breastfeeding for at least 90 days.

[TABLES 9-10 HERE]

9. Conclusion

In this paper, we have used exogenous variation in timing of birth to estimate the impacts of breastfeeding on children's development at different stages up to age 7. Our results are striking: we find strong effects on children's cognitive development and no effects on their non-cognitive skills or health (admittedly, our data exhibit some limitations to capture short-term effects on health). We find no effects on mother's mental health, the quality of the child-mother relationship, or parental investments in their children.

On top of the extensive evidence the paper provided supporting our identification strategy, this constellation of findings - strong effects on cognitive development but not on parental investments or other dimensions of child development - also intimates the absence of an omitted variables bias and further reinforces the validity of our strategy. Furthermore, the absence of effects on health suggests strongly that our results are not driven by weekend hospital services having an adverse effect children's health, though to mitigate concerns with this we focused the main analysis on children born through natural delivery (not C-section) and who were not placed in intensive care.

Their magnitude of our estimates are in line with Kramer et al. (2008) who find effects on cognition at age 6.5 years in the region of 1 standard deviation or even higher. Their study involved randomizing a breastfeeding promotion intervention that increased hospital support in Belarus, so their compliers are mothers who breastfeed only if adequate hospital support is obtained, and who thus share features with ours. Kramer et al. (2001, 2008) also find very weak effects on health and no effects on child behaviour/non-cognitive skills.

In terms of the mechanisms underlying the effects on cognition, we find no evidence that the warmth of the mother-to-child relationship is higher amongst those who were breastfed as infants, or that maternal mental health is any better. There is also no evidence of other maternal investments into the child changing in an effort to compensate for lack of breastfeeding. This suggests to us that the unique composition of breast milk has the potential to play an important role in brain and subsequent development, though further research is clearly needed before conclusions can be reached.

Given the stark disparities in breastfeeding by socioeconomic background, with breastfeeding rates amongst the high educated more than three times those of the low educated (48% versus 13% in the UK), the evidence provided suggests that breastfeeding may well contribute to the gap in children's cognitive development across the socio-economic spectrum. Moreover the instrument used to identify the effects, apart from providing a unique and credible source of variation, also suggests a specific policy focus - on hospital breastfeeding support - to help close this gap.

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Table 1. Differences in Breastfeeding Support and Breastfeeding Rates by Day of Birth

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	Low Educated				High Educated			
Source →	MUS			MCS	MUS			MCS
Day of Birth ↓	Received consistent advice	Received practical help	Received active support	Breastfed for at least 90 days	Received consistent advice	Received practical help	Received active support	Breastfed for at least 90 days
Sun	0.004	-0.014	-0.016	-0.055*	-0.013	0.002	0.000	-0.048
	(0.022)	(0.023)	(0.023)	(0.022)	(0.014)	(0.014)	(0.014)	(0.027)
Tue	-0.022	-0.021	-0.024	-0.030	-0.007	-0.013	-0.006	-0.019
	(0.022)	(0.024)	(0.023)	(0.021)	(0.014)	(0.014)	(0.013)	(0.026)
Wed	-0.007	-0.006	-0.018	-0.015	0.009	-0.004	0.003	-0.045
	(0.022)	(0.023)	(0.023)	(0.021)	(0.014)	(0.014)	(0.013)	(0.026)
Thurs	-0.007	-0.011	-0.021	-0.026	-0.007	-0.009	-0.011	-0.034
	(0.022)	(0.024)	(0.024)	(0.021)	(0.014)	(0.014)	(0.013)	(0.026)
Fri	-0.095**	-0.083**	-0.084**	-0.060**	-0.008	-0.005	-0.002	-0.041
	(0.022)	(0.023)	(0.023)	(0.021)	(0.014)	(0.014)	(0.013)	(0.025)
Sat	-0.028	-0.066**	-0.052*	-0.058**	0.006	0.007	0.006	-0.042
	(0.022)	(0.024)	(0.023)	(0.021)	(0.014)	(0.014)	(0.013)	(0.026)
Monday Mean	0.814	0.784	0.796	0.265	0.776	0.793	0.799	0.545
P-value Joint	0.000	0.001	0.006	0.0174	0.654	0.824	0.883	0.496
P-value Fri-Sun	0.000	0.000	0.001	0.0124	0.520	0.858	0.928	0.236
Observations	4914	4772	4813	5989	12946	12580	12820	5484

Notes . The top six cells report coefficients from an OLS regression over day of week dummies (Monday omitted). The dependent variable is at the top of the column. All columns exclude emergency and planned C-sections. Cols. 1 -3 and 5-7 are from the Maternity Users Survey (MUS). Cols 4 and 8 are from the Millenium Cohort Study (MCS) and also exclude children placed in intensive care. Standard errors in parentheses: ** p<0.01, * p<0.05.

Table 2. Distribution of Emergency C-Sections and Intensive Care Unit (ICU) stays by Day of Birth

	[1]	[2]	[3]	[4]	[5]	[6]
Day of Birth ↓	Emergency Caesarean	ICU	ICU among Vaginal Deliveries	Emergency Caesarean	ICU	ICU among Vaginal Deliveries
				(Difference with respect to Monday)		
Sun	11.88%	8.78%	6.21%	-0.018	0.008	-0.002
				(0.015)	(0.013)	(0.013)
Mon	13.66%	7.95%	6.44%			
Tue	11.80%	7.31%	5.55%	-0.019	-0.006	-0.009
				(0.015)	(0.012)	(0.012)
Wed	12.25%	9.32%	5.08%	-0.014	0.014	-0.014
				(0.015)	(0.012)	(0.012)
Thurs	13.74%	9.61%	6.09%	0.001	0.017	-0.003
				(0.015)	(0.012)	(0.012)
Fri	11.72%	9.07%	6.76%	-0.019	0.011	0.003
				(0.015)	(0.012)	(0.012)
Sat	11.13%	7.78%	6.18%	-0.025	-0.002	-0.003
				(0.015)	(0.012)	(0.012)
P-value Joint				0.456	0.442	0.805
P-value Fri-Sun				0.373	0.668	0.968
Observations	7296	7296	5747	7296	7296	5747

Notes . Columns 1 to 3 show distribution of the variable define in the heading of each column by day of birth. Columns 4 to 6 show estimates from separate OLS regressions (Monday omitted). Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through planned caesarean. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table 3. Balance by Day of Birth (extract from Tables II.1 and II.4 of Appendix II)

Variable	Fri-Sun	Mon-Thurs	t-stat	Variable	Fri-Sun	Mon-Thurs	t-stat
Mother and Baby				***Delivery***			
1st ante-natal before 11 weeks	0.405	0.391	1.092	Labour induced	0.302	0.309	-0.629
Attended ante-natal classes	0.243	0.241	0.146	Labour duration (hours)	8.953	8.705	0.912
Birth weight (kg)	3.362	3.352	0.701	Epidural	0.208	0.201	0.652
Premature	0.049	0.043	1.088	Absence of complications	0.756	0.766	-0.918
Length of gestation (days)	278.8	279.3	-1.706	***Postnatal hospital care***			
# avg. cig. per day	3.642	3.633	0.057	Child exam before discharge	0.942	0.942	0.004
Drank during pregnancy	0.250	0.246	0.434	Exam by Doctor	0.707	0.707	0.034
Longstanding illness	0.199	0.206	-0.681	Enough info about recovery	0.853	0.872	-1.939
Income Support	0.299	0.304	-0.426	Always treated respectfully	0.695	0.711	-1.204
				Always treated kindly	0.681	0.694	-0.982

Notes . Columns report sample means and t-statistic of the difference. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through c-sections (either emergency or planned) and children placed in intensive care after delivery. Variables related to postnatal hospital care are from the Maternity Users Survey 2007 with 5314 observations. The rest of the variables are from the Millennium Cohort Study with 5989 observations.

Table 4. First stage. Breastfed for at least 90 Days. Coefficient Estimates

	[1]	[2]	[3]	[4]	[5]	[6]
	PROBIT	OLS	OLS	PROBIT	OLS	OLS
Exposure to Weekend	-0.1504**	-0.0388**	-0.0353**			
	(0.0502)	(0.0132)	(0.0135)			
Hour				0.0099*	0.0024*	0.0028**
				(0.0042)	(0.0011)	(0.0011)
(Hour^2)/100				-0.0120*	-0.0030*	-0.0034*
				(0.0058)	(0.0015)	(0.0015)
(Hour^3)/10000				0.0037	0.0009	0.0011
				(0.0023)	(0.0006)	(0.0006)
P-value	0.002	0.003	0.005	0.000	0.000	0.001
F-stat		8.628	6.812		4.756	4.337
Hospital FE	No	No	Yes	No	No	Yes
Observations	5810	5810	5810	5810	5810	5810

Notes. Each column reports the coefficients from a regression in which the dependent variable is whether the child was breastfed for at least 90 days, and the independent variables include the exclusion restrictions listed in the first column (exposure to weekend or cubic polynomial in hour), and all of the variables listed in Table II.1 and Table II.4 (upper panel) of Appendix II, month of birth, interview months, and regional dummies. The model (Probit or OLS) is noted at the top of the column. The P-value and F-stat refer to the null hypothesis that the coefficient/s of the instrument is zero or jointly zero. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table 5. Effect of Breastfeeding on Child Development

	[1]	[2]	[3]	[4]	[5]	[6]
Exclusion Restriction →	***Exposure to weekend***			***Polynomial in hour***		
Estimation Method ↓	Cognitive Index	Non-Cognitive Index	Health Index	Cognitive Index	Non-Cognitive Index	Health Index
NTSLS	0.463**	0.320	0.026	0.451**	0.347	0.007
	(0.180)	(0.226)	(0.083)	(0.170)	(0.215)	(0.080)
TSLS	0.497	0.253	-0.407	0.467	0.584	-0.286
	(0.618)	(0.810)	(0.299)	(0.423)	(0.594)	(0.204)
OLS	0.057**	0.097**	0.018	0.057**	0.097**	0.018
	(0.019)	(0.023)	(0.009)	(0.019)	(0.023)	(0.009)
F statistic	7.023	5.701	8.580	3.728	3.094	4.713
P-value	0.0081	0.0170	0.0034	0.011	0.026	0.0027
Observations	5015	4957	5810	5015	4957	5810

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 4 (with the addition of hospital fixed effects). In columns 1 to 3 exposure to weekend is excluded from the second-stage regression, while in columns 4 to 6 the cubic polynomial in hour is excluded. F statistic and P-value correspond to the null hypothesis that the coefficient(s) of the excluded variable(s) are zero or jointly zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table 6. Effect of Breastfeeding on Indices at Different Quantiles

Percentile	**10**	**25**	**50**	**75**	**90**
Cognitive Index	1.251*	0.776*	0.503	0.344	0.189
	(0.499)	(0.374)	(0.331)	(0.316)	(0.455)
Non-cognitive Index	0.534	-0.024	-0.002	0.111	-0.041
	(0.744)	(0.556)	(0.457)	(0.428)	(0.450)
Health Index	-0.165	0.058	-0.219	-0.058	0.011
	(0.337)	(0.240)	(0.165)	(0.122)	(0.104)

Notes. Each cell reports the coefficient of a quantile regression of each index on breastfeeding, additional control variables and a sixth-order polynomial of the first stage residuals (control function). The percentile is indicated at the top of the column. Control variables are the same as in Table 4. Bootstrapped standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table 7. Effect of Breastfeeding on Parenting Activities

Estimation Method ↓	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		Age 3						
	Home Learning Environment Summary Index	Read to child every day	Take child to library once a week	Help child to learn alphabet every day	Teach child counting every day	Teach child songs/poems/ rhymes every day	Child paint/draw at home every day	Home learning Environment
NTSLS	0.233	0.061	0.095	0.105	-0.163	0.197	0.139	4.217
	(0.228)	(0.163)	(0.074)	(0.136)	(0.164)	(0.163)	(0.163)	(2.566)
TSLS	-1.036	-0.503	0.101	-0.301	-1.003	-0.539	-0.893	-16.522
	(0.912)	(0.628)	(0.277)	(0.477)	(0.755)	(0.639)	(0.713)	(12.209)
OLS	0.089**	0.058**	0.017	0.018	0.007	0.043*	0.007	0.892**
	(0.025)	(0.019)	(0.010)	(0.015)	(0.019)	(0.019)	(0.019)	(0.298)
F statistic	6.922	6.362	6.362	6.362	6.362	6.362	6.362	6.362
P-value	0.00854	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117
Mean		0.466	0.0546	0.189	0.469	0.506	0.445	24.62
SD		0.499	0.227	0.392	0.499	0.500	0.497	7.832
Observations	5062	4484	4484	4484	4484	4484	4484	4484

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column. The estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 5. Exposure to weekend is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient of the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table 8. Effect of Breastfeeding on Mother's Outcomes

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
		Mother's malaise index					
EstimationMethod ↓	Summary Index for mother malaise	9 months old	3 years old	5 years old	7 years old	Mother-child relationship	Mother-child conflict
NTSLS	0.178	-0.166	-0.202	2.125	-1.872	0.506	-1.341
	(0.187)	(0.600)	(1.322)	(1.632)	(1.485)	(3.555)	(2.486)
TSLS	0.165	-0.283	-1.848	0.658	-0.829	14.743	6.020
	(0.569)	(1.693)	(3.630)	(3.624)	(3.346)	(13.957)	(9.335)
OLS	0.025	-0.001	-0.032	-0.004	-0.232	0.082	-0.580*
	(0.020)	(0.060)	(0.161)	(0.159)	(0.165)	(0.375)	(0.267)
F statistic	8.580	8.628	8.077	7.720	9.205	5.528	5.528
P-value	0.0034	0.0033	0.0045	0.0055	0.0024	0.0188	0.0188
Mean	0.00146	1.739	3.534	3.473	3.492	29.03	14.55
SD	0.637	1.857	3.987	4.032	4.147	10.93	7.605
Observations	5810	5810	3535	3948	3552	4514	4514

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column. The dependent variable in col.1 is constructed from the malaise indices that are used in cols. 2-5. The age-specific malaise index at 9 months constructed from the 9-item Malaise Inventory, and the malaise indices at 3, 5 and 7 years are constructed from the 6-scale Kessler Inventory. The estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 5. Exposure to weekend is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table 9. Effect of Breastfeeding on Cognitive Index: Robustness

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
NTSLS	0.463**	0.565**	0.412*	0.462**	0.418*	0.497*	0.382**
	(0.180)	(0.215)	(0.170)	(0.177)	(0.174)	(0.204)	(0.148)
First Stage F-statistic	7.023	3.307	8.284	6.906	7.095	7.023	7.023
Observations	5015	3482	5588	5015	5015	5015	5015
[1] Include labour inductions	Y	N	Y	Y	Y	Y	Y
[2] Include emergency Caesareans	N	N	Y	N	N	N	N
[3] Control for polynomial in hour within the day (0-24)	N	N	N	Y	N	N	N
[4] Control for hour of birth dummies	N	N	N	N	Y	N	N
[5] Include imputed data	N	N	N	N	N	Y	N
[6] Control for hospital fixed effects	Y	Y	Y	Y	Y	Y	N

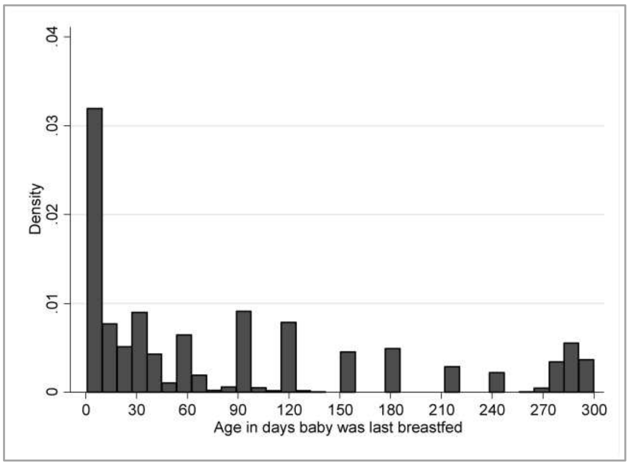
Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is Cognitive Index and the estimation method is NTSLS (non-linear two-stage least squares). Control variables are the same as in Table 5. Exposure to weekend is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Main sample contains low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Robustness exercise is indicated in the bottom rows. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table 10. Effect of Breastfeeding on Child Development: Several Breastfeeding Durations

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	Exposure to weekend				***Polynomial in hour***			
Index ↓	Was breastfed for at least 30 days	Was breastfed for at least 60 days	Was breastfed for at least 90 days	Was breastfed for at least 120 days	Was breastfed for at least 30 days	Was breastfed for at least 60 days	Was breastfed for at least 90 days	Was breastfed for at least 120 days
Cognitive Index	0.397	0.441*	0.463**	0.435*	0.389	0.425*	0.451**	0.447**
	(0.222)	(0.197)	(0.180)	(0.172)	(0.209)	(0.182)	(0.170)	(0.166)
Non-Cognitive Index	0.399	0.401	0.320	0.291	0.431	0.422	0.347	0.323
	(0.268)	(0.243)	(0.226)	(0.215)	(0.257)	(0.227)	(0.215)	(0.209)
Health Index	-0.097	0.000	0.026	0.104	-0.095	-0.022	0.007	0.077
	(0.096)	(0.089)	(0.083)	(0.083)	(0.092)	(0.083)	(0.080)	(0.080)

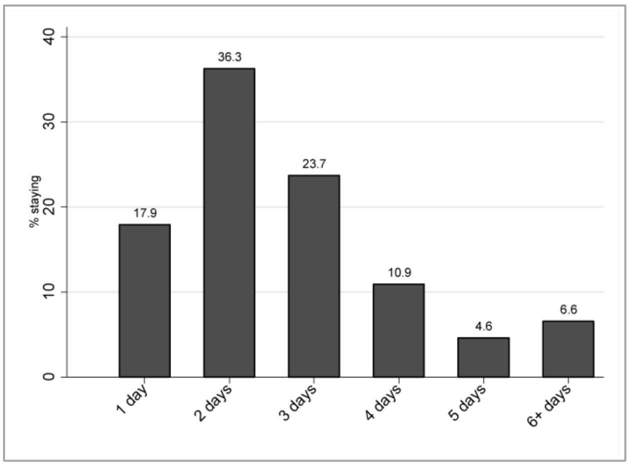
Notes . Column (3) and (7) are the same as our main results (Table 5, first row). The other columns replicate our main results but with other other breastfeeding durations (as indicated in the column heading). Estimation method is NTSLS (non-linear two-stage least squares). Control variables are the same as in Table 5. Exposure to weekend [cubic polynomial in hour] is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient(s) of the excluded variable(s) are zero or jointly zero, as estimated from an OLS regression where the dependent variable is indicated in the column heading, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Figure 1: Breastfeeding Duration in Days



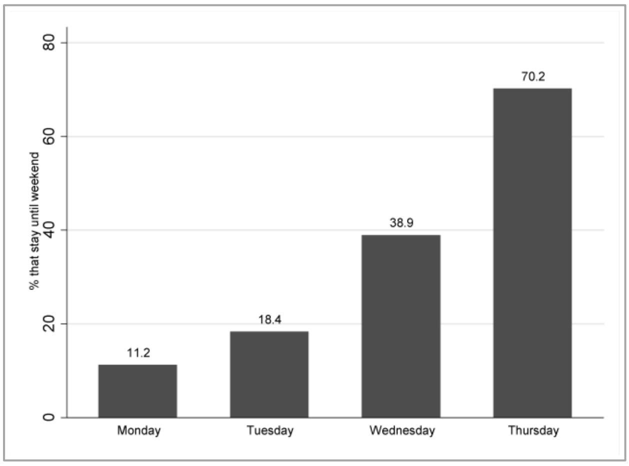
Mothers who never initiate breastfeeding were excluded: 45.7%. Sample comprises low educated mothers, but excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. Source: Millennium Cohort Study.

Figure 2: Length of Hospital Stay after Delivery



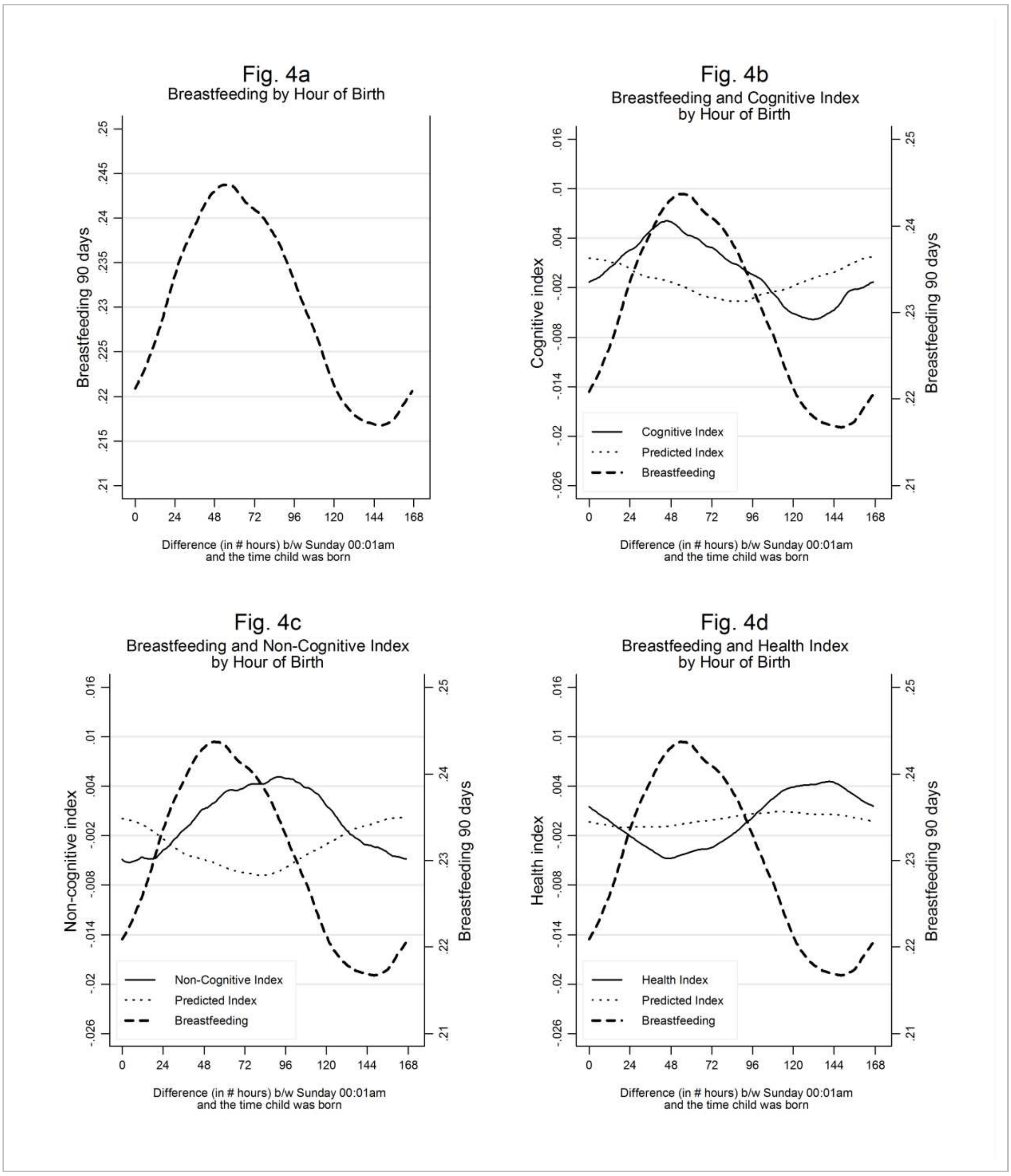
Sample comprises low educated mothers, but excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. Source: Millennium Cohort Study.

Figure 3: Actual Exposure to Weekend for those Born on Mon-Thurs



The figure shows the percentage of children who spent at least part of the weekend in hospital, according to their day of birth. Weekend is defined as the period from Friday 8am to Sunday 11.59pm. Sample comprises low educated mothers, but excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. Source: Millennium Cohort Study.

Figure 4: Relationship between Breastfeeding/Developmental Indices and Timing of Birth



In all four figures, the horizontal axis shows the hour of birth within the week (0 corresponds to Sunday 00:01-00:59 and 163 to 23:00-23:59 on Saturday). The solid and dashed lines are the estimates of the function ***F(***hour***)*** on the partially linear regression defined as **Y**= ***F(***hour***)***+X**β**+ **ε**, where *hour* is the variable in the horizontal axis, and X is a set of control variables (same as those in table 4). The estimate of the dashed line (which is the same in all four figures) is obtained by defining Y = 1 if the child was breastfed for at least 90 days and = 0 otherwise. In Figure 4b (4c) [4d], the solid line is obtained by defining Y as the cognitive (non-cognitive) [health] index. In all four figures, ***F(***hour***)*** is estimated following Robinson (1988) using Kernel regression (triangular Kernel with bandwidth of 72). The dotted line is a Kernel regression (triangular Kernel with bandwidth 72) of the dependent variable over *hour.* The dependent variable is the predicted index (cognitive in 4b, non-cognitive in 4c, and health in 4d) obtained from a regression of the actual index on the same covariates as those used in Table 4. Sample comprises low educated mothers (NVQ level 2 or less, or unknown NVQ level but left school before age 17), but excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. Source: Millennium Cohort Study.

Appendix I: Measurements

Not for Publication

Appendix I. Measurements

Cognitive Development

The first cognitive test is the British Ability Scales (BAS), which is measured directly from the child at ages 3, 5 and 7 (MCS2,3,4). Six different BAS tests have been administered across the MCS sweep. The BAS Naming Vocabulary test is a verbal scale which assesses spoken vocabulary (MCS2,3). Children are shown a series of coloured pictures of objects one at a time which they are asked to name. The scale measures the children's expressive language ability. In the BAS Pattern Construction Test, the child constructs a design by putting together flat squares or solid cubes with black and yellow patterns on each side (MCS3,4). The child's score is based on both speed and accuracy in the task. The BAS Picture Similarity Test assesses pictorial reasoning (MCS3). The BAS Word Reading Test the child reads aloud a series of words presented on a card (MCS4).

The second measure of cognitive ability is the Bracken School Readiness Assessment. This is used to assess the conceptual development of young children across a wide range of categories, each in separate subtests (Bracken 2002). MCS2 employs six of the subtests which specifically evaluate: colours, letters, numbers/counting, sizes, comparisons, and shapes.The test result used is a composite score based on the total number of correct answers across all six subtests.

Non-Cognitive Development

The behavioural development of children is measured using the Strengths and Difficulties Questionnaire (SDQ). This is a validated behavioural screening tool which has been shown to compare well with other measures for identifying hyperactivity and attention problems (Goodman, 1997). It consists of 25 items which generate scores for five subscales measuring: conduct problems; hyperactivity; emotional symptoms; peer problems; and pro-social behaviour. The child's behaviour is reported by a parent, normally the mother, in the computer assisted self-completion module of the questionnaire. At age 4 an age appropriate adapted version of the SDQ was used and at ages 5 and 7 the 4 - 15 years version was used.

Health

Various dimensions of child health are reported by the mother. At the 9-month survey she is asked whether the child has suffered any of the following list of health problems that resulted in him/her being taken to the GP, Health Centre or Health visitor, or to Casualty, or that resulted in a phonecall to NHS direct: chest infections, ear infections, wheezing/asthma, skin problems, persistent or severe vomiting, and/or persistent or severe diarrhoea.

At ages 3, 5 and 7, the mother is asked whether the child has any long-standing health condition, asthma (ever), eczema (ever), hayfever (ever) (note eczema and hayfever are pooled at age 3), wheezing/whistling in chest (ever). At age 3 we also observe whether the child has had recurring ear infections.

Maternal Behaviour/Parenting Activities

We measure three dimensions of maternal behaviour and investments. The first is the warmth of the relationship between the mother and child at three years from a self-reported instrument completed by mothers that assesses her perceptions of her relationship with her child (Pianta 1992).

The second is maternal mental health. At child age 9 months, it is measured from the Malaise Inventory (Rutter et al. 1970), a set of self-completion questions which combine to measure levels of psychological distress, or depression. It is a shortened version of the original 24-item scale that was developed from the Cornell Medical Index Questionnaire which comprises of 195 self-completion questions (Brodman et al. 1949, 1952). This self completion measure has been used widely in general population studies. In the MCS, the following 9 of the original 24 items of the Malaise Inventory were used: tired most of time; often miserable or depressed; often worried about things; easily upset or irritated; every little thing gets on your nerves and wears you out; often get into a violent rage; suddenly scared for no good reason; constantly keyed up or jittery; heart often races like mad. Yes/No answers are permitted, making total score of 9. At ages 3, 5 and 7, the Kessler 6 scale was used (Kessler et al. 2003). Both main and partner respondents used a computerised self-completion form. The six questions ask how often in the past 30 days the respondent had felt i) ‘so depressed that nothing could cheer you up’ ii) ‘hopeless’ iii) ‘restless or fidgety’ iv) ‘that everything you did was an effort’ v) ‘worthless’ vi) ‘nervous’. For each question respondents score between 0 (none of the time) and 3 (most or all of the time) making a total scale of 18.

Finally, we observe the home learning environment (HLE, based on activities carried out with the child in the home, see Bradley 1995) at ages 3, 5 and 7. In particular, at age 3 we observe frequency of: reading to the child, library visits, learn the ABC or alphabet, numbers or counting, songs, poems or nursery rhymes, painting or drawing. At ages 5 and 7 we observe the frequency of: reading, stories, musical activities, drawing/painting, physically active games, indoor games, park/playground. We consider these activities separately (coded as 0/1 dummy variables, where 1=whether the activity took place every day) and also combine the responses on frequency into a score “Home learning environment” ranging from 0 (do not perform any of said activities at all) to 42 (perform each of said activities every day).

Appendix II: Balance

Not for Publication

This Appendix expands section 5.3 and 5.4 of the paper. In the tables below, we will assess the comparability of babies (and their mothers) born at weekdays vs. weekends, as well as of the essential maternity services.

Table II.1 shows that the mother's characteristics (including antenatal services received, demographics, mother's health and lifestyle, socioeconomic status, birth weight of newborn) are fully comparable between deliveries that take place on the weekend (Fri-Sun) and weekday (Mon-Thurs). In all 90 variables compared, the differences between those born on weekdays and the weekend are very small in magnitude, and only 3 of them are statistically significant at the 5% level. It is worth highlighting that Table II.1 includes variables that are important predictors of child development such as newborn's birth weight, ethnicity, maternal smoking and drinking during pregnancy, mother's receipt of welfare benefits (social assistance), all of which are extremely similar across weekday and weekend births.

We scrutinize the relationship in more detail by checking whether *Exposure* or *Hour*, which are our precise exclusion restrictions, are related to maternal and newborn characteristics. We regress the newborn and mother's characteristics over a third order polynomial in $Hour_i$ and report in Table II.2 the p-value of the null hypothesis that the coefficients of the third order polynomial are zero. It can be seen that in the vast majority (97%, or 87 out of 90 variables) of cases, we cannot reject this null hypothesis at 5% of significance. In Table II.3 we repeat the same exercise but with *Exposure* instead of the third order polynomial in *Hour*, and obtain similar results (94%, 85 out of 90 variables).

Table II.1. Balance by day of birth

Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff
Antenatal				Back Pain/lumbago/sciatica	0.204	0.218	-1.310
Received ante-natal care	0.946	0.953	-1.141	Fits/convulsions/epilepsy	0.021	0.029	-1.931
First ante-natal was				Diabetes	0.011	0.011	-0.129
0-11 weeks	0.405	0.391	1.092	Cancer	0.008	0.012	-1.462
12-13 weeks	0.329	0.344	-1.220	Digestive or Bowel disorders	0.069	0.082	-1.897
≥ 14 weeks	0.184	0.189	-0.446	Diabetes during pregnancy	0.007	0.008	-0.015
Don't know	0.028	0.029	-0.217				
Attended ante-natal	0.243	0.241	0.146	***Mothers Socioeconomic Status***			
Received fertility	0.012	0.016	-1.357	Working during pregnancy	0.493	0.508	-1.118
Planned parenthood	0.448	0.451	-0.255	Live in house	0.820	0.823	-0.327
				# rooms	5.000	5.015	-0.446
Baby				Own outright	0.029	0.025	1.075
Female	0.504	0.492	0.959	Rent from Local Authority	0.294	0.291	0.256
Birth weight (kg)	3.362	3.352	0.701	Rent from Housing Association	0.101	0.110	-1.059
Premature	0.049	0.043	1.088	Rent privately	0.105	0.095	1.276
Length of gestation (days)	278.8	279.3	-1.706	Live with parents	0.059	0.056	0.522
Present at birth				Live rent free	0.016	0.019	-0.816
Father	0.794	0.791	0.245	Heating			
Mother's friend	0.045	0.054	-1.703	Open fire	0.036	0.034	0.400
Grandmother (in law)	0.259	0.243	1.417	Gas/electric fire	0.305	0.302	0.298
Someone else	0.109	0.113	-0.412	Central	0.874	0.896	-2.572
				No heating	0.011	0.010	0.702
Mothers Demographics				Damp or condensation at	0.164	0.165	-0.040
Age	26.405	26.456	-0.322	Assets			
Expected educ. at age 16	0.558	0.563	-0.365	Telephone	0.943	0.939	0.599
Married	0.443	0.454	-0.821	Dishwasher	0.195	0.192	0.330
Religion				Own computer	0.384	0.385	-0.066
No religion	0.562	0.550	0.871	Tumble dryer	0.589	0.594	-0.385
Catholic	0.075	0.080	-0.668	Own/access to car	0.728	0.723	0.490
Protestant	0.030	0.028	0.477	Noisy Neighbours			
Anglican	0.148	0.144	0.449	Very common	0.088	0.093	-0.655
Another type of	0.061	0.062	-0.082	Fairly common	0.137	0.115	2.610
Hindu	0.013	0.012	0.364	Not very common	0.390	0.403	-1.017
Muslim	0.101	0.114	-1.636	Not at all common	0.385	0.390	-0.383
Other	0.011	0.011	-0.089	Presence of rubbish and litter			
Ethnicity				Very common	0.152	0.153	-0.068
White	0.844	0.837	0.664	Fairly common	0.225	0.221	0.321
Mixed	0.014	0.010	1.391	Not very common	0.367	0.368	-0.050
Indian	0.022	0.021	0.260	Not at all common	0.256	0.258	-0.195
Pakistani/Bangladeshi	0.080	0.089	-1.308	Vandalism and damage to			
Black	0.029	0.030	-0.197	Very common	0.113	0.110	0.358
Other	0.011	0.012	-0.350	Fairly common	0.163	0.159	0.355
Mother's Mother is still	0.931	0.931	-0.047	Not very common	0.400	0.401	-0.039
Lived away from home	0.200	0.209	-0.885	Not at all common	0.324	0.330	-0.478
				Garden			
Mothers Health and Lifestyle				Own garden	0.816	0.818	-0.200
Smoked during	3.642	3.633	0.057	Shared garden	0.047	0.044	0.485
Drank during pregnancy	0.250	0.246	0.434	Social Assistance			
Longstanding illness	0.199	0.206	-0.681	Child Tax Credit	0.122	0.131	-1.041
Limiting longstanding	0.105	0.095	1.308	Working Families Tax Credit	0.252	0.242	0.908
If mother has ever had				Income Support	0.299	0.304	-0.426
Migraine	0.226	0.218	0.675	Jobseekers Allowance	0.044	0.048	-0.776
Hayfever or persistent	0.222	0.246	-2.159	Housing Benefit	0.259	0.258	0.057
Bronchitis	0.072	0.070	0.404	Council Tax Benefit	0.243	0.238	0.432
Asthma	0.171	0.178	-0.707	Invalid Care Allowance	0.015	0.013	0.665
Eczema	0.175	0.184	-0.925				

Notes. Figures in columns titled "Fri-Sun" and "Mon-Thurs" are sample means of the variable listed under the column titled "Variable". The t-statistic of the difference between the means listed in these two columns is shown under the column titled "t-stat diff". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. All variables are dummy variables, with the exception of birth weight, length of gestation, mother's age, smoked during pregnancy and # rooms. Number of observations 5989. Source: Millennium Cohort Study.

Table II.2. Balance by cubic polynomial in hour

Variable	p-value
Antenatal	
Received ante-natal care	0.639
First ante-natal was before:	
0-11 weeks	0.578
12-13 weeks	0.346
≥ 14 weeks	0.988
Don't know	0.292
Attended ante-natal classes	0.311
Received fertility treatment	0.147
Planned parenthood	0.651
Baby	
Female	0.620
Birth weight (kg)	0.664
Premature	0.472
Length of gestation (days)	0.439
Present at birth	
Father	0.638
Mother's friend	0.448
Grandmother (in law)	0.374
Someone else	0.439
Mothers Demographics	
Age	0.708
Expected educ. qual. at age 16	0.921
Married	0.298
Religion	
No religion	0.687
Catholic	0.597
Protestant	0.901
Anglican	0.991
Another type of Christian	0.896
Hindu	0.972
Muslim	0.057
Other	0.908
Ethnicity	
White	0.492
Mixed	0.128
Indian	0.483
Pakistani/Bangladeshi	0.122
Black	0.997
Other	0.353
Mother's Mother is still alive	0.658
Lived away from home before 17	0.521
Mothers Health and Lifestyle	
Smoked during pregnancy (cig. per day)	0.522
Drank during pregnancy	0.145
Longstanding illness	0.893
Limiting longstanding illness	0.622
If mother has ever had	
Migraine	0.972
Hayfever or persistent runny rose	0.125
Bronchitis	0.609
Asthma	0.949
Eczema	0.155
Back Pain/lumbago/sciatica	0.410
Fits/convulsions/epilepsy	0.117
Diabetes	0.838
Cancer	0.641
Digestive or Bowel disorders	0.033
Diabetes during pregnancy	0.901
Mothers Socioeconomic Status	
Working during pregnancy	0.186
Live in house	0.464
# rooms	0.376
Own outright	0.654
Rent from Local Authority	0.491
Rent from Housing Association	0.311
Rent privately	0.875
Live with parents	0.647
Live rent free	0.074
Heating	
Open fire	0.640
Gas/electric fire	0.601
Central	0.017
No heating	0.371
Damp or condensation at home	0.088
Assets	
Telephone	0.205
Dishwasher	0.924
Own computer	0.849
Tumble dryer	0.894
Own/access to car	0.641
Noisy Neighbours	
Very common	0.176
Fairly common	0.170
Not very common	0.416
Not at all common	0.352
Presence of rubbish and litter in the area	
Very common	0.760
Fairly common	0.956
Not very common	0.836
Not at all common	0.802
Vandalism and damage to property in the area	
Very common	0.918
Fairly common	0.947
Not very common	0.705
Not at all common	0.717
Garden	
Own garden	0.254
Shared garden	0.979
Social Assistance	
Child Tax Credit	0.327
Working Families Tax Credit	0.741
Income Support	0.740
Jobseekers Allowance	0.086
Housing Benefit	0.048
Council Tax Benefit	0.056
Invalid Care Allowance	0.529

Notes. Each cell reports the P-value of the joint hypothesis that the coefficients of a cubic polynomial in hour are jointly zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. All variables are dummy variables, with the exception of birth weight, length of gestation, mother's age, smoked during pregnancy and # rooms. Number of observations 5989. Source: Millennium Cohort Study.

Table II.3. Balance by Exposure to weekend

Variable	p-value	Variable	p-value
Antenatal		Back Pain/lumbago/sciatica	0.134
Received ante-natal care	0.541	Fits/convulsions/epilepsy	0.021
First ante-natal was before:		Diabetes	0.766
0-11 weeks	0.843	Cancer	0.315
12-13 weeks	0.951	Digestive or Bowel disorders	0.002
≥ 14 weeks	0.789	Diabetes during pregnancy	0.796
Don't know	0.816		
Attended ante-natal classes	0.668	***Mothers Socioeconomic Status***	
Received fertility treatment	0.901	Working during pregnancy	0.822
Planned parenthood	0.673	Live in house	0.847
		# rooms	0.645
Baby		Own outright	0.813
Female	0.254	Rent from Local Authority	0.291
Birth weight (kg)	0.803	Rent from Housing Association	0.960
Premature	0.163	Rent privately	0.886
Length of gestation (days)	0.224	Live with parents	0.535
Present at birth		Live rent free	0.630
Father	0.903	Heating	
Mother's friend	0.156	Open fire	0.574
Grandmother (in law)	0.164	Gas/electric fire	0.734
Someone else	0.397	Central	0.350
		No heating	0.846
Mothers Demographics		Damp or condensation at home	0.180
Age	0.763	Assets	
Expected educ. qual. at age 16	0.549	Telephone	0.539
Married	0.214	Dishwasher	0.561
Religion		Own computer	0.477
No religion	0.449	Tumble dryer	0.441
Catholic	0.596	Own/access to car	0.633
Protestant	0.722	Noisy Neighbours	
Anglican	0.959	Very common	0.076
Another type of Christian	0.991	Fairly common	0.083
Hindu	0.675	Not very common	0.814
Muslim	0.283	Not at all common	0.706
Other	0.921	Presence of rubbish and litter in the area	
Ethnicity		Very common	0.574
White	0.723	Fairly common	0.798
Mixed	0.029	Not very common	0.307
Indian	0.479	Not at all common	0.670
Pakistani/Bangladeshi	0.231	Vandalism and damage to property in the area	
Black	0.984	Very common	0.842
Other	0.546	Fairly common	0.853
Mother's Mother is still alive	0.385	Not very common	0.590
Lived away from home before 17	0.442	Not at all common	0.777
		Garden	
Mothers Health and Lifestyle		Own garden	0.674
Smoked during pregnancy (cig per day)	0.834	Shared garden	0.896
Drank during pregnancy	0.645	Social Assistance	
Longstanding illness	0.667	Child Tax Credit	0.852
Limiting longstanding illness	0.355	Working Families Tax Credit	0.865
If mother has ever had		Income Support	0.910
Migraine	0.946	Jobseekers Allowance	0.177
Hayfever or persistent runny rose	0.029	Housing Benefit	0.066
Bronchitis	0.638	Council Tax Benefit	0.049
Asthma	0.753	Invalid Care Allowance	0.445
Eczema	0.482		

Notes. Each cell reports the P-value of the hypothesis that the coefficient of the exposure to weekend variable (defined in section 6.1) is zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. All variables are dummy variables, with the exception of birth weight, length of gestation, mother's age, smoked during pregnancy and # rooms. Number of observations 5989. Source: Millennium Cohort Study

Regarding the comparability of essential maternity services, Table II.4 scrutinizes the comparability of delivery (using MCS data) and post-natal services (using MUS data). We observe an extensive set of characteristics, including whether the labor was induced, duration of labor, type of vaginal delivery (normal, forceps etc), type of pain relief used, whether/which complication occurred. The MUS allow us to explore post-natal care variables including whether the baby received a newborn health check and how staff treated the mother, as well as what she thought of the information she received. The values of all of these variables (and other more detailed variables also shown in Table II.4) are markedly similar between weekdays and weekends, and no observed differences are statistically significant at the 5% level.

Table II.4. Balance by day of birth: Hospital-Related variables

Variable	Fri-Sun	Mon-Thurs	t-stat diff
Delivery			
Labour induced	0.302	0.309	-0.629
Labour duration (hours)	8.953	8.705	0.912
Type Delivery:			
Normal	0.900	0.903	-0.387
Forceps	0.038	0.038	0.119
Vacuum	0.065	0.063	0.405
Other	0.008	0.007	0.713
Pain relief:			
None	0.099	0.107	-1.036
Gas and air	0.800	0.788	1.138
Pethidine	0.360	0.350	0.789
Epidural	0.208	0.201	0.652
General anaesthetic	0.003	0.002	0.836
TENS	0.073	0.072	0.117
Other	0.036	0.032	0.791
Complication:			
None	0.756	0.766	-0.918
Breech	0.003	0.003	-0.493
Other abnormal	0.019	0.020	-0.099
Very long labour	0.049	0.047	0.482
Very rapid labour	0.028	0.023	1.003
Foetal distress (heart)	0.078	0.068	1.516
Foetal distress (meconium)	0.035	0.038	-0.576
Other	0.081	0.077	0.587
Postnatal hospital care			
Had newborn exam before discharge	0.942	0.942	0.004
Newborn exam carried out by			
Doctor vs. Midwife, other or not checked	0.707	0.707	0.034
Doctor or Midwife vs. Other or not checked	0.883	0.876	0.672
Received enough info about your recovery	0.853	0.872	-1.939
During postnatal care…			
Always spoken to in a way that I could understand	0.728	0.726	0.163
Always treated with respect	0.695	0.711	-1.204
Always Treated with kindness	0.681	0.694	-0.982
Always given the info needed	0.644	0.639	0.335

Notes. Figures in columns titled "Fri-Sun" and "Mon-Thurs" are sample means of the variable listed under the column titled "Variable". The t-statistic of the difference between the means listed in these two columns is shown under the column titled "t-stat diff". Sample comprises low educated mothers, and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. All variables are dummy variables, with the exception of labour duration. Delivery related variables were collected in the Millennium Cohort Study with 5989 observations. Variables related to postnatal hospital care were collected in the Maternity Users Survey 2007 with 5314 observations.

For the MCS, in which we observe hour of birth, we can also check the relationship between the labor and delivery variables and the continuous variables that we use as exclusion restrictions (third order polynomial in *Hour* and *Exposure* as defined previously) as we did for Tables II.2 and II.3 above. The results, reported in Tables II.5 and II.6 show that the only tests rejected at the 5% level are those of labor inductions and epidural administration. Importantly however, a graphical inspection in Figure II.1 shows that this is not driven by a weekend-weekday difference (consistent with what the statistics in Table II.4 indicate) but rather due to a day-night pattern (inductions are usually started at daytime and associated births tend to occur later in the evening, and induced labors are twice as likely to involve the administration of epidural).[1] In the robustness of section 8.2, we show that our results are robust to excluding labor inductions, as well as controlling for a third order polynomial in time of birth within the day (taking values 0 to 23) as well as for 23 dummy variables for the hour of birth within the day. Note, moreover, that both induced labor and epidurals are very standard medical procedures and it would be difficult to argue that they affect child development (and moreover we control for them in the regressions).

[1] Among women with induced labors, 30% are administered and epidural; this compares to an administration rate of 15% amongst women whose labor is not induced.

Table II.5. Cubic polynomial of hour: Hospital-related variables

Variable	p-value
Delivery	
Labour induced	0.000
Labour duration (hours)	0.336
Type Delivery:	
Normal	0.095
Forceps	0.318
Vacuum	0.425
Other	0.414
Pain relief:	
None	0.187
Gas and air	0.178
Pethidine	0.538
Epidural	0.045
General anaesthetic	0.593
TENS	0.928
Other	0.600
Complication:	
None	0.868
Breech	0.918
Other abnormal	0.298
Very long labour	0.658
Very rapid labour	0.530
Foetal distress (heart)	0.547
Foetal distress (meconium)	0.550
Other	0.593

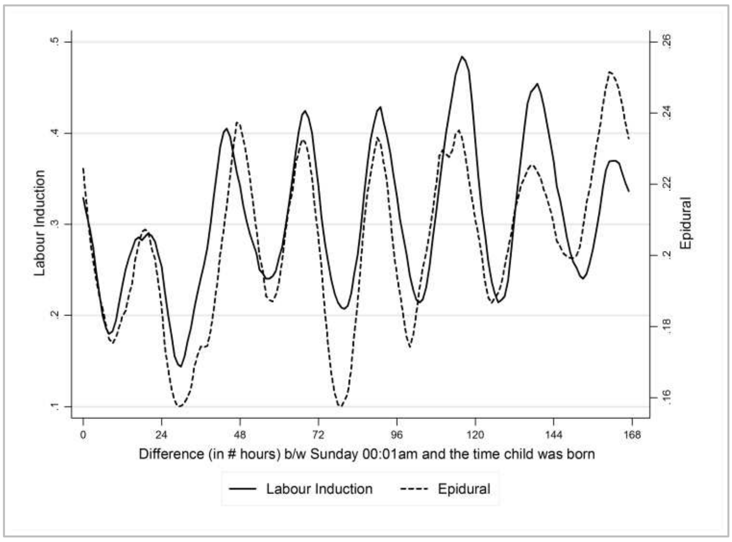
Notes. Each cell reports the P-value of the joint hypothesis that the coefficients of a cubic polynomial in hour are jointly zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. All variables are dummy variables, with the exception of labour duration. Number of observations 5989. Source: Millennium Cohort Study.

Table II.6. Exposure to weekend: Hospital-related variables

Variable	p-value
Delivery	
Labour induced	0.000
Labour duration (hours)	0.745
Type Delivery:	
Normal	0.249
Forceps	0.245
Vacuum	0.674
Other	0.070
Pain relief:	
None	0.057
Gas and air	0.548
Pethidine	0.339
Epidural	0.113
General anaesthetic	0.414
TENS	0.869
Other	0.329
Complication:	
None	0.772
Breech	0.685
Other abnormal	0.497
Very long labour	0.508
Very rapid labour	0.369
Foetal distress (heart)	0.662
Foetal distress (meconium)	0.229
Other	0.338

Notes. Each cell reports the P-value of the hypothesis that the coefficient of the exposure to weekend variable (defined in section 6.1) is zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. All variables are dummy variables, with the exception of labour duration. Number of observations 5989. Source: Millennium Cohort Study.

Figure II.1. Labour Induction and Epidural Use During Labour, by Hour of Birth



The horizontal axis shows the hour of birth within the week (0 corresponds to Sunday 00:01-00:59 and 163 to 23:00-23:59 on Saturday), the left vertical axis displays the proportion of deliveries in which labor was induced and the right vertical axis displays the proportion of deliveries for which an epidural was administered. The relation between the proportion of deliveries for which labor was induced (solid line) and the proportion of deliveries for which an epidural was administered (dashed line) was estimated using Kernel regression with a triangular Kernel and bandwidth of 6 for inductions and 9 for epidural. Sample comprises low educated mothers (NVQ level 2 or less, or those with unknown NVQ level but left school before age 17), but excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. Source: Millennium Cohort Study.

Appendix III:
Monte Carlo Simulation

Not for Publication

Appendix III. Monte Carlo Simulation

Given our sample and first-stage estimates, what estimates (or bias) should we expect if the true effect of breastfeeding on children's development is zero? And analogously, what should we expect if the true effect is positive? To answer these questions, as well as to investigate the finite sample properties of NTSLS, which is still relatively new in empirical practice, we perform a Monte Carlo simulation. We use our model estimates as well as our sample to define the data generating process so that the results are relevant for our subsequent empirical analysis.

The Data Generating Process (DGP) of the Monte Carlo simulation is specified using the sample and parameter values (both of the first stage and of the outcome equation) that we obtain when we estimate the model with the cognitive index as the outcome variable (Table 5 column 1 if we use *Exposure* as exclusion restriction, and Table 5 column 5 if we use the cubic polynomial in *Hour*). In what follows, we describe the Monte Carlo exercise using *Exposure,* but we also report the results of when we use the cubic polynomial in *Hour*.

The Monte Carlo design keeps the sample of (N=5015) observations, X_i and $Exposure_i$ variables fixed. We carry out seven different Monte Carlo simulations, one for each different value of α_1: $0, 0.05, 0.10, 0.15, 0.25, 0.35, 0.463$ (this latter one corresponds to the one estimated using actual data). The steps below require that we specify a value for ρ, the correlation between the unobservables of the breastfeeding equation and of the cognitive development equation, $(\varepsilon_i, \vartheta_i)$. We define a grid of possible values for ρ, and carry out the steps below for each value of the grid (for ease of notation, we omit the sub index of ρ, α, and the Monte Carlo replica sub index):

<u>Step 1</u>: Estimate the first stage model below using actual data: $Exposure_i$, X_i and B_i (Breastfeeding):

$$\dot{B}_i = \beta_0 + \beta_1 Exposure_i + \beta_2 X_i + \vartheta_i$$
$$B_i = 1 \; if \; \dot{B}_i \geq 0; B_i = 0 \; if \; \dot{B}_i < 0 \, ,$$

The estimates $[\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2]$ are saved, to be used in the steps below. Note that this step is independent of the chosen values of α_1 and ρ.

Step 2: Use NTSLS to estimate the parameters of the outcome equation (equation 2) on actual data: *Exposure*$_i$ or *hour*$_i$, X_i, B_i (breastfeeding), h_j (hospital fixed effect), Y_{ij} (cognitive index). The estimates $[\hat{\alpha}_0, \hat{\alpha}_1, \hat{\alpha}_2, \widehat{h_j}, \hat{\sigma}_\varepsilon^2]$ are saved, to be used in the steps below. The estimate of $[\hat{\alpha}_1]$ is the one reported in Table 5 col. 1 (Table 5 col. 4 if using *Hour*). Note that this step is also independent of the chosen values of α_1 and ρ.

Step 3: Obtain $\{\tilde{\varepsilon}_i, \tilde{\vartheta}_i\}_{i=1}^N$ draws of the bivariate normal distribution with variances (σ_ε^2,1) and correlation coefficient ρ.

Step 4: Using the parameter values of the first stage Probit model from step 1, $[\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2]$, we obtain simulated values for breastfeeding, $\widetilde{B_i}$, as $\widetilde{B_i} = 1[\hat{\beta}_0 + \hat{\beta}_1 Exposure_i + \hat{\beta}_2 X_i + \tilde{\vartheta}_i > 0]$.

Step 5: Using the parameter values of the outcome equation obtained in step 2, $[\hat{\alpha}_0, \hat{\alpha}_2, \widehat{h_j}, \hat{\sigma}_\varepsilon^2]$, we obtain simulated values for $\widetilde{Y_{ij}}$ as $\widetilde{Y_{ij}} = \hat{\alpha}_0 + \alpha_1 \widetilde{B_i} + \hat{\alpha}_2 X_i + \widehat{h_j} + \tilde{\varepsilon}_i$, where $\widetilde{B_i}$ comes from Step 4 and α_1 depends on the specific Monte Carlo simulation (α_1: 0, 0.05, 0.10, 0.15, 0.25, 0.35, 0.463).

Step 6: Using the 5015 observations of *Exposure*$_i$, X_i, and associated simulated values of $\widetilde{B_i}$ (from step 4), and $\widetilde{Y_{ij}}$ (from step 5), the second stage IV regression (equation 2) is estimated using NTSLS and TSLS to obtain $\bar{\bar{\alpha}}_1^{NTSLS}$ and $\bar{\bar{\alpha}}_1^{TSLS}$. The values of $\bar{\bar{\alpha}}_1^{NTSLS}$, $\bar{\bar{\alpha}}_1^{TSLS}$ are saved, as well as their estimated standard errors. In this step, we also compute the OLS estimator of equation (2) and save $\bar{\bar{\alpha}}_1^{OLS}$.

Step 7: Repeat steps 3-6 1,000 times, keeping *Exposure*$_i$, X_i, h_j, the values of α_1, ρ, and the parameters from steps 1 and 2 fixed.

The above steps will yield 1,000 values of $\bar{\bar{\alpha}}_1^{NTSLS}$, $\bar{\bar{\alpha}}_1^{TSLS}$ and $\bar{\bar{\alpha}}_1^{OLS}$ for each possible value of the (ρ, α_1) combination. For each value of α_1, we choose the value of ρ for which the average across the 1000 values of $\bar{\bar{\alpha}}_1^{OLS}$ is closest to the OLS estimate found in the data (reported in Table 5, cols. 1 and 4). Note that the chosen value of ρ is different depending on the value of α_1. For the case of $\alpha_1 = 0.463$, Table III.1 compares the descriptive statistics of the cognitive index and breastfeeding in the actual data with those of the simulated data to check that the simulated data replicate the empirical patterns of the actual data.

Table III.1. Monte Carlo: Comparison of Actual and Simulated Data

	Actual Data	Simulated Data- Exposure to weekend	Simulated Data - Polynomial in hours
Cognitive Index			
Average	0.0022	0.0024	0.0024
SD	0.5562	0.5553	0.5554
Breastfed			
Average	0.2389	0.2391	0.2390

Notes. The first column of the Table reports descriptive statistics for the variables cognitive index and breastfeeding for at least 90 days, for the sample used to estimate the first column of Table 5. The second and third columns report the same descriptive statistics across 1000 Monte Carlo simulations in which the parameters of the Data Generating Process correspond to the ones estimated using Non-Linear Two Stage Least Squares (first row and column of Table 5), using exposure to weekend or the polynomial in hours as exclusion restrictions. The first and second stage equations of the Data Generating Process assume bivariate normality with correlation coefficient chosen so that the average OLS estimate of breastfeeding on the cognitive index across the 1000 Monte Carlo simulations match the OLS estimate reported in the third row and first column of Table 5. Control variables correspond to the same as in Table 5. Source: Millennium Cohort Study.

For each value of α_1, Table III.2 reports the average, median, and standard deviation (SD) of $\bar{\bar{\alpha}}_1^{NTSLS}$ and $\bar{\bar{\alpha}}_1^{TSLS}$ across the 1,000 Monte Carlo samples, as well as the average across the 1,000 estimated standard errors of $\bar{\bar{\alpha}}_1^{NTSLS}$ and $\bar{\bar{\alpha}}_1^{TSLS}$. When the true effect of breastfeeding on cognitive development is set to zero ($\alpha_1 = 0$), both the NTSLS and TSLS averages and medians are centered at zero. The difference between the two methods is in the dispersion of the parameter estimates. The SD of $\widehat{\alpha}_1$ is three times larger when we use TSLS than NTSLS. Hence, given the parameter estimates of our first stage (which we use to simulate the data), we should expect $\widehat{\alpha}_1$ to be close to zero if there is truly no effect of breastfeeding (but dispersion will be much higher when using TSLS than NTSLS). Similar results (i.e. averages/medians being very close to the true effect but dispersion being much smaller with NTSLS than TSLS) are found for values of α_1 up to 0.15.

Table III.2. Monte Carlo: Comparison NTSLS vs. TSLS. Exclusion restriction Exposure to Weekend

	True α1 = 0		True α1 = 0.05		True α1 = 0.10		True α1 = 0.15	
	NTSLS	TSLS	NTSLS	TSLS	NTSLS	TSLS	NTSLS	TSLS
Average of $\hat{\alpha}_1$	0.014	-0.013	0.051	0.042	0.088	0.103	0.125	0.162
Median of $\hat{\alpha}_1$	0.014	-0.045	0.053	0.005	0.087	0.054	0.127	0.105
SD of $\hat{\alpha}_1$	0.145	0.660	0.145	0.643	0.144	0.670	0.144	0.663
Average of Standard Error of $\hat{\alpha}_1$	0.149	0.708	0.150	0.685	0.150	0.733	0.150	0.696
MSE	0.223	0.663	0.191	0.591	0.162	0.578	0.135	0.530

	True α1 = 0.25		True α1 = 0.35		True α1 = 0.463	
	NTSLS	TSLS	NTSLS	TSLS	NTSLS	TSLS
Average of $\hat{\alpha}_1$	0.198	0.282	0.280	0.374	0.362	0.509
Median of $\hat{\alpha}_1$	0.200	0.208	0.282	0.343	0.363	0.457
SD of $\hat{\alpha}_1$	0.146	0.641	0.150	0.662	0.148	0.660
Average of Standard Error of $\hat{\alpha}_1$	0.149	0.676	0.149	0.719	0.148	0.731
MSE	0.092	0.443	0.056	0.445	0.032	0.437

Notes. The first row reports the average across 1000 Monte Carlo simulations of the estimate of breastfeeding for at least 90 days in equation (2). The column heading indicates the effect of breastfeeding as assumed in the Monte Carlo simulations (the value of 0.463 correspond to the one estimated using actual data in Table 5). The rest of the parameters of the Data Generating Process, both first and second stage, including the sample size and control variables correspond to the ones obtained using the cognitive index as dependent variable (Table 5, cognitive index, NTSLS). The error terms of the first and second stage are assumed to be bivariate normal with correlation coefficient chosen so that the average OLS estimate of breastfeeding across 1000 simulations is equal to the one estimated in the actual data (0.057, see Table 5). The estimation method, NTSLS (Non-Linear Two Stage Least Squares) or TSLS (Two Stage Least Squares), is noted in the column heading. The second (third) row corresponds to the median (standard deviation) of the estimate of breastfeeding across the 1000 Monte Carlo simulations. The fourth row reports the average across the 1000 simulations of the estimated standard error of the breastfeeding coefficient. The fifth row reports the Mean Square Error of the breastfeeding coefficient. Source: Millennium Cohort Study.

The columns for values of α_1 ranging from 0.25 to 0.463 show that both TSLS and NTSLS estimators are biased towards zero, with the size of the bias larger for NTSLS (which means that NTSLS are particularly conservative).[1] The larger is α_1, the larger is the bias (towards zero). This is because the larger α_1, the further away α_1 is from its OLS estimate of 0.057, and hence the larger the endogeneity (correlation between the error terms of the equations) is. For a given strength of the first stage, the larger the endogeneity is, the worse are the properties of the instrumental variables estimators (Hall, Rudebusch and Wilcox 1996; Shea 1997). Note however that the far smaller dispersion of NTSLS with respect to TSLS is independent of the true value of

[1] Newey (1990) also reports a larger bias with NTSLS than with TSLS even when he uses the prediction obtained with the true Probit model instead of the estimated one as we do.

α_1. Similar results are obtained using the third order polynomial in *Hour* instead of *Exposure* as exclusion restriction (see Table III.3).

Table III.3. Monte Carlo: Comparison NTSLS vs. TSLS
Exclusion restriction Polynomial in Hour

	True α1 = 0		True α1 = 0.05		True α1 = 0.10		True α1 = 0.15	
	NTSLS	TSLS	NTSLS	TSLS	NTSLS	TSLS	NTSLS	TSLS
Average of $\hat{\alpha}_1$	0.020	0.007	0.056	0.050	0.093	0.096	0.130	0.140
Median of $\hat{\alpha}_1$	0.015	0.011	0.052	0.044	0.090	0.097	0.125	0.128
SD of $\hat{\alpha}_1$	0.142	0.404	0.142	0.406	0.144	0.409	0.142	0.418
Average of Standard Error of $\hat{\alpha}_1$	0.142	0.414	0.142	0.415	0.143	0.418	0.143	0.421
MSE	0.206	0.361	0.176	0.326	0.149	0.294	0.123	0.271

	True α1 = 0.25		True α1 = 0.35		True α1 = 0.451	
	NTSLS	TSLS	NTSLS	TSLS	NTSLS	TSLS
Average of $\hat{\alpha}_1$	0.207	0.227	0.277	0.316	0.351	0.414
Median of $\hat{\alpha}_1$	0.208	0.214	0.274	0.304	0.347	0.378
SD of $\hat{\alpha}_1$	0.143	0.414	0.142	0.420	0.140	0.413
Average of Standard Error of $\hat{\alpha}_1$	0.142	0.418	0.142	0.418	0.141	0.417
MSE	0.080	0.222	0.051	0.195	0.030	0.171

Notes. The first row reports the average across 1000 Monte Carlo simulations of the estimate of breastfeeding for at least 90 days in equation (2). The column heading indicates the effect of breastfeeding as assumed in the Monte Carlo simulations (the value of 0.451 correspond to the one estimated using actual data in Table 5). The rest of the parameters of the Data Generating Process, both first and second stage, including the sample size and control variables correspond to the ones obtained using the cognitive index as dependent variable (Table 5, cognitive index, NTSLS). The error terms of the first and second stage are assumed to be bivariate normal with correlation coefficient chosen so that the average OLS estimate of breastfeeding across 1000 simulations is equal to the one estimated in the actual data (0.057, see Table 5). The estimation method, NTSLS (Non-Linear Two Stage Least Squares) or TSLS (Two Stage Least Squares), is noted in the column heading. The second (third) row corresponds to the median (standard deviation) of the estimate of breastfeeding across the 1000 Monte Carlo simulations. The fourth row reports the average across the 1000 simulations of the estimated standard error of the breastfeeding coefficient. The fifth row reports the Mean Square Error of the breastfeeding coefficient. Source: Millennium Cohort Study.

It is known that weak instruments might result in the estimated standard errors being too small. However, the Monte Carlo results indicate that this is not a problem in our case. Indeed, the standard errors are correctly estimated (independently of the true value of α_1, the SD across the $\widehat{\alpha}_1$ estimates matches the average estimated standard error of $\widehat{\alpha}_1$ across the 1,000 Monte Carlo samples with either NTSLS or TSLS). For the case of *Exposure*, TSLS produces a few very large outiler values of $\bar{\bar{\alpha}}_1^{TSLS}$ which we eliminate (around 20) when computing Table III.2. This explains why the standard errors of $\bar{\bar{\alpha}}_1^{TSLS}$ are slightly overestimated. Note that this is not a problem when we use NTSLS, nor when we use the cubic polynomial in *Hour*.

In summary, using our sample and parameter estimates (including our first stage estimates) to simulate data, we find that (1) both NTSLS and TSLS are consistent if the true effect of breastfeeding is relatively small (including zero), (2) both NTSLS and TSLS are biased towards zero if the true effect is large, (3) the standard errors are correctly estimated. This means that our estimates are conservative and that, if anything, our estimates will be lower bounds. We also find that NTSLS is far more precise than TSLS.

Appendix IV: An Exercise on Misclassification Error

Not for Publication

Appendix IV. Misclassification Error

In this Appendix we show that a reasonable amount of misclassification error can explain most of the difference between the OLS and IV estimates that we report in columns 1 and 4 of Table 5. Indeed, Figure 1 showed that the breastfeeding durations reported by mothers exhibited very substantial clustering at 30, 60, 90, 120 and 150 days, raising the suspicion of substantial measurement error in the reported duration of breastfeeding which would then lead to misclassification error on whether the child was breastfed for 90 days or not.

We simulate true breastfeeding durations and cognitive index outcomes based on a Data Generating Process that we estimate previously using our data. Then, we purposefully create measurement error in the dummy variable of whether a child has been breastfed for 90 day or not, and analyse its implications for the OLS and IV estimates. Our objective is to simply show that a relatively simple model of misclassification error with reasonable misclassification probabilities, ranging between 0.11 and 0.16, can explain 90% of the difference between the IV and OLS estimates of the effect of breastfeeding on the cognitive index. The steps of the Monte Carlo simulation are the following:

Step 1: Estimate a Poisson model in which the dependent variable is the number of days that the child has been breastfed (denoted by *NB*) as reported in the data. The conditional mean of the Poisson process is modelled as:

$$E[NB|Exposure, X] = EXP(\beta_0 + \beta_1 Exposure_i + \gamma X_i).$$

The estimates $[\hat{\beta}_0, \hat{\beta}_1, \hat{\gamma}]$ are saved, to be used in the steps below.

Step 2: Use NTSLS to estimate the parameters of the outcome equation (equation 2) on actual data: $Exposure_i$, X_i, B_i (breastfeeding for at least 90 days), hospital fixed effects, h_j, Y_{ij} (cognitive index). The estimates $[\hat{\alpha}_0, \hat{\alpha}_1, \hat{\alpha}_2, \hat{h}_j, \hat{\sigma}^2_\varepsilon]$ are saved to be used in the steps below. Note that the estimates correspond to those in column 1 of Table 5.

Step 3: Obtain $\{\tilde{\varepsilon}_i\}_{i=1}^{N}$draws of the normal distribution with variance $\hat{\sigma}_{\varepsilon}^2$, and $\{\widetilde{NB}_i\}_{i=1}^{N}$ draws of the Poisson distribution with mean $E[NB|Exposure, X] = EXP(\hat{\beta}_0 + \hat{\beta}_1 Exposure_i + \hat{\gamma} X_i)$.

Step 4: For each individual in the sample, estimate a true breastfeeding binary variable as a function of the duration obtained in Step 3. That is:

$$\tilde{B}_i = 1 \; if \; \widetilde{NB}_i \geq 90; \tilde{B}_i = 0 \; if \; \widetilde{NB}_i < 90.$$

Step 5: Using the parameter values of the outcome equation obtained in step 2, $[\hat{\alpha}_0, \hat{\alpha}_1, \hat{\alpha}_2, \hat{h}_j, \hat{\sigma}_{\varepsilon}^2]$, we obtain simulated values for $\tilde{Y}_{ij}$ as $\tilde{Y}_{ij} = \hat{\alpha}_0 + \hat{\alpha}_1 \tilde{B}_i + \hat{\alpha}_2 X_i + \hat{h}_j + \tilde{\varepsilon}_i$, where $\tilde{B}_i$ (true breastfeeding binary variable) comes from Step 4.

Step 6: Using the true breastfeeding duration, $\widetilde{NB}_i$, we derive a contaminated breastfeeding variable duration variable, $\overline{\overline{NB}}_i$, according to the following process:

$\Pr(\overline{\overline{NB}}_i \geq 90 | \widetilde{NB}_i \leq 45)$=0[1]

$\Pr(\overline{\overline{NB}}_i = w | 45 < \widetilde{NB}_i \leq 75)$=1/3, w=30, 60, 90

$\Pr(\overline{\overline{NB}}_i = w | 75 < \widetilde{NB}_i \leq 105)$=1/3, w=60, 90, 120

$\Pr(\overline{\overline{NB}}_i = w | 105 < \widetilde{NB}_i \leq 135)$=1/3, w=90, 120, 150

$\Pr(\overline{\overline{NB}}_i < 90 | \widetilde{NB}_i > 135)$=0[2]

As we will discuss below, this process generates a slightly higher probability of falsely reporting breastfeeding for at least 90 days than falsely reporting breastfeeding for less than 90 days, a feature that we believe plausible, as interviewees might want to be seen to conform to the official recommendations.

Step 7: Using the contaminated breastfeeding duration variable, $\overline{\overline{NB}}_i$, we build a missmeasured binary variable of breastfeeding for at least 90 days, $\overline{\overline{B}}_i$, following

$$\overline{\overline{B}}_i = 0 \; if \; \overline{\overline{NB}}_i < 90 \; ; \; \overline{\overline{B}}_i = 1 \; if \; \overline{\overline{NB}}_i \geq 90$$

[1] Due to Step 7, we do not need to be specific about the probabilities of contaminated breastfeeding durations as long as it is less than 90 days.

[2] Due to Step 7, we do not need to be specific about the probabilities of contaminated breastfeeding durations as long as it is 90 days or more.

Step 8: Using actual $Exposure_i$, covariates X_i, hospital dummies, h_j, the cognitive index as obtained in Step 5, $\tilde{Y}_{ij}$, and the missmeasured binary variable of breastfeeding for at least 90 days, $\bar{\bar{B}}_i$, as obtained in Step 6; we estimate the outcome equation (equation 2) using NTSLS, TSLS, and OLS. We save $\bar{\bar{\alpha}}_1^{NTSLS}, \bar{\bar{\alpha}}_1^{TSLS}$ and $\bar{\bar{\alpha}}_1^{OLS}$.

Step 9: Repeat steps 3-8 1,000 times, keeping fixed $Exposure_i$, X_i, h_j, and the values of $[\hat{\alpha}_0, \hat{\alpha}_1, \hat{\alpha}_2, \hat{h}_j, \hat{\sigma}_\varepsilon^2]$ and $[\hat{\beta}_0, \hat{\beta}_1, \hat{\gamma}]$ that we estimated from steps 1 and 2.

The above steps will yield 1,000 values of $\bar{\bar{\alpha}}_1^{NTSLS}$, $\bar{\bar{\alpha}}_1^{TSLS}$ and $\bar{\bar{\alpha}}_1^{OLS}$. The results in in the first row of Table IV.1 report the average across the 1000 simulations. The averages for the IV estimators (0.482 for NTLS and 0.368 for TSL) compare very well to the true effect (0.463, see col. 1 of Table 5), suggesting that they correct the bias induced by the misclassification error that we specified in Step 6.[3] Unlike the IV estimators, the OLS estimator is severely downwards biased. This is interesting because the misclassification probabilities are not that high: $Pr\left(\bar{\bar{B}}_i = 0 \middle| \tilde{B}_i = 1\right) = 0.11$ and $Pr\left(\bar{\bar{B}}_i = 1 \middle| \tilde{B}_i = 0\right) = 0.16$. More generally, what this exercise shows is that the OLS bias might be very sensitive to misclassification probabilities of reasonably size (which might be plausible given the cluster of breastfeeding durations that we report in Figure 1).

[3] These IV estimates do not exhibit the bias discussed in Appendix IV because the process that determines the true breastfeeding duration is independent of the error term that determines the cognitive index.

Table IV.1. Monte Carlo: Misclassification Error.
Exclusion restriction: Exposure to Weekend

	True α1 = 0.451		
	NTSLS	TSLS	OLS
Average of $\hat{\alpha}_1$	0.482	0.368	0.103
Median of $\hat{\alpha}_1$	0.481	0.326	0.103
SD of $\hat{\alpha}_1$	0.057	0.521	0.023

Notes. The first row reports the average across 1000 Monte Carlo simulations of the estimate of a missmeasured binary variable of breastfeeding for at least 90 days. The column heading indicates the effect of breastfeeding as assumed in the Monte Carlo simulations (the value of 0.451 correspond to the one estimated using actual data in Table 5). The estimation method, NTSLS (Non-Linear Two Stage Least Squares), TSLS (Two Stage Least Squares) and OLS, is noted in the column heading. The second (third) row corresponds to the median (standard deviation) of the estimate of breastfeeding across the 1000 Monte Carlo simulations. Source: Millennium Cohort Study.

Appendix V:
Results by Age

Not for Publication

Appendix V. Results by Age

In this appendix, we report results on the effects of breastfeeding on children's development separately by age and measures. This not only provides insight into the magnitude of the effects, but also helps to see where the effects are most concentrated (and whether the index is masking effects at specific ages/for specific subtests). Note that in the tables in this appendix, effects are presented in terms of coefficient estimates, and the mean and standard deviation of the outcome variables are shown in the table for scaling purposes. As before, the tables report the NTSLS estimates along with the TSLS and OLS estimates.

Table V.1 shows estimates of the effects of breastfeeding on cognitive development. As discussed in section 4, measures of cognitive development at age 3 are based on the expressive language component of the British Ability Scales (BAS) and the Bracken School Readiness test; at ages 5 and 7 they are based on different subscales of the British Ability Scales. We find large and significant effects of breastfeeding on various dimensions of cognition of around 65% of a standard deviation in the expressive language score at ages 3 and 5 (the results are very similar regardless of whether we use *Exposure* or the cubic polynomial in *Hour*). Similarly large effects are estimated for school readiness (age 3) and pictorial reasoning and visuo-spatial skills (age 5).

By age 7, the effects are no longer statistically significant at conventional levels. In Appendix VI.2, we show that this is most like due to attrition from the sample over time. Although attrition is balanced according to whether the child was born at the weekend or weekday, it is the relatively poorest children who are more likely to attrit.

Figure V.1 Effect of Breastfeeding on Cognitive Outcomes at Ages 3, 5 and 7 years

	3 years		5 years			7 years		
	Expressive Language	School Readiness	Expressive Language	Pictorial Reasoning	Visuo-Spatial	Numerical	Verbal	Visuo-Spatial
Panel A: Exclusion restriction Weekend Exposure								
NTSLS	11.481*	8.009*	11.608*	5.229	13.517*	1.143	-12.403	9.996
	(4.797)	(3.466)	(4.815)	(3.993)	(6.641)	(1.045)	(10.975)	(6.004)
TSLS	20.809	7.438	20.241	13.581	22.198	-0.265	-10.707	-8.870
	(20.420)	(11.702)	(18.357)	(14.690)	(24.178)	(2.774)	(27.692)	(16.627)
OLS	1.715**	0.778	1.223*	0.880*	0.796	0.316**	1.860	1.401*
	(0.621)	(0.452)	(0.539)	(0.441)	(0.723)	(0.114)	(1.208)	(0.681)
F statistic	5.502	7.444	6.045	6.261	6.134	6.876	8.135	6.961
P-value	0.0190	0.00639	0.0140	0.0124	0.0133	0.00877	0.00437	0.00836
Panel B: Exclusion restriction Polynomial of Hour								
NTSLS	11.182*	7.983*	10.235*	5.478	14.530*	1.132	-9.221	9.163
	(4.656)	(3.359)	(4.568)	(3.850)	(6.330)	(0.979)	(10.255)	(5.623)
TSLS	14.868	9.483	5.841	9.464	23.297	0.527	0.224	-3.189
	(14.090)	(9.488)	(11.532)	(10.224)	(16.846)	(2.175)	(21.483)	(12.529)
OLS	1.715**	0.778	1.223*	0.880*	0.796	0.316**	1.860	1.401*
	(0.621)	(0.452)	(0.539)	(0.441)	(0.723)	(0.114)	(1.208)	(0.681)
F statistic	2.652	3.126	2.967	3.055	3.136	3.460	3.860	3.530
P-value	0.0471	0.0248	0.0308	0.0273	0.0244	0.0157	0.00903	0.0142
Mean	70.38	22.19	104.1	80.24	85.43	9.126	101.1	114.0
SD	17.74	12.55	15.64	11.75	19.70	2.871	30.97	16.68
Observations	4209	4001	4347	4353	4331	3886	3838	3870

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 4 (with the addition of hospital fixed effects). In panel A the exclusion restriction from the second-stage regressions is Exposure to Weekend while in Panel B is the Cubic polynomial in hour. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

The poorest children are also the ones who are most likely to benefit from breastfeeding, because they will be receiving fewer parental investments. Hence, the effect of breastfeeding is lower when attrition is higher. To partially correct for this, under the assumption of attrition on observables, in Table V.2 we report the results of the effects of breastfeeding on cognitive development using Inverse Probability Weighting.

Figure V.2. Inverse Probability Weighting. Effect of Breastfeeding on Cognitive Outcomes at Ages 3, 5 and 7 years

	3 years		5 years			7 years		
	Expressive Language	School Readiness	Expressive Language	Pictorial Reasoning	Visuo-Spatial	Numerical	Verbal	Visuo-Spatial
Panel A: Exclusion restriction Weekend Exposure								
NTSLS	11.124**	7.879**	11.197**	4.615	14.894**	1.181	-15.403	10.882*
	(4.849)	(3.507)	(5.271)	(4.328)	(7.281)	(1.142)	(12.009)	(6.547)
TSLS	31.254	10.178	24.066	15.315	19.199	-0.807	-22.370	-18.033
	(26.547)	(13.122)	(24.173)	(18.287)	(29.471)	(3.339)	(33.628)	(22.676)
OLS	1.611**	0.655	1.330**	0.990**	0.838	0.321***	2.234*	1.413**
	(0.635)	(0.451)	(0.554)	(0.445)	(0.736)	(0.116)	(1.256)	(0.704)
F statistic	4.382	6.614	4.400	4.679	4.502	5.139	6.326	5.003
P-value	0.036	0.010	0.036	0.031	0.034	0.024	0.012	0.025
Panel B: Exclusion restriction Polynomial of Hour								
NTSLS	11.010**	7.836**	9.782**	4.676	15.650**	1.168	-12.788	10.351*
	(4.770)	(3.406)	(4.988)	(4.152)	(6.918)	(1.075)	(11.216)	(6.163)
TSLS	20.741	10.378	3.159	8.484	21.852	0.116	-7.431	-7.091
	(17.120)	(10.401)	(13.250)	(11.462)	(19.154)	(2.556)	(24.707)	(15.679)
OLS	1.611**	0.655	1.330**	0.990**	0.838	0.321***	2.234*	1.413**
	(0.635)	(0.451)	(0.554)	(0.445)	(0.736)	(0.116)	(1.256)	(0.704)
F statistic	2.120	2.790	2.353	2.468	2.496	2.692	3.137	2.662
P-value	0.096	0.039	0.070	0.060	0.058	0.045	0.024	0.046
Mean	70.38	22.19	104.1	80.24	85.43	9.126	101.1	114.0
SD	17.74	12.55	15.64	11.75	19.70	2.871	30.97	16.68
Observations	4209	4001	4347	4353	4331	3886	3838	3870

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 4 (with the addition of hospital fixed effects). In panel A the exclusion restriction from the second-stage regressions is Exposure to Weekend while in Panel B is the Cubic polynomial in hour. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

We next turn to the effects on children's non-cognitive skills, as measured by the widely used Strengths and Difficulties Questionnaire. Estimates are shown in Table V.3. The effects on this domain are considerably weaker than the effects on cognition: at no age are the effects statically distinguishable from zero at conventional levels.

Figure V.3. Effect of Breastfeeding on Non-Cognitive Outcomes at Ages 3, 5 and 7 years

	3 years	**5 years**	**7 years**
	Strengths and Difficulties	Strengths and Difficulties	Strengths and Difficulties
Panel A: Exclusion restriction Weekend Exposure			
NTSLS	2.600	0.098	1.105
	(1.585)	(1.258)	(1.352)
TSLS	-2.299	2.450	0.929
	(5.359)	(3.558)	(3.592)
OLS	0.684**	0.305*	0.511**
	(0.175)	(0.136)	(0.163)
F statistic	6.314	7.097	8.490
P-value	0.0120	0.00775	0.00359
Panel B: Exclusion restriction Polynomial of Hour			
NTSLS	2.179	0.391	1.269
	(1.497)	(1.210)	(1.260)
TSLS	-2.012	2.768	2.590
	(3.873)	(2.926)	(2.746)
OLS	0.684**	0.305*	0.511**
	(0.175)	(0.136)	(0.163)
F statistic	3.045	3.085	4.444
P-value	0.028	0.026	0.004
Mean	24.98	23.70	24.48
SD	4.880	3.602	4.122
Observations	4126	4213	3817

Notes: Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 4 (with the addition of hospital fixed effects). In panel A the exclusion restriction from the second-stage regressions is Exposure to Weekend while in Panel B is the Cubic polynomial in hour. Exposure to Weekend is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is jointly zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

The final dimension of child development we consider is health, which we additionally observe at wave 1, when the child is approximately 9 months old. Hence, Tables V.4 - V.7 report results for 9 months, 3, 5 and 7 years of age. Our results are in line with those of the randomized trial conducted by Kramer et al. (2001), which found only weak effects on health, as well as Baker, and Milligan (2008).[1] It is also worth stressing that we are unlikely to pick up any health effect of breastfeeding that is present only during the period when the mother breastfeeds the child (and that ceases once breastfeeding discontinues).[2] This is because 2 out of 3 mothers who breastfed for at least 3 months are not breastfeeding by 9 months, the time when health outcomes are observed.

[1] Clearly, this result is not relevant for developing countries where hygienic conditions are very different and children who are not breastfed are at much higher risk of infection.

[2] It is plausible that breastfeeding improves health while the child is being breastfed, due to the transmission of the mother's antibodies to the child, protecting him/her from infections, but that this benefit ceases once breastfeeding is discontinued.

Figure V.4. Effect of Breastfeeding on Physical Outcomes at 9 months of age

	Obesity	Chest infections	Ear infections	Wheezing or asthma	Skin problems	Persistent or severe vomiting	Persistent or severe diarrhoea
Panel A: Exclusion restriction Weekend Exposure							
NTSLS	-0.072	0.042	0.092	-0.089	-0.017	0.112	0.035
	(0.080)	(0.151)	(0.095)	(0.090)	(0.130)	(0.092)	(0.091)
TSLS	0.383	-0.161	0.258	0.378	0.002	0.128	-0.099
	(0.271)	(0.432)	(0.298)	(0.286)	(0.364)	(0.253)	(0.258)
OLS	-0.030**	-0.012	0.005	-0.013	0.013	-0.001	-0.022*
	(0.008)	(0.015)	(0.010)	(0.008)	(0.013)	(0.009)	(0.009)
F statistic	8.989	8.644	8.644	8.644	8.644	8.644	8.644
P-value	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Panel B: Exclusion restriction Polynomial of Hour							
NTSLS	-0.073	-0.008	0.127	-0.077	-0.021	0.109	0.026
	(0.078)	(0.141)	(0.091)	(0.084)	(0.121)	(0.087)	(0.086)
TSLS	0.251	-0.231	0.337	0.107	-0.017	0.152	-0.065
	(0.191)	(0.320)	(0.222)	(0.189)	(0.264)	(0.190)	(0.190)
OLS	-0.030**	-0.012	0.005	-0.013	0.013	-0.001	-0.022*
	(0.008)	(0.015)	(0.010)	(0.008)	(0.013)	(0.009)	(0.009)
F statistic	4.589	4.822	4.822	4.822	4.822	4.822	4.822
P-value	0.003	0.002	0.002	0.002	0.002	0.002	0.002
Mean	0.0647	0.291	0.0878	0.0744	0.171	0.0696	0.0777
SD	0.246	0.454	0.283	0.262	0.377	0.254	0.268
Observations	5578	5806	5806	5806	5806	5806	5806

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 4 (with the addition of hospital fixed effects). In panel A the exclusion restriction from the second-stage regressions is Exposure to Weekend while in Panel B is the Cubic polynomial in hour. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Figure V.5. Physical Outcomes at 3 years of age

	Obesity	Long standing health condition	Recurring ear infections	Asthma (ever)	Eczema/ hayfever (ever)	Wheezing/whistling in chest (ever)
Panel A: Exclusion restriction Weekend Exposure						
NTSLS	-0.159*	-0.113	-0.005	-0.220	-0.221	-0.057
	(0.079)	(0.121)	(0.088)	(0.129)	(0.164)	(0.156)
TSLS	0.046	-0.724	-0.060	-0.575	-0.070	0.384
	(0.280)	(0.557)	(0.292)	(0.472)	(0.553)	(0.580)
OLS	0.001	-0.011	0.007	-0.023*	-0.022	-0.02
	-0.01	-0.014	-0.01	-0.012	-0.018	-0.018
F statistic	5.768	5.938	6.031	6.369	5.931	5.938
P-value	0.016	0.015	0.014	0.012	0.015	0.015
Panel B: Exclusion restriction Polynomial of Hour						
NTSLS	-0.149*	-0.098	0.010	-0.157	-0.106	-0.037
	(0.077)	(0.114)	(0.083)	(0.121)	(0.154)	(0.149)
TSLS	0.030	-0.491	0.020	-0.047	0.368	0.380
	(0.207)	(0.345)	(0.198)	(0.288)	(0.414)	(0.408)
OLS	0.001	-0.011	0.007	-0.023*	-0.022	-0.02
	-0.01	-0.014	-0.01	-0.012	-0.018	-0.018
F statistic	2.772	3.027	3.076	3.086	2.934	3.027
P-value	0.040	0.028	0.027	0.026	0.032	0.028
Mean	0.060	0.158	0.064	0.139	0.367	0.323
SD	0.237	0.365	0.245	0.346	0.482	0.468
Observations	4206	4484	4481	4409	4437	4484

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 4 (with the addition of hospital fixed effects). In panel A the exclusion restriction from the second-stage regressions is Exposure to Weekend while in Panel B is the Cubic polynomial in hour. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Figure V.6. Physical Outcomes at 5 years of age

	Obesity	Excellent health	Long standing health condition	Asthma (ever)	Eczema (ever)	Hayfever (ever)	Wheezing/whistling in chest (ever)
Panel A: Exclusion restriction Weekend Exposure							
NTSLS	-0.199*	0.016	0.096	-0.034	-0.060	0.081	0.114
	(0.093)	(0.177)	(0.143)	(0.136)	(0.167)	(0.112)	(0.165)
TSLS	-0.087	-0.143	-0.154	0.349	-0.081	0.550	0.184
	(0.281)	(0.524)	(0.421)	(0.417)	(0.495)	(0.412)	(0.485)
OLS	-0.018*	0.024	0.028*	0.000	0.008	0.011	-0.020
	(0.009)	(0.019)	(0.016)	(0.014)	(0.019)	(0.013)	(0.017)
F statistic	3.135	3.412	3.409	3.353	3.505	3.093	3.429
P-value	0.025	0.017	0.017	0.018	0.015	0.026	0.016
Panel B: Exclusion restriction Polynomial of Hour							
NTSLS	-0.159*	0.002	0.085	0.016	0.028	0.063	0.129
	(0.087)	(0.169)	(0.135)	(0.130)	(0.158)	(0.106)	(0.158)
TSLS	0.085	-0.163	-0.242	0.486	0.467	0.320	0.265
	(0.196)	(0.396)	(0.318)	(0.332)	(0.390)	(0.269)	(0.370)
OLS	-0.018*	0.024	0.028*	0.000	0.008	0.011	-0.020
	(0.009)	(0.019)	(0.016)	(0.014)	(0.019)	(0.013)	(0.017)
F statistic	3.135	3.412	3.409	3.353	3.505	3.093	3.429
P-value	0.025	0.017	0.017	0.018	0.015	0.026	0.016
Mean	0.062	0.478	0.194	0.169	0.329	0.106	0.302
SD	0.24	0.5	0.395	0.375	0.47	0.308	0.459
Observations	4341	4396	4395	4378	4392	4379	4394

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 4 (with the addition of hospital fixed effects). In panel A the exclusion restriction from the second-stage regressions is Exposure to Weekend while in Panel B is the Cubic polynomial in hour. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Figure V.7. Physical Outcomes at 7 years of age

	Obesity	Long standing health condition	Asthma (ever)	Eczema (ever)	Hayfever (ever)	Wheezing/whistling in chest (ever)
Panel A: Exclusion restriction Weekend Exposure						
NTSLS	-0.139	-0.111	-0.128	0.060	0.145	-0.047
	(0.107)	(0.138)	(0.133)	(0.162)	(0.129)	(0.154)
TSLS	-0.120	-0.223	0.368	0.407	0.352	0.368
	(0.296)	(0.370)	(0.382)	(0.485)	(0.367)	(0.439)
OLS	-0.009	0.012	-0.006	0.007	0.004	-0.005
	(0.012)	(0.016)	(0.015)	(0.020)	(0.015)	(0.018)
F statistic	7.263	8.099	8.178	7.745	7.351	8.069
P-value	0.007	0.004	0.004	0.005	0.007	0.005
Panel B: Exclusion restriction Polynomial of Hour						
NTSLS	-0.105	-0.078	-0.042	0.131	0.154	0.020
	(0.101)	(0.127)	(0.123)	(0.152)	(0.121)	(0.143)
TSLS	0.030	-0.042	0.535*	0.518	0.275	0.524
	(0.224)	(0.267)	(0.303)	(0.364)	(0.270)	(0.347)
OLS	-0.009	0.012	-0.006	0.007	0.004	-0.005
	(0.012)	(0.016)	(0.015)	(0.020)	(0.015)	(0.018)
F statistic	3.634	4.247	4.281	4.187	3.881	4.254
P-value	0.012	0.005	0.005	0.006	0.009	0.005
Mean	0.100	0.186	0.176	0.335	0.155	0.26
SD	0.300	0.389	0.381	0.472	0.362	0.439
Observations	3893	3942	3935	3939	3918	3943

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 4 (with the addition of hospital fixed effects). In panel A the exclusion restriction from the second-stage regressions is Exposure to Weekend while in Panel B is the Cubic polynomial in hour. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** $p<0.01$, * $p<0.05$. Source: Millennium Cohort Study.

Appendix VI: Attrition

Not for Publication

Attrition is known to be non-negligible across cohort studies worldwide. In the US Early Childhood Longitudinal Study-Birth Cohort attrition is around 21% by the time children are aged 3, while attrition is 40% in the Canadian National Longitudinal Survey of Children and Youth by the time children are 4 or 5 years old. In the MCS, a substantial effort is made to reduce attrition and children are followed up in subsequent waves even if they could not be reached in one of them. As a consequence, attrition is a non-absorbing state, and a child can return to the sample after exiting (Figure VI.1 shows the sample flow between waves 1 and 4).

For the purpose of the paper, the most important issue is whether attrition renders our identification strategy invalid. For this, it is necessary to establish whether attriters born at weekends have different characteristics than attriters born on weekdays. *A priori*, it is unlikely to be a problem - attrition is much more likely be related to parent's mobility and availability than to the day the child was born. In Table VI.1 we show that the difference in the attrition rate of weekday vs. weekend born children is practically zero (ranging between -0.9% and +0.8%). In Tables VI.2, we show that attrition is also uncorrelated with the exclusion restrictions that we use in the analysis: *Exposure* and the cubic polynomial in *Hour*. In Tables VI.3-VI.14 we also check that the observable characteristics of children born at weekends are comparable to those born at weekdays also amongst the non-attriters of each wave (Tables VI.3-VI.11) and amongst those who have non-missing values in the cognitive index (Tables V.12-V.14). We assess this comparability not only by using differences of means across weekend and weekday born children, but also by assessing how these observable characteristics are related to *Exposure* and *Hour* (essentially repeating the balance analysis of Appendix II but for the non-attriters of each wave and for the sample for which the cognitive index is not missing). We conclude that attrition is unrelated to our exclusion restrictions and our identification strategy remains valid for the sample available in each wave.

A different issue from the one discussed in the previous paragraph is whether the effects that we have estimated are also valid for the sample that has attrited. This would only be so if attrition was random, which is unlikely to be the case. In Table VI.15, we compare the characteristics of attriters (=1 if attrit in at least one wave; 0 if never attrit) with the characteristics of non-attriters. Those who attrit are less likely to attend antenatal classes, and more likely to have received their first prenatal check-up relatively later on in their pregnancy. They are also a little worse off (less likely to have attained the expected qualification at age 16, less likely to own certain assets, etc). If one believes that they are the families for whom breastfeeding represents a relatively more important input (as they may make fewer other investments compared to others) and thus most likely to benefit from breastfeeding on the margin, then this pattern would lead our estimates of the effects of breastfeeding to be downward-biased. This pattern of attrition is likely to explain our results in Table V.1 of Appendix V: the effects of breastfeeding at 7 years of age are smaller than at ages 3 and 5 (attrition is substantially higher at 7 years of age than at 3 or 5 years of age). To corroborate this further, Table VI.16 shows that the effects of breastfeeding at age 5 are smaller in the sample available at age 7 than in the sample available at age 5. For instance, the effect of breastfeeding on expressive language is 11.6 for the entire sample available at age 5 but only 6.0 for the sample available at age 7 (first row of Table VI.16).

VI. 1. Difference in Attrition Rates between Weekend and Weekday Born

	Attrition = overall cognitive and non-cognitive indices missing	Attrition = cognitive and non-cognitive indices missing in wave 2	Attrition = cognitive and non-cognitive indices missing in wave 3	Attrition = cognitive and non-cognitive indices missing in wave 4
Panel A: Without Control Variables				
Fri-Sun	0.0081	0.0060	-0.0014	-0.0099
	(0.009)	(0.011)	(0.011)	(0.012)
Attrition rate	0.128	0.234	0.244	0.319
Panel B: With Control Variables				
Fri-Sun	0.0096	0.0086	0.0000	-0.0091
	(0.009)	(0.011)	(0.011)	(0.012)

Notes. Panel A: the top cell reports the coefficient from separate OLS regressions of a dependent variable that takes value 1 if the child has attrited (as defined in the heading of each column) and 0 otherwise on a dummy variable that takes value 1 if the child is born during weekend (from Friday to Sunday). The bottom cell of Panel A reports the average attrition (as defined in the heading of each column) rate. Panel B reports the same coefficients as the top cell of Panel A but including other control variables (as in Table 4) in the OLS regressions. Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

VI. 2. Relation between Attrition and the Exclusion Restrictions

	Attrition = overall cognitive and non-cognitive indices missing	Attrition = cognitive and non-cognitive indices missing in wave 2	Attrition = cognitive and non-cognitive indices missing in wave 3	Attrition = cognitive and non-cognitive indices missing in wave 4
Panel A: Without Control Variables				
(a) Exposure to Weekend	0.0122	0.0040	-0.0074	-0.0109
	(0.011)	(0.014)	(0.014)	(0.015)
(b) Polynomial in Hour				
hour	0.0005	0.0019	0.0003	0.0009
	(0.001)	(0.001)	(0.001)	(0.001)
hour^2	-0.0000	-0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)
hour^3	0.0000	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)
P-value Joint	0.469	0.157	0.913	0.848
Panel B: With Control Variables				
(a) Exposure to Weekend	0.0174	0.0095	-0.0043	-0.0068
	(0.011)	(0.014)	(0.014)	(0.015)
(b) Polynomial in Hour				
hour	0.0002	0.0016	-0.0000	0.0005
	(0.001)	(0.001)	(0.001)	(0.001)
hour^2	-0.0000	-0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)
hour^3	0.0000	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)
P-value Joint	0.343	0.186	0.972	0.892

Notes. Panel A: the top cell reports the coefficient from separate OLS regressions of a dependent variable that takes value 1 if the child has attrited (as defined in the heading of each column) and 0 otherwise on (a) exposure to weekend or (b) cubic polynomial in hour. Panel B reports the same coefficients as the top cell of Panel A but including other control variables (as in Table 4) in the OLS regressions. Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. Standard errors in parentheses: ** $p<0.01$, * $p<0.05$. Source: Millennium Cohort Study.

Table VI.3 Balance by Day of Birth. Subsample for not attrited in MCS2

Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff
Antenatal				Someone else	0.108	0.113	-0.619	Own outright	0.030	0.026	0.731
Received ante-natal care	0.950	0.957	-1.207	***Mothers Demographics***				Rent from Local Authority	0.279	0.279	-0.021
First ante-natal was before:				Mother's age	26.727	26.812	-0.468	Rent from Housing Association	0.097	0.101	-0.472
0-11 weeks	0.420	0.397	1.529	Expected qualification at age 16	0.591	0.585	0.354	Rent privately	0.099	0.083	1.889
12-13 weeks	0.327	0.342	-1.110	Married	0.463	0.471	-0.505	Live with parents	0.057	0.052	0.797
≥ 14 weeks	0.178	0.190	-1.044	Religion				Live rent free	0.013	0.017	-1.064
Don't know	0.026	0.028	-0.494	No religion	0.557	0.545	0.799	Heating			
Attended ante-natal classes	0.251	0.241	0.799	Catholic	0.072	0.077	-0.612	Open fire	0.036	0.034	0.418
Received fertility treatment	0.013	0.018	-1.320	Protestant	0.027	0.029	-0.397	Gas/electric fire	0.307	0.302	0.374
Planned parenthood	0.468	0.467	0.072	Anglican	0.162	0.156	0.509	Central	0.878	0.901	-2.427
Delivery				Another type of Christian	0.066	0.067	-0.113	No heating	0.011	0.009	0.902
Labour induced	0.300	0.310	-0.686	Hindu	0.011	0.012	-0.210	Damp or condensation at home	0.156	0.165	-0.850
Labour duration (hours)	8.852	8.634	0.694	Muslim	0.092	0.103	-1.260	Assets			
Type Delivery:				Other	0.011	0.009	0.642	Telephone	0.952	0.943	1.272
Normal	0.900	0.897	0.300	Ethnicity				Dishwasher	0.211	0.210	0.057
Forceps	0.040	0.038	0.303	White	0.858	0.854	0.457	Own computer	0.411	0.405	0.397
Vacuum	0.065	0.066	-0.057	Mixed	0.012	0.011	0.586	Tumble dryer	0.602	0.604	-0.159
Other	0.009	0.009	0.044	Indian	0.022	0.021	0.151	Own/access to car	0.761	0.740	1.671
Pain relief:				Pakistani/Bangladeshi	0.073	0.082	-1.143	Noisy Neighbours			
None	0.098	0.106	-0.801	Black	0.025	0.023	0.410	Very common	0.086	0.083	0.395
Gas and air	0.806	0.790	1.342	Other	0.009	0.009	-0.033	Fairly common	0.128	0.116	1.236
Pethidine	0.364	0.357	0.482	Mother's Mother is still alive	0.935	0.930	0.730	Not very common	0.396	0.413	-1.181
Epidural	0.199	0.199	-0.060	Lived away from home before 17	0.188	0.204	-1.389	Not at all common	0.390	0.388	0.129
General anaesthetic	0.003	0.003	0.289	***Mothers Health and Lifestyle***				Rubbish and litter in the area			
TENS	0.081	0.078	0.396	Smoked during pregnancy (avg. cig. per day)	3.552	3.659	-0.584	Very common	0.150	0.149	0.034
Other	0.039	0.032	1.145	Drank during pregnancy	0.262	0.260	0.170	Fairly common	0.212	0.220	-0.577
Complication:				Longstanding illness	0.210	0.218	-0.613	Not very common	0.375	0.370	0.341
None	0.748	0.754	-0.488	Limiting longstanding illness	0.110	0.098	1.327	Not at all common	0.263	0.261	0.137
Breech	0.020	0.021	-0.129	If mother has ever had				Vandalism and damage to property			
Other abnormal	0.003	0.004	-0.916	Migraine	0.225	0.227	-0.171	Very common	0.113	0.101	1.269
Very long labour	0.050	0.047	0.341	Hayfever or persistent runny rose	0.226	0.251	-2.026	Fairly common	0.149	0.166	-1.552
Very rapid labour	0.032	0.025	1.261	Bronchitis	0.077	0.073	0.507	Not very common	0.413	0.400	0.888
Foetal distress (heart)	0.080	0.074	0.746	Asthma	0.173	0.182	-0.837	Not at all common	0.324	0.332	-0.568
Foetal distress (meconium)	0.036	0.042	-1.067	Eczema	0.176	0.186	-0.856	Garden			
Other	0.081	0.077	0.540	Back Pain/lumbago/sciatica	0.205	0.221	-1.229	Own garden	0.833	0.841	-0.768
Baby				Fits/convulsions/epilepsy	0.020	0.028	-1.829	Shared garden	0.044	0.035	1.455
Female	0.519	0.493	1.687	Diabetes	0.012	0.012	-0.163	Social Assistance			
Birth weight (kg)	3.372	3.360	0.830	Cancer	0.008	0.012	-1.280	Child Tax Credit	0.137	0.139	-0.228
Premature	0.047	0.043	0.644	Digestive or Bowel disorders	0.072	0.082	-1.240	Working Families Tax Credit	0.261	0.250	0.813
Length of gestation (days)	278.9	279.5	-1.9	Diabetes during pregnancy (only)	0.008	0.009	-0.276	Income Support	0.273	0.280	-0.531
Present at birth				***Mothers Socioeconomic Status***				Jobseekers Allowance	0.042	0.046	-0.720
Father	0.810	0.801	0.691	Working during pregnancy	0.521	0.536	-0.999	Housing Benefit	0.245	0.239	0.498
Mother's friend	0.039	0.050	-1.853	Live in house	0.837	0.845	-0.695	Council Tax Benefit	0.233	0.220	1.032
Grandmother (in law)	0.259	0.232	2.131	# rooms	5.051	5.080	-0.717	Invalid Care Allowance	0.016	0.015	0.023

Notes. Figures in columns titled "Fri-Sun" and "Mon-Thurs" are sample means of the variable listed under the column titled "Variable". The t-statistic of the difference between the means listed in these two columns is shown under the column titled "t-stat diff". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS2. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4585. Source: Millennium Cohort Study.

Table VI.4 Balance by Day of Birth. Subsample for not attrited in MCS3

Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff
Antenatal				Someone else	0.105	0.110	-0.562	Own outright	0.027	0.025	0.539
Received ante-natal care	0.950	0.961	-1.610	***Mothers Demographics***				Rent from Local Authority	0.283	0.274	0.661
First ante-natal was before:				Mother's age	26.671	26.857	-1.023	Rent from Housing Association	0.099	0.104	-0.572
0-11 weeks	0.413	0.403	0.653	Expected qualification at age 16	0.578	0.590	-0.792	Rent privately	0.099	0.094	0.579
12-13 weeks	0.330	0.339	-0.677	Married	0.463	0.474	-0.686	Live with parents	0.057	0.054	0.348
≥ 14 weeks	0.181	0.190	-0.790	Religion				Live rent free	0.015	0.018	-0.904
Don't know	0.027	0.028	-0.177	No religion	0.552	0.539	0.888	Heating			
Attended ante-natal classes	0.247	0.254	-0.500	Catholic	0.076	0.078	-0.325	Open fire	0.037	0.035	0.380
Received fertility treatment	0.011	0.018	-1.743	Protestant	0.030	0.030	-0.009	Gas/electric fire	0.306	0.295	0.760
Planned parenthood	0.460	0.459	0.109	Anglican	0.163	0.154	0.743	Central	0.873	0.903	-3.202
Delivery				Another type of Christian	0.060	0.067	-1.026	No heating	0.012	0.009	1.028
Labour induced	0.306	0.303	0.208	Hindu	0.013	0.010	0.823	Damp or condensation at home	0.161	0.170	-0.822
Labour duration (hours)	8.893	8.747	0.463	Muslim	0.095	0.109	-1.585	Assets			
Type Delivery:				Other	0.011	0.011	0.111	Telephone	0.950	0.948	0.314
Normal	0.901	0.900	0.072	Ethnicity				Dishwasher	0.208	0.207	0.102
Forceps	0.038	0.037	0.150	White	0.851	0.847	0.348	Own computer	0.411	0.406	0.335
Vacuum	0.064	0.066	-0.195	Mixed	0.014	0.007	2.014	Tumble dryer	0.598	0.601	-0.203
Other	0.009	0.007	0.908	Indian	0.020	0.022	-0.344	Own/access to car	0.759	0.738	1.616
Pain relief:				Pakistani/Bangladeshi	0.076	0.085	-1.085	Noisy Neighbours			
None	0.101	0.105	-0.523	Black	0.026	0.029	-0.539	Very common	0.088	0.084	0.482
Gas and air	0.803	0.788	1.260	Other	0.013	0.010	0.928	Fairly common	0.132	0.111	2.218
Pethidine	0.367	0.351	1.078	Mother's Mother is still alive	0.931	0.931	0.021	Not very common	0.393	0.411	-1.273
Epidural	0.203	0.200	0.302	Lived away from home before 17	0.198	0.207	-0.678	Not at all common	0.387	0.394	-0.493
General anaesthetic	0.002	0.002	0.125	***Mothers Health and Lifestyle***				Rubbish and litter in the area			
TENS	0.079	0.081	-0.246	Smoked during pregnancy (avg. cig. per day)	3.553	3.594	-0.220	Very common	0.150	0.143	0.671
Other	0.039	0.034	0.860	Drank during pregnancy	0.250	0.254	-0.368	Fairly common	0.218	0.224	-0.447
Complication:				Longstanding illness	0.208	0.212	-0.294	Not very common	0.377	0.374	0.217
None	0.752	0.764	-0.903	Limiting longstanding illness	0.110	0.096	1.590	Not at all common	0.255	0.259	-0.360
Breech	0.019	0.018	0.217	If mother has ever had				Vandalism and damage to property			
Other abnormal	0.002	0.003	-0.880	Migraine	0.227	0.227	-0.011	Very common	0.113	0.106	0.770
Very long labour	0.049	0.045	0.590	Hayfever or persistent runny rose	0.226	0.245	-1.508	Fairly common	0.148	0.155	-0.676
Very rapid labour	0.031	0.026	1.012	Bronchitis	0.076	0.076	0.024	Not very common	0.415	0.406	0.576
Foetal distress (heart)	0.082	0.070	1.411	Asthma	0.174	0.179	-0.511	Not at all common	0.324	0.333	-0.601
Foetal distress (meconium)	0.034	0.039	-0.929	Eczema	0.178	0.187	-0.787	Garden			
Other	0.079	0.079	-0.013	Back Pain/lumbago/sciatica	0.212	0.220	-0.676	Own garden	0.826	0.834	-0.720
Baby				Fits/convulsions/epilepsy	0.020	0.028	-1.882	Shared garden	0.043	0.041	0.224
Female	0.510	0.491	1.227	Diabetes	0.012	0.011	0.392	Social Assistance			
Birth weight (kg)	3.367	3.362	0.367	Cancer	0.006	0.012	-2.023	Child Tax Credit	0.130	0.139	-0.865
Premature	0.047	0.041	0.953	Digestive or Bowel disorders	0.067	0.088	-2.622	Working Families Tax Credit	0.260	0.244	1.264
Length of gestation (days)	278.9	279.5	-1.8	Diabetes during pregnancy (only)	0.009	0.007	0.729	Income Support	0.279	0.278	0.050
Present at birth				***Mothers Socioeconomic Status***				Jobseekers Allowance	0.041	0.046	-0.843
Father	0.806	0.803	0.291	Working during pregnancy	0.513	0.539	-1.692	Housing Benefit	0.247	0.239	0.656
Mother's friend	0.043	0.048	-0.829	Live in house	0.827	0.838	-0.938	Council Tax Benefit	0.235	0.220	1.177
Grandmother (in law)	0.259	0.231	2.156	# rooms	5.019	5.078	-1.444	Invalid Care Allowance	0.014	0.014	0.081

Notes. Figures in columns titled "Fri-Sun" and "Mon-Thurs" are sample means of the variable listed under the column titled "Variable". The t-statistic of the difference between the means listed in these two columns is shown under the column titled "t-stat diff". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS3. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4529. Source: Millennium Cohort Study.

Table VI.5 Balance by Day of Birth. Subsample for not attrited in MCS4

Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff
Antenatal				Someone else	0.106	0.110	-0.393	Own outright	0.029	0.023	1.216
Received ante-natal care	0.953	0.962	-1.476	***Mothers Demographics***				Rent from Local Authority	0.268	0.270	-0.186
First ante-natal was before:				Mother's age	26.768	26.951	-0.955	Rent from Housing Association	0.099	0.101	-0.164
0-11 weeks	0.418	0.402	1.061	Expected qualification at age 16	0.589	0.598	-0.592	Rent privately	0.103	0.092	1.200
12-13 weeks	0.330	0.344	-0.949	Married	0.468	0.481	-0.835	Live with parents	0.056	0.050	0.860
≥ 14 weeks	0.178	0.188	-0.794	Religion				Live rent free	0.013	0.017	-1.073
Don't know	0.027	0.029	-0.401	No religion	0.543	0.541	0.173	Heating			
Attended ante-natal classes	0.253	0.256	-0.200	Catholic	0.071	0.076	-0.595	Open fire	0.036	0.037	-0.198
Received fertility treatment	0.012	0.018	-1.657	Protestant	0.032	0.031	0.144	Gas/electric fire	0.308	0.295	0.916
Planned parenthood	0.469	0.468	0.068	Anglican	0.172	0.160	1.046	Central	0.882	0.899	-1.749
Delivery				Another type of Christian	0.062	0.065	-0.441	No heating	0.011	0.011	0.239
Labour induced	0.304	0.313	-0.647	Hindu	0.010	0.011	-0.240	Damp or condensation at home	0.160	0.168	-0.691
Labour duration (hours)	8.912	8.583	1.011	Muslim	0.098	0.104	-0.661	Assets			
Type Delivery:				Other	0.011	0.012	-0.143	Telephone	0.953	0.953	0.077
Normal	0.899	0.901	-0.236	Ethnicity				Dishwasher	0.210	0.211	-0.097
Forceps	0.039	0.037	0.301	White	0.856	0.853	0.256	Own computer	0.416	0.414	0.122
Vacuum	0.064	0.065	-0.091	Mixed	0.011	0.006	1.510	Tumble dryer	0.592	0.608	-1.075
Other	0.010	0.007	1.003	Indian	0.022	0.020	0.387	Own/access to car	0.760	0.748	0.877
Pain relief:				Pakistani/Bangladeshi	0.078	0.083	-0.500	Noisy Neighbours			
None	0.102	0.105	-0.367	Black	0.024	0.028	-0.928	Very common	0.084	0.083	0.139
Gas and air	0.800	0.788	0.924	Other	0.009	0.009	-0.067	Fairly common	0.130	0.111	1.837
Pethidine	0.366	0.351	0.964	Mother's Mother is still alive	0.933	0.936	-0.378	Not very common	0.385	0.411	-1.667
Epidural	0.202	0.200	0.149	Lived away from home before 17	0.195	0.195	0.000	Not at all common	0.401	0.395	0.358
General anaesthetic	0.002	0.003	-0.173	***Mothers Health and Lifestyle***				Rubbish and litter in the area			
TENS	0.082	0.081	0.102	Smoked during pregnancy (avg. cig. per day)	3.432	3.431	0.010	Very common	0.147	0.139	0.722
Other	0.039	0.036	0.520	Drank during pregnancy	0.255	0.254	0.093	Fairly common	0.214	0.227	-1.029
Complication:				Longstanding illness	0.208	0.216	-0.638	Not very common	0.379	0.369	0.638
None	0.753	0.760	-0.517	Limiting longstanding illness	0.105	0.097	0.816	Not at all common	0.260	0.264	-0.310
Breech	0.019	0.021	-0.359	If mother has ever had				Vandalism and damage to property			
Other abnormal	0.002	0.003	-0.675	Migraine	0.224	0.231	-0.492	Very common	0.112	0.107	0.459
Very long labour	0.049	0.041	1.109	Hayfever or persistent runny rose	0.221	0.242	-1.616	Fairly common	0.146	0.161	-1.272
Very rapid labour	0.030	0.027	0.659	Bronchitis	0.074	0.073	0.169	Not very common	0.417	0.398	1.254
Foetal distress (heart)	0.082	0.072	1.213	Asthma	0.174	0.178	-0.358	Not at all common	0.325	0.334	-0.644
Foetal distress (meconium)	0.035	0.039	-0.723	Eczema	0.182	0.195	-1.048	Garden			
Other	0.080	0.082	-0.264	Back Pain/lumbago/sciatica	0.209	0.224	-1.124	Own garden	0.835	0.842	-0.565
Baby				Fits/convulsions/epilepsy	0.018	0.024	-1.463	Shared garden	0.041	0.041	0.024
Female	0.513	0.500	0.789	Diabetes	0.013	0.011	0.567	Social Assistance			
Birth weight (kg)	3.373	3.357	1.009	Cancer	0.008	0.012	-1.392	Child Tax Credit	0.131	0.145	-1.296
Premature	0.049	0.038	1.735	Digestive or Bowel disorders	0.067	0.089	-2.636	Working Families Tax Credit	0.258	0.244	0.998
Length of gestation (days)	278.9	279.7	-2.345	Diabetes during pregnancy (only)	0.009	0.006	0.982	Income Support	0.269	0.270	-0.032
Present at birth				***Mothers Socioeconomic Status***				Jobseekers Allowance	0.043	0.044	-0.080
Father	0.813	0.805	0.680	Working during pregnancy	0.524	0.545	-1.361	Housing Benefit	0.247	0.238	0.646
Mother's friend	0.038	0.052	-2.140	Live in house	0.837	0.846	-0.752	Council Tax Benefit	0.235	0.220	1.104
Grandmother (in law)	0.257	0.233	1.757	# rooms	5.044	5.104	-1.373	Invalid Care Allowance	0.017	0.015	0.428

Notes. Figures in columns titled "Fri-Sun" and "Mon-Thurs" are sample means of the variable listed under the column titled "Variable". The t-statistic of the difference between the means listed in these two columns is shown under the column titled "t-stat diff". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS3. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4079.Source: Millennium Cohort Study.

Table VI.6 Relation between Regressors and Exposure to Weekend. Subsample for not attrited in MCS2

Variable	p-value	Variable	p-value	Variable	p-value
Antenatal		Someone else	0.902	Own outright	0.991
Received ante-natal care	0.785	***Mothers Demographics***		Rent from Local Authority	0.753
First ante-natal was before:		Mother's age	0.671	Rent from Housing Association	0.384
0-11 weeks	0.765	Expected qualification at age 16	0.337	Rent privately	0.737
12-13 weeks	0.532	Married	0.500	Live with parents	0.417
≥ 14 weeks	0.724	Religion		Live rent free	0.442
Don't know	0.689	No religion	0.209	Heating	
Attended ante-natal classes	0.243	Catholic	0.307	Open fire	0.323
Received fertility treatment	0.798	Protestant	0.704	Gas/electric fire	0.543
Planned parenthood	0.977	Anglican	0.831	Central	0.439
Delivery		Another type of Christian	0.749	No heating	0.692
Labour induced	0.000	Hindu	0.802	Damp or condensation at home	0.060
Labour duration (hours)	0.798	Muslim	0.446	Assets	
Type Delivery:		Other	0.540	Telephone	0.632
Normal	0.805	Ethnicity		Dishwasher	0.286
Forceps	0.457	White	0.871	Own computer	0.744
Vacuum	0.999	Mixed	0.134	Tumble dryer	0.289
Other	0.260	Indian	0.473	Own/access to car	0.793
Pain relief:		Pakistani/Bangladeshi	0.430	Noisy Neighbours	
None	0.087	Black	0.953	Very common	0.740
Gas and air	0.248	Other	0.342	Fairly common	0.725
Pethidine	0.599	Mother's Mother is still alive	0.823	Not very common	0.561
Epidural	0.348	Lived away from home before 17	0.432	Not at all common	0.589
General anaesthetic	0.524	***Mothers Health and Lifestyle***		Rubbish and litter in the area	
TENS	0.637	Smoked during pregnancy (avg. cigarettes per day)	0.491	Very common	0.580
Other	0.309	Drank during pregnancy	0.907	Fairly common	0.549
Complication:		Longstanding illness	0.854	Not very common	0.332
None	0.882	Limiting longstanding illness	0.203	Not at all common	0.953
Breech	0.592	If mother has ever had		Vandalism and damage to property	
Other abnormal	0.719	Migraine	0.521	Very common	0.620
Very long labour	0.831	Hayfever or persistent runny rose	0.141	Fairly common	0.239
Very rapid labour	0.449	Bronchitis	0.471	Not very common	0.854
Foetal distress (heart)	0.448	Asthma	0.879	Not at all common	0.671
Foetal distress (meconium)	0.329	Eczema	0.507	Garden	
Other	0.667	Back Pain/lumbago/sciatica	0.232	Own garden	0.203
Baby		Fits/convulsions/epilepsy	0.014	Shared garden	0.468
Female	0.047	Diabetes	0.873	Social Assistance	
Birth weight (kg)	0.661	Cancer	0.351	Child Tax Credit	0.668
Premature	0.294	Digestive or Bowel disorders	0.109	Working Families Tax Credit	0.588
Length of gestation (days)	0.213	Diabetes during pregnancy (only)	0.588	Income Support	0.974
Present at birth		***Mothers Socioeconomic Status***		Jobseekers Allowance	0.855
Father	0.567	Working during pregnancy	0.537	Housing Benefit	0.048
Mother's friend	0.691	Live in house	0.744	Council Tax Benefit	0.063
Grandmother (in law)	0.034	# rooms	0.981	Invalid Care Allowance	0.173

Notes. Each cell reports the P-value of the hypothesis that the coefficient of exposure to weekend is zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS2. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4585. Source: Millennium Cohort Study.

Table VI.7 Relation between regressors and Exposure to Weekend. Subsample for not attrited in MCS3

Variable	p-value	Variable	p-value	Variable	p-value
Antenatal		Someone else	0.385	Own outright	0.300
Received ante-natal care	0.561	***Mothers Demographics***		Rent from Local Authority	0.524
First ante-natal was before:		Mother's age	0.357	Rent from Housing Association	0.575
0-11 weeks	0.498	Expected qualification at age 16	0.995	Rent privately	0.448
12-13 weeks	0.562	Married	0.335	Live with parents	0.344
≥ 14 weeks	0.709	Religion		Live rent free	0.877
Don't know	0.614	No religion	0.448	Heating	
Attended ante-natal classes	0.700	Catholic	0.569	Open fire	0.526
Received fertility treatment	0.955	Protestant	0.453	Gas/electric fire	0.986
Planned parenthood	0.995	Anglican	0.601	Central	0.196
Delivery		Another type of Christian	0.429	No heating	0.811
Labour induced	0.000	Hindu	0.710	Damp or condensation at home	0.053
Labour duration (hours)	0.828	Muslim	0.555	Assets	
Type Delivery:		Other	0.665	Telephone	0.585
Normal	0.740	Ethnicity		Dishwasher	0.276
Forceps	0.431	White	0.786	Own computer	0.785
Vacuum	0.731	Mixed	0.016	Tumble dryer	0.384
Other	0.114	Indian	0.257	Own/access to car	0.814
Pain relief:		Pakistani/Bangladeshi	0.886	Noisy Neighbours	
None	0.219	Black	0.627	Very common	0.734
Gas and air	0.213	Other	0.245	Fairly common	0.153
Pethidine	0.301	Mother's Mother is still alive	0.465	Not very common	0.632
Epidural	0.425	Lived away from home before 17	0.251	Not at all common	0.768
General anaesthetic	0.765	***Mothers Health and Lifestyle***		Rubbish and litter in the area	
TENS	0.931	Smoked during pregnancy (avg. cigarettes per day)	0.510	Very common	0.919
Other	0.520	Drank during pregnancy	0.519	Fairly common	0.471
Complication:		Longstanding illness	0.558	Not very common	0.261
None	0.947	Limiting longstanding illness	0.392	Not at all common	0.521
Breech	0.816	If mother has ever had		Vandalism and damage to property	
Other abnormal	0.324	Migraine	0.474	Very common	0.427
Very long labour	0.890	Hayfever or persistent runny rose	0.078	Fairly common	0.236
Very rapid labour	0.245	Bronchitis	0.307	Not very common	0.999
Foetal distress (heart)	0.572	Asthma	0.808	Not at all common	0.689
Foetal distress (meconium)	0.157	Eczema	0.917	Garden	
Other	0.757	Back Pain/lumbago/sciatica	0.450	Own garden	0.432
Baby		Fits/convulsions/epilepsy	0.014	Shared garden	0.624
Female	0.065	Diabetes	0.778	Social Assistance	
Birth weight (kg)	0.487	Cancer	0.114	Child Tax Credit	0.572
Premature	0.304	Digestive or Bowel disorders	0.002	Working Families Tax Credit	0.534
Length of gestation (days)	0.272	Diabetes during pregnancy (only)	0.842	Income Support	0.733
Present at birth		***Mothers Socioeconomic Status***		Jobseekers Allowance	0.471
Father	0.878	Working during pregnancy	0.431	Housing Benefit	0.041
Mother's friend	0.855	Live in house	0.792	Council Tax Benefit	0.046
Grandmother (in law)	0.062	# rooms	0.320	Invalid Care Allowance	0.132

Notes. Each cell reports the P-value of the hypothesis that the coefficient of exposure to weekend is zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS3. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4529. Source: Millennium Cohort Study.

Table VI.8 Relation between regressors and Exposure to Weekend. Subsample for not attrited in MCS4

Variable	p-value	Variable	p-value	Variable	p-value
Antenatal		Someone else	0.284	Own outright	0.342
Received ante-natal care	0.813	***Mothers Demographics***		Rent from Local Authority	0.708
First ante-natal was before:		Mother's age	0.275	Rent from Housing Association	0.764
0-11 weeks	0.897	Expected qualification at age 16	0.958	Rent privately	0.854
12-13 weeks	0.665	Married	0.507	Live with parents	0.436
≥ 14 weeks	0.781	Religion		Live rent free	0.803
Don't know	0.639	No religion	0.752	Heating	
Attended ante-natal classes	0.603	Catholic	0.504	Open fire	0.964
Received fertility treatment	0.889	Protestant	0.587	Gas/electric fire	0.673
Planned parenthood	0.514	Anglican	0.639	Central	0.643
Delivery		Another type of Christian	0.999	No heating	0.456
Labour induced	0.000	Hindu	0.823	Damp or condensation at home	0.238
Labour duration (hours)	0.598	Muslim	0.764	Assets	
Type Delivery:		Other	0.639	Telephone	0.462
Normal	0.741	Ethnicity		Dishwasher	0.186
Forceps	0.600	White	0.781	Own computer	0.960
Vacuum	0.847	Mixed	0.100	Tumble dryer	0.128
Other	0.180	Indian	0.478	Own/access to car	0.861
Pain relief:		Pakistani/Bangladeshi	0.863	Noisy Neighbours	
None	0.287	Black	0.988	Very common	0.681
Gas and air	0.407	Other	0.341	Fairly common	0.390
Pethidine	0.447	Mother's Mother is still alive	0.390	Not very common	0.554
Epidural	0.353	Lived away from home before 17	0.419	Not at all common	0.807
General anaesthetic	0.924	***Mothers Health and Lifestyle***		Rubbish and litter in the area	
TENS	0.806	Smoked during pregnancy (avg. cigarettes per day)	0.995	Very common	0.965
Other	0.793	Drank during pregnancy	0.847	Fairly common	0.228
Complication:		Longstanding illness	0.484	Not very common	0.151
None	0.921	Limiting longstanding illness	0.573	Not at all common	0.687
Breech	0.593	If mother has ever had		Vandalism and damage to property	
Other abnormal	0.942	Migraine	0.530	Very common	0.851
Very long labour	0.698	Hayfever or persistent runny rose	0.061	Fairly common	0.125
Very rapid labour	0.217	Bronchitis	0.458	Not very common	0.515
Foetal distress (heart)	0.594	Asthma	0.898	Not at all common	0.691
Foetal distress (meconium)	0.183	Eczema	0.895	Garden	
Other	0.702	Back Pain/lumbago/sciatica	0.244	Own garden	0.565
Baby		Fits/convulsions/epilepsy	0.020	Shared garden	0.207
Female	0.051	Diabetes	0.672	Social Assistance	
Birth weight (kg)	0.577	Cancer	0.555	Child Tax Credit	0.451
Premature	0.083	Digestive or Bowel disorders	0.000	Working Families Tax Credit	0.315
Length of gestation (days)	0.059	Diabetes during pregnancy (only)	0.518	Income Support	0.674
Present at birth		***Mothers Socioeconomic Status***		Jobseekers Allowance	0.697
Father	0.804	Working during pregnancy	0.856	Housing Benefit	0.123
Mother's friend	0.508	Live in house	0.765	Council Tax Benefit	0.109
Grandmother (in law)	0.086	# rooms	0.326	Invalid Care Allowance	0.182

Notes. Each cell reports the P-value of the hypothesis that the coefficient of exposure to weekend is zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS4. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4079. Source: Millennium Cohort Study.

Table VI.9 Relation between Regressors and Cubic Polynomial in Hour. Subsample for not attrited in MCS2

Variable	p-value	Variable	p-value	Variable	p-value
Antenatal		Someone else	0.504	Own outright	0.650
Received ante-natal care	0.356	***Mothers Demographics***		Rent from Local Authority	0.898
First ante-natal was before:		Mother's age	0.620	Rent from Housing Association	0.411
0-11 weeks	0.443	Expected qualification at age 16	0.778	Rent privately	0.715
12-13 weeks	0.176	Married	0.505	Live with parents	0.682
≥ 14 weeks	0.947	Religion		Live rent free	0.186
Don't know	0.775	No religion	0.522	Heating	
Attended ante-natal classes	0.167	Catholic	0.550	Open fire	0.658
Received fertility treatment	0.025	Protestant	0.974	Gas/electric fire	0.401
Planned parenthood	0.750	Anglican	0.973	Central	0.048
Delivery		Another type of Christian	0.787	No heating	0.258
Labour induced	0.000	Hindu	0.973	Damp or condensation at home	0.053
Labour duration (hours)	0.322	Muslim	0.188	Assets	
Type Delivery:		Other	0.807	Telephone	0.065
Normal	0.089	Ethnicity		Dishwasher	0.712
Forceps	0.772	White	0.760	Own computer	0.830
Vacuum	0.280	Mixed	0.457	Tumble dryer	0.652
Other	0.725	Indian	0.674	Own/access to car	0.582
Pain relief:		Pakistani/Bangladeshi	0.331	Noisy Neighbours	
None	0.338	Black	0.833	Very common	0.202
Gas and air	0.096	Other	0.400	Fairly common	0.736
Pethidine	0.690	Mother's Mother is still alive	0.734	Not very common	0.230
Epidural	0.176	Lived away from home before 17	0.592	Not at all common	0.303
General anaesthetic	0.821	***Mothers Health and Lifestyle***		Rubbish and litter in the area	
TENS	0.912	Smoked during pregnancy (avg. cigarettes per day)	0.662	Very common	0.720
Other	0.451	Drank during pregnancy	0.111	Fairly common	0.366
Complication:		Longstanding illness	0.973	Not very common	0.796
None	0.955	Limiting longstanding illness	0.614	Not at all common	0.642
Breech	0.696	If mother has ever had		Vandalism and damage to property	
Other abnormal	0.212	Migraine	0.878	Very common	0.478
Very long labour	0.784	Hayfever or persistent runny rose	0.153	Fairly common	0.189
Very rapid labour	0.289	Bronchitis	0.573	Not very common	0.726
Foetal distress (heart)	0.655	Asthma	0.853	Not at all common	0.461
Foetal distress (meconium)	0.558	Eczema	0.263	Garden	
Other	0.523	Back Pain/lumbago/sciatica	0.195	Own garden	0.145
Baby		Fits/convulsions/epilepsy	0.151	Shared garden	0.719
Female	0.262	Diabetes	0.730	Social Assistance	
Birth weight (kg)	0.703	Cancer	0.667	Child Tax Credit	0.221
Premature	0.588	Digestive or Bowel disorders	0.463	Working Families Tax Credit	0.551
Length of gestation (days)	0.511	Diabetes during pregnancy (only)	0.906	Income Support	0.924
Present at birth		***Mothers Socioeconomic Status***		Jobseekers Allowance	0.154
Father	0.415	Working during pregnancy	0.301	Housing Benefit	0.031
Mother's friend	0.311	Live in house	0.646	Council Tax Benefit	0.018
Grandmother (in law)	0.051	# rooms	0.268	Invalid Care Allowance	0.497

Notes. Each cell reports the P-value of the joint hypothesis that the coefficients of a cubic polynomial in hour are jointly zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS2. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4585. Source: Millennium Cohort Study.

Table VI.10 Relation between Regressors and Cubic Polynomial in Hour. Subsample for not attrited in MCS3

Variable	p-value	Variable	p-value	Variable	p-value
Antenatal		Someone else	0.337	Own outright	0.115
Received ante-natal care	0.436	***Mothers Demographics***		Rent from Local Authority	0.582
First ante-natal was before:		Mother's age	0.349	Rent from Housing Association	0.365
0-11 weeks	0.201	Expected qualification at age 16	0.536	Rent privately	0.766
12-13 weeks	0.182	Married	0.554	Live with parents	0.676
≥ 14 weeks	0.724	Religion		Live rent free	0.097
Don't know	0.697	No religion	0.551	Heating	
Attended ante-natal classes	0.457	Catholic	0.220	Open fire	0.606
Received fertility treatment	0.045	Protestant	0.891	Gas/electric fire	0.649
Planned parenthood	0.851	Anglican	0.978	Central	0.002
Delivery		Another type of Christian	0.246	No heating	0.186
Labour induced	0.000	Hindu	0.771	Damp or condensation at home	0.014
Labour duration (hours)	0.464	Muslim	0.006	Assets	
Type Delivery:		Other	0.853	Telephone	0.723
Normal	0.166	Ethnicity		Dishwasher	0.669
Forceps	0.822	White	0.487	Own computer	0.978
Vacuum	0.276	Mixed	0.082	Tumble dryer	0.499
Other	0.553	Indian	0.433	Own/access to car	0.362
Pain relief:		Pakistani/Bangladeshi	0.069	Noisy Neighbours	
None	0.442	Black	0.903	Very common	0.328
Gas and air	0.311	Other	0.780	Fairly common	0.297
Pethidine	0.312	Mother's Mother is still alive	0.787	Not very common	0.500
Epidural	0.387	Lived away from home before 17	0.531	Not at all common	0.334
General anaesthetic	0.360	***Mothers Health and Lifestyle***		Rubbish and litter in the area	
TENS	0.729	Smoked during pregnancy (avg. cigarettes per day)	0.354	Very common	0.493
Other	0.714	Drank during pregnancy	0.121	Fairly common	0.676
Complication:		Longstanding illness	0.674	Not very common	0.765
None	0.832	Limiting longstanding illness	0.544	Not at all common	0.759
Breech	0.998	If mother has ever had		Vandalism and damage to property	
Other abnormal	0.302	Migraine	0.864	Very common	0.496
Very long labour	0.799	Hayfever or persistent runny rose	0.268	Fairly common	0.471
Very rapid labour	0.211	Bronchitis	0.708	Not very common	0.959
Foetal distress (heart)	0.347	Asthma	0.952	Not at all common	0.435
Foetal distress (meconium)	0.286	Eczema	0.618	Garden	
Other	0.878	Back Pain/lumbago/sciatica	0.829	Own garden	0.204
Baby		Fits/convulsions/epilepsy	0.172	Shared garden	0.969
Female	0.333	Diabetes	0.935	Social Assistance	
Birth weight (kg)	0.724	Cancer	0.332	Child Tax Credit	0.683
Premature	0.569	Digestive or Bowel disorders	0.014	Working Families Tax Credit	0.361
Length of gestation (days)	0.383	Diabetes during pregnancy (only)	0.998	Income Support	0.962
Present at birth		***Mothers Socioeconomic Status***		Jobseekers Allowance	0.064
Father	0.493	Working during pregnancy	0.046	Housing Benefit	0.127
Mother's friend	0.675	Live in house	0.462	Council Tax Benefit	0.075
Grandmother (in law)	0.346	# rooms	0.053	Invalid Care Allowance	0.393

Notes. Each cell reports the P-value of the joint hypothesis that the coefficients of a cubic polynomial in hour are jointly zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS3. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4529. Source: Millennium Cohort Study.

Table VI.11 Relation between Regressors and Cubic Polynomial in Hour. Subsample for not attrited in MCS4

Variable	p-value	Variable	p-value	Variable	p-value
Antenatal		Someone else	0.555	Own outright	0.379
Received ante-natal care	0.436	***Mothers Demographics***		Rent from Local Authority	0.822
First ante-natal was before:		Mother's age	0.386	Rent from Housing Association	0.777
0-11 weeks	0.201	Expected qualification at age 16	0.720	Rent privately	0.842
12-13 weeks	0.182	Married	0.466	Live with parents	0.924
≥ 14 weeks	0.724	Religion		Live rent free	0.313
Don't know	0.697	No religion	0.889	Heating	
Attended ante-natal classes	0.457	Catholic	0.195	Open fire	0.667
Received fertility treatment	0.045	Protestant	0.893	Gas/electric fire	0.743
Planned parenthood	0.851	Anglican	0.966	Central	0.127
Delivery		Another type of Christian	0.509	No heating	0.398
Labour induced	0.000	Hindu	0.642	Damp or condensation at home	0.296
Labour duration (hours)	0.260	Muslim	0.286	Assets	
Type Delivery:		Other	0.905	Telephone	0.890
Normal	0.099	Ethnicity		Dishwasher	0.626
Forceps	0.919	White	0.840	Own computer	0.942
Vacuum	0.175	Mixed	0.243	Tumble dryer	0.498
Other	0.611	Indian	0.362	Own/access to car	0.843
Pain relief:		Pakistani/Bangladeshi	0.299	Noisy Neighbours	
None	0.571	Black	0.849	Very common	0.543
Gas and air	0.475	Other	0.329	Fairly common	0.591
Pethidine	0.312	Mother's Mother is still alive	0.540	Not very common	0.292
Epidural	0.264	Lived away from home before 17	0.797	Not at all common	0.429
General anaesthetic	0.091	***Mothers Health and Lifestyle***		Rubbish and litter in the area	
TENS	0.966	Smoked during pregnancy (avg. cigarettes per day)	0.566	Very common	0.838
Other	0.802	Drank during pregnancy	0.170	Fairly common	0.166
Complication:		Longstanding illness	0.786	Not very common	0.804
None	0.974	Limiting longstanding illness	0.872	Not at all common	0.530
Breech	0.996	If mother has ever had		Vandalism and damage to property	
Other abnormal	0.179	Migraine	0.936	Very common	0.496
Very long labour	0.521	Hayfever or persistent runny rose	0.184	Fairly common	0.471
Very rapid labour	0.371	Bronchitis	0.619	Not very common	0.959
Foetal distress (heart)	0.498	Asthma	0.910	Not at all common	0.435
Foetal distress (meconium)	0.367	Eczema	0.418	Garden	
Other	0.627	Back Pain/lumbago/sciatica	0.627	Own garden	0.300
Baby		Fits/convulsions/epilepsy	0.201	Shared garden	0.604
Female	0.347	Diabetes	0.852	Social Assistance	
Birth weight (kg)	0.680	Cancer	0.454	Child Tax Credit	0.565
Premature	0.175	Digestive or Bowel disorders	0.004	Working Families Tax Credit	0.461
Length of gestation (days)	0.194	Diabetes during pregnancy (only)	0.939	Income Support	0.832
Present at birth		***Mothers Socioeconomic Status***		Jobseekers Allowance	0.037
Father	0.392	Working during pregnancy	0.108	Housing Benefit	0.126
Mother's friend	0.391	Live in house	0.469	Council Tax Benefit	0.049
Grandmother (in law)	0.383	# rooms	0.065	Invalid Care Allowance	0.431

Notes. Each cell reports the P-value of the joint hypothesis that the coefficients of a cubic polynomial in hour are jointly zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or those whose NVQ level is unknown but left school before 17), but excludes children born through caesarean sections (either emergency or planned), children placed in intensive care and attriters from MCS3. Attrition variable is defined as equal to one if all the developmental variables have missing values. All variables are dummy variables except for labour duration, birth weight, length of gestation, mother's age and # rooms. Number of observations 4079. Source: Millennium Cohort Study.

Table VI.12 Balance by Day of Birth. Subsample of those in Cognitive Index

Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff	Variable	Fri-Sun	Mon-Thurs	t-stat diff
Antenatal				Someone else	0.109	0.113	-0.491	Own outright	0.030	0.025	0.943
Received ante-natal care	0.949	0.957	-1.423	***Mothers Demographics***				Rent from Local Authority	0.282	0.286	-0.258
First ante-natal was before:				Mother's age	26.535	26.617	-0.481	Rent from Housing Association	0.101	0.105	-0.474
0-11 weeks	0.408	0.397	0.822	Expected qualification at age 16	0.568	0.578	-0.749	Rent privately	0.104	0.093	1.314
12-13 weeks	0.329	0.340	-0.834	Married	0.456	0.459	-0.213	Live with parents	0.059	0.055	0.602
≥ 14 weeks	0.183	0.191	-0.709	Religion				Live rent free	0.016	0.019	-0.954
Don't know	0.028	0.029	-0.216	No religion	0.555	0.545	0.736	Heating			
Attended ante-natal classes	0.247	0.246	0.071	Catholic	0.073	0.081	-0.973	Open fire	0.036	0.033	0.599
Received fertility treatment	0.011	0.016	-1.519	Protestant	0.028	0.028	-0.003	Gas/electric fire	0.304	0.301	0.281
Planned parenthood	0.455	0.453	0.169	Anglican	0.156	0.149	0.690	Central	0.875	0.899	-2.725
Delivery				Another type of Christian	0.063	0.065	-0.353	No heating	0.012	0.010	0.755
Labour induced	0.302	0.308	-0.451	Hindu	0.013	0.011	0.584	Damp or condensation at home	0.160	0.168	-0.738
Labour duration (hours)	8.896	8.704	0.649	Muslim	0.100	0.110	-1.084	Assets			
Type Delivery:				Other	0.011	0.011	-0.013	Telephone	0.948	0.942	0.927
Normal	0.903	0.902	0.159	Ethnicity				Dishwasher	0.199	0.201	-0.128
Forceps	0.038	0.036	0.294	White	0.847	0.844	0.297	Own computer	0.396	0.395	0.134
Vacuum	0.062	0.064	-0.249	Mixed	0.013	0.009	1.305	Tumble dryer	0.594	0.598	-0.273
Other	0.009	0.008	0.567	Indian	0.021	0.021	-0.186	Own/access to car	0.751	0.728	1.866
Pain relief:				Pakistani/Bangladeshi	0.080	0.086	-0.830	Noisy Neighbours			
None	0.101	0.105	-0.528	Black	0.028	0.028	-0.192	Very common	0.087	0.089	-0.308
Gas and air	0.802	0.790	1.073	Other	0.011	0.010	0.376	Fairly common	0.132	0.114	1.915
Pethidine	0.367	0.353	1.057	Mother's Mother is still alive	0.932	0.931	0.216	Not very common	0.391	0.406	-1.140
Epidural	0.201	0.200	0.067	Lived away from home before 17	0.202	0.210	-0.676	Not at all common	0.391	0.390	0.026
General anaesthetic	0.003	0.002	0.286	***Mothers Health and Lifestyle***				Rubbish and litter in the area			
TENS	0.076	0.077	-0.067	Smoked during pregnancy (avg. cig. per day)	3.616	3.634	-0.104	Very common	0.152	0.152	-0.016
Other	0.036	0.033	0.666	Drank during pregnancy	0.252	0.250	0.176	Fairly common	0.218	0.225	-0.635
Complication:				Longstanding illness	0.205	0.211	-0.524	Not very common	0.372	0.367	0.384
None	0.753	0.762	-0.698	Limiting longstanding illness	0.109	0.095	1.638	Not at all common	0.258	0.255	0.192
Breech	0.019	0.020	-0.329	If mother has ever had				Vandalism and damage to property			
Other abnormal	0.003	0.004	-0.784	Migraine	0.226	0.225	0.073	Very common	0.116	0.109	0.792
Very long labour	0.049	0.045	0.593	Hayfever or persistent runny rose	0.222	0.247	-2.104	Fairly common	0.149	0.163	-1.347
Very rapid labour	0.030	0.025	1.185	Bronchitis	0.077	0.072	0.642	Not very common	0.412	0.401	0.773
Foetal distress (heart)	0.079	0.071	1.171	Asthma	0.172	0.178	-0.530	Not at all common	0.323	0.327	-0.305
Foetal distress (meconium)	0.034	0.040	-1.087	Eczema	0.176	0.185	-0.829	Garden			
Other	0.081	0.077	0.536	Back Pain/lumbago/sciatica	0.207	0.220	-1.121	Own garden	0.823	0.827	-0.373
Baby				Fits/convulsions/epilepsy	0.019	0.028	-2.292	Shared garden	0.045	0.043	0.306
Female	0.511	0.495	1.081	Diabetes	0.011	0.012	-0.237	Social Assistance			
Birth weight (kg)	3.363	3.354	0.639	Cancer	0.008	0.012	-1.254	Child Tax Credit	0.127	0.132	-0.616
Premature	0.046	0.041	0.832	Digestive or Bowel disorders	0.069	0.085	-2.177	Working Families Tax Credit	0.258	0.245	1.036
Length of gestation (days)	278.9	279.4	-1.634	Diabetes during pregnancy (only)	0.008	0.008	-0.095	Income Support	0.287	0.295	-0.671
Present at birth				***Mothers Socioeconomic Status***				Jobseekers Allowance	0.041	0.047	-1.018
Father	0.799	0.796	0.226	Working during pregnancy	0.507	0.523	-1.128	Housing Benefit	0.251	0.254	-0.172
Mother's friend	0.043	0.052	-1.503	Live in house	0.826	0.831	-0.463	Council Tax Benefit	0.240	0.234	0.476
Grandmother (in law)	0.258	0.238	1.691	# rooms	5.016	5.049	-0.873	Invalid Care Allowance	0.015	0.014	0.223

Notes. Figures in columns titled "Fri-Sun" and "Mon-Thurs" are sample means of the variable listed under the column titled "Variable". The t-statistic of the difference between the means listed in these two columns is shown under the column titled "t-stat diff". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. All variables are dummy variables, with the exception of birth weight, length of gestation, mother's age, smoked during pregnancy and # rooms. Number of observations 5172. Source: Millennium Cohort Study.

Table VI.13 Exposure to Weekend. Subsample of those in Cognitive Index

Variable	p-value	Variable	p-value	Variable	p-value
Antenatal		Someone else	0.564	Own outright	0.554
Received ante-natal care	0.507	***Mothers Demographics***		Rent from Local Authority	0.520
First ante-natal was before:		Age	0.710	Rent from Housing Association	0.492
0-11 weeks	0.543	Had attained expected educ qual. at age 16	0.997	Rent privately	0.773
12-13 weeks	0.407	Married	0.496	Live with parents	0.700
≥ 14 weeks	0.596	Religion		Live rent free	0.740
Don't know	0.868	No religion	0.329	Heating	
Attended ante-natal classes	0.525	Catholic	0.482	Open fire	0.473
Received fertility treatment	0.693	Protestant	0.629	Gas/electric fire	0.744
Planned parenthood	0.538	Anglican	0.939	Central	0.365
Delivery		Another type of Christian	0.810	No heating	0.979
Labour induced	0.000	Hindu	0.782	Damp or condensation at home	0.043
Labour duration (hours)	0.805	Muslim	0.446	Assets	
Type Delivery:		Other	0.869	Telephone	0.505
Normal	0.665	Ethnicity		Dishwasher	0.215
Forceps	0.482	White	0.957	Own computer	0.568
Vacuum	0.907	Mixed	0.026	Tumble dryer	0.280
Other	0.094	Indian	0.184	Own/access to car	0.933
Pain relief:		Pakistani/Bangladeshi	0.593	Noisy Neighbours	
None	0.129	Black	0.867	Very common	0.283
Gas and air	0.264	Other	0.308	Fairly common	0.162
Pethidine	0.361	Mother's Mother is still alive	0.557	Not very common	0.665
Epidural	0.447	Lived away from home before 17	0.550	Not at all common	0.917
General anaesthetic	0.518	***Mothers Health and Lifestyle***		Presence of rubbish and litter in the area	
TENS	0.895	Smoked during pregnancy (# avg. cig per day)	0.706	Very common	0.627
Other	0.254	Drank during pregnancy	0.696	Fairly common	0.452
Complication:		Longstanding illness	0.773	Not very common	0.184
None	0.885	Limiting longstanding illness	0.184	Not at all common	0.722
Breech	0.898	If mother has ever had		Vandalism and damage to property in the area	
Other abnormal	0.482	Migraine	0.697	Very common	0.506
Very long labour	0.670	Hayfever or persistent runny rose	0.064	Fairly common	0.200
Very rapid labour	0.517	Bronchitis	0.240	Not very common	0.922
Foetal distress (heart)	0.728	Asthma	0.977	Not at all common	0.640
Foetal distress (meconium)	0.118	Eczema	0.438	Garden	
Other	0.659	Back Pain/lumbago/sciatica	0.187	Own garden	0.411
Baby		Fits/convulsions/epilepsy	0.009	Shared garden	0.777
Female	0.124	Diabetes	0.681	Social Assistance	
Birth weight (kg)	0.766	Cancer	0.247	Child Tax Credit	0.738
Premature	0.471	Digestive or Bowel disorders	0.004	Working Families Tax Credit	0.802
Length of gestation (days)	0.339	Diabetes during pregnancy	0.612	Income Support	0.835
Present at birth		***Mothers Socioeconomic Status***		Jobseekers Allowance	0.337
Father	0.857	Working during pregnancy	0.573	Housing Benefit	0.058
Mother's friend	0.616	Live in house	0.947	Council Tax Benefit	0.045
Grandmother (in law)	0.100	# rooms	0.596	Invalid Care Allowance	0.186

Notes. Each cell reports the P-value of the hypothesis that the coefficient of exposure to weekend is zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. It also excludes those for whom the cognitive index is missing. All variables are dummy variables, with the exception of birth weight, length of gestation, mother's age, smoked during pregnancy and # rooms. Number of observations 5172. Source: Millennium Cohort Study.

Table VI.14 Cubic Polynomial of Hour. Subsample of those in Cognitive Index

Variable	p-value	Variable	p-value	Variable	p-value
Antenatal		Someone else	0.334	Own outright	0.474
Received ante-natal care	0.508	***Mothers Demographics***		Rent from Local Authority	0.743
First ante-natal was before:		Age	0.607	Rent from Housing Association	0.451
0-11 weeks	0.340	Had attained expected educ qual. at age 16	0.689	Rent privately	0.831
12-13 weeks	0.108	Married	0.606	Live with parents	0.685
≥ 14 weeks	0.837	Religion		Live rent free	0.069
Don't know	0.390	No religion	0.586	Heating	
Attended ante-natal classes	0.193	Catholic	0.259	Open fire	0.530
Received fertility treatment	0.018	Protestant	0.972	Gas/electric fire	0.437
Planned parenthood	0.553	Anglican	0.975	Central	0.010
Delivery		Another type of Christian	0.691	No heating	0.343
Labour induced	0.000	Hindu	0.917	Damp or condensation at home	0.033
Labour duration (hours)	0.512	Muslim	0.025	Assets	
Type Delivery:		Other	0.884	Telephone	0.198
Normal	0.056	Ethnicity		Dishwasher	0.629
Forceps	0.655	White	0.497	Own computer	0.929
Vacuum	0.243	Mixed	0.259	Tumble dryer	0.373
Other	0.475	Indian	0.972	Own/access to car	0.324
Pain relief:		Pakistani/Bangladeshi	0.975	Noisy Neighbours	
None	0.183	Black	0.691	Very common	0.247
Gas and air	0.162	Other	0.917	Fairly common	0.427
Pethidine	0.347	Mother's Mother is still alive	0.025	Not very common	0.402
Epidural	0.169	Lived away from home before 17	0.884	Not at all common	0.391
General anaesthetic	0.803	***Mothers Health and Lifestyle***		Presence of rubbish and litter in the area	
TENS	0.887	Smoked during pregnancy (# avg. cig per day)	0.453	Very common	0.694
Other	0.601	Drank during pregnancy	0.184	Fairly common	0.566
Complication:		Longstanding illness	0.894	Not very common	0.674
None	0.910	Limiting longstanding illness	0.375	Not at all common	0.857
Breech	0.907	If mother has ever had		Vandalism and damage to property in the area	
Other abnormal	0.089	Migraine	0.961	Very common	0.777
Very long labour	0.792	Hayfever or persistent runny rose	0.167	Fairly common	0.261
Very rapid labour	0.492	Bronchitis	0.483	Not very common	0.776
Foetal distress (heart)	0.624	Asthma	0.914	Not at all common	0.674
Foetal distress (meconium)	0.274	Eczema	0.249	Garden	
Other	0.744	Back Pain/lumbago/sciatica	0.388	Own garden	0.258
Baby		Fits/convulsions/epilepsy	0.115	Shared garden	0.993
Female	0.524	Diabetes	0.650	Social Assistance	
Birth weight (kg)	0.550	Cancer	0.692	Child Tax Credit	0.335
Premature	0.819	Digestive or Bowel disorders	0.040	Working Families Tax Credit	0.570
Length of gestation (days)	0.682	Diabetes during pregnancy	0.916	Income Support	0.880
Present at birth		***Mothers Socioeconomic Status***		Jobseekers Allowance	0.058
Father	0.267	Working during pregnancy	0.145	Housing Benefit	0.034
Mother's friend	0.432	Live in house	0.523	Council Tax Benefit	0.023
Grandmother (in law)	0.248	# rooms	0.213	Invalid Care Allowance	0.460

Notes. Each cell reports the P-value of the joint hypothesis that the coefficients of a cubic polynomial in hour are jointly zero in a separate OLS regression in which the dependent variable is listed in the columns titled "Variable". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. It also excludes those for whom the cognitive index is missing. All variables are dummy variables, with the exception of birth weight, length of gestation, mother's age, smoked during pregnancy and # rooms. Number of observations 5172. Source: Millennium Cohort Study.

Table VI.15 Comparison between Attriters and Non-attriters

Variable	Non-attriters	Attriters	t-stat diff	Variable	Non-attriters	Attriters	t-stat diff	Variable	Non-attriters	Attriters	t-stat diff
Antenatal				Grandmother (in law)	0.234	0.272	-3.336	Own outright	0.026	0.028	-0.569
Received ante-natal care	0.960	0.936	3.957	Someone else	0.103	0.123	-2.355	Rent from Local Authority	0.260	0.337	-6.427
First ante-natal was before:				***Mothers Demographics***				Rent from Housing Association	0.095	0.121	-3.256
0-11 weeks	0.414	0.373	3.183	Age	27.241	25.312	12.327	Rent privately	0.086	0.118	-3.923
12-13 weeks	0.337	0.337	0.031	Had attained expected educ qual. at age 16	0.609	0.492	9.026	Live with parents	0.049	0.068	-2.917
≥ 14 weeks	0.181	0.194	-1.281	Married	0.497	0.383	8.821	Live rent free	0.013	0.023	-2.602
Don't know	0.027	0.031	-1.011	Religion				Heating			
Attended ante-natal classes	0.258	0.220	3.355	No religion	0.533	0.585	-3.983	Open fire	0.036	0.032	1.028
Received fertility treatment	0.017	0.010	2.431	Catholic	0.073	0.084	-1.423	Gas/electric fire	0.301	0.306	-0.413
Planned parenthood	0.486	0.399	6.669	Protestant	0.032	0.024	1.946	Central	0.895	0.875	2.312
Delivery				Anglican	0.174	0.106	7.651	No heating	0.011	0.010	0.498
Labour induced	0.303	0.310	-0.574	Another type of Christian	0.068	0.053	2.424	Damp or condensation at home	0.161	0.169	-0.813
Labour duration (hours)	8.632	9.059	-1.560	Hindu	0.011	0.013	-0.455	Assets			
Type Delivery:				Muslim	0.096	0.125	-3.577	Telephone	0.960	0.915	6.817
Normal	0.898	0.907	-1.185	Other	0.012	0.010	0.503	Dishwasher	0.227	0.145	8.157
Forceps	0.039	0.036	0.535	Ethnicity				Own computer	0.434	0.316	9.426
Vacuum	0.066	0.061	0.763	White	0.860	0.812	4.982	Tumble dryer	0.610	0.566	3.369
Other	0.008	0.006	1.068	Mixed	0.009	0.016	-2.373	Own/access to car	0.772	0.661	9.361
Pain relief:				Indian	0.022	0.021	0.361	Noisy Neighbours			
None	0.103	0.104	-0.104	Pakistani/Bangladeshi	0.077	0.097	-2.717	Very common	0.076	0.110	-4.447
Gas and air	0.796	0.790	0.507	Black	0.023	0.039	-3.339	Fairly common	0.117	0.135	-2.086
Pethidine	0.356	0.352	0.305	Other	0.009	0.016	-2.491	Not very common	0.411	0.379	2.498
Epidural	0.196	0.215	-1.771	Mother's Mother is still alive	0.936	0.925	1.612	Not at all common	0.397	0.376	1.613
General anaesthetic	0.003	0.002	0.143	Lived away from home before 17	0.182	0.238	-5.218	Rubbish and litter in the area			
TENS	0.087	0.052	5.335	***Mothers Health and Lifestyle***				Very common	0.134	0.178	-4.580
Other	0.038	0.028	2.301	Smoked during pregnancy (# avg. cig. per day)	3.371	4.008	-3.930	Fairly common	0.216	0.232	-1.458
Complication:				Drank during pregnancy	0.263	0.226	3.363	Not very common	0.381	0.349	2.573
None	0.754	0.773	-1.707	Longstanding illness	0.217	0.183	3.238	Not at all common	0.268	0.241	2.417
Breech	0.019	0.020	-0.483	Limiting longstanding illness	0.101	0.097	0.602	Vandalism/damage to property in the area			
Other abnormal	0.003	0.004	-0.392	If mother has ever had				Very common	0.101	0.125	-2.796
Very long labour	0.045	0.051	-1.025	Migraine	0.230	0.210	1.802	Fairly common	0.154	0.170	-1.653
Very rapid labour	0.030	0.019	2.617	Hayfever or persistent runny rose	0.236	0.234	0.217	Not very common	0.409	0.390	1.475
Foetal distress (heart)	0.077	0.065	1.911	Bronchitis	0.075	0.065	1.535	Not at all common	0.336	0.316	1.667
Foetal distress (meconium)	0.039	0.034	0.982	Asthma	0.180	0.167	1.362	Garden			
Other	0.081	0.074	1.031	Eczema	0.191	0.165	2.611	Own garden	0.855	0.765	8.728
Baby				Back Pain/lumbago/sciatica	0.221	0.200	1.922	Shared garden	0.033	0.062	-5.090
Female	0.508	0.482	2.005	Fits/convulsions/epilepsy	0.022	0.030	-2.019	Social Assistance			
Birth weight (kg)	3.370	3.337	2.527	Diabetes	0.012	0.009	1.079	Child Tax Credit	0.149	0.098	6.032
Breastfeeding 90 days	0.262	0.186	7.059	Cancer	0.010	0.010	0.283	Working Families Tax Credit	0.254	0.235	1.687
Born during weekend	0.430	0.415	1.161	Digestive or Bowel disorders	0.080	0.071	1.352	Income Support	0.246	0.380	-11.006
Premature	0.044	0.047	-0.642	Diabetes during pregnancy	0.008	0.006	0.870	Jobseekers Allowance	0.044	0.049	-0.891
Length of gestation (days)	279.3	278.8	1.8	***Mothers Socioeconomic Status***				Housing Benefit	0.223	0.308	-7.314
Present at birth				Working during pregnancy	0.553	0.431	9.389	Council Tax Benefit	0.210	0.282	-6.315
Father	0.820	0.755	6.035	Live in house	0.858	0.772	8.446	Invalid Care Allowance	0.016	0.012	1.486
Mother's friend	0.042	0.062	-3.338	# rooms	5.125	4.846	8.060				

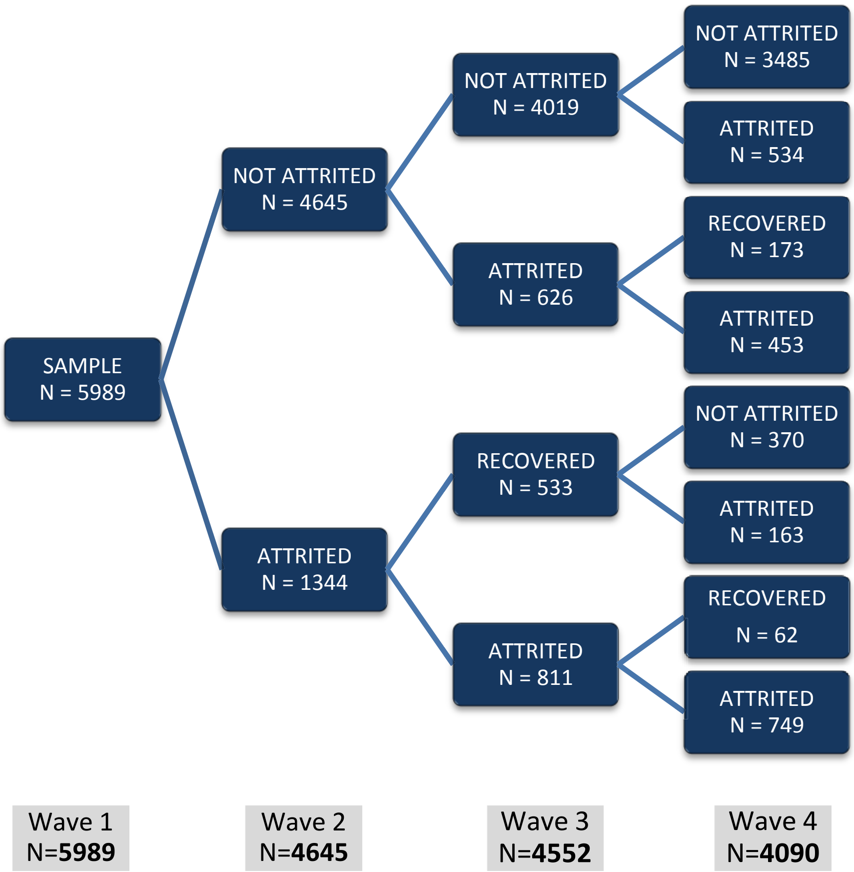
Notes. Figures in columns titled "Non-attriters" and "Attriters" are sample means of the variable listed under the column titled "Variable". The t-statistic of the difference between the means listed in these two columns is shown under the column titled "t-stat diff". Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Attriters=1 if attrit from the survey in at least 1 wave; Non-attriters=1 if never attrit from the survey. All variables are dummy variables, with the exception of birth weight, length of gestation, mother's age, smoked during pregnancy and # rooms. Number of observations 5989. Source: Millennium Cohort Study.

Table VI.16. Effect of Breastfeeding on Cognitive Outcomes at Ages 5

	5 years outcomes			5 years outcomes based on sample available at 7 years (MCS4)		
	Expressive Language	Pictorial Reasoning	Visuo-Spatial	Expressive Language	Pictorial Reasoning	Visuo-Spatial
Panel A: Exclusion Restriction Exposure to Weekend						
NTSLS	11.608*	5.229	13.517*	6.004	2.547	12.538
	(4.815)	(3.993)	(6.641)	(4.857)	(4.070)	(6.824)
TSLS	20.241	13.581	22.198	10.584	4.973	31.949
	(18.357)	(14.690)	(24.178)	(12.770)	(10.792)	(20.518)
OLS	1.223*	0.880*	0.796	1.235*	1.069*	0.924
	(0.539)	(0.441)	(0.723)	(0.570)	(0.477)	(0.780)
F statistic	6.045	6.261	6.134	7.961	8.295	8.063
P-Value Joint	0.0140	0.0124	0.0133	0.0048	0.0040	0.0045
Mean	104.1	80.24	85.43	104.7	80.50	86.29
SD	15.64	11.75	19.70	15.35	11.71	19.17
Observations	4347	4353	4331	3687	3691	3676
Panel B: Exclusion Restriction Polynomial in Hour						
NTSLS	10.235*	5.478	14.530*	4.586	3.209	13.185*
	(4.568)	(3.850)	(6.330)	(4.585)	(3.902)	(6.492)
TSLS	5.841	9.464	23.297	1.833	6.349	31.519
	(11.532)	(10.224)	(16.846)	(10.079)	(8.900)	(16.669)
OLS	1.223*	0.880*	0.796	1.235*	1.069*	0.924
	(0.539)	(0.441)	(0.723)	(0.570)	(0.477)	(0.780)
F statistic	2.967	3.055	3.136	3.530	3.672	3.572
P-Value Joint	0.0308	0.0273	0.0244	0.0143	0.0117	0.0135
Mean	104.1	80.24	85.43	104.7	80.50	86.29
SD	15.64	11.75	19.70	15.35	11.71	19.17
Observations	4347	4353	4331	3687	3691	3676

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column and the estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 5. In panel A the exclusion restriction from the second-stage regressions is exposure to weekend while in Panel B is the cubic polynomial in hour. F statistic and P-value correspond to the null hypothesis that the coefficient(s) on the excluded variable(s) is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Figure VI. 1. Attrition and Recovery by Wave for Low Educated Mothers



The figure shows how the initial sample of 5989 children born naturally (excludes C-sections) who have not been in intensive care and whose mother is low educated (NVQ level 2 or less, or unknown NVQ level but left school before age 17) have attrited and recovered. Attrition is defined as equal to 1 if child was not observed in the subsequent wave and 0 otherwise.

Appendix VII:
Additional Tables

Not for Publication

Table VII.1. Polynomial in Hour. Effect of Breastfeeding on Indices at Different Quantiles

Percentile	10	25	50	75	90
Cognitive Index	1.186**	0.676*	0.448	0.322	0.178
	(0.454)	(0.345)	(0.309)	(0.294)	(0.429)
Non-cognitive Index	0.646	0.042	0.054	0.104	-0.225
	(0.658)	(0.514)	(0.414)	(0.390)	(0.420)
Health Index	-0.132	0.039	-0.214	-0.057	-0.022
	(0.298)	(0.218)	(0.152)	(0.112)	(0.092)

Notes. Each cell reports the coefficient of a quantile regression of each index on breastfeeding, additional control variables and a sixth-order polynomial of the first stage residuals (control function). The exclusion restriction is a cubic polynomial in Hour. The percentile is indicated at the top of the column. Control variables are the same as in Table 4. Bootstrapped standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table VII.2. Exposure to Weekend. Effect of Breastfeeding on Parenting Activities for child at 5 years old

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Estimation Method ↓	Read to child every day	tell stories every day	perform musical activities every day	draws/paints with child every day	plays physically active games every day	plays games/toys indoors every day	Home learning Environment
NTSLS	0.029	-0.050	0.093	0.098	-0.053	-0.057	-0.131
	(0.175)	(0.116)	(0.169)	(0.097)	(0.090)	(0.150)	(2.480)
TSLS	0.344	0.135	0.666	0.313	-0.047	-0.403	0.230
	(0.530)	(0.340)	(0.560)	(0.316)	(0.269)	(0.457)	(7.196)
OLS	0.057**	0.012	0.046*	0.008	0.006	0.021	0.860**
	(0.019)	(0.013)	(0.018)	(0.011)	(0.010)	(0.016)	(0.277)
F statistic	7.560	7.534	7.603	7.560	7.607	7.607	7.768
P-value	0.0060	0.0061	0.0059	0.0060	0.0058	0.0058	0.0053
Mean	0.441	0.116	0.378	0.0841	0.0710	0.209	24.57
SD	0.497	0.321	0.485	0.278	0.257	0.407	7.287
Observations	4397	4396	4396	4397	4396	4396	4393

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column. Columns 1-6 are coded as 0/1 dummy variables; Column 7, the Home learning environment, is the sum of the frequency of each of the activities reported in columns 1-6 (where 1="occasionally"...7="7 times per week/constantly" (except in the case of library where 7="once a week")), taking a maximum value of 42. The estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 5. Exposure to weekend is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table VII.3. Exposure to Weekend. Effect of Breastfeeding on Parenting Activities for child at 7 years old

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Estimation Method ↓	Read to child every day	tell stories every day	perform musical activities every day	draws/paints with child every day	plays physically active games every day	plays games/toys indoors every day	Home learning Environment
NTSLS	0.175	0.107	0.243	-0.018	0.094	-0.037	3.098
	(0.161)	(0.097)	(0.166)	(0.072)	(0.084)	(0.103)	(2.584)
TSLS	0.041	0.454	-0.083	-0.006	0.006	0.150	-2.614
	(0.440)	(0.307)	(0.434)	(0.192)	(0.213)	(0.281)	(6.921)
OLS	0.027	-0.008	0.011	0.009	-0.002	0.005	0.627*
	(0.020)	(0.011)	(0.019)	(0.008)	(0.009)	(0.012)	(0.308)
F statistic	8.567	8.498	8.506	8.567	8.567	8.567	8.364
P-value	0.0034	0.0036	0.0036	0.0034	0.0034	0.0034	0.0039
Mean	0.343	0.0802	0.315	0.0403	0.0525	0.0910	21.20
SD	0.475	0.272	0.465	0.197	0.223	0.288	7.518
Observations	3944	3942	3943	3944	3943	3944	3940

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is listed at the top of the column. Columns 1-6 are coded as 0/1 dummy variables; Column 7, the Home learning environment, is the sum of the frequency of each of the activities reported in columns 1-6 (where 1="occasionally"...7="7 times per week/constantly" (except in the case of library where 7="once a week")), taking a maximum value of 42. The estimation method is listed in the left hand column (NTSLS denotes non-linear two-stage least squares; TSLS denotes two-stage least squares; OLS denotes ordinary least squares). Control variables are the same as in Table 5. Exposure to weekend is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Sample comprises low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table VII.4. Polynomial in Hour. Effects of Breastfeeding on Cognitive Index: Robustness

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
NTSLS	0.451**	0.507**	0.365*	0.446**	0.401*	0.481*	0.369**
	(0.170)	(0.187)	(0.160)	(0.167)	(0.164)	(0.192)	(0.143)
First Stage F-statistic	3.728	3.154	4.459	3.807	3.852	3.728	3.728
Observations	5015	3482	5588	5015	5015	5015	5015
[1] Include labour inductions	Y	N	Y	Y	Y	Y	Y
[2] Include emergency Caesareans	N	N	Y	N	N	N	N
[3] Control for polynomial in hour within the day (0-24)	N	N	N	Y	N	N	N
[4] Control for hour of birth dummies	N	N	N	N	Y	N	N
[5] Include imputed data	N	N	N	N	N	Y	N
[6] Control for hospital fixed effects	Y	Y	Y	Y	Y	Y	N

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is Cognitive Index and the estimation method is NTSLS (non-linear two-stage least squares). Control variables are the same as in Table 5. Cubic polynomial in hour is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficients on the third order polynomial in hour are jointly zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Main sample contains low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Robustness exercise is indicated in the bottom rows. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table VII.5. Exposure to Weekend. Effects of Breastfeeding on Non-Cognitive Index: Robustness

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
NTSLS	0.320	0.331	0.397	0.321	0.287	0.296	0.231
	(0.226)	(0.259)	(0.214)	(0.224)	(0.225)	(0.260)	(0.193)
First Stage F-statistic	5.701	2.420	6.688	5.570	5.733	5.701	5.701
Observations	4957	3424	5525	4957	4957	4957	4957
[1] Include labour inductions	Y	N	Y	Y	Y	Y	Y
[2] Include emergency Caesareans	N	N	Y	N	N	N	N
[3] Control for polynomial in hour within the day (0-24)	N	N	N	Y	N	N	N
[4] Control for hour of birth dummies	N	N	N	N	Y	N	N
[5] Include imputed data	N	N	N	N	N	Y	N
[6] Control for hospital fixed effects	Y	Y	Y	Y	Y	Y	N

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is Non-cognitive Index and the estimation method is NTSLS (non-linear two-stage least squares). Control variables are the same as in Table 5. Exposure to weekend is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Main sample contains low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Robustness exercise is indicated in the bottom rows. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table VII.6. Polynomial in Hour. Effects of Breastfeeding on Non-Cognitive Index: Robustness

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
NTSLS	0.347	0.337	0.407*	0.348	0.316	0.328	0.248
	(0.215)	(0.229)	(0.204)	(0.212)	(0.212)	(0.247)	(0.186)
First Stage F-statistic	3.094	2.640	3.769	3.129	3.169	3.094	3.094
Observations	4957	3424	5525	4957	4957	4957	4957
[1] Include labour inductions	Y	N	Y	Y	Y	Y	Y
[2] Include emergency Caesareans	N	N	Y	N	N	N	N
[3] Control for polynomial in hour within the day (0-24)	N	N	N	Y	N	N	N
[4] Control for hour of birth dummies	N	N	N	N	Y	N	N
[5] Include imputed data	N	N	N	N	N	Y	N
[6] Control for hospital fixed effects	Y	Y	Y	Y	Y	Y	N

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is Non-cognitive Index and the estimation method is NTSLS (non-linear two-stage least squares). Control variables are the same as in Table 5. Cubic polynomial in hour is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficients on the third order polynomial in hour are jointly zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Main sample contains low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Robustness exercise is indicated in the bottom rows. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table VII.7. Exposure to Weekend. Effects of Breastfeeding on Health Index: Robustness

	[1]	[2]	[3]	[4]	[5]	[6]
NTSLS	0.026	0.055	-0.006	0.020	0.022	-0.000
	(0.083)	(0.094)	(0.079)	(0.083)	(0.083)	(0.075)
First Stage F-statistic	8.580	4.116	9.443	8.419	8.428	8.580
Observations	5810	4033	6470	5810	5810	5810
[1] Include labour inductions	Y	N	Y	Y	Y	Y
[2] Include emergency Caesareans	N	N	Y	N	N	N
[3] Control for polynomial in hour within the day (0-24)	N	N	N	Y	N	N
[4] Control for hour of birth dummies	N	N	N	N	Y	N
[5] Control for hospital fixed effects	Y	Y	Y	Y	Y	N

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is Health Index and the estimation method is NTSLS (non-linear two-stage least squares). Control variables are the same as in Table 5. Exposure to weekend is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficient on the excluded variable is zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Main sample contains low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Robustness exercise is indicated in the bottom rows. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Table VII.8. Polynomial in Hour. Effects of Breastfeeding on Health Index: Robustness

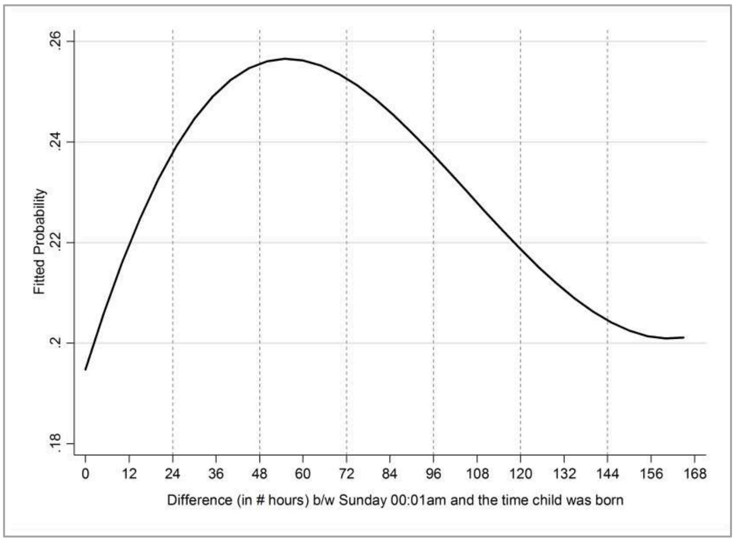
	[1]	[2]	[3]	[4]	[5]	[6]
NTSLS	0.007	0.015	-0.015	-0.010	-0.004	-0.009
	(0.080)	(0.086)	(0.076)	(0.079)	(0.079)	(0.073)
First Stage F-statistic	4.713	4.246	5.535	4.718	4.703	4.713
Observations	5810	4033	6470	5810	5810	5810
[1] Include labour inductions	Y	N	Y	Y	Y	Y
[2] Include emergency Caesareans	N	N	Y	N	N	N
[3] Control for polynomial in hour within the day (0-24)	N	N	N	Y	N	N
[4] Control for hour of birth dummies	N	N	N	N	Y	N
[5] Control for hospital fixed effects	Y	Y	Y	Y	Y	N

Notes. Each cell reports coefficient of breastfeeding for at least 90 days from separate regressions in which the dependent variable is Health Index and the estimation method is NTSLS (non-linear two-stage least squares). Control variables are the same as in Table 5. Cubic polynomial in hour is excluded from the second-stage regressions. F statistic and P-value correspond to the null hypothesis that the coefficients on the third order polynomial in hour are jointly zero, as estimated from an OLS regression where the dependent variable is breastfeeding for at least 90 days, and controls are as noted already. Main sample contains low educated mothers (NVQ level 2 or less, or NVQ level unknown but left school before 17), and excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care after delivery. Robustness exercise is indicated in the bottom rows. Standard errors in parentheses: ** p<0.01, * p<0.05. Source: Millennium Cohort Study.

Appendix VII: Figures

Not for Publication

VII. 1. Breastfeeding by hour born, Low Educated Mothers



The horizontal axis shows the hour of birth within the week (0 corresponds to Sunday 00:01-00:59 and 163 to 23:00-23:59 on Saturday). The vertical axis shows the predicted probability that a child will be breastfed for at least 90 days computed using a Probit model estimated using a cubic polynomial on the variable in the horizontal axis and the same set of control variables as Table 4. The probability is estimated for the average value of the control variables. Sample comprises low educated mothers (NVQ level 2 or less, or unknown NVQ level but left school before age 17), but excludes children born through caesarean sections (either emergency or planned) and children placed in intensive care. Source: Millennium Cohort Study.