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The Blow of Domestic Violence on Children's Health Outcomes

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This article unravels the effect of Domestic Violence on children's health production function. Drawing results from the UK Millennium Cohort Study, we find that there is a strong negative externality of household violence on children's health outcomes. Simultaneity between child health and Domestic Violence makes it difficult to identify a causal effect, so we use an instrumental approach to address the potential bias. Children living in a household in which there is Domestic Violence appear to be between 55% and 61% less likely to have their health rated as Excellent. Our results are robust and statistically significant across all specifications. Our paper not only sheds light on the negative impact of DV on children's health but provides a robust quantification of this effect.

Keywords: Intimate Partner Abuse; Domestic Violence; Spill-over Effects; Semi-Ordered Recursive Probit; Bivariate Recursive Probit; Child Health Production Function.

JEL Classification: I14, I18, I19

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1 Introduction

In the 2013/2014 release of the Crime Survey for England and Wales (CSEW)[1] there were 8.5% of women (approximately 1.4 million) reporting any type of domestic abuse[2] and 6.8% (roughly 1.1 million) reporting having experienced any type of partner abuse. Domestic violence (DV) leads to an average of two women being murdered each week and 30 men per year in the UK. Further, it accounts for 16% of all violent crime in the UK (CSEW 2004/2005 report), but it is the violent crime least likely to be reported and it is cited as the main reason for becoming homeless (Cramer & Carter 2002). The costs to the criminal justice system, health services, social care and housing have been estimated to be about £23 billion annually (Walby 2004).

Intimate Partner Abuse (IPA) has proven to be harmful for victims' labour outcomes, mental health problems and sense of self-worth and integrity (Chapman & Monk 2015). Parenting is obviously affected by this environmental stressor. IPA is associated with parental mental health problems such as depression (Carlson et al. 2003) and anxiety (Mertin & Mohr 2001). Indeed, for young women, IPA increases the risk of suffering major depressive disorders, post traumatic disorders and substance abuse disorders (Ehrensaft et al. 2006). Victimized mothers also tend to be more impulsive and to use harsh punishment on their children (Osofsky 1987).

Violence is seen as a way to coerce the victim in order to align their incentives with respect to the ones of the prosecutor. This may be manifested in various ways, from a lack of aggressor's self-esteem or as a source of gratification (Tauchen et al. 1991) to an instrument to extract monetary rents from the victim (Bloch & Rao 2002). Identifying the person who has control over resources is key to understanding IPA. However, so far, in the economic literature there is no consensus on the role of violence in the distribution of resources inside the household. Although, common factors throughout economic models point out that policies that increase the outside utility of victims also increase their bargaining power, the relationship of income and violence still remains unclear (Hidrobo & Fernald 2013).

In this paper, we study if there are spill-over effects of DV on children's health. An

[1]Crime Survey for England & Wales: http://www.ons.gov.uk/peoplepopulationandcommunity/crimeandjustice

[2]Domestic abuse in the CSEW survey includes: partner/ex-partner abuse (non-sexual), family abuse (non-sexual) and sexual assault or stalking carried out by a current or former partner or other family member.

equal opportunities commission report in 2007 estimated that around 750,000 children witness DV in the form of IPA in the United Kingdom. Paediatric literature suggests that those children suffer from a cumulative disadvantage because of living in a hostile environment (Culross 1999). Exposure may have detrimental effects for their well-being and interpersonal functioning development (Ehrensaft et al. 2003). Those witnessing DV are prone to be engaged in antisocial behaviour (such as delinquency and running away) (Dubowitz & King 1995, Wolfe & Korsch 1994) as well as having problems self-regulating themselves, in terms of mood, emotional expressivity, aggressive behaviour and hostile reactivity (Ehrensaft & Cohen 2012). Research highlights the fact that they are more likely to have poor self-esteem and are at greater risk of substance abuse later on in life (Holtrop et al. 2004). Evidence shows that aggressive behaviour during infancy may lead to rejection by their school peers (Dodge et al. 2003). A major negative consequence of IPA is the children's mimicking process. Children may internalize the use of violence as a normal mean to impose their criteria. Psychiatric literature has established that children who witness DV are more likely to use physical or psychological violence against their future partners (Magdol et al. 1998).

Overall, it is difficult to disentangle a unique mechanism on how DV can affect child's health. Instead, there may be different factors, such as the purely biological consequences of living under stressful and fearful environments. There is increasing evidence that stress early in life may induce changes in multiple neurochemical systems (Kaufman et al. 2000) and promote multiple alterations in the serotonergic system and reduce of the hippocampal volume (Kaufman et al. 2004). Depression, subsequent poor quality of parenting, higher risk taking and antisocial behaviours have been reported in adults that were exposed to early life stressors such as living in a household with domestic violence (Holtrop et al. 2004).

In work related to our analysis, Aizer (2011) provides evidence of the negative effect on birthweight of children born to mothers suffering DV while pregnant. In particular, hospitalization episodes of pregnant women due to violent assault reduces the birthweight of their babies by an average of 163 grams. In an innovative study, Carrell & Hoekstra (2010) review the *bad apple hypothesis* and point out that children who witness DV at home also show poor academic performance and generate negative externality effects on the performance of their peers. The analysis highlights that the presence of children ex-

posed to household's IPA, is associated to an increase in misbehaviour in their classrooms as well as to a significant decrease in school performance outcomes (maths and reading test scores, specifically) of their classmates.

While the evidence in the paediatric literature highlights a cumulative disadvantage on children's socio-emotional development, the economic literature has not yet succeeded in quantifying effect of IPA on a child's health production function. The objective of this study is to obtain estimates of the effect on child health of living under a disruptive violent environment. In the literature, the terms Intimate Partner Abuse (IPA) and Domestic Violence (DV) are often used interchangeably but hereafter we will use the term DV to refer to domestic abuse.

Our paper uses the Millennium Cohort Study (MCS) to estimate the impact on children health of growing up in a household in which there is DV. We exploit questions designed to capture the use of force of fathers on natural mothers. In our identification strategy we first examine the relationship between battered natural mothers and the child health production with a naïve specification, controlling for possible child heterogeneity and attrition bias. Secondly, we use an instrumental approach to control for the simultaneity of environmental factors that might affect both domestic violence and child health. Our instruments draw on the affective relation between the fathers and the paternal grandparents as well as on the difference in the regional unemployment levels between men and women. We estimate our specifications by means of a non-linear recursive system of equations. In line with previous results, our findings provide evidence of the existence of a large, negative and significant spill-over effect that translates into a child's health being between 55% and 61% less likely to be rated as *Excellent* when he/she is exposed to parental DV.

This paper extends the existing literature by providing evidence of the significance and magnitude of the negative spill-over effect of DV on the child's health production function. The remainder of the paper is structured as follows. The next section introduces the MCS data, presents the variables of interest and some descriptive statistics. Section III outlines the naïve empirical strategy examining the relationship between child's health and DV and provides a first set of results. Section IV extends the analysis to a bivariate model that controls for endogeneity, includes a discussion of the instruments used in this specification and shows the corresponding results. Section V concludes.

2 Millennium Cohort Study

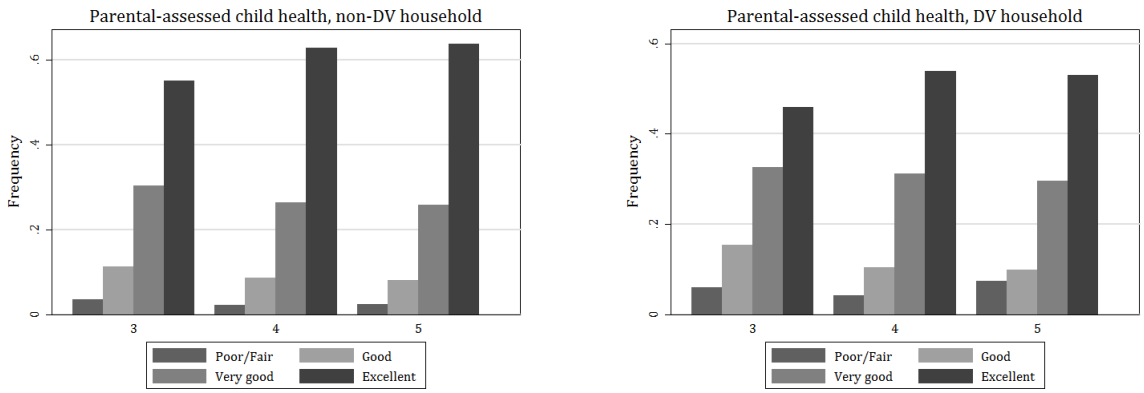
The Millennium Cohort Study (MCS) is a survey following nearly 19,000 children born in the UK in 2000-2001. The first wave was collected when these children were 9 months old. Consecutive waves were gathered when they were 3, 5, 7 and 11 years old. In this study, we use waves 3, 4 and 5 of the MCS, which were run when the children were aged 5, 7, and 11, respectively. As our interest is on the effect of DV on children's health, we specifically focus on children living with both their natural parents to avoid potentially distorting confounding factors. Our data contains information on the whether there exists DV in the household and on the children's health status over time, along with a battery of socio-demographic characteristics of the children and their parents, and basic traits of the household and the environment they live in.

2.1 Main variables of interest

2.1.1 Child health information

The MCS contains data on children's general health - elicited from parents from wave 3 onwards - as well as parents' health-related health variables and also information on whether the child suffers from specific medical conditions. The general health question asks to rate the child's health given five possible statuses: *Poor (5), Fair (4), Good (3), Very Good (2),* and *Excellent (1).* Parents are also asked whether child suffers from: *vision, hearing impairment, mobility, dexterity, learning or understanding, memory, mental health, stamina or breathing or fatigue, social or behavioral.* For the child's parental reported health, we merge the *Fair* and *Poor* categories because of their low frequency throughout the period considered. Additionally, to ease interpretation, we invert the numerical order so that higher values of the health variable represent better health states.

Figure 1 below summarises the frequency distribution of parent-reported child-health in waves 3 to 5 in households with and without DV. It is noticeable that for children in households where there exists DV, the frequency of *Excellent* health category is lower across the three waves.



(I) (II)

Figure 1: Parental-reported child health

In this study, we consider the parental-reported child health as a health-proxy as commonly done in the literature (Kuehnle 2014). Case et al. (2002) have showed that parental-reported child health and physician reports are highly correlated and therefore parental-report is a good proxy for child's health. The parent's ability in reporting child's health may be questioned if they suffer themselves from a health condition and consequently introducing some bias in the response. However, the literature has reported consistent evidence on the parents' ability in providing accurate information with respect to their child's health. McCormick et al. (1989) in a study carried out in New York showed how a depressed mother can accurately discriminate between their own reported health and that of the child. Pulsifer et al. (1994) examined maternal estimates concerning developmental age of their child and mothers' judgments were in line with objective measures of the child's development. Interestingly, whilst there is some skepticism among clinicians about the reliability of parental concern on child health (Diamond & Squires 1993), Glascoe et al. (1991) find that if the methodology to recover child health information from parents is collected systematically by using standardized surveys, there is a high correlation between survey information and factual outcomes.

We focus on parental-reported health for two reasons. First, although parents are asked if the child suffers from specific health conditions, there is a very low prevalence of diseases for children included in the study period as they are aged between 5 and 11 years old. Second, we do not have complete administrative data on the child's health care use for the last two waves. For the first three waves, administrative data on child's health care consumption was merged to the survey retrospectively but this is not available for

waves 4 and 5 (Mostafa & Wiggins 2015).

2.1.2 Domestic Violence Information

To capture the existence of violence in the household we use information on whether the mother experiences DV. In particular, the questionnaire includes the following question: *People often use force in a relationship - grabbing, pushing, shaking, hitting, kicking etc. Has your husband ever used force on you for any reason?*. The mother has three alternatives: *1 (Yes), 2 (No) and 3 (Don't want to answer)*. We define a dichotomous variable DV that equals 1 if the natural mother answers *Yes* and 0 if the answer is *No*. If the respondent answers *Don't want to answer* this is considered as a missing value. In this case the frequency of DV in our data is 3.80%, 3.46% and 3.61% for waves 3, 4 and 5, respectively. If we are accounting those answers as *Yes*, the percentage of households with DV goes up to 6.46% , 6.07% and 5.40%, respectively. Although the latter figures are more in line with the statistics from the 2013/2014 CSEW, we take a conservative approach and present the results estimated using the specifically reported *Yes* and *No* answers.

One of the major limitations of using self-assessed domestic violence data is the existence of unreporting, which may generate a downward bias in our coefficients and thus that our estimates are a lower-bound of the effects. Among the leading causes of undereporting found in the CSEW (2013/2014) are *embarrassment* (22.25% of the sample) and *it was a private matter* (12.92%). However, timing of DV reporting by mothers also matters with regards to the long-term influence on child's behaviour. The earlier mothers report the existence of DV, the lower the impact on child's development and the consequent lower effect that child's behaviour has on classroom disruption (Carrell and Hoekstra, 2012).

2.2 Relevant control variables

2.2.1 Child-related control variables

Currie (2009)'s survey of the literature on the relation between child health, income and parental education provides guidance on the possible pathways on how the socioeconomic environment/variables might affect the child health production function. Therefore, we

follow Currie (2009) and include health-related, environmental and socio-economic factors, transmitted inter-generationally or not, that might affect the child's health.

Child-specific variables included in the empirical strategy are age, gender (=1 if female) and a dummy on whether the child was born with low birthweight (2.5kg or below). We include information on the child's BMI and apply Saxena et al. (2004) gender-age specific BMI thresholds to define two dummies for obesity and overweight. Ethnicity has also been linked to child's health. For instance, Dearden et al. (2006) also using the MCS find that Asian and Black babies are 5% and 6% respectively more likely to be of low birth weight than white babies and this may affect their health later on in life. Thus, we control for ethnicity using a set of indicator variables that take value 1 if the child is of White, Bangladeshi/Indian/Pakistani, Black or Other background. Table A1 in the Appendix gives a summary of the control variables and their definition. Table 1 below reports the mean of the child's parental-reported health and control variables for each of the waves included in the study.

Table 1: Child Summary Statistics

	Age 5			Age 7			Age 11		
	DV			DV			DV		
	No	Yes	*Statistically different*	No	Yes	*Statistically different*	No	Yes	*Statistically different*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Health distributions									
(1) FairPoor	0.03	0.06	***	0.02	0.04	***	0.02	0.04	***
(2) Good	0.10	0.10		0.07	0.10	+	0.06	0.07	
(3) Very Good	0.29	0.34		0.25	0.31	+	0.24	0.31	+
(4) Excellent	0.59	0.50	***	0.66	0.54	***	0.68	0.57	**
Female	0.49	0.52		0.49	0.49		0.50	0.43	+
Obese	0.05	0.05		0.05	0.08	+	0.06	0.07	
Overweight	0.15	0.13		0.14	0.17		0.19	0.20	
Low birthweight	0.06	0.10	**	0.06	0.05		0.05	0.06	
White	0.93	0.90		0.92	0.92		0.92	0.92	
Bang/Ind/Pak	0.03	0.03		0.03	0.03		0.03	0.03	
Black	0.01	0.00		0.01	0.01		0.01	0.01	
Other	0.03	0.06	+	0.03	0.04		0.03	0.04	
Age	5.28	5.28		7.28	7.25		11.28	11.31	
N	5926	221		5221	185		4028	134	

Note: Averages calculated using data of children living with both natural parents for which there are no missing values for gender, race, birth weight, weight, month born, mother was a teenager when pregnant, parental long standing illness, parental smoking habits, parental education, parental age, parental working status, houshold income and type of dwelling.
N refers to the number of observations in each group.
Means are adjusted for the reference population weights given in each of the three MCS waves used for both the non-DV and the DV samples.
Significance levels : $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

2.2.2 Parental-related control variables

The empirical specification includes health- and non-health related variables taken from the parental questionnaire across the three waves. Table 2 in Appendix contains a list of all parental controls included. We include information on whether any of the parents have any long-term health conditions, whether they suffer from depression and also if they are current smokers. Tables 3 and 4 in Appendix shows the summary statistics for maternal and paternal characteristics. Mothers that suffer DV also suffer more frequently from chronic conditions, they are more likely to have been diagnosed with depression in every sampling period (50%, 49% and 55% in waves 3, 4 and 5, respectively) and report a higher percentage of smoking in any given sampling period. In the case of the male counterpart, the level of depression and smoking are statistically higher in a violent household across the last three waves available at the time of the study (26%, 27% and 31% for depression and 35%, 36% and 23% for smoking in waves 3, 4 and 5, respectively).

We also select a number of controls for parents' characteristics such as age and parental education. Cutler & Lleras-Muney (2010) highlight that education influences cognitive ability, and cognitive ability is associated to healthy behaviours. Educated parents are more likely to engage in stimulant discussion with their children as well as having a better network in case of health problems (if educated parents do not know a doctor directly, it is likely that they know somebody who knows one). In our case, fathers and mothers in both samples have a similar education distribution (as seen in Tables 3 and 4 in the Appendix).

Whether the father is unemployed may have some effects on the frequency of DV. The literature points out that the father being unemployed increases the likelihood for a mother being battered (Farmer & Tiefenthaler 1996). Therefore, we also include an indicator variable, *In-work*, that reflects the father's employment status.

The last of the parental characteristics included is a dummy on whether the mother was a teenager at the time of birth. Empirical evidence shows that being a teenage mother has an effect on the offspring's health.Berthoud & Robson (2001) find that 40% of teenager mothers were living in poverty by the time their child was 10 years of age while only 11% of the older mothers were. Pevalin et al. (2003) looks at the 1970 British Cohort Study and finds that children from younger mothers are more likely to be pre-term babies and to be born with low weight (less than 2.5Kg.).

2.2.3 Household control variables

A causal effect of neighborhood characteristics on health has been recently highlighted. Bilger & Carrieri (2013) examine the negative effect of crime, pollution and noise of the neighborhood on self-assessed health, presence of chronic conditions and limitations to daily activities. In another study, Jacob et al. (2013) show a decline of child mortality when the household is relocated to a less distressed neighborhood. In our study, we do not have specific information regarding the neighborhood where the child lives. However, we are able to control by whether the family lives in a Council house or Housing Association. This may be a good proxy as council houses are likely to be in areas of higher poverty (Atkinson & Kintrea 2001). Thus, not capturing properly the neighborhood effect would mean that our DV estimate on child's health is likely to be upward-biased.

Finally, the specifications include household income. There is a clear positive relationship between parental income and child health (Currie 2009, Violato et al. 2009, Kuehnle 2014). In the MCS income is defined as the combined annual income in a household from all sources after deductions and is given in thresholds levels. We take the midpoint of each reported interval and use the annual average consumer price index provided by the Office of National Statistics (ONS) to convert it into real income with base year 2005. As it is common in the literature, we take the natural logarithm of income to avoid estimation problems caused by its non-normality. The bottom panel in Tables 3 and 4 in the Appendix present the summary statistics at household level for both the council house dummy and income variables. Around 10 to 15% of the families who are living in a violent environment, i.e. the mother reports being subjected to DV, live in a council house or in a housing association in every sampling period. Income is also lower in such violent environments across all three sampling periods.

Next section presents the model in which we base our empirical strategy and a first set of results.

3 A model of child health and domestic violence

We investigate the existence and magnitude of the impact of living in a household with DV on the child's health production function. We start by estimating a naïve non-linear pooled specification controlling for unobserved heterogeneity and attrition. The basic

model specifies the child health production function as:

$$H_{it} = f(DV_{it}, X^c_{it}, X^m_{it}, X^f_{it}, X^H_{it}) \tag{1}$$

where H_{it} is the categorical variable of parental-reported child health that takes four possible values: *Fair/Poor (1), Good (2), Very Good (3)* and *Excellent (4).* DV_{it} is the indicator variable for DV, equal to 1 if the child's mother declares to be treated violently by her partner and 0 otherwise. X^c_{it} are child specific controls including age, ethnicity and whether the child is obese or overweight. X^m_{it} and X^f_{it} are mother and father controls, respectively. Both control vectors include indicators for health and non-health related variables. X^H_{it} are household controls containing family income and whether the family lives in a council house or a housing association.

Our first approach looks at the relationship of child health and DV using a simple Univariate Ordered Probit model. We define a latent health variable, H^*_i, as:

$$H^*_{it} = X_{it}\beta + c_i + \epsilon_{it}, \tag{2}$$

where i and t denote the child identifier and time period respectively; H^*_i is the health latent variable, X_{it} is the vector of variables $(DV_{it}, X^m_{it}, X^f_{it}, X^H_{it}, X^c_{it})$ defined as above, c_i are random individual-specific effects, that is, time-constant individual unobserved characteristics of the child that could potentially affect child's health (e.g.genetics or environmental factors like childcare setting), and ϵ_{it} is a normally distributed idiosyncratic error, i.e. $\epsilon_{it}|X_{it}, c_i \sim Normal(0, 1)$.

At each point in time, we do not observe the latent health variable, H^*_i, but the parent-reported categorical answer about the child's health, $j = 1, 2, 3, 4$. The observed category is j if the latent health lies between certain thresholds, i.e. $\alpha_{j-1} < H^*_i < \alpha_j$, where the thresholds, α_j, are to be estimated along with β. Formally:

$$Pr(H_i = j) = F(\alpha_j - X_i\beta - c_i) - F(\alpha_{j-1} - X_i\beta - c_i), \tag{3}$$

where *F(.)* is the cumulative normal distribution function.

A major concern of a pooled specification like the one in (2) is that identification relies on the unrealistic assumption that the time varying covariates in X_{it} are uncorrelated with the individual-specific effects, c_i . To address this concern, we apply the Chamberlain-

Mundlak device (CM hereafter), based on Chamberlain (1979) and Mundlak (1978) and regress child fixed effects, c_i, on the average over all periods of a set of the exogenous time-varying variables, Z_{it}, i.e.:

$$c_i = \psi + \bar{Z}_i\eta + a_i \tag{4}$$

The underlying rationale for applying the CM correction is that it replaces the child unobserved individual effect, c_i, for its linear projection onto the mean of the exogenous variables ($\bar{Z}_i$), a scalar ψ and a normally distributed projection error a_i uncorrelated with $\bar{Z}_i$ by construction, i.e. $a_i \sim Normal(0, \sigma_a^2)$. By substituting equation (4) into (2) we define a random effects structure.

3.1 Attrition bias

One of the major threats to the validity of our specification is the due to the non-random attrition from one survey sweep to another as it may bias our estimates. In particular, we expect the bias to be downwards because children with worse health conditions and/or from lower socio-economic background are more likely to drop out of the sample, possibly mitigating the effect of DV on children's health outcomes.

We correct for attrition by implementing the Inverse Probability Weighting (IPW) estimator to the pooled ordered probit (Wooldridge 2010, 2002). As in Contoyannis et al. (2004) , we estimate probit equations for having responded the survey's waves fourth and fifth, i.e. ($\xi_{it} = 1$) versus non-response ($\xi_{it} = 0$), against a set of covariates that are observed in the first wave (wave 3) of our study period. The inverse of the predicted probability is obtained, $\hat{p_{it}}$, and used to weight observations in waves 4 and 5 in the maximum likelihood estimation for both the pooled and the CM-adjusted ordered probit.[3] The validity of this approach relies on the set of covariates chosen to produce the probability of response. In this case, we assume that the same set of covariates used for each of the models to follow are good predictors for the missing data.

$$logL = \sum_{i}^{n}\sum_{t}^{T}(\xi_{it}/\hat{p_{it}})logL_{it} \tag{5}$$

[3]Following Contoyannis et al. (2004) and Wooldridge (2005), we do not adjust the standard errors of the estimation in order to avoid oversized standard errors.

3.2 Results of the basic model

Table 2 presents estimates of the effect of DV on child health when we use naïve pooled ordered probit specifications. See Table 5 in the Appendix for a full list of results of all covariates included in the specifications. The estimates of our baseline ordered probit model are presented in column 1, which is obtained by pooling data across the last three available sampling waves and controls simply for socieconomic and parental health variables. Column 2 presents the estimates of the CM-device ordered probit model correcting for unobserved individual heterogeneity. In columns 3 and 4, we present the results when we apply the IPW weight to the simple pooled ordered probit and the CM-corrected pooled ordered probit.

Table 2: Naïve Ordered Probit Models

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
Domestic violence	-0.151^{***}	-0.153^{***}	-0.168^{***}	-0.146^{**}
	(0.057)	(0.058)	(0.061)	(0.06)
Controls	X	X	X	X
Cut1	-0.337	-0.456	-0.2828	-0.438
	(0.244)	(0.346)	(0.254)	(0.365)
Cut2	0.447^{+}	0.331	0.4967	0.348
	(0.243)	(0.345)	(0.253)	(0.364)
Cut3	1.430^{***}	1.318^{***}	1.481^{***}	1.334^{***}
	(0.243)	(0.345)	(0.253)	(0.364)
N	15,713	15,713	14,991	14,991
ll	-1.41e+04	-1.41e+04	-1.47e+04	-1.42e+04

Notes: Standard errors in parentheses. Standard errors are robust to heteroskedasticity and clustered at child level in order to allow for repeated observations over time.
Models are estimated using the unbalanced sample.
Specifications in columns (2) and (4) include the parameterisation of the individual fixed effect as the mean of the exogenous independent variables, as indicated in equation (4).
Columns (3) and (4) include inverse probability weights (IPW) weights
Controls include the set of variables for the child, parental and household-related variables: child race, whether the child born with low weight, whether the child is obese or overweight, parental long-standing illness, parental depression, parental smoking, parental education, parental working status, teen mother, parental age, logarithm of household income, whether the family lives in a council house (or in a housing association).
Reference category for child's ethnicity is White. Reference category for parental education is No Education.
Time dummies for years corresponding to each wave are also included.
Significance levels $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Overall, results in table 2 indicate that there is a negative and significant effect of DV on the child's health production function. Nevertheless, based on the coefficient estimates, we cannot comment on the sign and magnitude of the effect of DV on child

health. To do so we need to obtain the Average Partial Effects (APEs) of DV on the probability of reporting the child's health status as any of the four categories *Poor/Fair (1), Good (2), Very Good (3)* and *Excellent (4)*. Because the only cut-off point significant at 99% across all specifications is the third one, which divides the parental-reported child health levels *Very Good* and *Excellent*, we only report the APE of DV on the probability of reporting child's health as *Excellent*. Later in the paper, we will exploit the fact that only the last threshold level - dividing the *Very good* and *Excellent*- is signficant and will model the child health variable as a dichotomous indicator variable that takes value 1 if parents rate the health of their child as *Excellent* and 0 otherwise.

Table 3: Average Partial Effects: Probability Excellent Health

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
Domestic violence	-0.057^{***}	-0.057^{***}	-0.063^{***}	-0.055^{**}
	(0.022)	(0.022)	(0.023)	(0.023)

Notes: Standard errors in parentheses. Standard errors calculated by Delta method.
Significance levels $^{+}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

Table 3 summarises the APEs that correspond to each of the univariate models presented in Table 4. As indicated above, the reported APEs refer to the impact of DV on the probability of reporting health as *Excellent*. The impact is negative and similar in magnitude across all specifications. Whilst the effect for unweighted analysis (columns (1) and (2)) is the same, the impact differs among specifications once we correct for sample attrition. Column 3 presents the effect of DV as being 6.3% less likely to report a child's health as *Excellent*. Nevertheless, once we control for the influence of child's unobserved heterogeneity, the effect decreases to 5.5%. Table 6 in the Appendix provides the APEs of all variables included in the univariate model specifications.

4 Breaking the simultaneity

While the negative impact of DV on the child health production is significant throughout all the above specifications, causation becomes a critical concern as, potentially, there exist unobserved factors simultaneously affecting both DV and parental reported child's health. Our strategy to be able to establish causality between DV and child's health relies

on making use of a recursive system of non-linear equations that addresses this circularity. To do so, we specify a reduced form of a system of two simultaneous equations for DV and child's health using a bivariate semi-ordered probit model. The first equation models the four-levels parental-reported child's health in the system; the second equation models the dichotomous indicator variable DV. It has been shown that such system can be identified if both equations contain the same set of regressors as long as there is enough data variation (Wilde 2000, Bridges & Disney 2010). However, to reinforce our identification strategy, we follow Maddala (1983) and include some variables in the second DV equation which are not used in the first parental-reported child's health equation.

Our empirical strategy is based on the use of two instruments in the second equation that are related to DV but orthogonal to parental-reported child health. The first instrument aims at correcting for familiar self selection into a violent environment.Pollak (2004) proposes an intergenerational model of DV in which behavioral strategies are transmitted from one generation to another. The model suggests that, in violent families, there is a certain degree of self-selection. Building on this finding, we develop an index variable that reflects the affective relation between the father and his own parents based on information provided in the MCS first sampling period, i.e. wave I. We do so by estimating latent class model (Lanza et al. 2013) that identifies father-to-own-parents affective relationship types (or clusters) in our panel, which we refer to as *relation index* hereafter.

We build the latent class model using answers to three questions: (a) frequency the natural father sees his father; (b) frequency the natural father sees his mother; and, (c) whether the natural father receives any economic support from his parents. Table 4 below shows the model fit criteria based on which we can select the optimal number of types as per father-to-own-parents affective relationships. The Akaike Information Criteria (AIC), the Schwarz Bayesian Information Criteria (BIC), the Adjusted Schwarz Bayesian Criteria (Adjusted BIC), and the Entropy index (Entropy R^2) coincide in identifying 6 as the optimal number of different types. This is also corroborated by the G^2 index which suggests that the more types, the better. However, using more than 6 father types leads our specification into negative degree of freedoms and higher AIC, BIC and Adjusted BIC.

Table 4: Index of clusters father-to-own-parents affective relationships

n. latent class	G^2	df	AIC	BIC	Adjusted BIC	Entropy R^2
3	4938.85	36	5008.85	5262.94	5151.72	0.82
4	2078.45	24	2172.45	2513.6	2364.29	0.88
5	500.31	12	618.31	1046.63	859.14	0.87
6	21.97	0	163.97	679.41	453.78	0.84
7	9.82	−12	175.82	778.37	514.61	0.84
8	8.16	−24	198.16	887.83	585.93	0.79
9	6.18	−36	220.18	996.97	6565.94	0.70
10	0.10	−48	238.10	1102.01	7234.84	0.68

Note: The term *n.latent class* stands for the number of possible analyzed latent classes. G^2 is the likelihood ratio statistic (the deviance between the likelihood from the reduced model and the saturated one). *df* are the degree of freedom. *AIC* is the Akaike information criteria. *BIC* is the Schwarz bayesian information criteria. *Adjusted BIC* is the adjusted Schwarz bayesian information criteria. *Entropy* R^2 is an overall measure of fuzziness, i.e. it reflects the distinguishability of the types ranging from 0 (fuzzy and suggesting no difference among latent classes) to 1 (types clearly different) (Ramaswamy et al. 1993, Kaplan & Keller 2011).

Our second instrument is based on the insights provided by several economic publications taking a more game-theoretical approach to explain the existence of DV.Tauchen et al. (1991) develop and estimate a non-cooperative household model of violence in which DV is seen as both a source of gratification and as a way to coerce the victim's behaviour. Violence increases the husband's utility directly, and indirectly by controlling his wife's behavior. Violence in equilibrium depends on the level of control over resources by each partner and on whether the reserve utility is binding (whether available options outside the cohabitation exist). Farmer & Tiefenthaler (1996) analyze the relation of care services for battered women and the prevalence of DV. Results indicate that policies that increase outside options to a violent household environment provide a higher bargaining power to women and are associated to lower DV prevalence. Thus, to proxy for women's bargaining power and the outside options available to women in a given family, as a second intrument we use the *difference between men and women's regional unemployment rates* based on data from the ONS. [4]

Below, we present a more sophisticated model of child's health and DV.

4.1 Identification Strategy

We estimate the relation between DV and child health using a simultaneous non-linear equations recursive system (Greene & Hensher 2010). The system of equations can be

[4]The rate of UK unemployment measured by the ONS-Labour Force Survey (LFS) uses the definition of unemployment specified by the International Labour Organisation. Unemployed people as those without a job who have been actively seeking work in the past 4 weeks and are available to start work in the next 2 weeks. It also includes those who are out of work but have found a job and are waiting to start it in the next 2 weeks. *see https://www.ons.gov.uk/employmentandlabourmarket/peoplenotinwork/unemployment*

expressed as follows:

$$\begin{aligned} H^*_{it} &= DV_{it,1}\delta_1 + \Psi_{it,1}\beta_1 + c_i + e_{it} = j \quad \text{if } \alpha_{\mathrm{j}-1} < \mathrm{H}^*_{\mathrm{it},1} < \alpha_{\mathrm{j}}, \quad \mathrm{j} = 1,2,3,4 \\ DV^*_{it} &= Z_{it,1}\delta_2 + \Psi_{it,2}\beta_2 + c^{dv}_i + e^{dv}_{it} \quad \mathrm{DV_{it}} = 1(\mathrm{DV^*_{it}} > 0) \end{aligned} \tag{6}$$

$$\begin{pmatrix} e^{dv}_{it} \\ e_{it} \end{pmatrix} \sim N \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right] \tag{7}$$

Subscripts 1 and 2 refer to the first and second equation, respectively. H^*_{it} is the latent variable for the parental-reported child health as outlined in section 3. DV^*_{it} is the latent variable for the existence of DV in the household and, thus, the observed DV is equal to one whenever $DV^*_{it} > 0$. The vector $Z_{it,1}$ contains the set of instruments unrelated to child health. $\Psi_{it,1}$ and $\Psi_{it,2}$ are the set of controls for both functions. Terms c^h_i and ci^{dv}_i are child individual effects. The error terms e^{dv}_{it} and e_{it} are identically distributed, with a bivariate normal distribution, with a mean of zero, unit variance and correlation coefficient equal to ρ as in (7), i.e. $Corr(e^{dv}_{it}, e_{it}) = \rho$. If ρ is equal to zero, the bi-probabilistic model becomes a pair of unrelated probabilistic models. If ρ is found to be statistically different from zero, this implies that there is correlation between the unobservable characteristics in the two equations. As shown in the results reported in the next section ρ is positive and statistically significant. Thus, the joint modelling approach is preferred as it allows to correct for the endogeneity of DV on the health production function.

We also incorporate the CM device to correct for the existence of unobserved heterogeneity by estimating the individual effects as:

$$\begin{aligned} c^h_i &= \psi + \bar{\Psi^h_{i,1}}\eta + a^h_i \\ c^{dv}_i &= \psi^{dv} + \bar{\Psi^{dv}_{i,2}}\eta + a^{dv}_i \end{aligned} \tag{8}$$

where $\bar{\Psi^h_{i1}}$ and $\bar{\Psi^{dv}_{i2}}$ are the means of the exogenous variables for the sample period, ψ^h and ψ^{dv} are scalars and a^h_i and a^{dv}_i are projection errors with zero mean and variances σ^{h2}_a and σ^{dv2}_a, respectively. Finally, we also adjust both specifications applying the IPW estimator presented in section 3 in order to correct for the bias associated to attrition.

4.2 Results Instrumental Variable approach

In this section we present the results from estimating the semi-ordered bivariate probit model as in (8). Table 5 shows the estimates obtained using a two stage approach and instrumenting DV. For parsimony, we only present the coefficients for the DV variable on the latent parental-reported child's health and the estimated coefficients of the instruments on the probability of suffering DV. Table 5 in the Appendix reports all estimated coefficients of the semi-ordered bivariate probit. The top panel in table 5 refers to the estimates of the impact of DV on child's health and the bottom panel presents the estimates of the second-stage probit model of the mother being subjected to DV.

First of all, the results in the first panel showing the estimates of DV on children's health are very robust across all specifications and, when compared to the results in the previous section, they show that controlling for the endogeneity of DV increases the magnitude of the impact of DV on health.

Second, in the DV equation we observe that both instruments used to predict the likelihood of suffering DV are significant and positive across all specifications. This confirms that there is a positive association between DV and the type of affective relationship between the natural father and his own parents and with the relative weaker position of women in the regional job market.

The Wald test indicates that we can reject the null hypothesis of ρ being different from zero across all specifications. This implies that the error terms in both equations are not distributed independently and therefore a bivariate approach is more appropriate than estimating two single equations. The estimated ρ is positive and indicative that there are unobserved characteristics that drive up both child's health and the likelihood of experiencing DV. The fact that ρ is not problematic as there may exist unobserved variables that influence positively both these variables, i.e. compensatory nurturing behaviour of the battered mother towards the child or closer health and social services monitoring of the child given the household context.

Table 5: Semi-ordered bivariate probit model

	Pooled Bioprobit (1)	CM Bioprobit (2)	IPW Pooled Bioprobit (3)	IPW CM Bioprobit (4)
		Ordered Probit Child Health		
Domestic violence	-0.9178^{***}	-0.8881^{***}	-1.0074^{***}	-0.9635^{***}
	(0.3355)	(0.3225)	(0.3384)	(0.3641)
Controls	X	X	X	X
		Probit Domestic Violence		
Relation index	0.030^{**}	0.029^{**}	0.031^{**}	0.0280^{+}
	(0.014)	(0.015)	(0.015)	(0.015)
Unemployment difference	0.066^{**}	0.065^{**}	0.060^{**}	0.055^{+}
	(0.028)	(0.029)	(0.030)	(0.030)
Controls	X	X	X	X
Cut11	-0.4599^{+}	-0.6748^{+}	-0.4150	-0.6187
	(0.2522)	(0.3575)	(0.2632)	(0.3790)
Cut12	0.3187	0.1079	0.3581	0.1656
	(0.2513)	(0.3563)	(0.2622)	(0.3776)
Cut13	1.2981^{***}	1.0919^{***}	1.3346^{***}	1.1435^{***}
	(0.2516)	(0.3560)	(0.2626)	(0.3774)
Cut21	1.6281^{***}	1.9641^{***}	1.6788^{***}	2.0731^{***}
	(0.5202)	(0.7394)	(0.5511)	(0.7705)
N	14569	14569	14025	14025
ll	$-1.50e+04$	$-1.49e+04$	$-1.62e+04$	$-1.57e+04$
		Wald test		
ρ	0.3374^{**}	0.3252^{**}	0.3623^{**}	0.3537^{**}
	0.1420	0.1378	0.1427	0.1543

Notes: Standard errors in parentheses. Standard errors are robust to heteroskedasticity and clustered at child level in order to allow for repeated observations over time.
Models are estimated using the unbalanced sample.
Specifications in columns (2) and (4) include the parameterisation of the individual fixed effect as the mean of the exogenous independent variables, as indicated in equation (4).
Columns (3) and (4) include inverse probability weights (IPW) weights
Controls include the set of variables for the child-, parental- and household-related variables: child race, whether the child born with low weight, whether the child is obese or overweight, parental long-standing illness, parental depression, parental smoking, parental education, parental working status, teen mother, parental age, logarithm of household income, whether the family lives in a council house (or in a housing association).
Reference category for child's ethnicity is White. Reference category for parental education is No Education.
Time dummies for years corresponding to each wave are also included.
Cut11, Cut12 and Cut13 are the estimated thresholds for the ordered probit and Cut21 is the threshold for the DV probit.
Significance levels $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

4.3 Extension: To be or not to be in *Excellent health* and DV

Due to the low percentage of cases of DV in the child health categories of *Fair/Poor* and *Good*, we define a new dichotomous variable *Excellent health* that equals to 1 if the child's parental-reported health is rated as *Excellent* and 0 otherwise. As per the results presented in Tables 2 and 5, the only significant cut-off point across all specifications is the third one, i.e. the threshold that divides parent-reported child health levels *Very Good* and *Excellent*. This provides support for redefining the child reported health variable as a dichotomous variable.

Figure 4 shows the plot of the proportion of children whose health was rated as *Excellent* in both the DV and non-DV household samples. Note that across the three waves there is a consistent gap of around 10 percentage points among the share of families that rate the health of their children as excellent between both types of families.

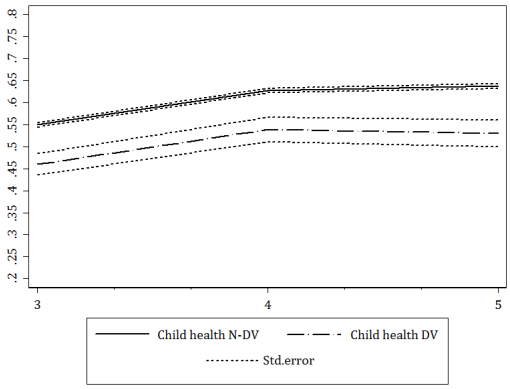


Figure 4. Proportion of children with parental-reported health *Excellent*

We model the relation between latent *Excellent health*, Eh^*, and latent DV, DV^*, as a recursive bivariate probit (Greene & Hensher 2010). Our identification strategy is based on the same set of instruments as in the semi-ordered bivariate ordered probit case:

$$\begin{aligned} EH^*_{it} &= DV_{it,1}\delta_1 + \Psi_{it,1}\beta_1 + c^h_i + e^h_{it}, \qquad \text{EH}_{\text{it}} = 1(\text{EH}^*_{\text{it}} > 0), \\ DV^*_{it} &= Z_{it,2}\delta_2 + \Psi_{it,2}\beta_2 + c^{dv}_i + e^{dv}_{it}, \qquad \text{DV}_{\text{it}} = 1(\text{DV}^*_{\text{it}} > 0) \end{aligned} \tag{9}$$

where EH^*_{it} is the latent dichotomous variable for the parent-reported child health, being 1 if excellent and 0 otherwise and DV^*_{it} is the latent variable for DV. Terms $\Psi_{it,1}$ and $\Psi_{it,2}$ are the set of controls for both functions and c^h_i and c^{dv}_i are child individual factors. Error terms e^h_{it} and e^{dv}_{it} are identically distributed, with a bivariate normal distribution, with a mean of zero and unit variance and correlation coefficient ρ. The value of ρ works

as in the semi-ordered probit section.

In the next section we present the estimation results of the above model and models in which We apply the CM device and for attrition, as in previous sections.

4.3.1 Results: The blow of DV on children's likelihood of being rated as in *Excellent* health

Table 6 provides the results for the bivariate recursive probit. The top panel provides the DV estimates for the first stage equation, i.e. that the child health is rated *Excellent*, (Eh^*_{it}=*1*). The coefficient for DV is negative and statistically significant as in all previous estimation results.

The second panel shows the estimates of the likelihood of the mother experiencing DV ($DV^*_{it} = 1$). The set of instruments used to estimate this equation are significant and positive, consistently with results in table 5. Table 6 also shows the results for the Wald test. Again, we reject the null hypothesis for ρ being equal zero in all specifications. Table 7 in the Appendix shows all estimated coefficients for the first equation on the ordered probit for parental-reported child's health and the second equation on the likelihood of DV.

Table 6: Bivariate Probit Models

	Pooled Biprobit (1)	CM Biprobit (2)	IPW Pooled Biprobit (3)	IPW CM Biprobit (4)
		Probit Excellent health		
Domestic Violence	-1.5832^{***}	-1.6425^{***}	-1.7047^{***}	-1.7654^{***}
	(0.2509)	(0.2375)	(0.2485)	(0.2515)
Controls	X	X	X	X
		Probit Domestic violence		
Relation index	0.0322^{***}	0.0314^{***}	0.0323^{***}	0.0297^{***}
	(0.011)	(0.011)	(0.011)	(0.011)
Unemployment difference	0.0727^{***}	0.0707^{***}	0.0681^{***}	0.0599^{**}
	(0.024)	(0.024)	(0.025)	(0.025)
Controls	X	X	X	X
N	14569	14569	14025	14025
ll	$-1.12e+04$	$-1.12e+04$	$-1.22e+04$	$-1.17e+04$
			Wald test	
ρ	0.6349^{***}	0.6633^{***}	0.68063^{***}	0.7174^{***}
	0.1088	0.1024	0.1074	0.1076

Notes: Standard errors in parentheses. Standard errors are robust to heteroskedasticity and clustered at child level in order to allow for repeated observations over time.
Models are estimated using the unbalanced sample.
Specifications in columns (2) and (4) include the parameterisation of the individual fixed effect as the mean of the exogenous independent variables, as indicated in equation (4).
Columns (3) and (4) include inverse probability weights (IPW) weights
Controls include the set of variables for the child-, parental- and household-related variables: child race, whether the child born with low weight, whether the child is obese or overweight, parental long-standing illness, parental depression, parental smoking, parental education, parental working status, teen mother, parental age, logarithm of household income, whether the family lives in a council house (or in a housing association).
Reference category for child's ethnicity is White. Reference category for parental education is No Education.
Time dummies for years corresponding to each wave are also included.
Significance levels $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 7 presents the summary of APEs of DV on the child's health production function associated to the bivariate recursive probit models presented in Table 6. All partial effects are significant at a level of 1% and negative. All other APEs of the set of controls included in the specifications can be found in Table 9 in the Appendix. The APEs are only reported for the probability of reporting *Excellent* health as specified in the first equation of the bivariate model.

Table 7: Average Partial Effects: Probability Excellent Health

	Pooled Biprobit (1)	CM Biprobit (2)	IPW Pooled Biprobit (3)	IPW CM Biprobit (4)
Domestic Violence	-0.5573^{***}	-0.5751^{***}	-0.5965^{***}	-0.6149^{***}
	(0.0855)	(0.0806)	(0.0840)	(0.0848)

Notes: Standard errors in parentheses. Standard errors calculated by Delta method.
Significance levels $^{+}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

These estimates indicate that children growing up in families in which the mother is battered by the father are between 55% (pooled bivariate recursive model, column (1)) and 61% (IPW bivariate recursive model, column (4)) less likely to have their health rated as *Excellent*. Thus, having corrected for the endogeneity of DV has only increased notably the magnitude of its impact on the parental reported child's health.

5 Conclusion

This paper looks at the relationship between DV and child health, using data from the Millennium Cohort Study, a large longitudinal and exhaustive sample of children representative for the UK. In this study, we bound the definition of DV to cases where a natural mother is battered by the natural father. We overcome several potential sources of bias in our identification strategy. Thus, we break the simultaneity between the two variables of interest (parental child-reported health and self-reported maternal DV) and correct for sample attrition and endogeneity given the categorical nature of the variables.

Exploiting a number of different specifications, we provide robust evidence of the existence of a *negative and significant effect* of DV on the parental-reported child health. First, this result is suggested by a basic ordered probit model. Second, as this naïve

univariate strategy does not account for factors that affect simultaneously DV and child health, we break the simultaneity bias and estimate a bivariate recursive semi-ordered probit. To identify causality, we make use of of two instruments in the probit equation of DV. The first instrument is a proxy for the type of affective relationship between the father and his own parents. The second instrument is the regional difference in unemployment between men and women. The results of the instrumental variable approach corroborate the notably negative and very significant effect of DV on child's health.

Further, to examine the robustness and more precise magnitude of the DV effect on reported child's health, we make use of a bivariate recursive probit model. To do so, we redefine child's health as a dichotomous variable, i,e, being rated as *Excellent* versus not. We base the undertaking of this simplifying approach on results of the ordered probit indicating that only the cut-off between *Excellent* and any other worse health category is sufficient to discriminate child's health. According to the estimates, children living in a household in which there is DV, are between 55% and 61% less likely to have their health rated as *Excellent*.

Our results are in line with the scarce existing literature relating children's health outcomes and DV. Thus, we establish that DV has a negative impact on children's health that goes beyond the compelling negative impact of DV on newborn birth weight.

In conclusion, the main contribution of this paper is to examine and quantify the negative spillover effect of DV on a child's health production function. Recent literature highlights the relationship between child's health and income and/or parental education but little was known about the full extent of environmental stressors such as DV on child's health. Our results provide sound evidence that growing up in a family in which the mother is battered has overwhelming effects on child's health and these results are consistent across all specifications even when we control for potential simultaneity of DV and child's health.

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6 Appendix

Table 1: Child specific variables definition

Variable	Definition
Child health	Parental-reported child health:1 if fair/poor, 2 if good, 3 if very good, 4 if excellent
Female	1 if female, 0 otherwise
Obese	1 if obese, 0 otherwise
Overweight	1 if overweight (and not obese), 0 otherwise
Low birthweight	1 if the child birth weight was lower or equal 2,5 Kg., 0 otherwise
White	1 if child race was white, 0 otherwise
Bang/Ind/Pak	1 if child race was Bangladesi,Indian or Pakistani, 0 otherwise
Black	1 if child race was black, 0 otherwise
Other	1 if child race was stated as other, 0 otherwise
Age	Age in years at 31st December of the current sampling period

Table 2: Parental (mother and father) specific variables definition

Variable	Definition
Long term health conditions	1 if the parent suffers chronic condition, 0 otherwise
Depression	1 if the parent has ever been diagnosed depression, 0 otherwise
Smoking	1 if the parent smoke tobacco, 0 otherwise
Teen mother	1 if mother was a teenager at the time of the child birth
Ever	1 if mother has ever suffered DV
Overweight	1 if the parent has a BMI between 25-29.9 kg/m^2 , 0 otherwise
Obese	1 if the parent has a BMI higher or equal than 30.0 kg/m^2 , 0 otherwise
GCSE grades (D-G) or equivalent	1 if the parent has the GCSE grade (D-G), 0 otherwise
O level or equivalent	1 if the parent has the O level, 0 otherwise
A level or equivalent	1 if the parent has the A level, 0 otherwise
First degree or equivalent	1 if the parent has the First degree, 0 otherwise
Higher degree or equivalent	1 if the parent has a Higher degree, 0 otherwise
Age	Age in years at 31st December of the current sampling period
In work	1 if the parent is working at the time of the questionnaire, 0 otherwise

Table 3: Mother summary statistics

	Age 5			Age 7			Age 11		
	Domestic violence			Domestic violence			Domestic violence		
	No	Yes	*Statistically Significant*	No	Yes	*Statistically Significant*	No	Yes	*Statistically Significant*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Health-related variables									
Long term health problems	0.22	0.31	***	0.23	0.32	***	0.17	0.26	***
Depression	0.27	0.50	***	0.30	0.49	***	0.32	0.55	***
Smoking	0.16	0.24	***	0.14	0.32	***	0.12	0.22	***
Education									
GCSE grades (D-G) or equivalent	0.06	0.09	**	0.06	0.07		0.05	0.09	**
O level or equivalent	0.28	0.25		0.27	0.25		0.24	0.29	
A level or equivalent	0.17	0.18		0.17	0.24	**	0.18	0.19	
First degree or equivalent	0.42	0.39		0.43	0.35	**	0.45	0.32	***
Higher degree or equivalent	0.07	0.08		0.07	0.09		0.09	0.11	
Other socioeconomic variables									
Age	35.50	35.43		37.57	37.04		41.79	41.60	
Teen mother	0.41%	0.47%		0.49%	0.00%		0.35%	0.00%	
In work	0.72	0.72		0.77	0.77		0.82	0.72	***
Households characteristics									
Income	10.32	10.26		10.38	10.24	***	10.39	10.24	***
Council House	0.07	0.12	***	0.06	0.15	***	0.05	0.10	**
N	5840	212		5142	182		3979	134	

Notes: The entries are means of family data who do not have missing values for gender, race, birth weight, weight, month born,mother was a teenager when pregnant,parental long standing illness, parental smoking habits, parental education (GCSE grades (D-G) to Higer Degree or Equivalent), parental age, parental working status, housing income and whether the family lives in a council house or in a housing association.Our sample only includes families where parents are cohabiting.
N stands for the number of observations.
Columns (3), (6) and (9) show the hypotheses testing for the difference in means of each variable between the DV and the non-DV households sub-samples.
Significance levels : $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 4: Father summary statistics

	Age 5			Age 7			Age 11		
	Domestic violence			Domestic violence			Domestic violence		
	No	Yes	*Statistically Significant*	No	Yes	*Statistically Significant*	No	Yes	*Statistically Significant*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Other health-related variables									
Long term health problems	0.23	0.25		0.23	0.30	**	0.16	0.23	**
Depression	0.11	0.26	***	0.14	0.27	***	0.17	0.31	***
Smoking	0.21	0.35	***	0.19	0.36	***	0.15	0.23	**
Education									
GCSE grades (D-G) or equivalent	0.06	0.07		0.06	0.06		0.06	0.08	
O level or equivalent	0.29	0.32		0.27	0.31		0.27	0.32	
A level or equivalent	0.18	0.19		0.18	0.15		0.17	0.15	
First degree or equivalent	0.38	0.34		0.38	0.38		0.39	0.37	
Higher degree or equivalent	0.09	0.08		0.10	0.10		0.12	0.08	
Other socioeconomic variables									
Age	37.82	37.70		39.77	40.12		43.99	44.58	
In work	0.96	0.94		0.96	0.93	+	0.96	0.90	***
Households characteristics									
Income	10.32	10.26		10.38	10.24	***	10.39	10.24	***
Council House	0.07	0.12	***	0.06	0.15	***	0.05	0.10	**
N	5840	212		5142	182		3979	134	

Note: Refer to notes in table 3.
Significance levels : $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 5: Univariate model results

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
Domestic violence	−0.1514***	−0.1526***	−0.1682***	−0.1464**
	(0.0574)	(0.0577)	(0.061)	(0.0603)
Child's Characteristics				
Age	0.02660***	0.007269	0.02700***	−0.002413
	(0.0047)	(0.0422)	(0.0048)	(0.0442)
Low birth weight	−0.1727***	−0.1701***	−0.1742***	−0.1621***
	(0.0515)	(0.0515)	(0.0535)	(0.0534)
Female	0.1070***	0.1069***	0.1081***	0.1108***
	(0.0243)	(0.0244)	(0.0252)	(0.0255)
Bang/Ind/Pak	−0.6076***	−0.5929***	−0.5820***	−0.5789***
	(0.059)	(0.0602)	(0.0636)	(0.0652)
Black	−0.3287***	−0.3166***	−0.2454**	−0.2331**
	(0.1071)	(0.1078)	(0.1084)	(0.1079)
Other	−0.2051***	−0.1943***	−0.1880***	−0.1671**
	(0.0669)	(0.0672)	(0.071)	(0.0725)
Obese	−0.3284***	−0.1306**	−0.3190***	−0.1745**
	(0.0461)	(0.0631)	(0.0484)	(0.0693)
Overweight	−0.06360**	−0.09729**	−0.05880^{+}	−0.1006**
	(0.0301)	(0.0397)	(0.0313)	(0.0421)
Mother's Characteristics				
Long-term health conditions	−0.2401***	−0.2402***	−0.2478***	−0.2408***
	(0.0271)	(0.0273)	(0.0281)	(0.0285)
Depression	−0.1574***	−0.1559***	−0.1525***	−0.1559***
	(0.0265)	(0.0267)	(0.0275)	(0.0277)
Smoking	−0.05457	−0.0194	−0.04906	−0.05564
	(0.0348)	(0.0562)	(0.0366)	(0.059)
O level or equivalent	−0.02752	−0.03601	−0.04849	−0.04759
	(0.0511)	(0.0514)	(0.0539)	(0.0545)
A level or equivalent	0.07801	0.0645	0.05747	0.05805
	(0.0549)	(0.0552)	(0.0574)	(0.0581)
First degree or equivalent	0.1052**	0.08704^{+}	0.08522	0.07659

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Table 5: Univariate Model Results – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
	(0.0517)	(0.0523)	(0.0544)	(0.0552)
Higher degree or equivalent	0.02365	0.006052	0.008497	-0.00862
	(0.0662)	(0.0669)	(0.0694)	(0.0704)
Age	0.003047	0.02287	0.001926	0.01157
	(0.0033)	(0.0283)	(0.0034)	(0.0293)
Teen mother	0.4241**	0.4055**	0.4395**	0.4065+
	(0.185)	(0.1856)	(0.212)	(0.2123)
In work	0.1023***	0.02589	0.1080***	0.03845
	(0.0266)	(0.0353)	(0.0279)	(0.0367)
Father's Characteristics				
Long-term health conditions	−0.1314***	−0.1345***	−0.1349***	−0.1436***
	(0.0272)	(0.0274)	(0.0282)	(0.0288)
Depression	−0.06434+	−0.06487+	−0.04776	−0.04916
	(0.0343)	(0.0347)	(0.0356)	(0.0363)
Smoking	−0.01643	−0.002883	−0.02372	−0.008549
	(0.0318)	(0.0464)	(0.0333)	(0.0496)
O level or equivalent	0.1041**	0.09987+	0.1075+	0.1108**
	(0.0523)	(0.0527)	(0.0552)	(0.0555)
A level or equivalent	0.1125**	0.1042+	0.1139**	0.1130+
	(0.0551)	(0.0554)	(0.0577)	(0.0582)
First degree or equivalent	0.1214**	0.1066**	0.1292**	0.1249**
	(0.0532)	(0.0538)	(0.0558)	(0.0562)
Higher degree or equivalent	0.2454***	0.2224***	0.2414***	0.2290***
	(0.065)	(0.0658)	(0.068)	(0.0686)
Age	0.002232	0.03799**	0.001805	0.03211+
	(0.0029)	(0.0166)	(0.003)	(0.0184)
In work	−0.07508	−0.08638	−0.06549	−0.08442
	(0.0563)	(0.0689)	(0.0589)	(0.0724)
Household Characteristics				
Linc couple	0.1316***	0.007713	0.1428***	0.02844
	(0.023)	(0.0301)	(0.024)	(0.0322)
Council house	−0.04965	0.09754	−0.05599	0.06864

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Table 5: Univariate Model Results – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
	(0.0495)	(0.139)	(0.053)	(0.1403)
Cut1	-0.3366	-0.4564	-0.2828	-0.4381
	(0.2438)	(0.3459)	(0.2543)	(0.3654)
Cut2	0.4468^{+}	0.3306	0.4969^{**}	0.3483
	(0.243)	(0.3452)	(0.2534)	(0.3644)
Cut3	1.4297^{***}	1.3177^{***}	1.4815^{***}	1.3337^{***}
	(0.2428)	(0.345)	(0.2534)	(0.3641)
N	15,713	15,713	14,991	14,991
pseudo R2	0.034	0.0372	0.0337	0.0372
Log likelihood	$-1.41E+04$	$-1.40E+04$	$-1.47E+04$	$-1.42E+04$

Notes:

Standard errors in parentheses. Standard errors are robust to heteroskedasticity and clustered at child level in order to allow for repeated observations over time.

Models are estimated using the unbalanced sample.

Specifications in columns (2) and (4) include the parameterisation of the individual fixed effect as the mean of any of the exogenous independent variables, as indicated in equation (4).

Columns (3) and (4) include inverse probability weights (IPW) to adjust for attrition.

Controls include the set of variables for the child-, parental- and household-related variables: child race, whether the child born with low weight, whether the child is obese or overweight, parental long-standing illness, parental depression, parental smoking, parental education, parental working status, teen mother, parental age, logarithm of household income, whether the family lives in a council house (or in a housing association).

Reference category for child's ethnicity is White. Reference category for parental education is No Education.

Time dummies for years corresponding to each wave are also included.

Significance levels $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 6: APEs Probability Excellent Health: Univariate models

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
Domestic violence	-0.057^{***}	-0.057^{***}	-0.063^{***}	-0.055^{**}
	(0.022)	(0.022)	(0.023)	(0.023)
Child's Characteristics				
Age	0.010^{***}	0.003	0.010^{***}	-0.001
	(0.002)	(0.016)	(0.002)	(0.017)
Low birth weight	-0.065^{***}	-0.064^{***}	-0.065^{***}	-0.061^{***}
	(0.019)	(0.019)	(0.020)	(0.020)
Female	0.040^{***}	0.040^{***}	0.040^{***}	0.041^{***}
	(0.009)	(0.009)	(0.009)	(0.009)
Bang/Ind/Pak	-0.228^{***}	-0.222^{***}	-0.218^{***}	-0.217^{***}
	(0.022)	(0.023)	(0.029)	(0.024)
Black	-0.123^{***}	-0.119^{***}	-0.092^{**}	-0.087^{**}
	(0.040)	(0.040)	(0.041)	(0.040)
Other	-0.077^{***}	-0.073^{***}	-0.070^{***}	-0.063^{**}
	(0.025)	(0.025)	(0.027)	(0.027)
Obese	-0.123^{***}	-0.049^{**}	-0.120^{***}	-0.065^{**}
	(0.017)	(0.024)	(0.018)	(0.026)
Overweight	-0.024^{**}	-0.036^{**}	-0.022^{+}	-0.038^{**}
	(0.011)	(0.0145)	(0.018)	(0.017)
Mother's Characteristics				
Long-term health conditions	-0.090^{***}	-0.090^{***}	-0.092^{***}	-0.090^{***}
	(0.010)	(0.010)	(0.011)	(0.011)
Depression	-0.059^{***}	-0.058^{***}	-0.057^{***}	-0.058^{***}
	(0.010)	(0.010)	(0.010)	(0.010)
Smoking	-0.020	-0.007	-0.018	-0.021
	(0.013)	(0.021)	(0.014)	(0.022)
O level or equivalent	-0.010	-0.014	-0.018	-0.018
	(0.019)	(0.019)	(0.020)	(0.020)
A level or equivalent	0.029	0.024	0.022	0.022
	(0.021)	(0.021)	(0.021)	(0.022)
First degree or equivalent	0.039^{**}	0.033^{+}	0.032	0.029

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Table 6: APEs Probability Excellent Health: Univariate models – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
	(0.019)	(0.020)	(0.020)	(0.021)
Higher degree or equivalent	0.009	0.002	0.003	-0.003
	(0.025)	(0.025)	(0.026)	(0.026)
Age	0.001	0.009	0.001	0.004
	(0.001)	(0.011)	(0.001)	(0.011)
Teen mother	0.159**	0.152**	0.164**	0.152+
	(0.069)	(0.069)	(0.079)	(0.079)
In work	0.038***	0.010	0.040***	0.014
	(0.010)	(0.013)	(0.010)	(0.014)
Father's Characteristics				
Long-term health conditions	−0.049***	−0.050***	−0.050***	−0.054***
	(0.010)	(0.010)	(0.011)	(0.011)
Depression	−0.024+	−0.024+	-0.018	-0.018
	(0.013)	(0.013)	(0.013)	(0.014)
Smoking	-0.006	-0.001	-0.009	-0.003
	(0.012)	(0.017)	(0.012)	(0.019)
O level or equivalent	0.039**	0.037+	0.040+	0.041**
	(0.020)	(0.020)	(0.021)	(0.021)
A level or equivalent	0.042**	0.039+	0.043**	0.042+
	(0.021)	(0.021)	(0.022)	(0.028)
First degree or equivalent	0.046**	0.040**	0.048**	0.047**
	(0.020)	(0.020)	(0.021)	(0.021)
Higher degree or equivalent	0.092***	0.083***	0.090***	0.086***
	(0.024)	(0.025)	(0.025)	(0.026)
Age	0.001	0.014**	0.001	0.012+
	(0.001)	(0.006)	(0.001)	(0.007)
In work	-0.028	-0.032	-0.025	-0.032
	(0.0211)	(0.026)	(0.022)	(0.027)
Household characteristics				
Linc couple	0.049***	0.003	0.053	0.011
	(0.009)	(0.011)	(0.009)	(0.012)
Council house	-0.019	0.037	-0.021	0.027

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Table 6: APEs Probability Excellent Health: Univariate models – Continued

	Pooled Oprobit	CM Oprobit	IPW Pooled Oprobit	IPW CM Oprobit
	(1)	(2)	(3)	(4)
	(0.019)	(0.052)	(0.020)	(0.056)

Notes:

Standard errors in parentheses. Standard errors calculated by Delta method.

Significance levels: $^{+}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

Coefficients of the averaged exogenous variables in the CM device are estimated but not reported here.

Table 7: Semi-ordered probit

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
	Ordered Probit Excellent Health			
Domestic violence	−0.9178***	−0.8881***	−1.0074***	−0.9635***
	(0.3355)	(0.3225)	(0.3384)	(0.3641)
Child's Characteristics				
Age	0.02591***	−0.00357	0.02585***	0.0001057
	(0.0049)	(0.0443)	(0.005)	(0.0466)
Low birth weight	−0.1420***	−0.1415***	−0.1409**	−0.1298**
	(0.0529)	(0.053)	(0.0553)	(0.0559)
Female	0.1018***	0.1014***	0.1008***	0.1034***
	(0.0253)	(0.0254)	(0.0262)	(0.0266)
Bang/Ind/Pak	−0.5617***	−0.5473***	−0.5475***	−0.5376***
	(0.0622)	(0.0634)	(0.0668)	(0.0687)
Black	−0.3097***	−0.2943**	−0.2225+	−0.2267+
	(0.1162)	(0.1172)	(0.1251)	(0.1275)
Other	−0.1808**	−0.1716**	−0.1676**	−0.1362+
	(0.0725)	(0.0728)	(0.0759)	(0.0767)
Obese	−0.3043***	−0.1135+	−0.2897***	−0.1548**
	(0.0483)	(0.066)	(0.051)	(0.0726)
Overweight	−0.05730+	−0.1012**	−0.04332	−0.09284**
	(0.0313)	(0.0412)	(0.0325)	(0.0442)
Mother's Characteristics				
Long-term health conditions	−0.2270***	−0.2294***	−0.2331***	−0.2345***
	(0.0292)	(0.0293)	(0.0303)	(0.0308)
Depression	−0.1366***	−0.1362***	−0.1253***	−0.1300***
	(0.0284)	(0.0285)	(0.0295)	(0.0299)
Smoking	−0.04828	−0.04433	−0.04014	−0.09262
	(0.0367)	(0.0584)	(0.0386)	(0.0626)
O level or equivalent	−0.06073	−0.06652	−0.06785	−0.04642
	(0.0536)	(0.0539)	(0.056)	(0.057)
A level or equivalent	0.05592	0.04668	0.05471	0.0797
	(0.0571)	(0.0574)	(0.0594)	(0.0604)

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Table 7: Semi-ordered probit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
First degree or equivalent	0.07395	0.06253	0.07286	0.09065
	(0.054)	(0.0546)	(0.0563)	(0.0576)
Higher degree or equivalent	−0.005385	−0.01553	−0.004737	0.001508
	(0.0695)	(0.0702)	(0.0727)	(0.0738)
Age	0.003309	0.01815	0.002517	−0.003112
	(0.0035)	(0.0296)	(0.0036)	(−0.031)
Teen mother	0.5654**	0.5537**	0.6350**	0.5790+
	(0.2107)	(0.212)	(0.2476)	(0.2405)
In work	0.09964***	0.02098	0.1070***	0.03771
	(0.0278)	(0.0367)	(0.0291)	(0.0385)
Father's Characteristics				
Long-term health conditions	−0.1130***	−0.1168***	−0.1151***	−0.1183***
	(0.0285)	(0.0287)	(0.0294)	(0.0301)
Depression	−0.03695	−0.03976	−0.01638	−0.01964
	(0.0367)	(0.0369)	(0.0381)	(0.0387)
Smoking	0.004109	0.02184	−0.0003034	0.01032
	(0.0333)	(0.0485)	(0.0349)	(0.0526)
O level or equivalent	0.09998+	0.09788+	0.1043+	0.1045+
	(0.0543)	(0.0546)	(0.0571)	(0.0566)
A level or equivalent	0.1153 ∗ ∗	0.1090+	0.1167+	0.1100+
	(0.057)	(0.0573)	(0.0598)	(0.0593)
First degree or equivalent	0.1387**	0.1289**	0.1479**	0.1421**
	(0.0551)	(0.0557)	(0.0575)	(0.0572)
Higher degree or equivalent	0.2522***	0.2361***	0.2476***	0.2293***
	(0.068)	(0.0688)	(0.071)	(0.071)
Age	0.00249	0.04999***	0.002073	0.04496**
	(0.0031)	(0.0177)	(0.0032)	(0.0197)
In work	−0.08978	−0.07785	−0.08363	−0.07758
	(0.0588)	(0.0723)	(0.0631)	(0.076)
Household Characteristics				
Linc couple	0.1211***	0.02261	0.1282***	0.03287
	(0.0238)	(0.0315)	(0.0247)	(0.0339)

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Table 7: Semi-ordered probit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
Council house	−0.04639	0.0412	−0.02404	0.03343
	(0.0539)	(0.1471)	(0.0578)	(0.1523)
		Probit Domestic Violence		
Relation index	0.03031**	0.02928**	0.03054**	0.02799+
	(0.0144)	(0.0146)	(0.0154)	(0.0154)
Unemployment difference	0.06563**	0.06523**	0.05969**	0.05355+
	(0.0281)	(0.0289)	(0.0295)	(0.0293)
Child's Characteristics				
Age	−0.01703+	−0.2189***	−0.02062+	−0.2215**
	(0.0102)	(0.0835)	(0.0108)	(0.0902)
Low birth weight	0.03785	0.0117	0.05522	0.02823
	(0.1037)	(0.106)	(0.1123)	(0.1161)
Female	−0.05842	−0.05629	−0.05233	−0.05408
	(0.0527)	(0.0534)	(0.0565)	(0.0565)
Bang/Ind/Pak	0.1302	0.1525	0.03112	0.05222
	(0.1376)	(0.1404)	(0.1368)	(0.1368)
Black	−0.154	−0.1678	−0.1149	−0.1765
	(0.2437)	(0.2394)	(0.2454)	(0.2423)
Other	0.173	0.177	0.1804	0.1737
	(0.1262)	(0.1279)	(0.1327)	(0.1327)
Obese	0.1595+	0.173	0.2101**	0.1776
	(0.0961)	(0.1147)	(0.1052)	(0.1278)
Overweight	0.01236	0.04455	0.02109	0.0676
	(0.0669)	(0.0789)	(0.0725)	(0.0849)
Mother's Characteristics				
Long-term health conditions	0.1491***	0.1425***	0.1598***	0.1371**
	(0.0528)	(0.0529)	(0.0574)	(0.0571)
Depression	0.2970***	0.2912***	0.3054***	0.3223***
	(0.0548)	(0.0553)	(0.0589)	(0.0586)
Smoking	0.2001***	−0.0843	0.2220***	−0.09717
	(0.067)	(0.1065)	(0.0725)	(0.1182)

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Table 7: Semi-ordered probit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
O level or equivalent	−0.2521**	−0.2497**	−0.2531**	−0.2435+
	(0.1169)	(0.1191)	(0.1252)	(0.1271)
A level or equivalent	−0.0828	−0.07984	−0.08877	−0.04252
	(0.1231)	(0.1258)	(0.1319)	(0.1343)
First degree or equivalent	−0.1924	−0.1808	−0.1859	−0.1739
	(0.1212)	(0.1241)	(0.1298)	(0.1337)
Higher degree or equivalent	−0.01516	−0.0045	0.004374	−0.00187
	(0.1412)	(0.144)	(0.1511)	(0.1534)
Age	0.00137	−0.01184	−0.0001963	−0.01347
	(0.0073)	(0.0522)	(0.008)	(0.057)
Teen mother	−0.3417	−0.4287	−0.4199	−0.5187
	(0.4622)	(0.4612)	(0.4589)	(0.4748)
In work	0.03567	−0.07826	0.05264	−0.05888
	(0.0577)	(0.0762)	(0.0627)	(0.0827)
Father's Characteristics				
Long-term health conditions	0.01213	0.00626	0.001162	−0.004783
	(0.057)	(0.0582)	(0.0613)	(0.0619)
Depression	0.2746***	0.2568***	0.3035***	0.2760***
	(0.0653)	(0.0667)	(0.0705)	(0.0717)
Smoking	0.1724***	−0.03045	0.1618**	−0.04939
	(0.0622)	(0.1003)	(0.0662)	(0.1074)
O level or equivalent	0.07559	0.0698	0.1014	0.03766
	(0.0996)	(0.1)	(0.1072)	(0.1059)
A level or equivalent	−0.03449	−0.03059	−0.007374	−0.03322
	(0.1091)	(0.11)	(0.1184)	(0.117)
First degree or equivalent	0.05429	0.06408	0.0819	0.06951
	(0.1022)	(0.1027)	(0.1092)	(0.1081)
Higher degree or equivalent	−0.03815	−0.01777	0.003646	−0.02156
	(0.1313)	(0.1323)	(0.1388)	(0.1376)
Age	0.007907	0.1051***	0.01158	0.09495**
	(0.0065)	(0.0366)	(0.0073)	(0.0392)
In work	−0.03841	0.1062	−0.04425	0.08278

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Table 7: Semi-ordered probit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
	(0.1092)	(0.135)	(0.1194)	(0.139)
Household Characteristics				
Linc couple	−0.05941	−0.04453	−0.06588	−0.06833
	(0.0478)	(0.0585)	(0.052)	(0.0646)
Council house	0.09199	−0.2202	0.1403	−0.1691
	(0.0994)	(0.1626)	(0.1071)	(0.2008)
Cut11	-0.4599^{+}	-0.6748^{+}	−0.415	−0.6187
	(0.2522)	(0.3575)	(0.2632)	(0.379)
Cut12	0.3187	0.1079	0.3581	0.1656
	(0.2513)	(0.3563)	(0.2622)	(0.3776)
Cut13	1.2981^{***}	1.0919^{***}	1.3346^{***}	1.1435^{***}
	(0.2516)	(0.356)	(0.2626)	(0.3774)
Cut21	1.6281^{***}	1.9641^{***}	1.6788^{***}	2.0731^{***}
	(0.5202)	(0.7394)	(0.5511)	(0.7705)
N	14569	14569	14025	14025
ll	$-1.50E+04$	$-1.49E+04$	$-1.62E+04$	$-1.57E+04$

Standard errors in parentheses. Standard errors are robust to heteroskedasticity and clustered at child level in order to allow for repeated observations over time.

Models are estimated using the unbalanced sample.

Specifications in columns (2) and (4) include the parameterisation of the individual fixed effect as the mean of any of the exogenous independent variables, as indicated in equation (4).

Columns (3) and (4) include weights to adjust for attrition.

Controls include the set of variables for the child-, parental- and household-related variables: child race, whether the child born with low weight, whether the child is obese or overweight, parental self-assessed health, parental long-standing illness, parental depression, parental smoking, parental education, parental working status, teen mother, parental age, logarithm of household income, whether the family lives in a council house (or in a housing association).

Reference category for child's ethnicity is White. Reference category for parental education is No Education.

Time dummies for years corresponding to each wave are also included.

Significance levels $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 8: Biprobit

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
		Probit Excellent Health		
Domestic violence	-1.5832^{***}	-1.6425^{***}	-1.7047^{***}	-1.7654^{***}
	(0.2509)	(0.2375)	(0.2485)	(0.2515)
Child's Characteristics				
Age	$0.02695**$	-0.01356	$0.02670**$	-0.004258
	(0.0051)	(0.0434)	(0.0052)	(0.0454)
Low birth weight	$-0.1163**$	$-0.1174**$	$-0.1163**$	$-0.1023**$
	(0.0453)	(0.0453)	(0.0476)	(0.048)
Female	$0.1012**$	$0.1013**$	$0.09845**$	$0.1023**$
	(0.0214)	(0.0215)	(0.0222)	(0.0226)
Bang/Ind/Pak	$-0.5991**$	$-0.5792**$	$-0.5928**$	$-0.5726**$
	(0.0619)	(0.0623)	(0.0664)	(0.0681)
Black	$-0.3159**$	$-0.3000**$	$-0.2363+$	$-0.2581**$
	(0.1176)	(0.1171)	(0.1309)	(0.1302)
Other	$-0.1481**$	$-0.1375**$	$-0.1288**$	-0.09172
	(0.0599)	(0.0599)	(0.0622)	(0.0621)
Obese	$-0.2826**$	-0.07839	$-0.2652**$	-0.119
	(0.0478)	(0.0832)	(0.0505)	(0.0884)
Overweight	$-0.06469**$	$-0.09911**$	$-0.05128+$	$-0.09013+$
	(0.0298)	(0.0492)	(0.0307)	(0.0513)
Mother's Characteristics				
Long-term health conditions	-0.1863^{***}	-0.1870^{***}	-0.1902^{***}	-0.1901^{***}
	(0.0266)	(0.0267)	(0.0277)	(0.0285)
Depression	-0.1232^{***}	-0.1227^{***}	-0.1099^{***}	-0.1168^{***}
	(0.0247)	(0.0247)	(0.0255)	(0.0262)
Smoking	-0.0153	-0.0357	-0.01055	-0.08271
	(0.0338)	(0.0689)	(0.0353)	(0.0742)
O level or equivalent	-0.08120^{+}	-0.08687^{+}	-0.09161^{+}	-0.06462
	(0.0487)	(0.0489)	(0.0504)	(0.0532)
A level or equivalent	0.05511	0.04676	0.05277	0.08396
	(0.0515)	(0.0517)	(0.0532)	(0.0559)

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Table 8: Biprobit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
First degree or equivalent	0.06541	0.05496	0.06724	0.09046^{+}
	(0.0491)	(0.0494)	(0.0507)	(0.054)
Higher degree or equivalent	−0.01116	−0.01982	−0.006216	0.003441
	(0.062)	(0.0624)	(0.0643)	(0.067)
Age	0.002505	0.01463	0.001746	−0.002817
	(0.003)	(0.0317)	(0.0032)	(0.0328)
Teen mother	0.5406**	0.5214**	0.6057**	0.5426^{+}
	(0.1931)	(0.1932)	(0.2246)	(0.2181)
In work	0.07344***	0.01857	0.07683 $*$ $**$	0.03756
	(0.0258)	(0.0463)	(0.0268)	(0.0486)
Father's characteristics				
Long-term health conditions	−0.1245***	−0.1273***	−0.1236***	−0.1288***
	(0.0268)	(0.0269)	(0.0277)	(0.0287)
Depression	−0.03578	−0.03802	−0.01462	−0.0143
	(0.0326)	(0.0326)	(0.0339)	(0.0346)
Smoking	0.004428	0.01859	0.006878	−0.007868
	(0.0301)	(0.0571)	(0.0314)	(0.0638)
O level or equivalent	0.08124^{+}	0.07928^{+}	0.08027^{+}	0.08486^{+}
	(0.0468)	(0.0469)	(0.0485)	(0.0493)
A level or equivalent	0.06292	0.05513	0.05905	0.05732
	(0.0494)	(0.0495)	(0.0513)	(0.0521)
First degree or equivalent	0.1014**	0.09112^{+}	0.1016**	0.1045**
	(0.0474)	(0.0477)	(0.049)	(0.05)
Higher degree or equivalent	0.2213***	0.2040***	0.2108***	0.1941***
	(0.0579)	(0.0583)	(0.0598)	(0.0615)
Age	0.0022	0.06381***	0.001914	0.05273***
	(0.0027)	(0.0182)	(0.0028)	(0.0204)
In work	−0.09214	−0.08025	−0.09299	−0.0966
	(0.0583)	(0.0939)	(0.0615)	(0.0971)
Household characteristics				
Linc couple	0.1135***	0.01207	0.1236***	0.01724

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Table 8: Biprobit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
	(0.0221)	(0.0409)	(0.0228)	(0.0425)
Council house	−0.05608	0.06208	−0.0254	0.05738
	(0.049)	(0.1734)	(0.0523)	(0.1818)
		Probit Domestic violence		
Relation index	0.03222 ∗ ∗∗	0.03142∗∗∗	0.03233∗∗∗	0.02967∗∗∗
	(0.0106)	(0.0106)	(0.0112)	(0.0112)
Unemployment difference	0.07272 ∗ ∗∗	0.07071 ∗ ∗∗	0.06812 ∗ ∗∗	0.05985 ∗ ∗
	(0.0238)	(0.0241)	(0.0247)	(0.0245)
Child's characteristics				
Age	−0.01823+	−0.2277∗∗∗	−0.02204∗∗	−0.2310∗∗∗
	(0.0097)	(0.073)	(0.01)	(0.078)
Low birth weight	0.02878	−0.001551	0.04213	0.01236
	(0.0818)	(0.0821)	(0.0903)	(0.0925)
Female	−0.05916	−0.05539	−0.05242	−0.05232
	(0.0403)	(0.0405)	(0.0429)	(0.0431)
Bang/Ind/Pak	0.1361	0.1639	0.04322	0.07112
	(0.1204)	(0.1219)	(0.1335)	(0.1321)
Black	−0.1629	−0.1741	−0.1504	−0.179
	(0.2505)	(0.2423)	(0.2439)	(0.2416)
Other	0.1637+	0.1628+	0.1730+	0.1623
	(0.0989)	(0.0985)	(0.103)	(0.1005)
Obese	0.1550+	0.1483	0.1946 ∗ ∗	0.1443
	(0.0819)	(0.1428)	(0.0886)	(0.1501)
Overweight	0.01996	0.05023	0.033	0.07793
	(0.0571)	(0.0927)	(0.0607)	(0.0971)
Mother's characteristics				
Long-term health conditions	0.1517 ∗ ∗∗	0.1428 ∗ ∗∗	0.1611 ∗ ∗∗	0.1371 ∗ ∗∗
	(0.0461)	(0.046)	(0.0491)	(0.0493)
Depression	0.2935 ∗ ∗∗	0.2874 ∗ ∗∗	0.2998 ∗ ∗∗	0.3150 ∗ ∗∗
	(0.0434)	(0.0434)	(0.0466)	(0.0468)
Smoking	0.2078 ∗ ∗∗	−0.07555	0.2342 ∗ ∗∗	−0.07592
	(0.0561)	(0.1176)	(0.0606)	(0.1264)

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Table 8: Biprobit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
O level or equivalent	−0.2567 * **	−0.2577 * **	−0.2606 * **	−0.2562 * **
	(0.0855)	(0.0861)	(0.0914)	(0.0931)
A level or equivalent	−0.08768	−0.09043	−0.09517	−0.05562
	(0.0897)	(0.0907)	(0.096)	(0.0978)
First degree or equivalent	−0.2018 * *	−0.1958 * *	−0.1998 * *	−0.1951 * *
	(0.0875)	(0.0883)	(0.0932)	(0.0958)
Higher degree or equivalent	−0.01868	−0.01092	−0.006704	−0.01388
	(0.1078)	(0.1089)	(0.1138)	(0.1161)
Age	0.001911	−0.0163	0.0007257	−0.0106
	(0.0056)	(0.0501)	(0.0061)	(0.0533)
Teen mother	−0.2467	−0.332	−0.2986	−0.3915
	(0.4477)	(0.4439)	(0.4418)	(0.4504)
In work	0.03265	−0.08546	0.05037	−0.06169
	(0.0483)	(0.0876)	(0.0515)	(0.0919)
Father's characteristics				
Long-term health conditions	−0.001559	−0.01168	−0.01043	−0.02251
	(0.0493)	(0.0499)	(0.0529)	(0.0538)
Depression	0.2617 * **	0.2394 * **	0.2852 * **	0.2560 * **
	(0.0526)	(0.0533)	(0.0575)	(0.0589)
Smoking	0.1636 * **	−0.063	0.1482 * **	−0.09117
	(0.052)	(0.1069)	(0.0553)	(0.1163)
O level or equivalent	0.06114	0.05147	0.08112	0.01257
	(0.0875)	(0.0868)	(0.094)	(0.0923)
A level or equivalent	−0.05162	−0.05043	−0.03411	−0.0631
	(0.094)	(0.0934)	(0.102)	(0.1001)
First degree or equivalent	0.04277	0.05076	0.06425	0.04871
	(0.089)	(0.0883)	(0.0949)	(0.0936)
Higher degree or equivalent	−0.02971	−0.00781	0.003309	−0.01988
	(0.1109)	(0.111)	(0.1158)	(0.1146)
Age	0.008793+	0.1007 * **	0.01250 * *	0.08430 * *
	(0.005)	(0.0329)	(0.0055)	(0.0361)
In work	−0.02962	0.1729	−0.04115	0.1568

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Table 8: Biprobit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
	(0.0971)	(0.186)	(0.1029)	(0.1838)
Household characteristics				
Linc couple	−0.07498+	−0.07878	−0.08451+	−0.1054
	(0.042)	(0.0798)	(0.0453)	(0.0851)
Council house	0.0792	−0.225	0.1243	−0.1677
	(0.081)	(0.233)	(0.0882)	(0.2528)
N	14569	14569	14025	14025
ll	$-1.12E+04$	$-1.12E+04$	$-1.22E+04$	$-1.17E+04$

Standard errors in parentheses. Standard errors are robust to heteroskedasticity and clustered at child level in order to allow for repeated observations over time.

Models are estimated using the unbalanced sample.

Specifications in columns (2) and (4) include the parameterisation of the individual fixed effect as the mean of any of the exogenous independent variables, as indicated in equation (4).

Columns (3) and (4) include weights to adjust for attrition.

Controls include the set of variables for the child-, parental- and household-related variables: child race, whether the child born with low weight, whether the child is obese or overweight, parental self-assessed health, parental long-standing illness, parental depression, parental smoking, parental education, parental working status, teen mother, parental age, logarithm of household income, whether the family lives in a council house (or in a housing association).

Reference category for child's ethnicity is White. Reference category for parental education is No Education.

Time dummies for years corresponding to each wave are also included.

Significance levels $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 9: APEs Probit Excellent Health: Biprobit

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
Domestic violence	−0.5572775 * **	−0.5751322 * **	−0.5964716 * **	−0.6148904 * **
	(0.0855266)	(0.0805826)	(0.0840423)	(0.0848062)
Child's characteristics				
Age	0.0094873 * **	−0.0047476	0.0093411 * **	−0.001483
	(0.0017964)	(0.0151926)	(0.0018133)	(0.0158039)
Low birth weight	−0.0409524 * **	−0.041099 * **	−0.0406902 * *	−0.0356173 * *
	(0.0159528)	(0.0158606)	(0.016647)	(0.016736)
Female	0.0356235 * **	0.0354547 * **	0.0344487 * **	0.0356232 * **
	(0.0075445)	(0.0075193)	(0.0077636)	(0.0078809)
Bang/Ind/Pak	−0.2108687 * **	−0.2028115 * **	−0.2074025 * **	−0.1994472 * **
	(0.0217318)	(0.0217669)	(0.0231329)	(0.0236229)
Black	−0.1111791 * **	−0.1050319 * **	−0.0826964+	−0.0898819 * *
	(0.0413521)	(0.0409744)	(0.0457735)	(0.0453427)
Other	−0.0521137	−0.0481512 * *	−0.0450616 * *	−0.0319448
	(0.021076 * **)	(0.0209833)	(0.0217858)	(0.021616)
Obese	−0.0994731	−0.027448	−0.0927943 * **	−0.0414312
	(0.0168301)	(0.029122)	(0.0176618)	(0.0307848)
Overweight	−0.0227703 * *	−0.0347034 * *	−0.0179442+	−0.0313912+
	(0.0104682)	(0.0172349)	(0.0107483)	(0.0178784)
Mother's characteristics				
Long term health conditions	−0.0655675 * **	−0.065489 * **	−0.0665373 * **	−0.0662035 * **
	(0.0093893)	(0.0093562)	(0.0097038)	(0.0099213)
Depression	−0.0433822 * **	−0.0429497 * **	−0.0384429 * **	−0.0406766 * **
	(0.0087077)	(0.0086531)	(0.0089447)	(0.0091548)
Smoking	−0.005385	−0.012502	−0.0036911	−0.0288099
	(0.0118929)	(0.0241126)	(0.0123442)	(0.0258487)
O level or equivalent	−0.028582+	−0.0304173+	−0.0320547+	−0.0225067
	(0.0171403)	(0.0170987)	(0.0176247)	(0.0185216)
A level or equivalent	0.0193983	0.0163748	0.0184654	0.0292424
	(0.0181157)	(0.0180918)	(0.0186003)	(0.0194572)
First degree or equivalent	0.0230227	0.0192438	0.0235283	0.0315087+
	(0.0172859)	(0.0173039)	(0.017757)	(0.0188158)
Higher degree or equivalent	−0.003928	−0.0069392	−0.0021751	0.0011985
	(0.0218345)	(0.021834)	(0.0224952)	(0.0233257)
Age	0.0008818	0.0051224	0.0006109	−0.0009811
	(0.0010661)	(0.0111024)	(0.0011087)	(0.0114411)
Teen mother	0.1902741 * *	0.1825797 * *	0.2119376 * *	0.1889817+
	(0.0680348)	(0.0676958)	(0.0786185)	(0.0760014)
In work	0.0258518 * **	0.0065015	0.0268811 * **	0.013082
	(0.0090654)	(0.0162168)	(0.0093674)	(0.0169438)
Father's characteristics				

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Table 9: APEs Probit Excellent Health: Biprobit – Continued

	Pooled Oprobit (1)	CM Oprobit (2)	IPW Pooled Oprobit (3)	IPW CM Oprobit (4)
Long term health conditions	−0.0438244 * **	−0.0445819 * **	−0.0432448 * **	−0.0448529 * **
	(0.009434)	(0.0094282)	(0.0096873)	(0.0099792)
Depression	−0.0125929	−0.0133117	−0.0051142	−0.0049794
	(0.0114885)	(0.0114296)	(0.0118604)	(0.0120649)
Smoking	0.0015585	0.0065102	0.0024066	−0.0027406
	(0.010589)	(0.0200005)	(0.0109724)	(0.0222244)
O level or equivalent	0.0285943+	0.027762+	0.0280863+	0.0295577+
	(0.01645)	(0.0164006)	(0.0169628)	(0.0171531)
A level or equivalent	0.0221478	0.0193034	0.0206609	0.019966
	(0.0173964)	(0.0173423)	(0.0179398)	(0.0181282)
First degree or equivalent	0.0356832+	0.0319084+	0.0355619 * *	0.0364039 * *
	(0.0166899)	(0.016702)	(0.017152)	(0.0173911)
Higher degree or equivalent	0.0778886 * **	0.0714194 * **	0.0737748 * *	0.0676135 * **
	(0.0203771)	(0.0204052)	(0.0209157)	(0.0214138)
Age	0.0007745	0.0223429 * **	0.0006696	0.0183671 * **
	(0.0009463)	(0.006347)	(0.0009826)	(0.0070793)
In work	−0.0324336	−0.0280989	−0.032538	−0.0336463
	(0.0205211)	(0.032863)	(0.021526)	(0.0338082)
Household's characteristics				
Linc couple	0.0399338 * **	0.0042254	0.0432501 * *	0.0060034
	(0.0077609)	(0.0143136)	(0.0079691)	(0.014795)
Council house	−0.0197385	0.0217391	−0.0088891	0.0199857
	(0.0172558)	(0.0607127)	(0.0182873)	(0.0633082)

Notes:

Standard errors in parentheses. Standard errors calculated by Delta method.

Significance levels $^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Coefficients of the second equation and the averaged exogenous variables in the CM device are estimated but not reported here.