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MATERNAL POSTPARTUM DEPRESSION EFFECTS ON CHILD'S HEALTH

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Maternal Postpartum Depression Effects on Child's Health

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Abstract

Several studies indicate that children, whose mother experienced postpartum depression, are at greater risks of emotional, behavioural, cognitive and interpersonal problems later in life. However, maternal postpartum depression might influence child's development by affecting his health outcomes. Using data from the Millennium Cohort Study (UK data service), we investigate whether maternal postpartum depression has any impact on early child health development and if differences exist when the child is the first-born. In detail, we study the effects of maternal postpartum depression on a range of potential child health diseases at ages of 3, 5, 7 and 11 years and on the number of injuries or accidents occurred at the child, for which he was taken to the hospital. Our findings show a non-negligible impact of maternal postpartum depression for first-born children on those health issues enhanced by a stressful environment: wheezing (throughout childhood) and hay fever (at early ages). At later ages (7 and 11 years), children with a mother who experienced postpartum depression are also more likely to suffer from asthma. Furthermore, results indicate a significant strong effect of maternal postpartum depression on the accident rate at the ages of 3 and 5 years (the incidence-rate ratios are of 1.205 and 1.289 respectively).

Keywords: maternal postpartum depression; early childhood development; children health.
JEL classification: I120, I140, J130.

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1 Introduction

According to the World Health Organization, 13% of mothers who have just given birth suffer of a mental disorder, primarily diagnosed as depression. It represents a relevant public health issue affecting women and their families (Warner et al., 1996). Mothers provide the largest share of human contact with the infants and mediate their contact with the external world (Grace et al., 2003). The family environment is the primary source of experience of a child and it is characterized by its own social and economic resources, including: parenting skills and education, cultural practices and approaches, intra-familial relations and the health status of family's members indeed (Irwin et al., 2007).

Several studies indicate that children of a mother with depression are at greater risks of emotional, behavioural, cognitive and interpersonal problems later in life (Luoma et al., 2001; Beck, 1998; Carter et al., 2001). According to Murray (1992), maternal postpartum depression appeared to make offspring more sensitive to the threats related to low social classes and gender (boys appear to be at a greater risk of poor development than girls). Moreover, maternal postpartum depression could influence child's development by affecting his health outcomes. Early child health and development (ECD) is important for health in later life (Case et al., 2002; Irwin et al., 2007). Inequalities in health, as well as in cognitive development and socio-emotional functioning, emerge early in life (Doyle et al., 2009; Case et al., 2002; Violato et al., 2011). In addition, poor health experienced in childhood is associated with poorer health, adverse educational and labor market outcomes in adulthood (Case et al., 2005). Therefore, unhealthy children represent a cost for the society in the short run, since they increase the demand for health resources, and in the long run due to the losses in economic productivity (Doyle et al., 2015). Actions taken in order to reduce the social gradient in child development might have an impact on later social gradients in health (Campbell et al., 2014). A strong body of research demonstrates that early intervention is more efficient in biologically and economically terms, since at early stages, development is more responsive to external stimuli (Halfon et al., 2001).

The aims of the present study are to investigate whether maternal postpartum depression has an impact on (i) child's health outcomes, (ii) and the number of injuries or accidents occurred at the child, for which he was taken to the hospital. We want to assess whether any effect exists and if it persists as the child grows up. Moreover, we want to ascertain if having older siblings, makes the new-born less vulnerable to the negative consequences of maternal postpartum depression given the previous acquired experience of the mother in taking care of the offspring. In our analysis, we use the UK-Millennium Cohort Study (MCS), a longitudinal birth cohort study administered by the Centre for Longitudinal Studies and available through the UK Data Service.

The rest of the paper proceeds as follows: in Section 2 an overview of the literature on child health inequalities and maternal postpartum depression is provided, in Section 3 the model specification is outlined, in Section 4 the empirical analysis and the results are discussed, and in Section 5 conclusions are drawn.

2 Literature review

Every child is born with an initial health endowment as birth-weight and gestation age. However, his health status might be affected by several factors even before birth. Evans and Kantrowitz (2002)

reported that *in utero* exposure to environmental toxins[1] might lead to teratological effects. Even in low doses, toxins may produce cognitive and behavioural abnormalities, including attentional and memory disorders, lower Intelligent Quotient, and poorer academic achievements. Moreover, other behavioural problems as impulse control, frustration intolerance and aggression have also been associated with the exposure to several toxins. In addition, the toxicological effects appear to be especially dangerous during the critical period of fetal development (Evans and Kantrowitz, 2002). Not only exposure to environmental toxins seems to be dangerous for fetal development but exposure to stressful situation might harm child health as well. Quintana-Domeque and Ródenas-Serrano (2017) investigated the effect of *in utero* exposure to a sustained terrorist conflict on birth outcomes. Focusing on ETA[2] terrorism in Spain in the period between 1980 and 2003, they found that exposure to terrorism early in pregnancy, measured by the number of bomb casualties in the mother's province of residence, is associated with a major prevalence of low birth weight, and lower fraction of 'normal' babies. Moreover, focusing on the most tragic ETA attack in the '80s, the authors found that exposure to bomb casualties increases fetal deaths. They claimed that their results are consistent with the fact that many bio-active mediators of maternal stress are also associated with pathophysiology of stillbirth. Other studies have investigated the effect on birth-outcomes at an aggregate level, mainly birth-weight, of *in utero* exposure to maternal stressors such as hurricanes, landmines-explosions, number of injuries in the al-Aqsa Intifdada, and homicide rates (Torche, 2011; Camacho, 2008; Mansour and Rees, 2012; Koppensteiner and Manacorda, 2016).

Apart from stress generated by natural disasters or terror attacks, a large proportion of mothers, up to 70%, experience a brief psychological disturbance after delivery called postnatal blues (Robertson et al., 2003). Maternity blues should not be confused with postpartum depression. The former occurs within a few days after childbirth (on day 3 or 4), and persists for hours up to several days. It is characterized by mood lability, irritability, tearful, generalized anxiety, and sleep and appetite disturbance. No treatment is required apart from reassurance (Kennerley and Gath, 1989; Robertson et al., 2003). The latter occurs within the first 12 months after childbirth and most cases require treatment by a health professional. The symptoms include those of maternity blues as well as poor concentration and memory, feelings of guilt, of being inadequate and unable to cope with the infant (Robertson et al., 2003). Postpartum depression is estimated to affect approximately $10 - 15\%$ of women following childbirth (Warner et al., 1996). Untreated postpartum depression can persist for months to years, affecting health and psychological well-being of the mother (Cooper et al., 1988; Beck, 2001; Blom et al., 2010).

Extreme severe depressive episodes with psychotic symptoms are attributed instead to puerperal psychosis which affect only the $0.1\% - 0.2\%$ of mothers (Robertson et al., 2003). It involves extreme disorganization of thought, bizarre behaviour and unusual hallucinations. Conversely to postpartum depression, the puerperal psychosis outbreaks within the first two weeks after delivery and requires immediate intervention because of the risk of infanticide and suicide (Kendell et al., 1987; Wisner et al., 2002).

The symptoms in women with postpartum depression are similar to those in women who have depression unrelated to childbirth (Wisner et al., 2002), except from the content which might be associated with the child (Robertson et al., 2003). Epidemiological studies have identified a set of risk factors which might increase the probability of developing postpartum depression. These are: history of depression, prenatal anxiety, low social support and poor marital relationship (O'hara

[1]Principally identified in heavy metals (e.g., lead), solvents (e.g., cleaning fluids), and pesticides.

[2]ETA, abbreviation of *Basque Euskadi ta Askatasuna* (Basque Homeland and Liberty), was a terrorist organization who sought to gain independence for a Basque homeland in northern Spain and southern France.

and Swain, 1996; Beck, 2001). Using a large birth cohort study in the Netherlands embedded in the Generation R study, Blom et al. (2010) found that several perinatal complications were significantly associated with postpartum depression. In particular, they observed that preeclampsia[3], hospitalisation during pregnancy, emergency caesarean section, suspicion of fetal distress, a medically indicated delivery provided by an obstetrician and hospital admission of the baby increased the risk of postpartum depression. In their study, postpartum depression was assessed with the Edinburgh postnatal depression scale distributed to mothers two months after delivery. The authors claimed that several mechanism might explain the association between pregnancy and delivery complications with postpartum depression. These could be: physical and hormonal changes in the woman, her physical health, personality differences as well as psychological mechanism. Expectations about pregnancy, delivery, and postpartum period might lead to feelings of disappointment and failure when complications occur. Conversely, unplanned pregnancy was not found associated with maternal distress. In her review, Heh (2003) reports that social support is an important factor to reduce the effect of postnatal depression. Mental health and physical well-being can be promoted through instrumental and emotional support.

A number of studies has found an association between early maternal depression and adverse cognitive and emotional child development (Murray and Cooper, 1997; Kelly et al., 2011). In their study, Murray and Cooper (1997) supposed that the association between the occurrence of postnatal depression and adverse infant outcomes might be mediated by three different mechanisms: (i) child's exposure to the mother's depressive symptoms; (ii) parenting difficulties associated with the occurrence of maternal depression; (iii) third factor variables (environmental adversity, genetic factors).

According to epigenetic studies, the relationship between early life experience, including perinatal environment and health in adulthood might be partially mediated by parental influences on the development of neuronal systems that underlie the expression of behavioural and endocrine responses to stress. Most of the epigenetic literature on the environmental regulation of the development of responses to stress comes from postnatal handling research with rodents (experiments on humans are forbidden for obvious reasons). Weaver et al. (2004) found that maternal behavioural in rats is responsible for stable long-lasting alterations of DNA methylation and chromatic structure. In particular, maternal behavioural permanently alters the development of hypothalamic-pituitary-adrenal responses to stress through tissue-specific effects on gene expression. However, the authors showed that the epigenomic state of a gene can be established through behaviouralal programming and that is potentially reversible.

In general, excessive hypothalamic-pituitary-adrenal and sympathetic responses to stress are associated to an increased risk, for both humans and non-humans populations, of a variety of disorders, including heart disease, diabetes, anxiety, depression and drug addiction. Stress is a risk factor for a wide range of diseases indeed, going from autoimmune disorders to mental illness (Meaney, 2001). Neuroendocrine or immunologic changes induced by stress may affect airway inflammation and reactivity through immunologic and neural pathways that may lead to wheeze (Wright et al., 2002).

Epidemiological studies suggest that maternal distress, broadly defined not focusing on postpartum depression, may lead to the development of early childhood wheezing and asthma. In a cohort of 490 families with a history of asthma or allergy, Wright et al. (2002) found that parental stress, measured when the child was 2 to 3 months old, predicts childhood wheeze at 14 months

[3]Hypertensive condition in pregnancy characterized by high blood pressure, sometimes also with fluid retention and proteinuria.

of age. Using the Canadian health care and prescription databases 'Manitoba', Kozyrskyj et al. (2008) found an association between continued exposure to maternal distress (from postpartum period up to 7 years) and asthma at the age of 7 years for those children living in high-income households. Though, exposure to maternal depression and anxiety only in the first year of life was not associated with asthma at later ages. Similar evidence was found by Turney (2011), who analysed the impact of maternal depression on children health outcomes at the age of 5, using US data from the Fragile Families and Child Wellbeing Study. The author reported that children of chronically depressed mothers were about twice as likely to have had an asthma attack, hay fever or respiratory allergies, or eczema or skin allergies in the last year (when they were 4 years old), compared to their counterparts with never depressed mothers. In the analysis, maternal chronic depression was found to worse general health of the offspring at the age of 5. Moreover, children whose mother has experienced persistent depression, are more likely to have gone to the emergency room in the previous year, while the association between maternal depression and doctor visits for accident or injuries is only marginally significant.

In the British context instead, Propper et al. (2007), using cross-sectional data from the Avon Longitudinal Study of Parents and Children, identified a strong association between mothers with poor mental health measured at the 17th week of gestation and poor general health of their child at various ages in early- to mid-childhood (from 6 months to 7 years). The researchers investigated also the association of maternal perinatal distress with child asthma and body mass index at the age of 7. It was found that maternal poor mental health increases child's probability of suffering from asthma, but has no effect on his body mass index.

Another study by Violato et al. (2009), using the first three surveys of the UK Millennium Cohort Study, found that maternal psychological distress is associated with an increasing probability of suffering from wheeze at age of 5, but not at previous age. In addition to this, no effect of maternal distress was identified on the probability of suffering from asthma. In this study, maternal depression was measured with a time lag with respect to the time in which child health outcomes were measured.

The literature on the consequences of maternal depression for the offspring is growing, although few studies focus on the impact of postpartum depression on physical child health outcomes and even fewer assess whether it persists throughout the childhood until adolescence. The present paper contributes to the existing literature by assessing whether exposure to maternal postpartum depression itself, not chronic maternal distress, has an impact on a specific set of child health outcomes, using a large, cohort study not restricted to high-risk children. Moreover, this is the first paper that, to the best of our knowledge, investigate when not first-born child are less exposed to the possible negative consequences of maternal postpartum depression. Eventually, we verify if the impact continues as the child grows up.

3 Model specification

Childhood health is the result of an initial health endowment as well as parents and external inputs. Following the framework of Grossman (2000) and Jacobson (2000), as outlined by Noonan et al. (2018), we can express the child-health production function as follows:

$$CH_{i,t} = \alpha_0 + \alpha_1 h_{i,t=0} + \alpha_2 X_{i,t} + \alpha_3 Ln(Y_{i,t}) + \sum_{z=1}^{Z} \alpha_{z,PS} PS_{z,i,t} + \sum_{j=1}^{J} \alpha_{j,PI} PI_{j,i,t} + \sum_{s=1}^{S} \alpha_{s,PS} OP_{s,t} + \epsilon_{i,t} \quad (1)$$

where $CH_{i,t}$ represents the child health, i denotes the child, t the time; $h_{i,t=0}$ is the child initial stock of health (e.g., birth-weight, gestational age); $X_{i,t}$ is a set of family characteristics other than income and some child characteristics; $Y_{i,t}$ is the family income considered in its logarithm form; while the three summation terms are related to 'parental stress', 'parental investment' and 'other family related pathways'; and $\epsilon_{i,t}$ is the error term. In the present study, we are mainly interested in the impact of maternal postpartum depression on child health outcomes. Therefore, our estimation model can be expressed as follows:

$$CH_{i,t} = \alpha + \beta_1 PPD_{j,t=0} + \beta_2 (OlderSib_{i,t=0} * PPD_{j,t=0}) + \gamma 1 h_{i,t=0} + \gamma_2 X_{it} + \varepsilon_{i,t} \quad (2)$$

where $CH_{i,t}$ is the child health outcome, i and t denote respectively the child and his age in years, $PPD_{j,t=0}$ is postpartum depression of the mother of child i; $OlderSib_{i,t=0} * PPD_{i,t=0}$ is the interaction between maternal postpartum depression and having older siblings, that is to say not being the first-born; $h_{i,t=0}$ is the initial child health endowment (e.g. born preterm, underweight); X_{it} is a set of other child characteristics; and $\varepsilon_{i,t}$ is the error term. However, some risk factors in the newborn's health, might be the same that trigger postpartum depression. This is the case for maternal longstanding illness, health problems during pregnancy, social support and family income. They might affect child health outcomes directly and consequently the exclusion of these variables from our estimation model (2) could arise endogeneity issues. We can define maternal postpartum depression with the following equation:

$$PPD_{j,t=0} = \alpha + \beta_1 X_{j,t=0} + \beta_2 Z_{j,t=-1} + \beta_3 W_{j,t=0} + \beta_4 Ln(Y_{j,t=0}) + \beta_5 K_{j,t=0} + u_{j,t} \quad (3)$$

where $PPD_{j,t=0}$ is the postpartum depression detected when the child is less than 12 months old; $X_{j,t=0}$ is a set of maternal characteristics including demographic characteristics and longstanding illness; $Z_{j,t=-1}$ is a set of maternal characteristics referred only to the pregnancy period, such as employment status and health attitudes (e.g. smoking habit, alcohol consumption); $W_{j,t=0}$ is a set of variables describing the labour and any health issues occurred during it or following childbirth; $Y_{j,t=0}$ is the logarithm of the household income; while $K_{j,t=0}$ includes a set of background variables in order to control for social support and environmental risk factors measured after the birth of the child (e.g. presence of child's father in the household, grandparents alive), and $u_{j,t}$ is the error term. Adjusting for the common risk factors, child's health model (2) can be rewritten in a restricted form as follows:

$$CH_{i,t} = \alpha + \beta_1 PPD_{j,t=0} + \beta_2 (OlderSib_{i,t=0} * PPD_{j,t=0}) + \gamma_1 h_{i,t=0} + \gamma_2 X_{i,t} + \gamma_3 LN(Y_{i,t=0}) + \gamma_4 X_{j,t} + \zeta_{i,t} \quad (4)$$

where X_{it} is a set of child characteristics only; $Y_{i,t=0}$ is the logarithm of the household income; $X_{j,t}$ is a set of variables including mother, family and environmental characteristics which are risk factors for both maternal postpartum depression and child's health; and $\zeta_{i,t}$ is the error term. In order to avoid reverse causality between maternal postpartum depression and child health status, we did not considered child health outcomes as dependent variables at the time that postpartum depression is detected but we included them as control variables.

In addition to the impact of maternal postpartum depression on child health outcomes, we are interested in whether a mother suffering from postpartum depression could lead to a more vulnerable home environment for the child. In order to assess it, we took into consideration as potential outcome the number of accidents or injuries for which the child has been needed medical assistance (it was taken to the doctor or hospital. Postpartum depression may affect the way mothers watch over their offspring. We can express the impact of maternal postpartum depression on the number of accidents occurring to a child with the following equation:

$$ACC_{i,t} = \alpha + \beta_1 PPD_{j,t=0} + \beta_2(OlderSib_{i,t=0} * PPD_{j,t=0}) + \beta_3 h_{i,t=0} + \beta_4 X_{it}\eta_{i,t} \quad (5)$$

where $ACC_{i,t}$ is the number of accidents occurring at time t for individual i; $PPD_{j,t=0}$ is maternal postpartum depression; $OlderSib_{i,t=0} * PPD_{j,t=0}$ is the interaction between maternal postpartum depression and having older siblings; $h_{i,t=0}$ is the initial child health endowment;$X_{i,t}$ is a set of other child characteristics; and $\eta_{i,t}$ the error term. Though, as for the child health outcomes, it is important to adjust the model for other variables that might influence both PPD and the number of accidents. Therefore, equation (5) becomes:

$$ACC_{i,t} = \alpha+\beta_1 PPD_{j,t=0}+\beta_2(OlderSib_{i,t=0}*PPD_{j,t=0})+\gamma_1 h_{i,t=0}+\gamma_2 X_{i,t}+\gamma_3 LN(Y_{i,t=0})+\gamma_4 X_{j,t}+\nu_{i,t} \quad (6)$$

where $X_{i,t}$ is a set of child characteristics only; $Y_{i,t=0}$ is the family income considered in its logarithm form; $X_{j,t}$ is a set of variables including mother, family and environmental characteristics which are risk factors for both maternal postpartum depression and child's health; $\nu_{i,t}$ is the error term.

4 Empirical Analysis

4.1 Data description

The Millennium Cohort Study (MCS) is a multidisciplinary survey, following the life of around 19,000 children born in the United Kingdom between September 2000 and January 2002. The sample design allowed for an oversampling of families living in disadvantaged areas, in the smaller nations of the UK, and in areas with high ethnic minority populations in England. These are the groups of families who are usually hard to reach (Connelly and Platt, 2014). Data were collected when children were around 9 months of age, in a series of follow-up surveys at the ages of 3, 5, 7, 11 and most recently at 14 years.

At each sweep, home interviews were conducted and parents answered also some questions via self-completion. A large amount of information was gathered regarding socioeconomic circumstances, demographic characteristics, home learning, family routine, parental health, parenting activities and attitudes. At the age of 9 months extensive information was collected about antenatal care, labour and delivery, breastfeeding, cohort member's health and growth. Starting from the second sweep, when children were 3 years old, the interviewer conducted a number of age-appropriate cognitive assessments with each cohort member. Information about cohort members socioemotional difficulties was collected as well. At the age of 7 years, for the first time cohort members completed a short questionnaire on their own, covering topics including their daily lives, activities, schooling, friendships and parents. In addition to this, a questionnaire was mailed to cohort members' class teachers.

The MCS provides longitudinal data particularly suited to our empirical analysis since it contains information on mother's physical and mental well-being when the cohort member is 9 months old, and cohort member's health outcomes as he grows up until adolescence. We use data from the first five sweeps of the survey; the first sweep includes 18,552 families (18,818 cohort members), but due to attrition the sample size drops to 15,590 families in the second sweep and to 15,246 in the third, even counting for new included families. In the fourth and fifth sweep, the sample counts 13,857 and 13,287 families respectively. We restrict our investigation to singleton children whose natural mother answered the first survey; the analysis is then conducted on four Millennium Cohort Study samples based on the availability of cohort member's health information and number of accidents at the ages of 3, 5, 7 and 11 (Appendix A provides summary statistics for the samples used in the analysis).

4.2 Variables definitions

Child health outcomes

We selected the diseases whose outbreak might be eased by a stressful environment according the existing literature. These are: wheezing/whistling in the last 12 months, asthma, eczema and hay fever[4]. As far as child health outcomes at the age of 9 months are concerned, we could recover the information whether the child had ever suffered from wheezing/asthma, skin problems (including eczema), and other breathing problems. Moreover, in order to run a placebo test, we took into consideration other child health issues with no evidence of being advanced by a stressful environment in the literature. These are recurring earing infections at the age of 3 years and hearing problems at the age of 5, 7 and 11 years. Even if the information gathered is based on mothers responses rather than medical records, we are not worried about over or under-reporting due to the nature of the diseases themselves which are hard to neglect. All child health outcomes are measured using binary variables.

Number of accidents or injuries

The number of accidents or injuries measured the number of times that cohort members had an accident or injury for which the child needed medical assistance (he was taken to the doctor, health center, or hospital). At the age of 3 years (sweep 2), it was asked if an accident or injury had ever happened until that moment, while at the ages of 5, 7 and 11 years (sweeps 3, 4 and 5) the question was limited to the ones occurred since the previous interview. Few children were reported to be involved in more than four accidents at any sweep. For our analysis we decided to take into consideration only the cases where no more than four accidents were reported to exclude the most severe vulnerable situations from our study.

Maternal Postpartum depression

Maternal postpartum depression was measured using a modified version of the Malaise Inventory, where only 9 items were selected, as documented in the technical report of the first MCS sweep. The mother answered via self-completion to 9 'yes-no' questions regarding her mental well-being[5]. The

[4]In the second sweep, the interviewer asked to cohort member's parents whether the child had ever suffered from eczema or hay fever in the same question, consequently the affirmative answer of the parents might regards one of the two diseases or even both. While in the third and following sweeps, it was asked separately if the child had suffered from eczema and hay fever.

[5]Whether she felt tired, miserable or depressed, worried, often get into a violent rage, become scared, easily upset or irritated, keyed up and jittery, every little thing get on her nerves and wear them out, and heart often race like

set of questions are used to detect physical and psychological symptoms of anxiety and depression; a score of 4 or above, out of 9, is considered a signal of psychological distress. Therefore, as done in Flouri et al. (2010) and Malmberg and Flouri (2011), we constructed our indicator of maternal postpartum depression as a binary variable which takes value equal to one in case of a score higher than four in the Malaise Inventory. In order to take account of recursive missing values in the Malaise Inventory, we constructed a binary variable equal to one if the mother answered at least to one question but did not complete the questionnaire. We excluded from the analysis those observations for which all the answers to the Malaise Inventory are missing. Eventually, we constructed an interaction term between maternal postpartum depression and the presence of older siblings living in the household, presuming that a mother who has already taken care of other children would have acquired a certain experience on how to handle child's needs and soften the possible negative consequences of postpartum depression.

Child's characteristics

To control for child's characteristics, we considered: gender, age of the child at the interview, ethnicity, his health stock (birth weight, preterm), the presence of siblings living in the household when he was born. To define the ethnic group to which the child belongs, we used the 6 category Census class (White, Mixed Ethnicity, Indian, Pakistani and Bangladeshi, Black or Black British, and other ethnic group). The samples are balanced in terms of gender (in the second sweep the sample is composed for the 51% by males), more than four fifths are White (87% in the second sweep).

Males are exposed to a greater probability of premature birth and deformity, at birth they are physically less developed than females and they are more likely to experience developmental disorders as they grow up (Kraemer, 2000; Gualtieri and Hicks, 1985). However, previous researches have reported that there is no specific difference in wheeze severity between males and females even if at preschool age there is a significantly greater prevalence of wheeze among boys than girls (Luyt et al., 1994). The presence of older siblings seems to protect against the development of eczema, hay fever, and asthma after the age of 2 years, while it appears to increase the incidence of early asthma (McKeever et al., 2001). Using data from Tucson Children's Respiratory Study, Ball et al. (2000) found that child's exposure to other children in or out of the home, during the first six months of life, leads to more frequent wheezing during preschool years. In contrast, such exposure protects against the development of asthma and frequent wheezing later during childhood.

As for ethnicity, Forno and Celedon (2009) pointed out that it is correlated with racial ancestry, which might affect health disparities through differences in the frequency of disease-susceptibility alleles. In particular, they focused on the causes of ethnic disparities in asthma and argued that ethnic group influences disparities in asthma morbidity through diverse mechanisms that go beyond genetic predisposition. One of the main mechanism is definitely the socioeconomic status, indeed certain minority ethnic groups are disproportionately represented among the poor and poverty has been associated with increased asthma morbidity as well.

Mother's characteristics

As far as mother's characteristics are concerned, we created a set of dummies respectively if the mother was younger than 30 years at childbirth; if she had a longstanding[6] illness, disability or

mad.

[6]It refers to anything that has troubled the person over a period of time or that is likely to affect her over a period of time.

infirmity; if she suffered from any health problems during pregnancy; if she was working while pregnant; if she attended ante-natal classes; if she breastfed more or less than 6 months or not at all and if she consumed tobacco and/or alcohol during pregnancy.

More educated mother may combine health inputs more efficiently (Grossman, 1972), e.g. be involved in preventative care and changing health behaviours during pregnancy (Doyle et al., 2015). On the other hand, Violato et al. (2009) found an association between higher maternal education and child suffering from asthma/wheezing. The researchers suggested that more educated mothers may be more interested in pursuing a professional career, spending more time at work and consequently pay less attention to the regular prevention and management of childhood respiratory diseases. Smoking during pregnancy has been shown to reduce birth weight and to longer gestation (Rosenzweig and Schultz, 1982), it appears to be related to childhood obesity as well (von Kries et al., 2002).

On top of the usual socio-demographic and health variables, we decided to include attendance at ante-natal classes as control because during the course the mother might have received some precious instructions on how to take care of the child that make her feel more self-confident and aware of the difficulties that she had to face in the months following child-birth. Moreover, she might have been informed about the risks of postpartum depression and that she might find support in health care services whenever she needs.

Difficulties at birth

We took into consideration any reported difficulties at birth or in the first week, such as: delay in breathing, jaundice requiring hospital treatment, infection or suspected one, breech birth, other abnormal lie (shoulder first during labour), long or rapid labour, fetal distress during labour and caesarean section delivery. They might affect child health development, as well as they might have an impact on maternal well-being rising feeling of inadequacy in the mother.

Family's characteristics and environmental risks

Finally, we considered family's characteristics, whether the mother could count on family's support, as well as environmental risks at urban local area. In detail, we generated a dummy if nobody was present at birth (during labour and delivery), if natural father was present in the household at time of the first interview, if maternal parents were alive at time of the first interview and finally, if pollution, grime, environmental problems were common at time of the first interview. Furthermore, to assess the economic family's status, we considered the logarithm of the predicted equalised weekly net family income at the time of the first interview. We chose not to include the frequency of visits of grandparents to the newborn and if they help the mother in any way because it might be influenced by postpartum depression indeed. If grandparents perceive that the mother needs help in caring for the child and herself, they might visit the new family more often. It might be also the case that the mother, if suffering from psychological distress, asks for support to her parents. For the same reasons, we could not include information on how often the mother met her friends and whether she attended religious services at the time of the first interview.

4.3 Empirical strategy

First, we perform logistic regressions to investigate the impact of postpartum depression on child health outcomes, which are all dichotomous. Then, for analysing the effects of postpartum depres-

sion on the number of accidents we use Poisson regression models, since the dependent variable is a counting variable with an asymmetric distribution. Separate regressions were run for each outcome variable at ages of 3, 5, 7 and 11 years. In order to take into account the clustered sample design and the unequal probability of being sampled, survey sample weights have been used throughout the analysis. The study population was stratified by UK country, namely England, Wales, Scotland and Northern Ireland. In sweep 2, advantaged and disadvantaged areas were identified within each country, only in England it was additionally recognized an ethnic area. Therefore, all models adjust for the official UK country where the interview took place, when using data from the second sweep the detailed geographical partition was adopted.

4.4 Results

In the following tables, we present the estimated marginal effects of maternal postpartum depression and of the most relevant controls on child health outcomes, as well as on the number of accidents at the ages of 3, 5, 7 and 11 years (full estimates tables available upon request). Table 1 shows that maternal postpartum depression has a positive and significant effect in increasing the probability that at the age of 3 years the child has suffered from wheezing in the previous 12 months. Children, whose mother experienced postpartum depression, are 5.60% (significant at 1% level) more likely to suffer from wheezing at the age of 3 years with respect to other children. In addition to this, the presence of older siblings living in the household appears to increase the probability of suffering from wheezing. However, the interaction between maternal postpartum depression and siblings presents a negative marginal effect.

The combined effect of maternal postpartum depression and the interaction between it and siblings is not statistically different from zero, meaning that maternal postpartum depression has an impact on child wheezing only if he is the first-born one. The experience that the mother acquired in taking care of a previous child may protect the new-born from the negative consequences of maternal postpartum depression, and make him less vulnerable to wheezing. The impact of postpartum depression on child's wheezing persists as child grows up. When the child is 5 years old, having a mother who suffered from postpartum depression makes him 4.22% more likely to suffer from wheezing (significant at 5% level). When the child is 7 years old, the marginal effect of maternal depression on child wheezing seems to decrease to 2.96% (significant at 10% level). While at the age of 11 years, it is estimated to be equal to 5.92% (significant at 1% level). We tested whether the differences between the marginal effects across the ages are statistically different from zero. However, we fail to reject the hypothesis that the differences are statistically different from zero, we cannot claim that the impact of maternal postpartum decreases in magnitude as the child grows up.

Even if wheezing is often associated with asthma, we do not observe a similar pattern in the association between maternal postpartum depression and child suffering from asthma (Table 1 and 2). When the cohort member is around 7 years old, the past exposure to maternal postpartum depression makes him 3.37% more likely to suffer from asthma (significant at 10%). While, as teenagers, the marginal effect of maternal postpartum depression is estimated to be equal to 4.87% (significant at 5%). However, the differences between marginal effects at different ages are not statistically different from zero. This connection between postpartum depression and child asthma at later age, might be due to the fact that asthma takes more time to outbreak and wheezing might be a risk factor itself.

Different pattern can be seen in the link between maternal postpartum depression and other

child health diseases. At the age of 3 years, a child whose mother experienced postpartum depression seems 5.52% more likely to suffer from eczema or hay fever (significant at 5% level). Conversely, no relationship arises between maternal postpartum depression and child suffering from eczema at following ages. On the other hand, estimates in Table 1 show a significant association between suffering from hay fever at the age of 5 years and maternal postpartum depression. Children whose mother suffered from postpartum depression, are 3.76% more likely to suffer from hay fever than their counterpart (significant at 5% level). The interaction between maternal postpartum depression and siblings is significant at 10% level. The combined marginal effect of postpartum depression and the interaction with siblings is no more statistically different from zero. That is to say there is no significant effect of maternal postpartum depression in children with older siblings. At the ages of 7 and 11, the marginal effect of maternal postpartum depression on suffering from hay fever is equal to 3.37% and 4.87% respectively but is no more significant. When the cohort member was 3 years old, the information regarding eczema and hay fever was declared together, so we could not show the impact of maternal postpartum depression on eczema and hay fever separately. However, we might infer that the effect we found at the age of 3 years was mainly driven by the relationship between maternal distress and child suffering from hay fever.

Focusing now our attention on the relationship between maternal postpartum depression and the accident rate, Table 3 presents the incidence-rate ratio of accidents from the age of 3 to the age of 11 years due to postpartum depression and other cofounders. Results indicate a strong impact of mother's postpartum depression in increasing the incidence rate ratio at 3 and 5 years. At the age of 3 years, children whose mother experienced postpartum depression are expected to have a incidence rate on the number of accidents 1.21 times greater with respect to children whose mother had no mental distress (significant at 1% level). At the age of 5 years, the incidence ratio is equal instead to 1.29 (significant at 1% level). As the child grows the effect of maternal postpartum is no more significant.

Table 1: Marginal effects on child health outcomes at the ages of 3 and 5

	Age 3			Age 5			
	Wheeze	Asthma	Hay fever	Wheeze	Asthma	Hay fever	Eczema
Postpartum depression	0.0560***	0.00988	0.0552**	0.0422**	0.0128	0.0376**	0.00795
	(0.0203)	(0.0140)	(0.0260)	(0.0181)	(0.0159)	(0.0155)	(0.0250)
Missing values in Mal. Inventory	0.103	0.0253	0.0799	0.0757	0.0884	0.0644	0.115
	(0.0780)	(0.0574)	(0.0871)	(0.0621)	(0.0701)	(0.0514)	(0.0794)
Siblings living in household (S1)	0.0315***	0.0148*	-0.00200	0.00886	0.00387	-0.0244***	0.0159
	(0.0112)	(0.00779)	(0.0148)	(0.0104)	(0.00941)	(0.00845)	(0.0145)
Interaction postpartum depression and siblings	-0.0534***	-0.00950	-0.0362	-0.0200	-0.00962	-0.0249*	-0.0313
	(0.0177)	(0.0147)	(0.0305)	(0.0178)	(0.0176)	(0.0129)	(0.0305)
Observations	13145	12925	13033	13042	12993	12976	13032
Diffusion observation	20%	13%	37%	16%	15%	11%	34%

Notes: Marginal effects at means of the regressor and most relevant controls (logistic regression models). Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The models include controls for child's characteristics (gender, age at the interview, ethnicity, birth weight, preterm babies), difficulties at birth or in the first week (delay in breathing, jaundice requiring hospital treatment, infection or suspected one, breech birth, other abnormal lie, long or rapid labour, fetal distress during labour and caesarean delivery), mother's characteristics (age below 30 years at time of birth, longstanding illness, disability or infirmity, asthma, problems during pregnancy, age when left education, working while pregnant, attendance at ante-natal classes, smoking and consumption of alcohol during pregnancy, breastfeeding more or less than 6 months), family's characteristics (logarithm of the predicted equivalised weekly net family income (S1), natural father present in household (S1), maternal parents alive (S1), nobody present at birth during labour and delivery) and area level risk (environmental problems common at time of the first interview).

Table 2: Marginal effects on child health outcomes at the ages of 7 and 11

	Age 7				Age 11			
	Wheeze	Asthma	Hay fever	Eczema	Wheeze	Asthma	Hay fever	Eczema
Postpartum depression	0.0296*	0.0337*	0.0307	0.00848	0.0592***	0.0487**	0.0314	0.0337
	(0.0165)	(0.0183)	(0.0188)	(0.0255)	(0.0229)	(0.0214)	(0.0237)	(0.0262)
Missing values in Mal. Inventory	0.0562	0.109	0.0442	0.0526	0.129	0.0929	0.135	0.00558
	(0.0569)	(0.0738)	(0.0654)	(0.0837)	(0.0888)	(0.0757)	(0.0865)	(0.0729)
Siblings living in household (S1)	0.00930	-0.00257	-0.0147	-0.00526	0.0121	0.00769	-0.00880	-0.00158
	(0.00971)	(0.0104)	(0.0108)	(0.0152)	(0.0131)	(0.0117)	(0.0139)	(0.0155)
Interaction postpartum depression and siblings	-0.0182	-0.0194	-0.0204	-0.0411	-0.0267	-0.0189	-0.0283	-0.0394
	(0.0158)	(0.0182)	(0.0198)	(0.0312)	(0.0238)	(0.0219)	(0.0270)	(0.0302)
Observations	11852	11883	11858	11904	11316	11339	11336	11338
Diffusion observation	12%	16%	15%	34%	22%	18%	25%	31%

Notes: Marginal effects at means of the regressor and most relevant controls (logistic regression models). Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The models include controls for child's characteristics (gender, age at the interview, ethnicity, birth weight, preterm babies), difficulties at birth or in the first week (delay in breathing, jaundice requiring hospital treatment, infection or suspected one, breech birth, other abnormal lie, long or rapid labour, fetal distress during labour and caesarean delivery), mother's characteristics (age below 30 years at time of birth, longstanding illness, disability or infirmity, asthma, problems during pregnancy, age when left education, working while pregnant, attendance at ante-natal classes, smoking and consumption of alcohol during pregnancy, breastfeeding more or less than 6 months), family's characteristics (logarithm of the predicted equivalised weekly net family income (S1), natural father present in household (S1), maternal parents alive (S1), nobody present at birth during labour and delivery) and area level risk (environmental problems common at time of the first interview).

Table 3: Incidence ratios on the number of injuries/accidents occurred to the child

	Age 3	Age 5	Age 7	Age 11
Postpartum depression	1.205***	1.289***	1.136	1.077
	(0.0843)	(0.108)	(0.108)	(0.0823)
Siblings living in household (S1)	1.051	1.203***	1.125*	0.987
	(0.0470)	(0.0625)	(0.0688)	(0.0508)
Interaction Postpartum depression and siblings	0.935	0.871	0.963	0.940
	(0.0835)	(0.0911)	(0.117)	(0.102)
Observations	13099	12940	11822	11170
Mean of the number of accidents	0.46	0.34	0.29	0.51

Notes: Exponential coefficients of the regressor and most relevant controls (poisson regression models). Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The models include controls for child's characteristics (gender, age at the interview, ethnicity, birth weight, preterm babies), difficulties at birth or in the first week (delay in breathing, jaundice requiring hospital treatment, infection or suspected one, breech birth, other abnormal lie, long or rapid labour, fetal distress during labour and caesarean delivery), mother's characteristics (age below 30 years at time of child's birth, longstanding illness, disability or infirmity, asthma, problems during pregnancy, age when left education, working while pregnant, attendance at ante-natal classes, smoking and consumption of alcohol during pregnancy, breastfeeding more or less than 6 months), family's characteristics (logarithm of the predicted equivalised weekly net family income (S1), natural father present in household (S1), maternal parents alive (S1), nobody present at birth during labour and delivery) and area level risk (environmental problems common at time of the first interview).

4.5 Robustness Checks

In order to test the robustness of our results, we run a falsification test assessing the relationship between maternal postpartum depression and other child health issues for which, to the best of our knowledge, the medical literature does not report evidence of a relationship between the outbreak and a stressful environment. Basically, we investigate alternative outcomes which should not be affected by maternal postpartum depression but would be affected by potential cofounders, such as environmental risks. If the estimated marginal effect of the regressor postpartum depression is significant it may mean that our model (4) is underspecified. Therefore, we take into consideration recurring earing infections at the age of 3 years, and hearing problems at the ages of 5, 7 and 11 years. As previously claimed, the information gathered is based on mother's responses rather than medical records, and all child health outcomes are defined through binary variables. We estimate logistic models[7] for the child health outcome at each age controlling for child's characteristics, difficulties at birth or in the first week, mother's characteristics, family's characteristics and an indicator of environmental risk. As shown in Table 4, no relevant effect of maternal postpartum depression on new-born can be detected in recurring earing infections and hearing problems during his childhood.

As an additional robustness check, we perform propensity score matching estimators to derive the average treatment effect on treated of having been exposed to maternal postpartum depression on health outcomes and on the number of accidents occurred to the child. Assuming that maternal postpartum depression depends on a vector of observable variables, we can compare the health status

[7]Full tables available upon request.

Table 4: Marginal effect of maternal postpartum depression on child health (Falsification test)

	Ear infections^{+}	Hearing problems^{+}		
	Age 3	Age 5	Age 7	Age 11
Postpartum depression	0.00834	-0.0207	-0.0174	-0.0174
	(0.0118)	(0.0150)	(0.0157)	(0.0157)
Siblings living in household (S1)	0.00459	-0.0131	-0.00203	-0.00203
	(0.00671)	(0.0100)	(0.0101)	(0.0101)
Interaction postpartum depression and siblings	-0.00789	0.0102	0.0103	0.0103
	(0.0123)	(0.0223)	(0.0228)	(0.0228)
Observations	13125	13023	11906	11906
Diffusion observation	7%	12%	12%	8%

Notes: Marginal effects reported at the mean (logistic regression models).
Standard errors in parentheses. $^{*}p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
All models adjust for child's characteristics, difficulties at birth or in the first week, mother's characteristics, family's characteristics and area level risk.
$^{+}$ Ear infections in the second sweep, hearing problems in the third and following sweeps.

Table 5: Propensity score matching: child health outcomes and N. of accidents

	Wheeze (ATET)	Asthma (ATET)	Eczema (ATET)	Hay fever (ATET)	N. of accidents (ATET)	Ear infections^{+} (ATET)
Age 3	0.0313**	0.00496	–	0.0229	0.0856***	-0.00864
	(0.0151)	(0.0134)		(0.0170)	(0.0265)	(0.0101)
Observations	13148	12928		13036	13102	13128
Treated	1854	1816	–	1831	1846	1851
Control	11294	11112		11205	11256	11277
Age 5	0.0233*	0.0120	-0.0233	0.0245**	0.0596***	-0.00326
	(0.0140)	(0.0134)	(0.0171)	(0.0119)	(0.0227)	(0.0119)
Observations	13047	12998	13037	12981	12943	13028
Treated	1846	1838	1843	1833	1828	1841
Control	11201	11160	11194	11148	11115	11187
Age 7	0.0377***	0.0293**	-0.0227	0.00240	0.0420*	0.00656
	(0.0128)	(0.0146)	(0.0176)	(0.0142)	(0.0223)	(0.0126)
Observations	11856	11887	11908	11862	11826	11910
Treated	1669	1674	1677	1668	1665	1678
Control	10187	10213	10231	10194	10161	10232
Age 11	0.0206	0.0299**	-0.00311	0.0348**	-0.0235	0.00435
	(0.0169)	(0.0152)	(0.0183)	(0.0166)	(0.0318)	(0.0108)
Observations	11323	11346	11345	11343	11177	11349
Treated	1605	1608	1608	1607	1572	1609
Control	9718	9738	9737	9736	9605	9740

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
$^{+}$ Ear infections at the age of 3 years, hearing problems at the age of 5, 7, and 11 years.

of the children, whose mother suffered from postpartum depression, with a sample of children who share the same probability of having a mother with postpartum depression but eventually did not experience it. The covariate information we use for the propensity score matching regards child's characteristics, mother's characteristics, family's and enviromental characteristics[8]. In order to take advantage of a larger sample, we did not divide the analysis between first-born children and others but we use the information of siblings living in the household to perform the propensity score matching. In the implementation of the propensity score matching, Abadie-Imbens robust standard errors are considered (Abadie and Imbens, 2016).

On the one hand, as far as child health outcomes are concerned, the estimated average treatment effects on the treated in Table 5 highlight a positive effect of maternal postpartum depression on the probability that the child suffers from wheezing at ages of 3, 5 and 7 years, and from hay fever at the ages of 5 and 11 years (at 5% significant level). Moreover, it indicates an effect of maternal postpartum depression on child asthma at the ages of 7 and 11 years (significant at 5% level). We estimate the average effects of maternal postpartum depression also on child health outcomes used in the falsification test, but no association was found. On the other hand, as it regards the number of accidents occurred to cohort member, this is positively associated with maternal postpartum depression at the ages of 3, 5 years (significant at 1% level), and at the age of 7 years (significant at 10% level). These findings are in line with the previous results.

In order to tackle possible improper distributional assumptions which underlie the choices of Logit and Poisson regression models, for diseases and number of accidents respectively, we perform linear regression models. The obtained results are in line with the ones of our baseline models (see Tables 2-6 in Appendix B).

Eventually, being concerned of a possible problem of omitted variable bias, we apply the method developed by Oster (2019) to determine bias-adjusted estimates and to bound the coefficients of interest in the presence of such omitted variables bias. Following the procedure illustrated by Oster (2019), firstly we choose a level of $Rmax = 1.3$, which corresponds to the R-squared obtained from a theoretical regression of the outcome on regressor, observed and unobserved controls ($Rmax = 1$ would be the case that the dependent variable is fully explained by the regressor and observed controls). Then, referring to δ as the relative degree of the selection of observable and unobservable variables, we compute the bounds of our interested estimated coefficients with $\delta = 0$ (corresponding to the original estimates) and with $\delta = 1$ (corresponding to the assumption of equal selection between observed and unobserved variables). In addition to this, we determine the value of δ for which the estimator would produce a 'treatment' effect of zero ($\beta = 0$). If this value of δ is greater than 1, we can conclude that our results are robust. As shown in Table 6, focusing on the estimated coefficients which were significant in our baseline models, the computed δ is always greater than one, therefore we can conclude that our results are indeed robust to omitted variable bias.

[8]Covariate balance table in Appendix B, Table 1.

Table 6: Robustness analyses against omitted variables bias

Age	Outcome	Regressor	Beta	Se	r2	Bounds	Delta
3	**Wheezing**	**PPD**	0.058	(0.021)	0.052	[0.058,0.065]	**1.98**
3	**Wheezing**	**Int. w. siblings**	-0.066	(0.026)	0.052	[-0.195,-0.066]	**-1.32**
3	Asthma	PPD	0.011	(0.017)	0.107	[-0.041,0.011]	0.34
3	Asthma	Int. w. siblings	-0.009	(0.021)	0.107	[-0.099,-0.009]	-0.25
3	**Hay fever / Eczema**	**PPD**	0.052	(0.024)	0.076	[0.052,0.076]	**3.30**
3	Hay fever / Eczema	Int. w. siblings	-0.036	(0.030)	0.076	[-0.119,-0.036]	-1.91
5	**Wheezing**	**PPD**	0.048	(0.020)	0.042	[0.015,0.048]	**1.16**
5	Wheezing	Int. w. siblings	-0.026	(0.025)	0.042	[-0.133,-0.026]	-0.50
5	Asthma	PPD	0.016	(0.019)	0.077	[-0.031,0.016]	0.51
5	Asthma	Int. w. siblings	-0.013	(0.023)	0.077	[-0.095,-0.013]	-0.37
5	**Hay fever**	**PPD**	0.049	(0.019)	0.029	[0.049,0.080]	**4.12**
5	Hay fever	Int. w. siblings	-0.045	(0.022)	0.029	[-0.110,-0.045]	-3.05
5	Eczema	PPD	0.008	(0.023)	0.076	[0.008,0.037]	-0.69
5	Eczema	Int. w. siblings	-0.030	(0.029)	0.076	[-0.034,-0.030]	1.98
7	**Wheezing**	**PPD**	0.034	(0.019)	0.036	[0.026,0.034]	**1.55**
7	Wheezing	Int. w. siblings	-0.026	(0.023)	0.036	[-0.100,-0.026]	-0.84
7	**Asthma**	**PPD**	0.042	(0.021)	0.079	[0.008,0.042]	**1.11**
7	Asthma	Int. w. siblings	-0.030	(0.025)	0.079	[-0.140,-0.030]	-0.69
7	Hay fever	PPD	0.036	(0.021)	0.032	[0.036,0.057]	4.43
7	Hay fever	Int. w. siblings	-0.030	(0.025)	0.032	[-0.076,-0.030]	-4.57
7	Eczema	PPD	0.008	(0.024)	0.069	[0.008,0.044]	-0.58
7	Eczema	Int. w. siblings	-0.039	(0.031)	0.069	[-0.039,-0.032]	1.57
11	**Wheezing**	**PPD**	0.060	(0.023)	0.051	[0.047,0.060]	**1.56**
11	Wheezing	Int. w. siblings	-0.030	(0.029)	0.051	[-0.150,-0.030]	-0.54
11	**Asthma**	**PPD**	0.053	(0.023)	0.060	[0.025,0.053]	**1.29**
11	Asthma	Int. w. siblings	-0.024	(0.029)	0.060	[-0.138,-0.024]	-0.45
11	Hay fever	PPD	0.033	(0.024)	0.035	[0.033,0.049]	3.80
11	Hay fever	Int. w. siblings	-0.032	(0.030)	0.035	[-0.086,-0.032]	-3.32
11	Eczema	PPD	0.033	(0.025)	0.051	[0.033,0.074]	-6.03
11	Eczema	Int. w. siblings	-0.041	(0.032)	0.051	[-0.082,-0.041]	14.23
3	**N. of Accidents**	**PPD**	0.097	(0.040)	0.031	[0.061,0.097]	**1.36**
3	N. of Accidents	Int. w. siblings	-0.037	(0.049)	0.031	[-0.220,-0.037]	-0.41
5	**N. of Accidents**	**PPD**	0.092	(0.034)	0.020	[0.079,0.092]	**1.49**
5	N. of Accidents	Int. w. siblings	-0.043	(0.043)	0.020	[-0.194,-0.043]	-0.46
7	N. of Accidents	PPD	0.038	(0.031)	0.022	[-0.021,0.038]	0.78
7	N. of Accidents	Int. w. siblings	-0.003	(0.041)	0.022	[-0.124,-0.003]	-0.05
11	N. of Accidents	PPD	0.043	(0.046)	0.021	[0.043,0.046]	2.11
11	N. of Accidents	Int. w. siblings	-0.037	(0.063)	0.021	[-0.132,-0.037]	-1.25

5 Conclusions

This paper examined the impact of maternal postpartum depression on child's health development. Poor health experienced in childhood has been associated with poorer health, adverse educational and labour market outcomes in adulthood. In our analysis, we used data from the Millennium Cohort Study and we wanted to investigate whether maternal postpartum depression had an impact on early child health development before child enter in primary school and as he grows up. In detail, we assessed the effects of maternal postpartum depression on health child's outcomes, and on the number of injuries or accidents occurred at the child, for which he was taken to the hospital at ages of 3, 5, 7 and 11 years. Our estimation results show a non-negligible impact of maternal postpartum depression on those child health issues advanced by a stressful environment, as wheezing throughout childhood and hay fever in early years (at age 3 and 5). The most striking result to emerge from the analysis is that the presence of older siblings living in household mediates the impact of maternal postpartum depression by reducing its effect on the likeliness of the outbreak of wheeze at age 3 and hay-fever at age 5. In reviewing the literature, no data was found on the role of siblings, or previous experience acquired by the mother in mediating the effect of postpartum depression. However, more research is needed to better understand the mechanism which underlies this mediation effect. At later ages (7 and 11 years), children with a mother who experienced postpartum depression are more likely to suffer from asthma. Moreover, the results indicate a significant strong effect of maternal postpartum depression on the accident rate at the ages of 3 and 5 years (the incidence-rate ratio is of 1.205 and 1.289 respectively). Findings suggest a link between maternal postpartum depression and children's health, where maternal depression may contribute in the transmission of health inequalities through generations. The results are robust to different model specifications and to omitted variable bias test. Moreover, we could successfully test our results on child health outcomes through a falsification test. Eventually, findings about child health outcomes and number of accidents hold up using propensity score matching method.

A Appendix

Table 1: Descriptive Statistics - S2 sample

	mean	sd	median	min	max	count
Psychological distress (Malaise Inventory)	0.14	0.35	0.00	0	1	13145
Missing values in Mal. inventory	0.00	0.06	0.00	0	1	13145
Age of CM at S2 (days)	1145.07	73.82	1121.00	969	1651	13145
Male	0.51	0.50	1.00	0	1	13145
Cohort Member Ethnic Group: White	0.87	0.34	1.00	0	1	13145
Cohort Member Ethnic Group: Mixed	0.03	0.16	0.00	0	1	13145
Cohort Member Ethnic Group: Indian	0.02	0.15	0.00	0	1	13145
Cohort Member Ethnic Group: Pakistani and Bangladeshi	0.05	0.22	0.00	0	1	13145
Cohort Member Ethnic Group: Black or Black British	0.03	0.16	0.00	0	1	13145
Cohort Member Ethnic Group: Other (inc Chinese)	0.01	0.10	0.00	0	1	13145
Birth weight	3.38	0.57	3.40	0	7	13145
Born under-weight	0.06	0.23	0.00	0	1	13145
Preterm babies (below 32 weeks)	0.03	0.16	0.00	0	1	13145
Siblings living in HH S1	0.58	0.49	1.00	0	1	13145
Mother with Postpartum depression and more than one child	0.09	0.28	0.00	0	1	13145
Age mother below 30 years	0.52	0.50	1.00	0	1	13145
Age mother left education	17.68	2.54	17.00	1	35	13145
Mother worked during pregnancy	0.67	0.47	1.00	0	1	13145
Ante-natal classes	0.37	0.48	0.00	0	1	13145
Mother smoked during pregnancy	0.21	0.41	0.00	0	1	13145
Mother drank alcohol when pregnant	0.31	0.46	0.00	0	1	13145
Mother had problems during pregnancy	0.39	0.49	0.00	0	1	13145
Mother: longstanding illness, disability or infirmity	0.22	0.41	0.00	0	1	13145
Mother suffers from asthma	0.17	0.37	0.00	0	1	13145
Breastfeeding less than 6 months	0.41	0.49	0.00	0	1	13145
Breastfeeding more than 6 months	0.23	0.42	0.00	0	1	13145
Delay in breathing at birth or difficulties in first week	0.07	0.26	0.00	0	1	13145
Jaundice requiring hospital treatment in first week	0.07	0.26	0.00	0	1	13145
Infection or suspected infection in first week	0.04	0.19	0.00	0	1	13145
Breech birth - feet first during labour	0.03	0.16	0.00	0	1	13145
Other abnormal lie eg shoulder first during labour	0.03	0.18	0.00	0	1	13145
Very long labour	0.07	0.26	0.00	0	1	13145
Very rapid labour	0.03	0.16	0.00	0	1	13145
Fetal distress during labour	0.15	0.36	0.00	0	1	13145
Caesarian delivery	0.22	0.41	0.00	0	1	13145
S1 Wheezing or asthma at 9 months	0.07	0.25	0.00	0	1	13145
S1 Skin problems at 9 months (incl. eczema)	0.20	0.40	0.00	0	1	13145
S1 Other breathing problems at 9 months	0.01	0.09	0.00	0	1	13145
No one else present at birth	0.05	0.21	0.00	0	1	13145
Natural father present in household (S1)	0.85	0.35	1.00	0	1	13145
Ln of predicted equivalised weekly net family income	5.82	0.72	5.92	3	7	13145
Maternal Grandmother is alive (S1)	0.93	0.25	1.00	0	1	13145
Maternal Grandfather is alive (S1)	0.84	0.37	1.00	0	1	13145
Pollution, environmental problems (S1)	0.22	0.41	0.00	0	1	13145
S2 Whether CM had wheezing/whistling in last 12 months	0.20	0.40	0.00	0	1	13145
S2 Whether CM ever had asthma	0.13	0.33	0.00	0	1	12925
S2 Whether CM ever had hay fever/eczema	0.37	0.48	0.00	0	1	13033
S2 Whether CM had recurring ear infections	0.07	0.25	0.00	0	1	13125
Number of accidents S2 (<= 4)	0.46	0.72	0.00	0	4	13098
S2 England - Advantaged	0.28	0.45	0.00	0	1	13145
S2 England - Disadvantaged	0.24	0.42	0.00	0	1	13145
S2 England - Ethnic	0.10	0.30	0.00	0	1	13145
S2 Wales - Advantaged	0.05	0.22	0.00	0	1	13145
S2 Wales - Disadvantaged	0.11	0.31	0.00	0	1	13145
S2 Scotland - Advantaged	0.07	0.25	0.00	0	1	13145
S2 Scotland - Disadvantaged	0.06	0.24	0.00	0	1	13145
S2 Northern Ireland - Advantaged	0.04	0.20	0.00	0	1	13145
S2 Northern Ireland - Disadvantaged	0.06	0.24	0.00	0	1	13145

Notes: CM stands for Cohort Member. S1 and S2 stand for Wave 1 and Wave 2 respectively.

Table 2: Descriptive Statistics - S3 sample

	mean	sd	median	min	max	count
Psychological distress (Malaise Inventory)	0.14	0.35	0.00	0	1	13042
Missing values in Mal. inventory	0.00	0.07	0.00	0	1	13042
Age of CM at S3 (days)	1905.26	90.79	1902.00	1608	2238	13042
Male	0.51	0.50	1.00	0	1	13042
Cohort Member Ethnic Group: White	0.87	0.34	1.00	0	1	13042
Cohort Member Ethnic Group: Mixed	0.03	0.16	0.00	0	1	13042
Cohort Member Ethnic Group: Indian	0.02	0.15	0.00	0	1	13042
Cohort Member Ethnic Group: Pakistani and Bangladeshi	0.05	0.22	0.00	0	1	13042
Cohort Member Ethnic Group: Black or Black British	0.03	0.16	0.00	0	1	13042
Cohort Member Ethnic Group: Other (inc Chinese)	0.01	0.10	0.00	0	1	13042
Birth weight	3.38	0.57	3.40	0	7	13042
Born under-weight	0.06	0.24	0.00	0	1	13042
Preterm babies (below 32 weeks)	0.03	0.16	0.00	0	1	13042
Siblings living in household (S1)	0.58	0.49	1.00	0	1	13042
Mother with Postpartum depression and more than one child	0.09	0.28	0.00	0	1	13042
Age mother below 30 years	0.52	0.50	1.00	0	1	13042
Age mother left education	17.69	2.54	17.00	1	35	13042
Mother worked during pregnancy	0.67	0.47	1.00	0	1	13042
Ante-natal classes	0.37	0.48	0.00	0	1	13042
Mother smoked during pregnancy	0.22	0.41	0.00	0	1	13042
Mother drank alcohol when pregnant	0.31	0.46	0.00	0	1	13042
Mother had problems during pregnancy	0.39	0.49	0.00	0	1	13042
Mother: longstanding illness, disability or infirmity	0.22	0.41	0.00	0	1	13042
Mother suffers from asthma	0.17	0.37	0.00	0	1	13042
Breastfeeding less than 6 months	0.41	0.49	0.00	0	1	13042
Breastfeeding more than 6 months	0.23	0.42	0.00	0	1	13042
Delay in breathing at birth or difficulties in first week	0.07	0.26	0.00	0	1	13042
Jaundice requiring hospital treatment in first week	0.07	0.26	0.00	0	1	13042
Infection or suspected infection in first week	0.04	0.19	0.00	0	1	13042
Breech birth - feet first during labour	0.02	0.15	0.00	0	1	13042
Other abnormal lie eg shoulder first during labour	0.03	0.18	0.00	0	1	13042
Very long labour	0.07	0.26	0.00	0	1	13042
Very rapid labour	0.03	0.16	0.00	0	1	13042
Fetal distress during labour	0.15	0.36	0.00	0	1	13042
Caesarian delivery	0.21	0.41	0.00	0	1	13042
S1 Wheezing or asthma at 9 months	0.07	0.25	0.00	0	1	13042
S1 Skin problems at 9 months (incl. eczema)	0.19	0.40	0.00	0	1	13042
S1 Other breathing problems at 9 months	0.01	0.09	0.00	0	1	13042
No one else present at birth	0.05	0.21	0.00	0	1	13042
Natural father present in household (S1)	0.85	0.36	1.00	0	1	13042
Ln of predicted equivalised weekly net family income	5.81	0.72	5.91	3	7	13042
Maternal Grandmother is alive (S1)	0.93	0.25	1.00	0	1	13042
Maternal Grandfather is alive (S1)	0.84	0.37	1.00	0	1	13042
Pollution, environmental problems (S1)	0.22	0.41	0.00	0	1	13042
S3 Whether CM had wheezing in last 12 months	0.16	0.37	0.00	0	1	13042
S3 Whether CM ever had asthma	0.15	0.36	0.00	0	1	12991
S3 Whether CM ever had hay fever	0.11	0.31	0.00	0	1	12974
S3 Whether CM ever had eczema	0.34	0.47	0.00	0	1	13030
S3 Whether CM ever had hearing problems	0.12	0.33	0.00	0	1	13021
Number of accidents S3 (<= 4)	0.34	0.63	0.00	0	4	12938
S3 England	0.61	0.49	1.00	0	1	13042
S3 Northern Ireland	0.11	0.31	0.00	0	1	13042
S3 Scotland	0.13	0.33	0.00	0	1	13042
S3 Wales	0.15	0.36	0.00	0	1	13042

Notes: CM stands for Cohort Member. S1 and S3 stand for Wave 1 and Wave 3 respectively.

Table 3: Descriptive Statistics - S4 sample

	mean	sd	median	min	max	count
Psychological distress (Malaise Inventory)	0.14	0.35	0.00	0	1	11852
Missing values in Mal. inventory	0.00	0.07	0.00	0	1	11852
Age of CM at S4 (months)	86.81	3.02	86.73	76	101	11852
Male	0.51	0.50	1.00	0	1	11852
Cohort Member Ethnic Group: White	0.87	0.34	1.00	0	1	11852
Cohort Member Ethnic Group: Mixed	0.02	0.16	0.00	0	1	11852
Cohort Member Ethnic Group: Indian	0.02	0.14	0.00	0	1	11852
Cohort Member Ethnic Group: Pakistani and Bangladeshi	0.05	0.21	0.00	0	1	11852
Cohort Member Ethnic Group: Black or Black British	0.03	0.16	0.00	0	1	11852
Cohort Member Ethnic Group: Other (inc Chinese)	0.01	0.09	0.00	0	1	11852
Birth weight	3.39	0.57	3.40	0	7	11852
Born under-weight	0.06	0.23	0.00	0	1	11852
Preterm babies (below 32 weeks)	0.03	0.16	0.00	0	1	11852
Siblings living in household (S1)	0.58	0.49	1.00	0	1	11852
Mother with Postpartum depression and more than one child	0.09	0.28	0.00	0	1	11852
Age mother below 30 years	0.52	0.50	1.00	0	1	11852
Age mother left education	17.74	2.54	17.00	1	34	11852
Mother worked during pregnancy	0.68	0.47	1.00	0	1	11852
Ante-natal classes	0.37	0.48	0.00	0	1	11852
Mother smoked during pregnancy	0.21	0.41	0.00	0	1	11852
Mother drank alcohol when pregnant	0.32	0.46	0.00	0	1	11852
Mother had problems during pregnancy	0.39	0.49	0.00	0	1	11852
Mother: longstanding illness, disability or infirmity	0.22	0.41	0.00	0	1	11852
Mother suffers from asthma	0.16	0.37	0.00	0	1	11852
Breastfeeding less than 6 months	0.41	0.49	0.00	0	1	11852
Breastfeeding more than 6 months	0.23	0.42	0.00	0	1	11852
Delay in breathing at birth or difficulties in first week	0.07	0.26	0.00	0	1	11852
Jaundice requiring hospital treatment in first week	0.07	0.26	0.00	0	1	11852
Infection or suspected infection in first week	0.04	0.19	0.00	0	1	11852
Breech birth - feet first during labour	0.02	0.15	0.00	0	1	11852
Other abnormal lie eg shoulder first during labour	0.03	0.18	0.00	0	1	11852
Very long labour	0.07	0.25	0.00	0	1	11852
Very rapid labour	0.03	0.16	0.00	0	1	11852
Fetal distress during labour	0.15	0.36	0.00	0	1	11852
Caesarian delivery	0.21	0.41	0.00	0	1	11852
S1 Wheezing or asthma at 9 months	0.07	0.25	0.00	0	1	11852
S1 Skin problems at 9 months (incl. eczema)	0.20	0.40	0.00	0	1	11852
S1 Other breathing problems at 9 months	0.01	0.09	0.00	0	1	11852
No one else present at birth	0.05	0.21	0.00	0	1	11852
Natural father present in household (S1)	0.86	0.35	1.00	0	1	11852
Ln of predicted equivalised weekly net family income	5.83	0.72	5.93	3	7	11852
Maternal Grandmother is alive (S1)	0.93	0.25	1.00	0	1	11852
Maternal Grandfather is alive (S1)	0.84	0.37	1.00	0	1	11852
Pollution, environmental problems (S1)	0.22	0.41	0.00	0	1	11852
S4 Whether CM had wheezing in last 12 months	0.12	0.33	0.00	0	1	11852
S4 Whether CM ever had asthma	0.16	0.37	0.00	0	1	11825
S4 Whether CM ever had hay fever	0.15	0.36	0.00	0	1	11800
S4 Whether CM ever had eczema	0.34	0.48	0.00	0	1	11846
S4 Whether CM ever had hearing problems	0.12	0.32	0.00	0	1	11848
Number of accidents S4 (<= 4)	0.29	0.58	0.00	0	4	11820
S4 England	0.62	0.49	1.00	0	1	11852
S4 Wales	0.15	0.36	0.00	0	1	11852
S4 Scotland	0.12	0.33	0.00	0	1	11852
S4 Northern Ireland	0.11	0.31	0.00	0	1	11852

Notes: CM stands for Cohort Member. S1 and S4 stand for Wave 1 and Wave 4 respectively.

Table 4: Descriptive Statistics - S5 sample

	mean	sd	median	min	max	count
Psychological distress (Malaise Inventory)	0.14	0.35	0.00	0	1	11316
Missing values in Mal. inventory	0.00	0.07	0.00	0	1	11316
Age of CM at S5 (years)	10.91	1.64	11.08	-1	12	11316
Male	0.51	0.50	1.00	0	1	11316
Cohort Member Ethnic Group: White	0.86	0.34	1.00	0	1	11316
Cohort Member Ethnic Group: Mixed	0.03	0.16	0.00	0	1	11316
Cohort Member Ethnic Group: Indian	0.02	0.14	0.00	0	1	11316
Cohort Member Ethnic Group: Pakistani and Bangladeshi	0.05	0.22	0.00	0	1	11316
Cohort Member Ethnic Group: Black or Black British	0.03	0.16	0.00	0	1	11316
Cohort Member Ethnic Group: Other (inc Chinese)	0.01	0.10	0.00	0	1	11316
Birth weight	3.38	0.57	3.40	0	7	11316
Born under-weight	0.06	0.23	0.00	0	1	11316
Preterm babies (below 32 weeks)	0.03	0.16	0.00	0	1	11316
Siblings living in household (S1)	0.58	0.49	1.00	0	1	11316
Mothers with Postpartum depression and more than one child	0.09	0.28	0.00	0	1	11316
Age mother below 30 years	0.51	0.50	1.00	0	1	11316
Age mother left education	17.77	2.57	17.00	1	34	11316
Mother worked during pregnancy	0.68	0.46	1.00	0	1	11316
Ante-natal classes	0.38	0.48	0.00	0	1	11316
Mother smoked during pregnancy	0.21	0.40	0.00	0	1	11316
Mother drank alcohol when pregnant	0.31	0.46	0.00	0	1	11316
Mother had problems during pregnancy	0.39	0.49	0.00	0	1	11316
Mother: longstanding illness, disability or infirmity	0.22	0.41	0.00	0	1	11316
Mother suffers from asthma	0.16	0.37	0.00	0	1	11316
Breastfeeding less than 6 months	0.42	0.49	0.00	0	1	11316
Breastfeeding more than 6 months	0.24	0.42	0.00	0	1	11316
Delay in breathing at birth or difficulties in first week	0.07	0.26	0.00	0	1	11316
Jaundice requiring hospital treatment in first week	0.07	0.25	0.00	0	1	11316
Infection or suspected infection in first week	0.04	0.19	0.00	0	1	11316
Breech birth - feet first during labour	0.02	0.15	0.00	0	1	11316
Other abnormal lie eg shoulder first during labour	0.03	0.18	0.00	0	1	11316
Very long labour	0.07	0.26	0.00	0	1	11316
Very rapid labour	0.03	0.16	0.00	0	1	11316
Fetal distress during labour	0.15	0.36	0.00	0	1	11316
Caesarian delivery	0.22	0.41	0.00	0	1	11316
S1 Wheezing or asthma at 9 months	0.07	0.25	0.00	0	1	11316
S1 Skin problems at 9 months (incl. eczema)	0.20	0.40	0.00	0	1	11316
S1 Other breathing problems at 9 months	0.01	0.09	0.00	0	1	11316
No one else present at birth	0.05	0.21	0.00	0	1	11316
Natural father present in household (S1)	0.86	0.35	1.00	0	1	11316
Ln of predicted equivalised weekly net family income	5.83	0.72	5.93	3	7	11316
Maternal Grandmother is alive (S1)	0.93	0.25	1.00	0	1	11316
Maternal Grandfather is alive (S1)	0.84	0.37	1.00	0	1	11316
Pollution, environmental problems (S1)	0.22	0.42	0.00	0	1	11316
S5 Whether CM had wheezing in last 12 months	0.22	0.41	0.00	0	1	11316
S5 Whether CM ever had asthma	0.18	0.39	0.00	0	1	11312
S5 Whether CM ever had hay fever	0.25	0.43	0.00	0	1	11309
S5 Whether CM ever had eczema	0.31	0.46	0.00	0	1	11311
S5 Whether CM ever had hearing problems	0.08	0.27	0.00	0	1	11315
Number of accidents S5 (<= 4)	0.51	0.80	0.00	0	4	11170
S5 England	0.63	0.48	1.00	0	1	11316
S5 Wales	0.15	0.36	0.00	0	1	11316
S5 Scotland	0.12	0.32	0.00	0	1	11316
S5 Northern Ireland	0.11	0.31	0.00	0	1	11316

Notes: CM stands for Cohort Member. S1 and S5 stand for Wave 1 and Wave 5 respectively.

B Appendix

Table 1: Covariate balance - Sweep 2 sample

	Raw std difference	Matched std difference	Raw ratio	Matched ratio
Male	.0453765	.0097207	.9971244	.9989396
White ethnic group	-.139184	.0223988	1.313456	.9635916
Mixed ethnic group	.0439633	-.0177229	1.281032	.9135047
Indian ethnic group	.0565732	-.0062475	1.409026	.9665924
Pakistani and Bangladeshi ethnic group	.1329855	-.0179905	1.650272	.9453672
Black or Black British ethnic group	.0365034	0	1.232576	1
Age of CM S2 (days)	.0511537	-.0269086	1.117976	.9128722
Preterm babies (below 32 weeks)	.01448	-.0094931	1.087063	.94895
Age mother below 30	.1962681	-.0121276	.9597924	1.005164
Mother: longstanding illness, disability or infirmity	.4158057	.0033384	1.505746	1.0017
Mother: problems during pregnancy	.2520132	-.0043141	1.073206	.9999069
Age mother left educ	-.2470811	.0138834	.8123159	1.108552
Mother worked during pregnancy	-.2499221	.0315163	1.144695	.992251
Ante-natal classes	-.1632637	.0343394	.8955761	1.031615
Mother drank alcohol when pregnant	-.0080994	.0140372	.9938743	1.011866
Breastfeeding less than 6 months	-.0242655	-.0087913	.9913806	.9965648
Breastfeeding more than 6 months	-.1337504	.0254681	.824712	1.044222
Mother suffers from asthma	.1471286	.0185237	1.271544	1.026688
Caesarian delivery	.0145244	-.0154459	1.020207	.9800699
Delay in breathing at birth or difficulties in first week	.094069	.0354598	1.329435	1.105465
Jaundice requiring hospital treatment in first week	.0652872	-.0057206	1.229558	.98345
Infection or suspected infection in first week	.0330036	.0053075	1.16742	1.024161
Breech birth - feet first during labour	.0229753	.0268952	1.145116	1.172569
Other abnormal lie eg shoulder first during labour	.014192	.077719	1.076536	1.564379
Very long labour	.0481168	.0059596	1.169604	1.018615
Very rapid labour	.0585911	-.0086991	1.385423	.957488
Foetal distress during labour	.0315299	.0355825	1.061535	1.069473
Ln of predicted equivalised weekly net family income	-.3616572	-.0187245	1.045748	1.073956
Siblings living in HH S1	.1175621	-.0201602	.9528751	1.01136
No one else present at birth	.0719994	-.0240631	1.332542	.9185084
Maternal grandparents are both alive S1	-.0387529	.0169285	1.057728	.9773433
Pollution, environmental problems S1	.1952245	-.0294463	1.255652	.9744768
Born under-weight	.0477166	-.0352253	1.188958	.8907123
Mother smoked during pregnancy	.2848047	-.0057691	1.376375	.9956207
Natural father resident in HH S1	-.2231243	-.0130622	1.466313	1.018018
Maternal Grandmother is alive S1	-.0481537	.0039792	1.172225	.9877345
Maternal Grandfather is alive S1	-.0168359	.0187261	1.031854	.9673716
England - Advantaged	-.167345	-.015538	.8290975	.9795577
England - Disadvantaged	.0584273	-.0244912	1.072196	.9739963
England - Ethnic	.1106025	-.0176543	1.32224	.9618195
Wales - Advantaged	-.0711883	-.0140972	.726761	.934122
Wales - Disadvantaged	.1133072	.0219928	1.302901	1.047709
Scotland - Advantaged	-.1091286	-.0052454	.6524584	.9770057
Scotland - Disadvantaged	.0481641	.0649973	1.188927	1.268672
Northern Ireland - Advantaged	-.0784729	.0097524	.6750711	1.057062

Notes: CM stands for Cohort Member. S1 stands for Wave 1 when CM was 9 months old.

Table 2: Estimated effects on child health outcomes at age of 3 (linear regression model)

	Wheezing	Asthma	Hay-fever/ Eczema
Postpartum depression	0.0584***	0.0107	0.0517**
	(0.0211)	(0.0169)	(0.0242)
Siblings living in household (S1)	0.0307***	0.0145	-0.00167
	(0.0115)	(0.00900)	(0.0137)
Interaction PPD and siblings	-0.0657**	-0.00950	-0.0357
	(0.0259)	(0.0206)	(0.0302)
Observations	13145	12925	13033
R^2	0.052	0.107	0.076

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Estimated effects on child health outcomes at age of 5 (linear regression model)

	Wheezing	Asthma	Hay-fever	Eczema
Postpartum depression	0.0480**	0.0161	0.0493***	0.00751
	(0.0199)	(0.0187)	(0.0191)	(0.0234)
Siblings living in household (S1)	0.00843	0.00272	-0.0246***	0.0150
	(0.0107)	(0.0101)	(0.00876)	(0.0135)
Interaction PPD and siblings	-0.0259	-0.0126	-0.0451**	-0.0301
	(0.0248)	(0.0228)	(0.0219)	(0.0295)
Observations	13042	12993	12976	13032
R^2	0.042	0.077	0.029	0.076

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Estimated effects on child health at age of 7 (linear regression model)

	Wheezing	Asthma	Hay-fever	Eczema
Postpartum depression	0.0345*	0.0421**	0.0365*	0.00806
	(0.0186)	(0.0209)	(0.0211)	(0.0242)
Siblings living in household (S1)	0.00974	-0.00376	-0.0140	-0.00476
	(0.0103)	(0.0109)	(0.0109)	(0.0142)
Interaction PPD and siblings	-0.0256	-0.0301	-0.0304	-0.0394
	(0.0230)	(0.0255)	(0.0254)	(0.0307)
Observations	11852	11883	11858	11904
R^2	0.036	0.079	0.032	0.069

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Estimated effects on child health at ages of (linear regression model)

	Wheezing	Asthma	Hay-fever	Eczema
Postpartum depression	0.0595***	0.0526**	0.0331	0.0329
	(0.0229)	(0.0227)	(0.0243)	(0.0254)
Siblings living in household (S1)	0.0116	0.00776	-0.00821	-0.00131
	(0.0129)	(0.0119)	(0.0137)	(0.0148)
Interaction PPD and siblings	-0.0300	-0.0239	-0.0319	-0.0407
	(0.0292)	(0.0285)	(0.0301)	(0.0317)
Observations	11316	11339	11336	11338
R^2	0.051	0.060	0.035	0.051

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Estimated effects on number of injuries/accident occurred to the child (linear regression model)

	Age 3	Age 5	Age 7	Age 11
Postpartum depression	1.102**	1.096***	1.038	1.044
	(0.0435)	(0.0371)	(0.0322)	(0.0475)
Siblings living in household (S1)	1.022	1.063***	1.032*	0.992
	(0.0208)	(0.0184)	(0.0181)	(0.0278)
Interaction PPD w siblings	0.964	0.958	0.997	0.964
	(0.0473)	(0.0409)	(0.0411)	(0.0604)
N	13099	12940	11822	11170

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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