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Understanding the Relationship between Parental Income and Multiple Child Outcomes: a decomposition analysis

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Abstract
In this paper we explore the association between family income and children's cognitive ability (IQ and school performance), socio-emotional outcomes (self esteem, locus of control and behavioural problems) and physical health (risk of obesity). We develop a decomposition technique that allows us to compare the relative importance of the adverse family characteristics and home environments of low income children in accounting for different outcomes. Using rich cohort data from the UK we find that poor children are disadvantaged at age 7 to 9 across the full spectrum of outcomes, the gradient being strongest for cognitive outcomes and weakest for physical health. We find that some aspects of environment appear to be associated with the full range of outcomes - for example, maternal smoking and breastfeeding, child nutrition, parental psychological functioning. We also find some some aspects of the environment of higher income households hinder child development. We conclude that many aspects of growing up in poverty are harmful to children's development, and that narrowly-targeted interventions are unlikely to have a significant impact on intergenerational mobility.

Keywords: Child outcomes, income, pathways, mediating factors

JEL Classification: I12; I31; I32; J13

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1. Introduction

Understanding what drives the deficits of poor children is of key importance to academics interested in the process of life cycle skill formation and to policymakers concerned with intergenerational social mobility. A large body of research has documented the cognitive ability and socio-emotional deficits of low-income children (e.g. Duncan and Brooks-Gunn, 1997; Duncan et al., 1994; Dearing et al., 2001; Taylor et al., 2004). More recently, attention has turned to deficits in non-cognitive skills, including self esteem, outlook on life, motivation and persistence (e.g. Heckman, Urzua and Stixrud, 2006; Blanden et al. 2007).

A considerable focus of research has been to isolate the impact of income on these outcomes. Many studies find that the direct income effect is only a moderate part of the observed relationship between low income and child development (e.g. Blau, 1999; Morris and Gennetian, 2003, Dahl and Lockner, 2005). A much smaller set of studies have examined how income is translated into better childhood outcomes (e.g. Guo and Harris 2000; Yeung et al, 2002).

Quantifying the causal effect of income is clearly important, as is understanding how it translates into outcomes. But a focus solely on income leaves unanswered questions about what it is, if not lack of income, that accounts for the poorer outcomes of low-income children. In this paper we propose and implement a decomposition analysis that allows us to examine both the impact of income in comparison to other aspects of family disadvantage and how these measures of disadvantage, including income, are associated with the behaviours of parents and the immediate environment in which children live. We do this for a range of childhood outcomes within a single unified model. Our approach is informed by ecological models of child development and utilises the distinction between distal and proximal factors as an organising concept. This approach permits us to compare the impact of income with other correlated measures of parental disadvantage, to examine what aspects of environment matter for which outcomes using the same measures of environment for a range of outcomes, and to identify the direct role of income compared to other aspects of parents' disadvantage and behaviour. We do not claim that the associations we find are causal. Our aim is instead to provide a comprehensive description of the circumstances in which different types of developmental deficits arise among low-income children using common definitions of income, family characteristics, environment and parental behaviours.

To implement this approach we use a cohort data set that contains measures of a large number of outcomes for children in middle childhood. The outcomes we examine are cognitive ability (IQ and school performance), socio-emotional outcomes (self esteem, locus of control and behavioural problems) and physical health (risk of obesity). These have not been analysed simultaneously in research to date. Our data (the ALSPAC cohort from the UK) also contain considerable detail on environmental risk factors and measures of parental advantage and disadvantage. The richness of our data allows us to explore the role of a wider variety of proximal factors than in previous research and our methodology enables us to summarise the relative importance of these numerous factors in a way that is easily comparable across outcomes.

We find that children in low-income households are disadvantaged across the full spectrum of outcomes compared with their better-off counterparts. However, different aspects of the socio-economic disadvantage that underlie parental poverty vary markedly in their association with different outcomes. We find that the child care and school environments are negligible in importance compared with the role of the home environment provided by low income parents for outcomes at ages up to 8. We find, in common with earlier research, that poorer cognitive stimulation and poorer parental psychological functioning are important mediators between income and cognitive outcomes. However, we also show that psychological functioning is also an important mediator for children's mental health. We also find there are aspects of higher income lifestyles that are associated with relatively poorer developmental outcomes in children: environments heavily focused on learning and car use appear to put children at greater risk of obesity; greater use of certain types of childcare puts children at greater risk of behavioural problems. Finally, our finding that different aspects of the child's immediate home environment are differentially associated with different outcomes suggests that our measures of home environment are not simply picking up common unobserved heterogeneity.

The paper is structured as follows. Section 2 examines some evidence on the emergence of low income children's deficits and factors that explain why low-income children fall behind. Section 3 discusses our modelling approach and sets out the decomposition methodology. Section 4 describes the data and shows the unconditional relationship between income and outcomes. Section 5 presents the results of our decomposition analysis. Section 6 discusses the results in the light of previous findings and provides conclusions.

2. Background

2.1. Income gradients in childhood abilities

Both theory and evidence support the notion that outcomes in childhood are crucial for adult social and economic success. The dynamic model of human capital accumulation developed by James Heckman and co-authors argues that the benefits of investments in human skills accumulate over time because more able individuals progress more easily and quickly (see e.g. Carneiro and Heckman, 2003; Cunha and Heckman, 2007). Empirically, many studies have shown that all six of the child outcomes examined in this paper are predictive of various dimensions of wellbeing in adulthood (e.g. Blanden et al., 2007; Fergusson, Horwood and Ridder, 2005a and 2005b; Gregg and Machin, 1998; Daniels, 2006). The developmental deficits of low-income children, therefore, have long term social consequences.

There is a vast, mostly US, literature that establishes that children growing up in poverty exhibit poorer cognitive ability and socio-emotional outcomes than their more affluent counterparts. A number of findings have been established. Firstly, differences by parental income are apparent in the developmental outcomes of children as young as 2 (Klebanov et al. 1998; Dearing et al., 2001; Taylor et al., 2004). Secondly, the early cognitive deficits of poor children tend to be somewhat larger than socio-emotional deficits (Duncan et al., 1994; Duncan and Brooks-Gunn, 2000). Thirdly, the timing and depth of poverty matter. Persistent poverty is a far stronger predictor of adverse outcomes than is transitory poverty (Blau, 1999; Brooks-Gunn and Duncan, 1997) and early income (i.e. in the preschool years) has greater effects than income in later periods (Votruba-Drzal, 2006; Duncan et al., 1998). Fourthly, the relationship between family income and child development appears to be non-linear, such that the income gradient tapers off at higher levels of income (Duncan and Brooks-Gunn, 1997; Dearing et al., 2001)[1].

The UK differs from the US in terms of healthcare provision, educational institutions and racial composition, all of which may affect the observed relationship between income and child development. However, Aughinbaugh and Gittleman (2003) compare the income gradients in a range of child outcomes for a US and a UK cohort and find that the relationships documented in the US literature are highly similar across the two countries.

[1] The relationship between obesity and family income has received markedly less attention, but several studies have found that low-income children are at greater risk of overweight and obesity than high income children (Kumanyika and Grier, 2006; Alaimo et al., 2001). Hofferth and Curtin (2005) find a non-linear relationship between income and childhood BMI.

One aim of much of the literature has been to establish how far the observed relationship between income and child development is causal. In general, estimates of the raw association are substantially reduced when other socio-demographic characteristics, like maternal education and family structure, are controlled. Several studies have tried to control for unobservable as well as observable differences between low and high income families through the use of fixed effect models, randomised control experiments or Instumental Variables (e.g. Morris and Gennetian, 2003; Blau, 1999, Dahl and Lockner, 2005). The results of these studies suggest that estimates of the direct or causal impact of income on child outcomes are reduced, but not eliminated, when unobservables are taken into account. The limited size of the direct income effects has led some authors to express scepticism as to how far increases in income would raise the attainment of poor children (e.g. Blau, 1999). However, when the importance of income is compared with the importance of other determinants of child development, such as maternal IQ, the quality of the home environment and maternal depression, income emerges as a relatively powerful factor in its own right (Taylor et al., 2004).

2.2. Factors mediating the relationship between income and outcomes

Many of the studies described above establish firmly the link between income and outcomes but do not systematically examine the question of *why* low-income children fall behind. This paper explores which aspects of low-income children's environments account for their developmental deficits, by focusing not only on the income gradient in outcomes but also on the processes that mediate the relationship between income and outcomes. Within the child development literature a factor is termed a mediator if it is both causally affected by the level of household income (or some other characteristic), and then in turn causally influences the child outcome. The concept of mediation is particularly salient for the relationship between income and child outcomes because money does not directly 'buy' better test scores, but rather impacts on well-being through the way that it is allocated to different types of expenditure and behaviours/time use. In the present study, we follow two recent papers that focus on mediating processes - Guo and Harris (2000) and Yeung, Linver and Brooks-Gunn (2002). As these papers do, we explore multiple mediating pathways simultaneously, allow for as many confounding factors as possible and contrast the relative importance of different mechanisms.

Guo and Harris and Yeung et al. distinguish between two broad types of mediating mechanisms, which we replicate as closely as possible. The financial capital or investment model posits that poverty affects child development because it hampers parents' ability to purchase the materials, experiences and services that are conducive to successful development. This perspective corresponds closely to economists' views of human capital accumulation (e.g. Becker and Tomes, 1986). Mediating mechanisms of this type are operationalised in the two papers with measures of the physical home environment (such as whether it is clean and safe); measures of cognitively stimulating materials in the home environment (such as books and CDs) and of stimulating parental behaviours (such as the frequency the child is read to and taken to museums); and measures of childcare cost and quality. In contrast, the family process perspective argues that income impacts on non-material parental resources, such as the way parents monitor their children and respond to their needs. Key factors emphasised by this perspective are perceived financial strain, parental psychological well-being and the warmth and sensitivity of parent-child interactions. Yeung et al. explicitly model a pathway in which subjective feelings of financial pressure impact on maternal mental health, which in turn affect parenting style and harshness of discipline[2]. Other variables included in at least one of the models are child birth weight and maternal pregnancy behaviours like smoking and drinking, although these tended to be treated as controls rather than potential mediators.

Guo and Harris focus on the relationship between income and cognitive outcomes only, whilst Yeung et al. also include a measure of externalising behaviour problems. Both studies find that lower levels of cognitive stimulation in the home environment are the most important factor in explaining the poorer cognitive outcomes of low-income children, with smaller, but still significant, roles for parenting style, the physical home environment and maternal psychological well-being. In contrast, it is greater depression among low-income mothers that plays the biggest role in explaining their children's higher rates of behavioural problems, while the nature of the home environment is relatively less important. Neither study finds evidence that the differential childcare experiences of low-income children are a driver of their developmental deficits. Yeung et al. conclude that "there is no single pathway through which family income operates on child outcomes…To promote healthy development of children in multiple domains of functioning, a multipronged approach is needed."

[2] Guo and Harris include measures of parenting style, but not measures of maternal depression or subjective financial pressure.

3. Methodology

3.1. Conceptual framework

Our framework is based on a distinction between 'proximal' and 'distal' processes, a distinction that has its origins in ecological models of development (e.g. Bronfenbrenner, 1979, 1986). A distal factor describes some feature of the child's background that is correlated with developmental outcomes. Proximal factors can be thought of as mediating pathways, or interceding reasons why the distal factor exerts an influence on the outcome. These are factors closer to the lived experience of the child that impact directly on attainment, such as the nature of day-to-day parent-child interactions.

In this approach family income is one of a number of distal factors, such as parental education, family size and local deprivation, which impact on children's outcomes only insofar as they shape the environment experienced by the child, but do not 'directly' operate on the outcomes themselves. We classify all our explanatory variables as either distal or proximal, and the two sets of variables are treated differently in our decomposition technique. 'Direct' effects of distal family characteristics on the outcome are allowed by the model, but our interpretation of these is that they proxy for the effects of unobservable proximal factors. In other words, if all proximal factors were fully observed then these direct distal effects would be zero. The classification of variables into distal or proximal is not something that can be established statistically, but comes from previous research into the determinants of child development.

Given this model, the unconditional association between income and the child outcome (the income gradient) can be thought of as representing the sum of a particular set of pathways between different variables. Firstly, income has a direct association with the proximate environment parents are able to provide for the child, some aspects of which are observed and some which are not. Secondly, part of the income gradient reflects compositional differences between low and high income parents in terms of family characteristics, which themselves are independently associated with proximal factors, both observed and unobserved. Different aspects of a given proximate environment will vary in their implications for different child outcomes. Our decomposition technique allows us to break down the overall observed income gradient in each outcome into these different components, to quantify the importance of specific aspects of low income children's environments in generating developmental deficits, and to throw light on which characteristics of low income families are most strongly associated with these adverse proximal factors.

We examine here a far richer array of child outcomes than previous research to give a more comprehensive picture of these contrasting pathways. We also expand the set of potential mediating variables beyond those used by other studies. Specifically, we widen the scope of maternal psychological functioning beyond depression and subjective financial pressure to include measures of the frequency and severity of shocks experienced by the household; the quality of the parental relationship; the extent and depth of the mother's social networks; and the mother's beliefs with regard to personal responsibility (locus of control). We include measures of breastfeeding and child's diet (the latter at age 3) as additional health-related factors, and other dimensions of the physical home environment such as crowding, noise and access to a car or garden. Finally, we explore the role of the schools attended by children.

Our approach has clear parallels with structural equation modelling (SEM) techniques (see Guo and Harris, 2000 and Yeung et al. 2002). The key difference is that SEM reduces the high dimensionality of the data by treating observed variables as indicators of unobserved latent constructs. Multiple variables, each of which captures a slightly different aspect of the environment, are combined into a single index on the basis of the strength of their inter-correlation. This enables the researcher to estimate the full system of associations between a tractable number of variables. In contrast, our model estimates the relationship between each pair of explanatory variables specified by the model (using OLS regression). Dimensionality is reduced in two ways. Firstly, our focus is solely on the mediation of the relationship between a single measure of income and a single outcome, and hence each pathway can be captured by a scalar that represents a portion of the overall gradient. Secondly, because the total income gradient is simply the sum of all the individual path coefficients, we can aggregate the results at as broad or as fine a level as we choose by simply summing over selected groups of coefficients. To give an example, we represent the part of the income gradient explained by the poorer health-related behaviours of low income parents as the sum of the path coefficients via each of the birth weight, smoking, breastfeeding and child diet variables.

The decomposition technique we adopt has several advantages over SEM for the question addressed here. Firstly, it allows us to decompose the income gradient at a very fine level in a way that is directly comparable across different child outcomes. This issue is not apparent in research that focuses on a single aspect of child development, but is key when comparing across outcomes. The aggregation of a number of measures of, say, the home learning

environment into a single index obscures the fact that certain features may be more important for socio-emotional than for cognitive development[3]. Secondly, the object of interest in our analysis is the observed, unconditional income gradient in child outcomes. Our method provides a way to quantify the degree to which it is the other family characteristics of low income families that drive the observed income gradient, and does so as part of an integrated set of estimates that also compare directly the proximal factors through which income and other distal factors operate. As the model is derived from OLS estimates, this also has the advantage that our estimates are comparable with reduced form estimates of the overall impact of income on outcomes. Because SEM attempts to model a causal process between income and outcomes, the influence of other related family characteristics is netted out at the start, and it is difficult, if only in terms of presentation, to quantify the role of other pathways in accounting for the income gradient. Finally, because the model is based on a system of OLS equations it is based on a very transparent set of assumptions, and it is computationally simple to handle a very large number of variables, including discrete and categorical variables, and those with no natural ordering in terms of a single index.

Our analysis is a method of describing the patterns in outcomes across a sample of children. Our decomposition technique provides a way of assessing the strength of specific associations between an unusually rich set of observed factors when each is allowed to 'compete' simultaneously with the rest. We cannot infer that, for an individual child, a change in any given factor would result in a causal effect on either parenting behaviours or test scores as there may be unobserved factors (most obviously, innate inherited characteristics) that drive parental socio-economic status, parenting behaviours and children's ability. However, many of the pathways examined may reflect some element of causality[4]. And even without firm evidence of causality, we argue that it is valuable, particularly from a policy perspective, to identify the particular groups of poor children who are most at risk of developmental deficits.

3.2. Empirical model

The unconditional income gradient in the *j*th developmental outcome (O_{ij}; $j = 1,\ldots,J$; $i = 1,\ldots,N$ children) is defined as $\hat{\delta}_j$ from the OLS regression of O_{ij} on the log of family income (Y_i):

[3] Our method allows us to aggregate up and discuss the influence of the 'home learning environment' as a whole, but also to narrow down the focus and explore directly whether the assumption of a single latent construct is valid when analysing multiple dimensions of child development.

[4] Evidence from epidemiology, economics and other disciplines has addressed this issue in a variety of cases: see Section 6.

$$O_{ij} = \delta_j Y_i + e_{ij} \qquad e_{ij} \perp Y_i \qquad (1)$$

The overall gradient is the sum of a number of 'pathways', which are built up from a set of underlying regressions that specify the nature of the relationships between income, other family characteristics, the proximal environment experienced by children, and developmental outcomes. In what follows we set out these assumptions and show how they combine to give a disaggregated expression for $\hat{\delta}_j$.

Our underlying path model is expressed diagrammatically in Figure 1. The path coefficients are estimated according to the following set of OLS equations:

$$O_{ij} = \gamma_j P_i + \theta_j C_i + \pi_j Y_i + \mu_{ij} \qquad \mu_{ij} \perp P_i, C_i, Y_i \qquad (2)$$

$$P_i = \beta C_i + \lambda Y_i + \eta_i \qquad \eta_i \perp C_i, Y_i \qquad (3)$$

$$C_i = \alpha Y_i + \nu_i \qquad \nu_i \perp Y_i \qquad (4)$$

where P_i is an $m \times 1$ vector of proximal variables; C_i is an $n \times 1$ vector of family characteristics; γ_j, θ_j, β, λ and α are $1 \times m$, $1 \times n$, $m \times n$, $m \times 1$ and $n \times 1$ matrices of coefficients respectively; π_j is a scalar coefficient; η_i and ν_i are vectors of orthogonal error terms and μ_{ij} is a scalar orthogonal error.

Equation (2) specifies the child outcome as a function of all the variables in the model. C_i and Y_i are included in equation (2), not as direct determinants of the child outcome, but rather as proxies for unobservable proximal factors that may be correlated with the observed factors P_i. Large and significant estimates of θ_j and π_j imply that there are systematic differences in the unobserved proximate influences on outcome *j* between children from different social backgrounds. The inclusion of C_i and Y_i will help to mitigate omitted variable bias in the estimates of γ_j, given that the γ_j are identified from differences in observed proximal factors between children from equivalent family backgrounds. Note also that the effect of a given proximal factor on the outcome is estimated conditional on all other proximal factors.

Equation (3) embodies the assumption that the proximate environment provided by parents reflects the constraints imposed by their socio-economic resources, of which income is only a

part. The parameter vector on income in equation (3), λ, captures the net association of income with each proximal variable, holding other family characteristics constant.

Equation (4) 'closes the system' in the sense that it captures the unconditional relationship between family characteristics and income. Differences in proximal factors associated with particular family characteristics can only drive the income gradient if those characteristics are concentrated in low-income families. The parameter vector α captures the degree to which each family characteristic is concentrated amongst the poor.

Substitution of (3) and (4) into (2) allows us to write the decomposition:

$$\begin{aligned} O_{ij} &= (\gamma_j \beta\alpha + \gamma_j \lambda + \theta_j \alpha + \pi_j) Y_i + (\gamma_j \eta_i + \theta_j \nu_i + \mu_{ij}) \\ &\equiv \delta_j Y_i + e_i \end{aligned} \quad (5)$$

Given our assumptions, the unconditional income gradient, δ, can be written as the sum of four types of term, each of which represents a different pathway from *Y* to *O* in Figure 1. These terms can also be combined in different ways to give alternative decompositions of the income gradient.

The first decomposition we show in Section 5.1 factors the component terms as follows:

$$\delta \equiv \gamma_j \beta\alpha + \gamma_j \lambda + \theta_j \alpha + \pi_j \equiv \underbrace{\gamma_j (\beta\alpha + \lambda)}_{\substack{\textit{Effect via observed proximals}}} + \underbrace{(\theta_j \alpha + \pi_j)}_{\substack{\textit{Effect via unobserved proximals}}} \quad (6)$$

The first term captures the extent to which differences in observed proximal factors between low- and higher-income families can account for the overall income gradient. The combined path coefficient on a given proximal factor has the interpretation of the income gradient that would be generated if low- and higher-income families differed only in that proximal factor, but were equivalent in all other ways. Substitution of (4) into (3) shows that the term $(\beta\alpha + \lambda)$ captures the total, or unconditional relationship between income and each proximal factor, which then translates into an impact on outcome *j* via multiplication by the coefficient vector γ_j. The second term in (6) captures the partial effect of income on the outcome that operates through unobserved proximal channels. Substitution of (4) into (2) shows that the term $(\theta_j \alpha + \pi_j)$ can be thought of as the coefficient on income in a model that conditions only on the vector P_i. This form of the decomposition highlights the importance of different proximal factors for the income gradients in different outcomes, without distinguishing which

family characteristics drive the differential proximate environments of low-income children. Since the pathway from income to P_i is invariant across outcomes ($\beta\alpha + \lambda$ has no j subscript), differences in the gradients generated by a given proximal factor solely reflect differences in γ_j, the impact of that factor on each of the developmental outcomes.

The second form of the decomposition, which we show in Section 5.2, uses

$$\delta \equiv \gamma_j \beta\alpha + \gamma_j \lambda + \theta_j \alpha + \pi_j \equiv \underbrace{(\gamma_j \beta + \theta_j)\alpha}_{\substack{\textit{Effect due to differential characteristics}}} + \underbrace{(\gamma_j \lambda + \pi_j)}_{\substack{\textit{Residual or direct income effect}}} \quad (7)$$

The first term in (7) captures the gradients generated by adverse family characteristics of low-income families, abstracting from the extent to which these characteristics are associated with observed or unobserved proximal influences. Substitution of (3) to (2) shows that $(\gamma_j \beta + \theta_j)$ can be thought of as the coefficient vector on C_i in an outcome regression conditioning only on income. As such it corresponds to the estimated effects of distal factors such as family structure and parental education in the linear models of Duncan and Brooks-Gunn (1997) and the related child poverty literature. The multiplication of these estimates by the parameter vector α gives an estimate of how far differences in the prevalence of a given characteristic between low- and higher-income families translate into differences in the child outcome[5]. The second term in (7) is the residual income effect estimated by Duncan, Brooks-Gunn and others, and captures the association of income with the outcome, holding family characteristics constant. This estimate is frequently interpreted as a 'causal' estimate of financial resources themselves, when heterogeneity in the other characteristics is taken into account[6]. This form of the decomposition highlights the fact that poverty is a multi-dimensional phenomenon, and that different aspects of poverty (lack of income, lone parenthood, lack of education and deprived local environment) differ in their impact on child outcomes.

The third and final decomposition shown in Section 5.3 integrates the first two decompositions by partitioning the characteristics and residual income pathways from (7) according to their association with different proximal factors.

[5] Or, alternatively, the amount by which the unconditional income gradient is reduced when a given characteristic is controlled.

[6] It is only a causal estimate if income is not correlated with other unobserved family characteristics that also shape the proximate child environment.

$$\delta \equiv \underbrace{\underbrace{\gamma_j \beta \alpha}_{\substack{\text{Via observed proximals}}} + \underbrace{\theta_j \alpha}_{\substack{\text{Via unobserved proximals}}}}_{\substack{\text{Effect due to differential characteristics}}} + \underbrace{\underbrace{\gamma_j \lambda}_{\substack{\text{Via observed proximals}}} + \underbrace{\pi_j}_{\substack{\text{Via unobserved proximals}}}}_{\substack{\text{Residual income effect}}} \quad (8)$$

This decomposition breaks down the pathways from the characteristics (including income) into those operating via observable proximals and those that are unobserved. It explores how far the gradients generated by the differential characteristics of low- and higher-income families operate through the various observed and unobserved proximal factors. The component of the gradient generated by, say, the adverse effects of lone parenthood, reflects the influence of lone parenthood on each proximal factor (the first term of (8)), plus an unexplained influence (the second term). Similarly, the residual or direct effect of income from (7) captures the net effect of income on each proximal factor (the third term of (8)) and an unexplained component (the fourth term). These last two terms correspond in spirit to the structural equation models of Guo and Harris (2000) and Yeung et al.(2002). In these models the influence of family characteristics is conditioned out at the start, and the estimates relate to the proximate pathways through which the residual income effect operates. Our approach also allows us to compare the pathways of income with those of other distal factors associated with low income.

The methodology has thus far been expressed in terms of vectors of variables. In practice the path coefficient $\gamma_j \beta \alpha$, for example, is the sum of many component path coefficients $\sum_a \sum_b \gamma_{ja} \beta_{ab} \alpha_b$, each representing the path of income via the *b*th characteristic variable and the *a*th proximal variable. In order to draw some broad conclusions from our results, we define groupings of variables and sum over the relevant component path coefficients to present a sub-total. The first two decompositions explore the relative importance of individual variables in driving the combined group coefficients, whilst the third, full, decomposition explores the inter-relationships between each grouping of variables.

The parameters in equations (2) to (4) are estimated by OLS, and the combined path coefficients in (5) to (8) are derived by multiplying and summing these estimates. Item non-response among variables on the right hand side of each of the structural equations is controlled through a full set of missing variables, whilst dependent variables are composed of

valid observations only. Standard errors for the path coefficients are estimated by bootstrapping with 200 repetitions[7].

4. Data

4.1. The ALSPAC cohort

ALSPAC is a cohort study that started by recruiting pregnant women who were resident in the Avon area of England whose expected date of delivery fell between 1st April 1991 and 31st December 1992. The enrolment sample consisted of 14, 541 women[8], of which 13 801 (95%) went on to become the mothers of surviving offspring at 12 months, with multiple births leading to a total of 13 971 children in the study at that age. The Avon area has a population of 1 million and includes the city of Bristol (population 0.5 million), and a mixture of rural areas, inner city deprivation, suburbs and moderate sized towns[9].

Study families were surveyed with high frequency from the time of pregnancy onwards, with mothers completing 4 postal questionnaires prior to the birth, plus a further 5 on family characteristics and a further 8 focusing on the study child in the first 4 years after the birth alone. The study also contains data from a number of other sources. Three clinics took place when the children were 7, 8 and 9 years of age, in which children were administered a range of detailed hands-on physical, psychometric and psychological tests. A number of external sources of information have also been matched to the ALSPAC children. These include records from the National Pupil Database (NPD), which contains school identifiers and results on national Key Stage school tests for all children in the public school system, and information of local deprivation at the small area level (the government-produced Indices of Multiple Deprivation, IMD).

4.2. Child outcome measures

[7] The bootstrap produces 200 estimates of each path coefficient by re-sampling from the estimation sample. The significance of the estimate is calculated by deriving a *z*-score and comparing this with the standard normal distribution in a two-tailed test.
[8] Believed to be between 80 to 90 percent of all those who had a pregnancy during this period.
[9] The 1991 census was used to compare the population of mothers with infants under 1 year of age resident in Avon with those in the whole of Britain. The sample is broadly representative of the national population although the mothers of infants in Avon were slightly more likely to be affluent, on average, than those in the rest of Britain. The ALSPAC sample is not entirely representative of all eligible mothers in the area, with a slight shortfall again in the less affluent and non-white mothers. See www.alspac.bris.ac.uk.

IQ. Our measure of IQ is the short form of the Wechsler Intelligence Scale for Children (WISC-III UK), administered by ALSPAC's psychology team to children at the age of 8[10]. We use the raw total IQ score, which is the sum of scores on five verbal sub-tests: information, similarities, arithmetic, vocabulary and comprehension; and five performance sub-tests: picture completion, coding, picture arrangement, block design and object assembly.

Academic achievement. Our measure of achievement is based on the child's performance in Key Stage 1 (KS1), a set of standardised national tests administered to all children in public schools at the end of Year 3 (when most children are aged 7). The three sub-tests cover reading, writing and mathematics[11]. We use the average of these three scores.

Locus of control. Locus control is defined as a measure of "a generalized attitude, belief or expectancy regarding the nature of the causal relationship between one's own behaviour and its consequences" (Rutter, 1966). Individuals with an 'external' locus of control tend to attribute outcomes to luck, chance, fate or the interventions of others, whilst those with an 'internal' locus of control tend to believe that their own efforts are a decisive influence. 'Internal' individuals are expected to be more active in pursuing goals and to show greater ingenuity and persistence when confronted with obstacles than 'external' individuals. Our measure of locus of control is the shortened version of the Nowicki-Strickland Internal-External scale (NSIE scales) for preschool and primary children (Nowicki and Duke, 1974a). The scale consists of 12 questions (available on request) read out to the child by an examiner during an ALSPAC clinic at age 8, each requiring a yes/no answer. Each response was coded 0 or 1 and summed to create a total score.

Self esteem. Self esteem is described by Lawrence (1981) as "the child's affective evaluation of the sum total of his or her characteristics both mental and physical". It was measured at age 8 at a clinic using a 12-item shortened form of Harter's Self Perception Profile for Children (Harter, 1985; available on request). Responses to the 12 items were scored from 1 to 4 (higher scores indicating greater self esteem) and summed to give a total.

Behavioural problems. These are measured by responses to the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). This instrument has been shown to be a good

[10] This was then the most up-to-date version of the WISC, the most widely used individual ability test world-wide. See Wechsler, Golombok and Rust (1992).
[11] The child is assigned a national curriculum level which we convert into a points score following DfES guidelines: http://www.standards.dfes.gov.uk/performance/archive/.

predictor of conduct, emotional, hyperactivity and any psychiatric disorders in children of the age examined here (Goodman et al. 2000). The SDQ comprises 4 sub-scores, each derived from the responses to 5 questions, relating to hyperactivity, emotional symptoms, conduct problems and peer problems (full details available on request). Items are scored from 0 to 2 and summed to create a total behavioural problems score (Goodman 1999)[12]. We use teacher-rated scores when children are aged between 6 and 7 to allay concerns that maternal ratings are biased by factors such as maternal depression (e.g. Fergusson et al., 1993)[13].

Fat mass. The ALSPAC cohort contains direct measures of the fat mass of children at age 9 obtained by using dual-energy X-ray absorptiometry (DXA), a costly method involving a full body scan that is highly accurate (Morrison et al., 1994). The measure used in this paper is total body fat mass in grams adjusted for age of child in months, sex, height and height squared[14].

All six measures of child outcomes used in the study are normalised on child sex, cohort year and month of birth, then standardised to mean 100, standard deviation 10 on the full sample of children with non-missing values for that outcome. The original locus of control, behaviour and body fat measures are all such that higher scores indicate more adverse outcomes. We estimate models using these original variables, but to facilitate comparison we reverse the sign of the coefficients for these outcomes in the presentation of our results. Hence in all cases a coefficient of 1 on an explanatory variable is associated with an improvement of one-tenth of a standard deviation in the given outcome, where that standard deviation relates to all children in the survey rather than to the restricted estimation sample (see below).

[12] The SDQ also contains a fifth component score, pro-social behaviour, which is excluded when calculating total behavioural difficulties.
[13] The teacher's assessment is unavailable for 65% of our working sample as not all teachers completed the relevant questionnaires.
[14] Obesity is defined as an excess of body fat. The measure most commonly used to define obesity is body mass index (BMI), the ratio of weight to height squared, which is a measure of over/underweight rather than of lean/fat. Although the two are highly correlated, individuals who are unusually muscular may be overweight but not fat, and hence screen false positive for fatness according to BMI (Power et al., 1997).

4.3 Early income and other distal characteristics

Income. Our measure of family income is constructed from banded information on weekly disposable household income taken from two questionnaires at child age 3 and 4[15]. We average over the two measures to reduce measurement error and use the log.

Family structure and life cycle. This group contains an indicator of lone parent status (equal to 1 if the mother did not live with a partner at any of 4 dates between birth and child age 4); the number of older and younger siblings in the household at age 4; and the mother's age at the birth of the study child.

Parental labour market status. Paternal employment is measured by whether the mother's partner was out of work never, once or more than once at any of seven dates between the pregnancy and child age 4. Maternal employment measures are whether the mother ever worked full-time between birth and age 4, whether she worked part-time only, or whether she did not work at all. Occupational class of the mother and partner are defined from information gathered during pregnancy on current or last job[16].

Parental education. Mother's and partner's highest qualifications, collected during pregnancy[17]; we also include variables for the mother's mother's and mother's father's highest qualifications.

Local environment. These measures are the social deprivation of the people living in the local electoral ward (around 5500 persons) of residence of the child at birth[18]; indicators of housing tenure (always in owner-occupied accommodation between birth and age 3; ever in public housing between birth and age 3; other); and an indicator of whether the child is non-white[19].

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[15] We impute median values for the bands using data on a comparable sample from the nationally representative Family Expenditure Survey, convert the income variables to real values using the 1995 RPI as a base and equivalise using the OECD modified scale. We also impute the value of housing benefit for families who do not directly receive housing payments.

[16] Responses are coded from 1 to 6 using OPCS job codes: 1 = professional; 2 = managerial/technical; 3 = skilled non-manual; 4 = skilled manual; 5 = semi-skilled; 6 = unskilled.

[17] Coded: 1 = CSE/no qualifications; 2 = Vocational/O-level; 3 = A-level; 4 = Degree.

[18] The IMD is derived from 6 composite indicators in the domains of Income; Employment; Health Deprivation and Disability; Education, Skills and Training; Housing; and Geographical Access to Services. See http://www.communities.gov.uk/documents/citiesandregions/pdf/131309

[19] We group the race/ethnicity dummy with local environment in order to avoid the need to present it as a grouping in its own right. Since non-white children make up only 4% of the birth cohort, ethnic differences in child outcomes can at the most only account for a tiny fraction of the overall income gradients.

4.4. Proximal variables

Parental psychological functioning. We use a large range of measures covering mental health and interpersonal relationships. Many of these are observed at several dates: in most cases we use the average to reduce measurement error and to generate long term measures.

First, we have a measure of maternal anxiety, depression and somaticism, measured by the Crown-Crisp Experiential Index (CCEI; Crown and Crisp, 1979). This was self-assessed by mothers at 6 dates spanning the early period of pregnancy to child age 3[20]. We use the average of these 6 measures. Second, we have a measure of the frequency and severity of life event shocks experienced by the household. Mothers were asked whether each of 41 life events had occurred in recent months, and if so, how strongly she was affected[21]. Responses were scored on a 5-point scale ranging from 0 (did not happen) to 5 (affected me a lot) and summed. Our measure is the average weighted life events score over four dates between 8 months and 4 years post-birth. Third, we have a measure of subjective financial distress constructed from a composite score from responses to five items asking the mother how difficult she currently finds it to afford food, clothing, heating, rent or mortgage and things she needs for the child. Reponses are scored from 0 (not difficult) to 3 (very difficult) and summed. We use is the average of three scores taken at child age 8 months, 2 years and 3 years. Fourth, there are three measures of quality of the parental relationship in early childhood. An affection score is derived from the responses to 6 items related to how frequently the mother and partner engage in behaviours like kissing or hugging, making plans and talking over their feelings. Responses are scored from 0 to 3, summed and averaged over 3 dates between 8 months and 4 years post-birth. An aggression score is derived from questions on how frequently the mother and her partner argued in the past 3 months, and whether 5 events such as hitting, throwing things and walking out of the house in anger occurred in the same period. The total score ranges from 0 to 14, and our final variable is an average over scores at 8 months and 3 years. Finally, a shared activities variable is constructed in a similar manner, using 5 items (each scored from 0 to 3) on how frequently the parents took part in activities together such as going out for a drink, a meal or to the cinema in the last 3 months. Fifth, we measure the harshness of maternal discipline using a variable on how often the mother smacks the child when he or she is naughty at age 3. Responses are scored 1 (never), 2 (once a month or less), 3 (once a week), or 4 (daily). Sixth,

[20] See http://www.alspac.bris.ac.uk/protocol/Appendix%204_files.htm#crown_crisp for further details.
[21] Examples are: A friend or relative was ill; You had problems at work; You argued with your partner; You moved house; You had a major financial problem. See http://www.alspac.bris.ac.uk/protocol/Appendix%204_files.htm#life_events.

maternal social networks are captured by two scales, each administered during pregnancy and again at child age 2. The social networks scale is derived from 10 items, each scored from 0 to 3, relating to the number and strength of the mother's relationships with friends and relatives. The social support scale has the same format, but in this case the 10 items relate to perceived levels of emotional, financial and instrumental support. We use the average scores for each scale over the two time points. Finally, maternal locus of control is measured using the Adult Nowicki-Strickland Internal-External scale (ANSIE; Nowicki and Duke, 1974b). This 12-item scale was completed by mothers during the pregnancy.

Pre-school childcare. We distinguish between childcare prior to, or after, the age of 3. We distinguish 6 types of care in the first 3 years: father, other relative or friend, nannies and babysitters, childminders, centre-based care and other. Childcare mode was recorded at 8 weeks, 8 months, 15 months and 24 months. For each type, we distinguish whether it was used at any date and if so, whether it was ever used for more than 15 hours per week. For childcare of 3 and 4 year olds we construct similar variables, although we use slightly different categories due to the shifting nature of childcare modes over time. For this period we distinguish between care of less or more than 15 hours per week (with a residual 'not used at all' category) by relatives (including the father), nannies, childminders, playgroups, nurseries and other modes of care.

Health behaviours and health at birth. As a measure of the child's health at birth, we include measures of birth weight in kilograms, and dummies for whether the child was born pre-term (less than 37 weeks gestation) and whether the child was low birth weight (less than 2.5 kg) but not pre-term. Parental smoking is measured by whether the mother smoked at all in pregnancy, and whether there was a smoker in the child's household at age 4. Breastfeeding variables capture whether the mother breastfed: never, for less than 3 months, for 3 to 6 months, for 6 to 12 months or for more than 12 months. ALSPAC is unique amongst cohort studies for gathering detailed information on children's eating patterns and nutritional intake. We use data from a mother-completed postal questionnaire on the child's consumption of 43 different foodstuffs at the age of 3, analysed by North et al. (2000) to construct 4 types of diet: 'junk food', 'healthy food', 'traditional food' and 'snack food'[22].

[22] North et al. (2000) use principal components analysis to identify four dietary types from these data. 'Junk food' loads heavily on convenience foods such as french fries, burgers, fried foods and takeaway meals and on foods like chips, candy, cookies, chocolate and carbonated drinks. 'Healthy food' loads on vegetables, salad, fruit, fish, rice, pasta and pulses and on vegetarian substitutes for meat products. 'Traditional food' represents the traditional British 'meat and two veg' diet, loading heavily onto consumption of meat and

Home learning environment. We construct a number of variables to capture the degree of cognitively stimulating materials and activities in the child's early environment. Variables of this type are standard in research on the relationship between family background and child outcomes, and correspond closely to a number of items from the widely-used Home Observation for the Measurement of the Environment (HOME) scale.

Cognitively stimulating materials are captured in part by the age at which the child is first recorded as owning at least 10 books – at 6, 18, 30 or 42 months, or not at all by 42 months[23]. Material items are measured by a toy score, derived from the number of 12 different toys (such as blocks, jigsaws and interlocking toys) the child has at age 2.

Several measures of parental activities are constructed. The first is a maternal teaching score, derived from questions on whether the mother teaches the child each of 10 items such as numbers, shapes, rhymes and the alphabet. Items are scored from 0 to 3 according to whether the child is first taught: not at all, by 42 months, by 30 months or by 18 months, then summed[24]. Second, to allow for differential effects of parenting activities by the identity of the parent and the age of the child, we derive four variables capturing maternal and paternal inputs at both 18 and 42 months. These variables measure the frequency the parent reads to and sings songs to the child and are scored from 0 to 8 (a score of 8 indicating that the parent reads and sings to the child every day). Third, we measure how frequently the child is taken to visit the library and other places of interest such as museums between the ages of 18 and 42 months. The score for each ranges from 0 to 6 (6 indicating visits of at least once a week at all three dates of measurement).

Physical home environment. This group of variables contains a diverse range of measures of material hardship. They include whether the household is without the use of a car, or a garden or yard; whether damp, condensation and mould, or noise from inside or outside the household are a serious problem; and a crowding index for the household defined as number of persons per room. For the indicator variables, we define the problem as present if it was

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poultry, potatoes, root vegetables, green vegetables and legumes. 'Snack food' relates in general to foods that require little cooking, such as puddings, cakes, cheese, bread and fruit. The purpose of these dietary types is to provide a summary of the child's eating patterns in general: they are not designed to measure specific factors such as calorie or fat content directly.

[23] We use this form of coding, rather than a measure such as average number of books, because of lack of variation in the number of books owned. Only 6% of children own less than 10 books by age 3.

[24] Lack of variation in the age 3 teaching items means that this method better distinguishes the experiences of children.

recorded as so at any available date of 8 months, 2 or 3 years after the birth, and similarly we take the average of the crowding index across available time points.

School composition and quality. The census structure of the ALSPAC cohort within a single geographical area allows us to explore the contribution of schools. We use school dummies as explanatory variables, which capture the effect on scores of attendance at a particular school, relative to the reference school. The use of school fixed effects hence captures the contribution of all factors common to a given school, including peer group composition, school resources and the quality of teaching[25].

4.5. Sample selection

Since our research question concerns income gradients in child outcomes, our primary selection criterion is that observations have non-missing data on family income. The linking of ALSPAC to the National Pupil Database means that the cognitive scores from Key Stage 1 records are available for all children who make up the eligible birth cohort, regardless of whether they were recruited to the study or whether they dropped out before mid-childhood. Sample sizes for the other outcomes measures are therefore markedly smaller than for the Key Stage 1 outcomes, since they require participation in the study from pregnancy to age 7, 8 or 9. Detailed analyses of the composition of each sample (available on request) reveal that although our working samples tend to have slightly more favourable outcomes with less dispersion than the full samples, these differences are small. The composition of our samples is highly similar across outcomes, at least in terms of observable demographic characteristics. Descriptive statistics for all variables are provided in Table A7. Figures in this table relate to the sample with non-missing income data and at least one child outcome[26].

4.6 The income gradients

Figure 2 shows the raw income gradients in each of our 6 child outcomes, estimated as the $\hat{\delta}_j$ from equation (1). We find that children raised in poverty are falling behind their better-off counterparts by mid-childhood in terms of the full spectrum of developmental outcomes

[25] School dummies are defined only for cases in which at least 5 non-missing values of the outcome measure are observed within the same school. Children in schools with less than 5 valid observations are grouped together in a single category, and children whose school IDs are missing are similarly grouped in a separate single category. Over 70 percent of the sample children are in schools with at least 20 valid observations, and 40 to 50 percent are in schools with at least 50 valid observations.

[26] For descriptive information on school-level factors, we use the mean within-school outcome scores for each child (defined only for children in schools with at least 5 valid observations), but use school fixed effects in the analyses.

examined here (all gradients are significant at the 1% level). The gradient is largest for cognitive outcomes, where a unit change in the log of income is associated with an increase in IQ of nearly 0.6 of a standard deviation, and only a marginally smaller increase in academic achievement scores (Key Stage 1). The gradients in socio-emotional outcomes are around a third to a half as large as those in cognitive outcomes, with the steepest gradient in locus of control and the shallowest in self esteem, and with behavioural problems falling somewhere between the two. The gradient in fat mass is the smallest of all six outcomes, at around 0.13 of a standard deviation. The finding that it is cognitive development that is most strongly associated with early family income is in line with findings from previous research discussed in Section 2.3. However, Figure 2 also shows that poor children are not only disadvantaged in terms of intellectual development, but also in terms of other aspects of personal development that matter for adult health and social and economic success.

Table A2 shows the unconditional correlation of each proximal variable with income and the six child outcomes. Higher outcomes scores indicate more favourable outcomes on all measures. Virtually all the proximals are significantly correlated with family income in the expected direction at the 1% level[27]. Table A2 also shows that, with a very few exceptions, all proximal variables are significantly correlated with at least one developmental outcome, and in most cases with multiple outcomes. The table also shows the association of family characteristics with income. It is clear that low income parents differ in distal characteristics from richer parents[28]. In summary, the environments experienced by low income children differ in numerous respects to those of more affluent

[27] Low income mothers exhibit greater anxiety and depression, experience more frequent and severe shocks and financial pressure, have less affectionate, more conflicting marital relationships, smack their children more frequently, have fewer social networks and a more external outlook on life. They are much more likely to smoke, feed their children junk food diets and less likely to breastfeed. Low income children have fewer cognitively stimulating materials in the early home environment and receive less cognitive stimulation from both parents. They are less likely to experience all forms of non-maternal childcare, particularly care of long hours. They are more likely to grow up in homes that are damp, noisy and crowded and to lack access to a car or garden and they attend schools in which their peers have poorer cognitive, socio-emotional and health outcomes.

[28] Low income mothers are much more likely to be single parents, to be younger at the time of the birth and to have already had children. They are more likely to remain out of the labour force during the entire pre-school period than better-off mothers, much less likely to work full-time and tend to be employed in lower-skilled occupations. Their partners are also more likely to experience spells out of the labour force and similarly to be employed in low-skilled jobs. Low income parents have fewer educational qualifications and tend to come from families which themselves had lower educational attainment. Finally, they tend to live in more deprived areas and are more likely to live in public housing.

children: our methodology is designed to disentangle which aspects particularly hamper development of which aspects of human capital

5. Results

The decomposition model outlined in Section 3.2 breaks down the overall income gradient into the sum of a large number of different terms. The findings are presented in three sections. Firstly, we focus on the total relationships between income, proximal mediating factors and developmental outcomes. The findings show the relative importance of different types of mediator for the outcomes of poor children as a group. Secondly, we abstract from the role of proximal factors and focus on which of the multiple dimensions of poverty matter most for each outcome, so asking about the relative impact of low income, relative to other family characteristics. These results fit within the linear regression framework used in the literature on the effects of child poverty on child outcomes (e.g. Duncan and Brook-Gunn 1997). Finally, we bring the two strands of the analysis together and explore how far each income gradient reflects the adverse environments experienced by children in different socio-economic groups. Here, the paths through which income affects children when other socio-economic characteristics are controlled correspond to structural equation estimates from the developmental psychology literature (e.g. Guo and Harris, 2000). Discussion of our results in the light of existing literatures is in Section 6.

5.1. Income, proximal mediators and child outcomes

Table 1 presents the estimates of equation (6) and so explores the overall importance of different types of proximal factor in explaining the observed deficits of poor children. For each broad grouping of factors the sub-total of the coefficients on the individual measures is shown in bold, with a detailed decomposition of the overall grouping underneath. The coefficient (as a percentage of the overall income gradient for that outcome) is in brackets beneath each estimate. These results abstract from whether differences in the home environment are driven by income or by other observed characteristics of low-income families. However, the association of the home environment with each child outcome is estimated holding income and other socio-economic characteristics constant, and so is purged of the correlation with other family characteristics that have an independent influence on children's outcomes.

The first panel of Table 1 shows that the proximal factors - the environmental variables - differ in the extent to which they can explain the deficits of poor children. Differences in the observed environments of low and high income children predict an income gradient in cognitive outcomes that accounts for about one-third of the raw gradient. This figure rises to about one-half for the non-cognitive gradients and around three-fifths for the (smaller) mental and physical health gradients.

The second panel of Table 1 shows that the poorer psychological functioning of low income mothers plays a substantial role in explaining their children's deficits across the full spectrum of developmental outcomes but most notably with behavioural problems where it alone accounts for a full 60 percent of the overall income gradient. The decomposition results presented below the first line of this panel show that the strong association between low income mothers' psychological functioning and child development reflects the cumulative influence of a number of different types of stressor. The greater external locus of control of low income mothers has a significant independent association with five out of six developmental outcomes. The greater anxiety and depression, and the harsher discipline, of low income mothers are associated with poorer self esteem and greater behavioural problems in children. It is also associated (with smaller effects) with cognitive development. Lack of social support, limited social networks and the greater frequency of shocks experienced by low income mothers have quantitatively important implications for children's mental and physical health, though cognitive and non-cognitive outcomes appear less sensitive to these factors. Self-reported financial pressure is associated with children's fat mass and locus of control but less supportive, more conflicting, parental relationships do not appear to be important factors underpinning the deficits of low income children.

The third panel of Table 1 shows the early childcare experiences of poor children are associated with a more external locus of control and higher fat mass later in childhood[29]. But for later pre-school childcare, we find an offsetting process: the childcare choices of higher income parents are associated with greater behavioural problems in children. Examination of the coefficients (available from the authors) reveals that children who are cared for by nannies or nurseries for at least 15 hours a week at age 3 and 4 (but not those cared for by childminders) have more teacher-reported behaviour problems at age 7. As low income

[29] Examination of the underlying path coefficients (available from authors) reveals that in the case of locus of control, this is driven by the fact that low income children are less likely to be exposed to at least 15 hours a week of care by nannies, childminders or nurseries in this period, while higher income children appear to benefit from these types of care.

children are substantially less likely to experience these types of care, pre-school childcare experiences serve to reduce inequalities in child behaviour by around 15 percent. Interestingly, the childcare experiences of higher income children play relatively little role in raising their school attainment or cognitive functioning at age 7 to 8.

The health behaviours of low income parents account for the income gradient across the full spectrum of outcomes. The higher parental smoking, lower breastfeeding and different diets provided to children at age 3 by low income mothers predict over half of the overall observed gradient in fat mass. The strong association of these variables with physical health in children is unsurprising. However, breastfeeding and children's diet also have important implications for children's behaviour and, to a lesser extent, for cognitive and non-cognitive outcomes as well.

Looking at the relative importance of different health-related aspects of lifestyle, we find no evidence that poorer health at birth, as measured by birth weight and gestation, is a factor that disadvantages poor children later in life. This largely reflects the fact that income is not strongly correlated with birth weight in our sample[30]. Children of parents who smoke exhibit significantly poorer mental and physical health and the concentration of smoking in poorer families is a factor that accounts for around one-fifth of the overall gradients in behavioural problems and fat mass. In contrast, parental smoking does not appear to have negative implications for either the cognitive or non-cognitive development of poor children. Breastfeeding is independently positively associated with four out of the six child outcomes, so the higher probability that low income mothers do not breastfeed, or breastfeed for only short durations, helps to account for a modest amount of poor children's deficits. But it is not the case that children who receive less breastfeeding have either poorer self esteem or more behavioural problems. Low income children differ from higher income children in terms of their eating patterns at age 3. Greater consumption of highly processed 'junk' food that is high in fats and sugars and lower consumption of fresh, healthy, nutritious food at this age can explain around a fifth of the overall income gradient in fat mass at age 9. Early diet has some association with cognitive outcomes as well, although again little predictive power for non-cognitive and behavioural outcomes.

[30] Correlation of income and low birth weight = 0.05. The lack of gradient in birth weight is attributable to free public care for all.

The fourth panel shows the poorer cognitive stimulation provided in the home environments of low income children, in terms of both materials and parental activities, contributes significantly to their cognitive and non-cognitive deficits. However, the relative importance of these types of measure is no greater than the importance of maternal psychological functioning and health-related behaviours. The quality of the home learning environment is negatively associated with fat mass. This 'offset' finding is intriguing, and is paralleled by a similar finding on the relationship between physical home environment and fat mass. Together, these findings suggest that the home environments provided by higher-income families may foster cognitive and non-cognitive development at the expense of fat mass. The magnitude of these effects is non-trivial. They imply that without the protective effects of environments that appear to encourage physical activity the deficit of low income children in fat mass would be half as large again.

Of the different aspects of the home learning environment shown in the fourth panel of Table 1, the detailed decompositions show it is the lack of books and toys in poor children's early environments that most strongly predict later deficits in cognitive and socio-emotional outcomes. However, each of the component associations makes some contribution to the overall deficits, suggesting it is a 'package' of parental behaviours that characterises the cognitively stimulating early home environments of higher income families, rather than one particular activity. It is this same package of behaviours, however, that appears to increase the risk of childhood obesity amongst higher income children.

With the exception of the offsetting effect on fat mass, we find no association between poor physical home environment and children's developmental outcomes. The offset for fat mass is associated with car ownership, which may be associated with lower routine activities such as walking to school and shops. The results suggest that if the income differential in car ownership was eliminated, the income gradient in fat mass would rise by over 20 percent. Our finding on the importance of car ownership for children's risk of obesity highlights an advantage of our decomposition technique over methods that utilise the concept of latent variables. If our measures of physical environment were combined into a single index, as is common, the importance of car ownership would be disguised as a more moderate impact of physical environment in general. We also find a significant link between the poor physical conditions of low income children's homes and a reduced risk of obesity. This suggests that low income children burn more calories because of the colder temperature of their homes,

again helping to offset other aspects of their environments that encourage excess calorie consumption.

Perhaps surprisingly, there is no association with the composition and quality of schools attended by poor children at ages 7 to 8. This suggests that the early schooling experiences of low income children do little to either overcome or exacerbate the detrimental nature of their home environments.

5.2. Income, the other distal factors and child outcomes

Table 2 presents estimates of equation (7), so abstracting from proximal processes. It explores the question of how the distal factors - the long-term parental characteristics - compared to income per se are associated with the poorer outcomes of low income children. The first finding is that when we allow for the independent influence of the different socio-economic characteristics on child outcomes, the role of income is relatively small. The income gradient in fat mass is eliminated completely, while the gradients in cognitive outcomes and locus of control are reduced by around four-fifths. The drop is somewhat smaller for the gradients in self esteem and behavioural problems at 45 and 60 percent respectively. Put another way, financial resources are only one of a number of types of capital that low income parents are lacking and that impact on their children's development.

Table 2 also shows that there is no one type of disadvantage that drives the deficits of poorer children. The children of low income parents fall behind whether family poverty arises from marital and fertility decisions, economic inactivity or low-skilled employment, low educational attainment or a deprived local environment. However, it is also clear that certain types of disadvantage have implications for some types of development but not others. The marital, fertility and employment characteristics of low income families are associated with environments that fail somewhat to foster cognitive skill and a sense of personal control in children. But parents in households that are disadvantaged along these dimensions appear as successful as their more advantaged counterparts in supporting the development of other aspects of human capital, like self esteem and mental and physical health.

The second panel of the table shows that the poorer cognitive outcomes and more external locus of control of children with disadvantaged family structures do not reflect differences between single and two-parent families. Lone parenthood per se has no substantive effect on

any child outcome. Larger family size is associated with reduced cognitive functioning and self-esteem but is somewhat protective of behaviour. Younger mothers when the child was born are associated with lower locus of control.

The third panel shows the role of parental labour market characteristics. This plays no role in health or self esteem differences, and a small role for cognitive and self esteem outcomes. The detailed decomposition in this panel shows another example of an 'offsetting' effect, whereby the characteristics of higher-income families are associated with poorer rather than better outcomes in children. In this case, the greater prevalence of full-time employment amongst higher-income mothers in the pre-school period is modestly associated with poorer outcomes across all aspects of child development[31]. The long work hours of higher income mothers hence serve to reduce inequalities (albeit only marginally) in the development of poor and better off children. We also find that the children of parents employed in low skilled occupations perform more poorly on cognitive tests and locus of control, but find no evidence that paternal unemployment exerts an independent effect on children's development when income and other family characteristics are controlled for.

The fourth panel shows that it is the lower educational attainment of low income parents, more than any other characteristic, that is associated with the poorer development of their children. Three-quarters of the observed income gradient in fat mass is explained by the fact that low income parents have less education and the children of less educated parents tend to be less healthy, regardless of family income. Education is also important for both cognitive and non-cognitive outcomes, accounting for half the observed gradients in IQ and locus of control, and around a third of the gradients in academic performance and self esteem. The association of education with child behavioural problems is weaker than with the other outcomes, accounting for only a quarter of the overall gradient. It is notable that the lower education of poor parents is associated with a deficit in child IQ that is more than one-tenth of a standard deviation larger than the equivalent gap in academic performance. This may reflect the influence of genetic factors in ability is greater than for educational attainment.

The detailed decomposition in the fourth panel explores the relative importance of maternal, paternal and maternal grandparents' educational qualifications in explaining the income

[31] We also distinguish between mothers who worked part-time or not at all in the pre-school period. However, there is little difference in household income levels, on average, between these two types of household and hence differences in child outcomes between the two groups cannot contribute to the overall income gradient.

gradients. In general we find roughly equal roles for maternal and paternal education. We also find some evidence that grandparents' education is an independent predictor of child outcomes, even when parental education and other characteristics are controlled. The children of less educated grandparents have lower IQ and more external locus of control than other children, although these differences are modest. Differences in fat mass by grandparents' education, however, can account for a proportion of the income gradient that is comparable with that generated by parental education. On the other hand, we find no role for low grandparents' education in explaining the poorer academic achievement, self esteem and behaviour of low income children. The contrast between IQ and Key Stage 1 in the importance of grandparents' education is again suggestive that it is a marker for genetic factors.

The last panel of Table 2 shows that the deprived local environments of low income children are independently associated with poorer cognitive development, and with poorer mental health and fat mass, but not on average with non-cognitive outcomes. Hence children from deprived neighbourhoods do not have lower self esteem or less of a sense of personal control than children growing up in more affluent neighbourhoods. The relative importance of local environment for IQ and school performance is the opposite of that for parental education, accounting for twice as much of the income gradient in school achievement as in IQ. This is again suggestive that environmental factors have a greater influence on achievement test scores relative to genetic factors.

The detailed decomposition results show whether it is neighbourhood deprivation in general, or residence in public housing, that drives the finding of the importance of local environment. In general, both factors are associated with deficits in children's development. We find a particularly large adverse association between public housing and school performance, one that is nearly three times as large as between public housing and IQ. This suggests that the environments of children in public housing exert a negative influence on ability to do well in school tests that is not primarily driven by lower cognitive ability. This finding points to the importance of public housing for other factors that contribute to academic success, such as school inputs, peer culture and social norms but may also reflect the selection into public housing of those who have severe housing crisis. We also find a very large association between public housing and greater teacher-reported behavioural problems in children, even when family background characteristics are controlled. Differences in the behaviour of

children between those in public and private housing can account for one-third of the overall income gradient. This is more than is contributed by differences in parental education.

In summary, we find that the characteristics of poor families explain a different proportion of the observed income gradient for different outcomes. All of the (shallower) gradient in child obesity is accounted for by these characteristics, while at the other extreme, only half of the self esteem income gradient is accounted for. Of the characteristics, parental education accounts for the largest share in the income gradient for all outcomes.

5.3. The role of the adverse proximal factors associated with particular types of socio-economic disadvantage

Table 3 presents estimates of equation (8). The first panel shows how the residual, within-socio-economic-group association of income and child outcomes is transmitted through observed and unobserved proximals. These estimates correspond in spirit to the results of structural equation analyses of the causal influence of family income like Guo and Harris (2000), in the sense that in both cases the effects of other family characteristics are conditioned out.

The first line presents the residual income gradient (repeated from Table 2) which shows the lack of a significant net effect of income on locus of control, behaviour and fat mass, though, except for fat mass, the residual income affect is still a substantial fraction of the gross effects. The rest of the top panel shows how the residual effect of income is transmitted through the proximals. Holding constant other types of parental capital, income is strongly associated with the types of maternal psychological functioning that promote self esteem, positive behaviour and better physical health in children. These estimates are large in magnitude and point to a potential mechanism through which financial resources may impact parents' ability to foster positive outcomes in children. There is limited evidence that income itself is a determinant of health behaviours and aspects of the home learning environment that promote cognitive and non-cognitive development. For fat mass, family income is important in predicting the learning-focused environments, car ownership and physical conditions that *increase* obesity risk amongst higher income children.

The final line of this panel shows the direct (or residual) effect of income on each outcome, or the part of the income gradient that cannot be accounted for by any of the variables in the model. We are able to explain virtually all of the association between income and locus of

control, behavioural problems and fat mass but are left with unexplained income differences in cognitive outcomes and self esteem that account for around 15 percent of each gradient operating via environmental processes that we do not observe.

The rest of Table 3 explores how the other characteristics associated with low income operate through the environmental factors. In comparison with the direct impact of income, family structure, labour market status and the local environment play relatively little role in explaining the income gradient childhood disadvantage. Decomposing these, the second panel shows lone parenthood, teen motherhood and larger family size are jointly associated with poorer home learning environments that affect cognitive and non-cognitive outcomes. They are also associated with childcare choices and health behaviours that predict child fat mass, although this is offset somewhat by the fact that the home environments of children in these types of families promote greater physical activity. The third panel shows labour market status of poor parents operate through a more diffuse set of channels. The lower skilled occupations and greater economic inactivity of low income parents affect children's cognitive development and locus of control to some degree through their impact on maternal psychological functioning, preschool childcare choices and health-related behaviours. There remains a significant unexplained association between labour market status and academic performance, however, that is not paralleled by a similar association with IQ. This suggests that whatever the mechanisms are that drive the association with Key Stage 1, they are unlikely to be wholly genetic. Parental labour market disadvantage is associated with child mental and physical health solely because of the poorer health-related behaviours of parents who are less successful in the labour market.

The fourth panel shows the importance of parental education and the routes by which it operates. The association of education with the poorer outcomes of poor children is larger than the direct income effect. The decomposition shows that parental education is associated to a modest degree with all the types of environmental factors that we observe rather than operating through one dominant pathway. The exception is the association of parental education with health behaviours that predict child obesity, where over a quarter of the total observed income gradient in fat mass at 9 can be explained by the poorer health behaviours of less educated parents in the first years of the child's life. But what is most noticeable about the effects of parental education is that they do not substantially operate through the types of environmental process measured here. The final line of this panel shows the unexplained influence of education has a substantial role in driving the income gradients in all six child

outcomes[32]. This is in contrast with all other distal influences where the proximals do explain a large proportion of the association between income and distal factors for mental and physical health outcomes.

Local deprivation impacts developmental outcomes through different mechanisms for the different outcomes. The importance of neighbourhood for cognitive outcomes is largely unexplained by the mediators in our model, with notably no evidence of a role for effects of school quality or composition. In contrast, the poorer psychological functioning and health-related behaviours of mothers in low income neighbourhoods explain a large part of their children's deficits in mental and physical health. Again, we see evidence of an 'offset effect': families in higher income neighbourhoods, are more likely to own cars and have warmer homes (conditional on individual family resources) and this has adverse consequences for children's physical activity levels.

6. Discussion and conclusions

This paper has shown that poor children are disadvantaged across multiple socio-economic outcomes but that the pathways through which low income operates differ across outcomes; there are some pathways that seem to be important for almost all outcomes; and that the distal factors, particularly parental education, also explain a relatively large proportion of the income gradient[33].

In summary, there is a family income gradient for all six measures of child outcomes, these are largest for cognitive outcomes and smallest for obesity. Our proximal measures of parents psychological functioning, pre-school care, parental health behaviours, the home learning environment and the physical home environment can account for around one third of the cognitive income gradients but 50 to 60% of the flatter mental and physical health outcome gradients. Parental education is very strongly associated with all six outcomes and explains a sizeable fraction of the income gradient, however, this is not substantially transmitted by the

[32] There is again a contrast between IQ and academic performance where the unobserved factors associated with education predicts IQ more strongly than school test results.

[33] This final result also suggests that our measures of distal factors are not simply acting as proxies for permanent income or some other single-dimensional unobserved heterogeneity. For example, a possible interpretation is that as income is volatile and likely to be measured with error, characteristics like education and social class may act as proxies for permanent income. Our findings, however, point away from this conclusion. If a measure such as paternal occupational class were simply a proxy for permanent income, and permanent income were the real driver behind children's skill formation, then we would expect the effects to be far more uniform across different characteristics and outcomes.

proximal factors we observe. How parental education affects children's outcomes remains unexplained.

The proximal drivers of the child outcomes differ strongly by outcome, the largest observed proximal influence for cognitive outcomes are psychological functioning and the home learning environment, with a significant role for health behaviours (e.g. breastfeeding and diet). For behavioural outcomes and beliefs, psychological functioning is strongly dominant with depression, mother's locus of control, more chaotic lives and harsh discipline all playing a role. For obesity, health behaviours are strongly dominant with offsets whereby the home learning environment and car ownership among the more affluent reduces the obesity income gradient. That different family behaviours matter for different outcomes suggests that there is not a single unobserved factor driving these results.

We now discuss the key findings in the light of recent research.

6.1. The role of parental education and other characteristics of low income families

Differences in the outcomes of children of less- and more-educated parents are the single biggest driver of the observed deficits of poor children in general. These differences are estimated holding constant family income and a rich set of other family background characteristics so do not operate via the impact of educational attainment on parents' (observable) socio-economic success in adulthood.

The strength of the relationship between parental education and child outcomes is likely to reflect three distinct processes. Firstly, genetic traits that affect an individual's ability to acquire education, such as cognitive skill, will be transmitted to children biologically. Secondly, innate traits that are associated with educational success may be positively correlated with other innate skills, such as parenting ability. In this case the acquisition of qualifications by parents has no causal effect on children, but the mechanism is environmental rather than genetic, in that more educated parents also provide better developmental environments. Thirdly, there may be a causal effect, whereby the process of acquiring educational capital increases individuals' knowledge and ability as parents and shapes their values and goals for their children.

Our data does not allow us to establish the relative importance of these three explanations. Firstly, a rich body of work has attempted to identify the degree of causality in the intergenerational correlation of educational attainment and comes to the conclusion that the

genetic transmission is substantial[34]. Secondly, we find that the bulk of the parental education component in all six income gradients operates through mediating processes that we do not observe in our data. So differences in observable behaviours such as teaching and reading to children and differences in psychological functioning are a factor here, they only account for a small proportion on the education gradient. The unexplained differences in child outcomes associated with parent's education alone can account for between a quarter and two-fifths of the deficits of low income children. Feinstein, Duckworth and Sabates (2004) note that parental education influences most of the factors that have been found to matter for children's attainments: many of these will be unobservable even in a rich data set such as ALSPAC. Thirdly, we find small but significant differences in several child outcomes by maternal grandparents' education, even when parental education is held constant (see also Hill and O'Neill, 2004, and Feinstein, 2000)[35].

Whilst low parental education is strongly associated with poorer child outcomes across the board, the other socio-demographic characteristics vary in their importance for different outcomes. This suggests that the variables are not simply picking up unobserved heterogeneity. Many of our findings echo others in the literature. For example, single parenthood in itself appears not to be a source of the income gradient and in itself has no negative consequences for any aspect of child development. Most studies find that children in non-intact families perform worse across a range of tests than children in intact families but these differences become small when the influence of other correlated characteristics of single parent families are netted out (McLanahan, 1997; Cooksey, 1997; Amato, 2005; Gennetian, 2005) and in some cases disappear altogether (Clarke-Stewart et al., 2000; Carlson and Corcoran, 2001)[36].

[34] For example, Sacerdote (2007) explores the relationship between adopted mother's schooling and the educational outcomes of a group of Korean adoptees in the US and finds that just under three-quarters of the observed association between maternal and child education can be attributed to genetic factors. Many other studies have also found that the effect of maternal education is reduced substantially and even disappears altogether when inherited or unobserved factors are accounted for, although the effects of father's education tends to remain positive and significant (Behrman and Rosenzweig, 2002; Plug, 2004; Black et al., 2005; Bjorklund et al., 2006, 2007; Chevalier et al., 2005).

[35] Examination of the detailed path coefficients (available on request) shows that the effects of grandparents' education almost entirely reflect differences by grandfather's, rather than grandmother's education, and that these effects are mostly unexplained by the mediating processes in our model. These findings are certainly consistent with a genetic interpretation.

[36] Of course, family breakdown may itself be an important cause of poverty, but our results suggest that policy efforts aimed at reducing the prevalence of family breakdown will be no more successful at alleviating the consequences of child poverty than policies targeted directly at the economic resources of low income single mothers.

Although it is the adverse family characteristics of poor children that underlie the majority of the income gradients in child outcomes, we do find a significant role for the wider local environment beyond the family in predicting low income children's deficits in both cognitive and health outcomes. While the correlation between neighbourhood deprivation and poorer outcomes is well established, less is known about the mechanisms through which the estimated effects operate. Leventhal and Brooks-Gunn (2000) provide three potential explanations. Firstly, they argue that the availability and quality of institutional resources such as childcare facilities, schools and recreational facilities may play a role. Our finding that children in deprived neighbourhoods tend to be fatter than other children is relevant to recreational facilities broadly defined[37]. But we find no evidence that the composition and quality of schools in low income neighbourhoods is a factor in explaining the deficits of poor children in any aspect of child development[38]. The second is the poorer mental and physical health and weaker social support networks of parents in low income neighbourhoods. We find some support for this view in that differences in psychological functioning associated with deprived local environments contribute significantly to the deficits of low income children in behavioural outcomes and fat mass, although this is less true for cognitive and non-cognitive outcomes. We also find some support for Leventhal and Brooks-Gunn's third mechanism of norms or collective efficacy. They characterise this mechanism as relating largely to monitoring and rule enforcement by non-parental local residents. We find, however, that some 10 percent of the income gradients in both behavioural problems and fat mass can be accounted for by the poorer health-related behaviours of parents in deprived neighbourhoods. This suggests there may be a role for local social norms in shaping the smoking, breastfeeding and eating habits of low income mothers (see also Macintyre et al., 2002; Ellen et al., 2001). Finally, selection may be a fourth potential explanation.

6.2. The role of specific proximal mediators

Our results on the roles of different environmental mediators provide support for both the 'investment' perspective and the 'family process' perspective, a finding in common with both Guo and Harris (2000) and Yeung et al. (2002), but our findings differ somewhat from those studies. Our results are consistent with Yeung et al.'s finding that psychological functioning

[37] The burgeoning literature on childhood obesity and the built environment (see Sallis and Glanz, 2006) links the availability of safe, high-quality recreational facilities like parks and playgrounds to children's physical activity levels and emphasises the poor nutrition environment of deprived neighbourhoods.

[38] Since the effects of schools are estimated conditional on measures of local deprivation, it is possible that collinearity between school quality and local area characteristics leaves us unable to identify independent effects of schools within neighbourhoods. If poor school environments were a primary mechanism linking neighbourhood with child outcomes we would expect school effects to dominate and leave only a residual unexplained role for local environment.

is a more important mediator for socio-emotional than for cognitive outcomes. We find poorer parental psychological functioning to be a key mediating factor between family income and the full spectrum of child outcomes and find it to be particularly important for behavioural problems. But in contrast to earlier findings we find that it is mother's locus of control rather than depression which is the single largest influence. Also in contrast to Yeung et al we do not find that the early home learning environment is the primary driver behind poor children's cognitive deficits. The fraction of the income gradients in IQ and school performance accounted for by these variables is relatively modest at around 10 percent, a figure comparable with both the psychological functioning and health behaviours components. Indeed, it is a key finding of this study that the health-related behaviours of low income parents are as important as parental psychological functioning and learning-related behaviours for cognitive outcomes and are potentially much more important for child mental and physical health.

A second broad conclusion that can be drawn from our results is that it is the adverse characteristics of low income children's *home* environments that matter for successful development[39]. Maternal smoking is strongly linked to both behavioural problems and risk of obesity in children. Our results imply that if smoking rates among low income mothers were to fall to the rates of their higher income counterparts, the income gradients for fat mass and child behaviour would fall by one fifth. The observed association may not be causal - mothers who smoke may have unobserved attitudes and higher discount rates that also affect parenting behaviours. However, there is evidence that exposure to nicotine impacts on hormones and metabolic programming in a manner that increases the risk of psychiatric problems (e.g. Linnet et al., 2003; Ernst et al., 2001). The fact that we find no association of smoking with either cognitive or non-cognitive outcomes is also suggestive that smoking is not simply a marker for unobserved heterogeneity. Similar arguments can be made regarding the strong association of breastfeeding with fat mass later on in childhood. Again a body of work has highlighted the potential protective metabolic effects of breastfeeding (Harder et al., 2005; Arenz et al., 2004; Owen et al., 2005), and the lack of association between breastfeeding and socio-emotional outcomes like self esteem and behaviour points away from the hypothesis that breastfeeding is simply a proxy for mother-child bonding.

[39] We find only modest roles for childcare experiences, and none for school environments (conditional on all other factors), in explaining why poorer children fall behind their better off counterparts.

The importance of nutrition for children's well being has been the focus of much recent government activity in the UK. Sorhaindo and Feinstein (2006) review the literature on the impact of nutrition on children's health and schooling outcomes. One key conclusion of their study is that much of the groundwork in cultivating food preferences in children is laid early in life, before the start of school. Our findings support this view, in that consumption of junk, healthy, snack and traditional foods at age 3 are predictive of fat mass at age 9 and also of cognitive outcomes at age 7/8, even when a host of confounding factors are controlled for.

6.3. Adverse consequences of higher-income lifestyles

Our results show that there are aspects of higher income lifestyles that are associated with relatively poorer developmental outcomes in children. Long hours of maternal employment in the pre-school period, which are more common amongst higher income mothers, are associated with slightly lower cognitive, non-cognitive and behavioural outcomes in children. An extensive literature on the effects of early maternal employment (see Waldfogel, 2002, for a review) has argued that maternal employment may disrupt the formation of crucial mother-child attachments or result in greater maternal stress. It has also been hypothesised that the care and supervision provided by non-maternal carers is inferior to that provided by the mother, for example because of reduced breastfeeding. Examination of the detailed path coefficients (available on request) shows that, for behavioural outcomes, the negative effects of maternal employment can be explained entirely by the greater disruption experienced by the children of working mothers (as measured by the weighted life events score) and by the adverse effects of long hours of non-maternal childcare at age 3/4. The effects on other outcomes are largely unexplained, however, and it is notable that we find no pathway of maternal employment through breastfeeding, maternal cognitive activities or anxiety and depression. This suggests that maternal employment has an effect on the quality of mother-child interactions that is not measurable in terms of observable behaviours, perhaps via an influence on bonding and children's feelings of security.

The finding that the childcare choices of higher income parents are associated with greater behavioural problems in children is one that has been reported by a number of other studies (e.g. Belsky et al., 2007; Bates et al., 1994; Vandell and Corasaniti, 1990). The finding that long hours of centre-based care in particular are associated with greater externalising behavioural problems in school age children is replicated exactly in our study.

The most substantial way in which higher income lifestyles appear to impact adversely on children is through home environments that raise the risk of childhood obesity, which we hypothesise are related to physical activity. Learning-focused activities and behaviours, car ownership and the temperature of the home in the pre-school period are all associated with greater fat mass in children at age 9. Although lack of physical activity has received considerable attention as a cause of rising obesity levels, to date this has not been linked to levels of parental affluence. This result shows that the adverse effects of other risk factors faced by low income children are somewhat disguised by the protective effects of their home environments on calorie expenditure. The magnitude of this effect is non-trivial as it implies that, without these offsetting mechanisms, the income gradient in child fat mass would be half as large again.

6.4 The role for income

Much attention has focused on the question of how much household income matters for children's development. Our results show that, despite the importance of parental education, the income gradient remains when the independent effects of socio-economic characteristics are netted out (with the exception of child obesity).

Clearly, caution is needed in interpreting these income gradients as causal as they will also capture the effects of any unobserved family characteristics that drive both children's development and the family's income generating capacity. However, noting that any unobserved factors of this kind are, by definition, orthogonal to the many included regressors, we can draw some tentative conclusions. Although some 75 percent of the raw income gradients in the cognitive outcomes are eliminated by the inclusion of socio-economic controls, a unit change in the log of income predicts a gap of over one-tenth of a standard deviation in both IQ and Key Stage 1 scores. The magnitude of this effect in accounting for the overall cognitive deficits of poor children is much larger than the contributions of both their adverse family structures and poor parental labour market outcomes, and is also double the importance of deprived local neighbourhood for IQ, although of comparable importance to neighbourhood for school performance. Only low parental education is a more important predictor of low income children's cognitive deficits. For the socio-emotional outcomes of self esteem and behavioural problems, the income effect is proportionately larger than for cognitive outcomes (although somewhat smaller in absolute terms) and, as a single factor, is more important than any of the other socio-economic characteristics.

Hence, whilst our results clearly show that lack of income is only one of a host of disadvantages faced by low income children, it would be misleading to conclude that income plays no role in parents' ability to foster positive developmental outcomes. Indeed, if the income gradient does reflect causality, then in comparative terms low household income must be considered one of the primary drivers behind the deficits – broadly defined – of poor children.

Our results also throw some light on the mechanisms through which lack of household income impacts on children. A key finding is the importance of parental psychological functioning as a mediator by which low income is associated with children's socio-emotional and health outcomes. This specific pathway alone accounts for a quarter of the overall income gradients in child self esteem and fat mass and nearly 40 percent of the gradient in behavioural problems. Studies which focus on the relationship between income and cognitive development alone will hence understate the importance of having a low income parent on children's development. We also find some evidence of small to moderate effects of income on the childcare, health and home learning environments that matter for child outcomes. Finally, a large fraction of the residual income gradients in cognitive outcomes are unexplained by the mediating processes in our data.

In conclusion, the decomposition approach implemented here allows us to address the question of what is associated with the gap in development on a range of outcomes between poor and rich children. In general, we find that both the family characteristics and the environments associated with parental poverty vary markedly in their association with the income gradient in different outcomes. We find that cognitive outcomes have the strongest relationship with family income and that a relatively small fraction of this relationship – around a third – can be accounted for by observed proximal environmental factors[40]. But this is in contrast with the finding that the observed environmental processes explain almost all the income gradients in socio-emotional and health outcomes.

Our unified approach also echoes previous research which has documented the role of poorer cognitive stimulation and poorer parental psychological functioning as mediators between

[40] The cognitive deficits of low-income children are also strongly related to lack of parental education which also proxies inherited ability

income and child outcomes. Indeed, we find that poorer psychological functioning of mothers is associated with the gap between rich and poor children in all the outcomes we examine here, including obesity. But we also find poor health-related behaviours are key drivers behind both the greater behavioural problems and the higher risk of obesity of low-income children.

Our approach also indicates where behaviour may have unexpected associations with the low income gradient. For example, we find that the poorer health-related behaviours of low income parents (smoking, breastfeeding and child nutrition) are at least as important as poorer cognitive stimulation and poorer parental psychological health for cognitive outcomes in explaining poor children's deficits. We also show that some of the environments of low income children may be protective. The learning-focused environments of children in more affluent families, along with their greater car ownership, appear to increase the risk of childhood obesity by discouraging physical activity. The use of long hours of childcare at age 3 and 4 also appears to foster greater behavioural problems in the children of the better-off.

Finally, our results show that the relationship between family income and child-wellbeing operates through a number of different channels. Interventions that are narrowly targeted on one aspect of the home environment of the poor may only improve outcomes in one area of development. But if adult social and economic success depends on a broad spectrum of skills and abilities, then a more multi-faceted approach is needed to reduce intergenerational persistence.

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Figure 1: Path diagram

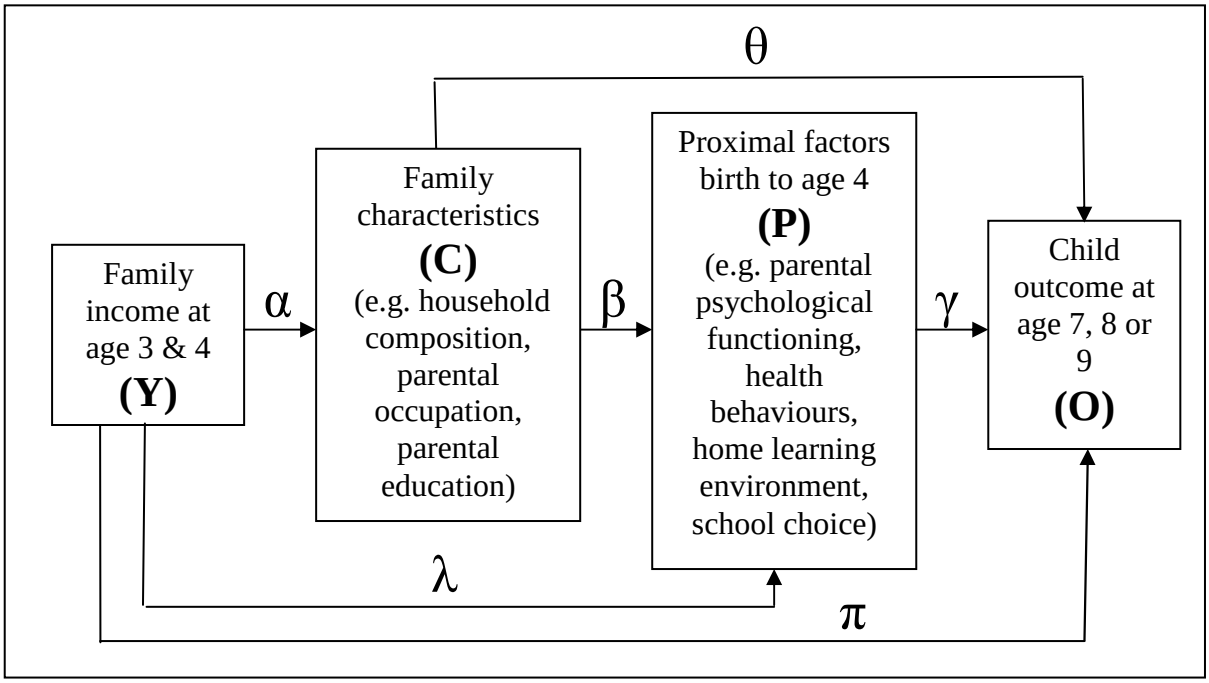
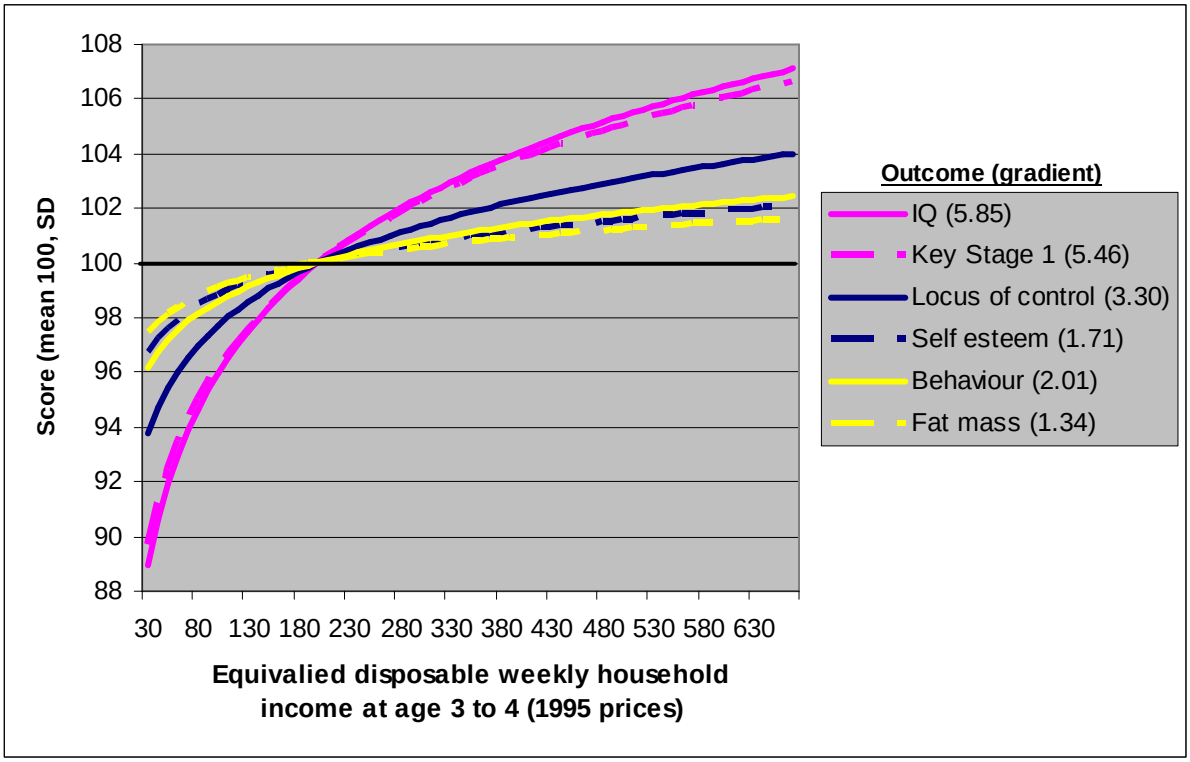


Figure 2: Estimated income gradients in child outcomes in middle childhood



Higher scores reflect more favourable outcomes on all 6 measures (figure depicts absolute values of gradients).

Gradients are $\hat{\delta}_j$ from the OLS regression: $outcome_{ij} = cons + \delta_j \ln(income)_i + e_{ij}$

All gradients statistically significant at the 1% level.

Table 1: Income, proximal mediating factors and child outcomes

	IQ	KS1	Locus	Self esteem	Behaviour	Fat mass
Total income gradient	**5.85 *** [100.0]**	**5.46 *** [100.0]**	**3.30 *** [100.0]**	**1.71 *** [100.0]**	**2.01 *** [100.0]**	**1.34 *** [100.0]**
Total explained by observed environmental mediators	1.87 *** [31.9]	1.86 *** [34.0]	1.78 *** [53.9]	0.78 ** [45.6]	1.27 ** [62.9]	0.79 ** [58.8]
Total unexplained	3.99 *** [68.1]	3.61 *** [66.0]	1.52 *** [46.1]	0.93 * [54.4]	0.75 [37.1]	0.55 [41.2]
Psychological functioning	**0.66 *** [11.2]**	**0.56 *** [10.2]**	**0.48 ** [14.6]**	**0.68 *** [39.8]**	**1.23 *** [60.9]**	**0.50 *** [37.2]**
CCEI	0.05 [0.9]	0.06 * [1.1]	0.12 * [3.7]	0.14 ** [8.3]	0.12 * [5.9]	-0.07 [-5.1]
Weighted life events	-0.06 [-1.0]	-0.02 [-0.4]	0.00 [0.0]	0.05 [3.2]	0.22 *** [10.8]	0.09 * [6.4]
Financial difficulties	0.14 [2.4]	0.13 [2.4]	-0.05 [-1.5]	0.18 [10.4]	0.02 [0.9]	0.13 [9.5]
Parental relationship	-0.03 [-0.5]	-0.14 *** [-2.5]	-0.09 [-2.8]	-0.06 [-3.5]	-0.09 [-4.6]	0.01 [0.9]
Frequency of smacking	0.11 *** [1.9]	0.05 ** [1.0]	0.11 *** [3.3]	0.18 *** [10.4]	0.13 ** [6.4]	-0.00 [-0.3]
Social networks	0.08 [1.4]	0.07 [1.2]	0.06 [1.7]	0.08 [4.7]	0.40 *** [20.1]	0.15 * [11.3]
Maternal locus of control	0.35 *** [6.0]	0.40 *** [7.4]	0.34 *** [10.2]	0.11 [6.2]	0.43 *** [21.4]	0.19 * [14.4]
Pre-school childcare	**0.16 [2.7]**	**0.07 [1.3]**	**0.44 *** [13.4]**	**-0.16 [-9.2]**	**-0.28 [-14.0]**	**0.20 [14.8]**
Birth to age 3	0.13 [2.2]	0.09 [1.6]	0.37 ** [11.3]	0.01 [0.8]	0.04 [1.8]	0.27 ** [20.5]
Age 3 to school entry	0.03 [0.6]	-0.02 [-0.3]	0.07 [2.1]	-0.17 [-10.1]	-0.32 ** [-15.9]	-0.08 [-5.7]
Health behaviours	**0.38 *** [6.4]**	**0.59 *** [10.8]**	**0.43 *** [13.0]**	**0.03 [1.9]**	**0.66 *** [32.8]**	**0.72 *** [53.6]**
Birth weight	0.04 * [0.7]	0.04 ** [0.7]	0.01 [0.4]	0.01 [0.6]	0.00 [0.1]	-0.03 [-2.0]
Smoking	-0.17 ** [-3.0]	0.01 [0.3]	0.07 [2.3]	0.01 [0.61]	0.39 *** [19.5]	0.29 *** [21.9]
Breastfeeding	0.21 *** [3.5]	0.14 *** [2.7]	0.17 ** [5.1]	-0.01 [-0.3]	0.12 [6.1]	0.17 *** [12.8]
Eating patterns	0.30 *** [5.1]	0.39 *** [7.2]	0.17 [5.2]	0.02 [1.0]	0.14 [7.1]	0.28 ** [20.8]

Continued overleaf

Table 1: Income, proximal mediating factors and child outcomes (continued)

	IQ	KS1	Locus	Self esteem	Behaviour	Fat mass
Home learning environment	**0.54 *** [9.3]**	**0.60 *** [11.1]**	**0.33 ** [10.1]**	**0.37 *** [21.9]**	**0.21 [10.4]**	**-0.26 ** [-19.8]**
Books and toys	0.39 *** [6.7]	0.29 *** [5.4]	0.16 * [4.8]	0.20 ** [11.6]	0.16 [8.2]	-0.12 [-9.0]
Maternal teaching	0.10 *** [1.6]	0.10 *** [1.9]	0.02 [0.5]	0.07 ** [4.1]	0.08 * [3.9]	-0.03 [-2.6]
Maternal reading/singing	-0.06 [-1.1]	0.00 [-0.1]	0.02 [0.6]	-0.04 [-2.3]	0.03 [1.5]	0.02 [1.5]
Paternal reading/singing	0.12 ** [2.0]	0.35 *** [6.5]	0.12 [3.5]	0.06 [3.8]	0.01 [0.4]	-0.07 [-5.1]
Trips to library, museums, etc	0.00 [-0.1]	-0.14 ** [-2.6]	0.02 [0.7]	0.08 [4.8]	-0.07 [-3.6]	-0.06 [-4.6]
Physical home environment	**0.05 [0.8]**	**0.10 [1.9]**	**-0.01 [-0.2]**	**-0.26 [-15.3]**	**-0.31 [-15.5]**	**-0.40 ** [-30.3]**
Car ownership	-0.08 [-1.3]	0.06 [1.2]	-0.04 [-1.2]	-0.11 [-6.5]	0.09 [4.5]	-0.29 *** [-21.8]
Has garden	0.02 [0.4]	-0.05 [-1.0]	0.00 [0.0]	-0.07 [-4.1]	-0.07 [-3.6]	0.02 [1.4]
Noise	0.00 [0.0]	0.02 [0.5]	0.02 [0.7]	0.02 [0.9]	0.08 [3.9]	-0.02 [-1.2]
Crowding	0.14 [2.4]	0.08 [1.4]	0.14 [4.1]	-0.05 [-2.9]	-0.23 [-11.2]	0.02 [1.6]
Damp/condensation/mould	-0.04 [-0.6]	-0.01 [-0.1]	-0.12 * [-3.8]	-0.05 [-2.7]	-0.18 * [-9.0]	-0.14 ** [-10.3]
School FE	**0.08 [1.4]**	**-0.07 [-1.3]**	**0.10 [3.0]**	**0.11 [6.5]**	**-0.23 [-11.6]**	**0.05 [3.4]**
N	5708	8727	5390	5857	3294	6113

Notes

Results show Coefficient
[% total income gradient]

Results in bold are sub-totals over the individual coefficients that follow.

All outcomes standardised to mean 100, SD 10.

Higher scores indicate more favourable outcomes for all measures. Negative estimates hence relate to a pathway in which the relative characteristics of higher-income families have adverse consequences for children's development.

***, ** and * indicate significance at the 1, 5 and 10% levels respectively.

Table 2: Income, family characteristics and child outcomes

	IQ	KS1	Locus	Self esteem	Behaviour	Fat mass
Total income gradient	**5.85 *** [100.0]**	**5.46 *** [100.0]**	**3.30 *** [100.0]**	**1.71 *** [100.0]**	**2.01 *** [100.0]**	**1.34 *** [100.0]**
Total explained by socio-economic characteristics	4.49 *** [76.7]	4.23 *** [77.4]	2.68 *** [81.3]	0.77 ** [44.9]	1.21 *** [60.2]	1.36 *** [101.6]
Residual income effect	1.36 *** [23.3]	1.23 *** [22.6]	0.62 [18.7]	0.94 ** [55.1]	0.80 [39.8]	-0.02 [-1.6]
Family structure and lifecycle	**0.48 *** [8.2]**	**0.45 *** [8.2]**	**0.46 *** [14.1]**	**0.13 [7.3]**	**0.10 [5.0]**	**-0.13 [-9.7]**
Lone parenthood	-0.22 * [-3.7]	0.03 [0.6]	0.08 [2.4]	0.02 [1.4]	0.22 [10.9]	-0.13 [-9.6]
Siblings	0.37 *** [6.4]	0.34 *** [6.3]	0.09 [2.7]	0.17 ** [9.8]	-0.18 * [-9.1]	-0.06 [-4.5]
Mother's age	0.32 *** [5.5]	0.07 [1.4]	0.30 *** [9.0]	-0.07 [-3.9]	0.07 [3.3]	0.06 [4.4]
Parental labour market status	**0.39 * [6.6]**	**0.65 *** [11.9]**	**0.52 ** [15.9]**	**-0.02 [-1.0]**	**0.10 [5.2]**	**0.08 [5.9]**
Mother's employment	-0.14 ** [-2.5]	-0.13 ** [-2.4]	-0.16 * [-4.7]	-0.16 ** [-9.2]	-0.16 * [-8.0]	-0.10 [-7.4]
Father's employment	-0.11 [-1.9]	0.01 [0.2]	0.01 [0.4]	0.04 [2.0]	-0.03 [-1.3]	0.13 [10.1]
Mother's occupation	0.20 * [3.5]	0.26 *** [4.7]	0.36 *** [11.0]	0.10 [5.6]	0.05 [2.3]	0.12 [9.3]
Father's occupation	0.44 *** [7.5]	0.51 *** [9.4]	0.30 ** [9.2]	0.01 [0.5]	0.25 [12.2]	-0.08 [-6.0]
Parental education	**3.03 *** [51.8]**	**1.93 *** [35.2]**	**1.65 *** [50.1]**	**0.63 *** [36.9]**	**0.52 ** [25.7]**	**0.99 *** [74.0]**
Mother's qualifications	1.43 *** [24.4]	0.93 *** [17.0]	0.84 *** [25.5]	0.25 [14.9]	0.24 [11.8]	0.26 * [19.5]
Father's qualifications	1.26 *** [21.5]	0.91 *** [16.7]	0.62 *** [18.7]	0.38 ** [22.2]	0.20 [10.2]	0.44 *** [32.9]
Grandparents' qualifications	0.35 *** [5.9]	0.08 [1.5]	0.19 ** [5.8]	0.00 [-0.3]	0.07 [3.7]	0.29 *** [21.6]
Local environment	**0.59 *** [10.1]**	**1.20 *** [22.0]**	**0.04 [1.3]**	**0.03 [1.7]**	**0.49 ** [24.3]**	**0.42 *** [31.4]**
Local deprivation	0.22 ** [3.7]	0.26 *** [4.7]	0.04 [1.1]	-0.18 * [-10.5]	-0.15 [-7.3]	0.22 ** [16.4]
Housing tenure	0.38 *** [6.6]	0.97 *** [17.8]	0.07 [2.0]	0.26 * [15.1]	0.65 *** [32.0]	0.21 [15.5]
Ethnicity	-0.01 [-0.1]	-0.03 ** [-0.5]	-0.06 ** [-1.9]	-0.05 ** [-2.8]	-0.01 [-0.5]	-0.01 [-0.5]
N	5708	8727	5390	5857	3294	6113

See notes to Table 1

Table 3: The role of adverse environmental factors associated with particular types of socio-economic disadvantage

	IQ	KS1	Locus	Self esteem	Behaviour	Fat mass
Residual income gradient	**1.36 *** [23.3]**	**1.23 *** [22.6]**	**0.62 [18.7]**	**0.94 ** [55.1]**	**0.80 [39.8]**	**-0.02 [-1.6]**
Psychological functioning	0.24 * [4.1]	0.14 [2.5]	0.15 [4.7]	0.41 *** [24.2]	0.77 *** [38.3]	0.35 ** [26.0]
Pre-school childcare	0.08 [1.3]	-0.02 [-0.3]	0.21 ** [6.5]	-0.05 [-3.2]	-0.22 [-10.8]	0.07 [5.3]
Health behaviours	0.00 [-0.1]	0.14 *** [2.5]	0.08 [2.5]	0.10 ** [6.0]	0.13 [6.6]	0.00 [0.0]
Home learning environment	0.13 * [2.2]	0.13 ** [2.3]	0.08 [2.5]	0.13 * [7.7]	0.11 [5.5]	-0.14 ** [-10.7]
Physical home environment	0.02 [0.4]	0.06 [1.2]	-0.01 [-0.3]	-0.10 [-6.0]	-0.11 [-5.6]	-0.17 ** [-12.9]
School FE	0.01 [0.1]	0.03 [0.5]	0.00 [0.1]	0.14 [8.5]	0.05 [2.4]	-0.01 [-0.7]
Unobserved processes	0.90 ** [15.3]	0.76 *** [13.9]	0.09 [2.8]	0.31 [17.9]	0.07 [3.4]	-0.11 [-8.6]
Family structure and lifecycle	**0.48 *** [8.2]**	**0.45 *** [8.2]**	**0.46 *** [14.1]**	**0.13 [7.3]**	**0.10 [5.0]**	**-0.13 [-9.7]**
Psychological functioning	0.04 [0.6]	0.04 * [0.7]	0.03 [0.8]	0.02 [1.4]	0.12 ** [6.0]	0.02 [1.7]
Pre-school childcare	0.03 [0.4]	0.03 [0.5]	0.04 [1.1]	0.02 [1.2]	0.01 [0.6]	0.06 ** [4.4]
Health behaviours	0.03 [0.4]	0.03 [0.6]	0.03 [0.8]	-0.03 [-1.6]	0.03 [1.6]	0.11 *** [8.5]
Home learning environment	0.12 *** [2.0]	0.20 *** [3.7]	0.12 *** [3.5]	0.09 ** [5.5]	0.05 [2.5]	-0.05 [-4.0]
Physical home environment	0.00 [0.1]	0.02 [0.3]	0.00 [0.1]	-0.04 [-2.2]	-0.04 [-2.1]	-0.07 ** [-5.1]
School FE	-0.01 [-0.2]	0.02 [0.3]	0.00 [0.1]	-0.01 [-0.8]	0.02 [1.1]	-0.04 [-2.6]
Unobserved processes	0.29 * [4.9]	0.12 [2.1]	0.25 [7.6]	0.06 [3.8]	-0.09 [-4.7]	-0.17 [-12.6]

Continued overleaf

Table 3: The role of adverse environmental factors associated with particular types of socio-economic disadvantage (continued)

	IQ	KS1	Locus	Self esteem	Behaviour	Fat mass
Parental labour market status	**0.39 ***	**0.65 *****	**0.52 ****	**-1.04**	**0.10**	**0.08**
	[6.6]	**[11.9]**	**[15.9]**	**[2.1]**	**[5.2]**	**[5.9]**
Psychological functioning	0.07 **	0.08 ***	0.05	0.04	0.04	0.03
	[1.2]	[1.5]	[1.6]	[-0.0]	[1.9]	[2.5]
Pre-school childcare	0.02	0.01	0.14 **	-0.07	-0.04	0.04
	[0.4]	[0.1]	[4.4]	[-4.1]	[-2.0]	[2.9]
Health behaviours	0.02	0.07 ***	0.07 **	0.00	0.13 **	0.08 **
	[0.3]	[1.3]	[2.2]	[0.2]	[6.4]	[6.3]
Home learning environment	0.03	0.01	0.01	0.03	-0.02	-0.02
	[0.5]	[0.1]	[0.3]	[1.8]	[-1.2]	[-1.5]
Physical home environment	0.00	0.01	0.01	-0.01	-0.03	-0.02
	[0.0]	[0.1]	[0.3]	[-0.6]	[-1.2]	[-1.2]
School FE	0.08	-0.03	0.06	0.00	-0.04	-0.01
	[1.4]	[-0.6]	[1.8]	[0.0]	[-1.8]	[-0.6]
Unobserved processes	0.17	0.51 ***	0.17	-0.01	0.06	-0.03
	[2.9]	[9.2]	[5.3]	[-0.5]	[3.1]	[-2.5]
Parental education	**3.03 *****	**1.93 *****	**1.65 *****	**0.63 *****	**0.52 ****	**0.99 *****
	[51.8]	**[35.2]**	**[50.1]**	**[36.9]**	**[25.7]**	**[74.0]**
Psychological functioning	0.27 ***	0.23 ***	0.19 ***	0.14 **	0.12	-0.01
	[4.7]	[4.2]	[5.9]	[8.5]	[6.0]	[-0.4]
Pre-school childcare	0.03	-0.01	0.12 **	-0.09 *	-0.12 *	0.05
	[0.6]	[-0.1]	[3.8]	[-5.3]	[-5.8]	[3.4]
Health behaviours	0.31 ***	0.20 ***	0.15 **	-0.08	0.15	0.38 ***
	[5.2]	[3.7]	[4.7]	[-4.7]	[7.6]	[28.2]
Home learning environment	0.22 ***	0.17 ***	0.11 *	0.10 *	0.01	-0.03
	[3.7]	[3.1]	[3.4]	[5.7]	[0.3]	[-2.2]
Physical home environment	0.02	0.01	0.03 *	0.01	-0.02	0.03 *
	[0.3]	[0.1]	[0.8]	[0.7]	[-1.0]	[2.4]
School FE	0.08	-0.11 **	0.10	-0.01	-0.10	0.03
	[1.4]	[-2.0]	[3.1]	[-0.9]	[-5.1]	[2.1]
Unobserved processes	2.10 ***	1.44 ***	0.94 ***	0.56 ***	0.48 *	0.54 ***
	[35.9]	[26.3]	[28.4]	[32.9]	[23.7]	[40.6]

Continued overleaf

Table 3: The role of adverse environmental factors associated with particular types of socio-economic disadvantage (continued)

	IQ	KS1	Locus	Self esteem	Behaviour	Fat mass
Local environment	**0.59 *** [10.1]**	**1.20 *** [22.0]**	**0.04 [1.3]**	**0.03 [1.7]**	**0.49 ** [24.3]**	**0.42 *** [31.4]**
Psychological functioning	0.04 [0.7]	0.07 *** [1.2]	0.05 ** [1.7]	0.06 ** [3.6]	0.17 *** [8.6]	0.10 *** [7.4]
Pre-school childcare	0.00 [0.0]	0.06 ** [1.1]	-0.08 ** [-2.4]	0.04 [2.1]	0.08 [3.9]	-0.02 [-1.2]
Health behaviours	0.03 [0.5]	0.15 *** [2.7]	0.09 * [2.7]	0.03 [2.0]	0.21 *** [10.6]	0.14 *** [10.6]
Home learning environment	0.06 * [1.0]	0.10 *** [1.8]	0.01 [0.4]	0.02 [1.3]	0.07 * [3.3]	-0.02 [-1.5]
Physical home environment	0.00 [0.1]	0.01 [0.2]	-0.03 [-1.0]	-0.12 [-7.1]	-0.11 [-5.5]	-0.18 ** [-13.5]
School FE	-0.07 [-1.2]	0.03 [0.5]	-0.07 [-2.1]	-0.01 [-0.4]	-0.17 [-8.3]	0.07 [5.3]
Unobserved processes	0.54 *** [9.1]	0.79 *** [14.5]	0.07 [2.1]	0.00 [0.3]	0.23 [11.6]	0.32 * [24.3]

See Notes to Table 1

Table A1: Descriptive statistics for all variables

Variable	Mean	Std. Dev.	Min	Max	% Non-missing [1]
Child outcome measures [2]					
IQ at 8	100.18	9.92	66.02	129.00	0.60
Key Stage 1 at 7	100.82	9.27	60.86	124.37	0.92
Locus of control at 8	99.89	9.98	70.36	125.25	0.57
Self esteem at 8	100.03	9.98	59.37	119.79	0.62
Behaviour at 7	99.90	9.93	85.27	152.10	0.35
Fat mass at 9	99.91	9.83	74.83	158.35	0.65
Average weekly disposable income [3]	222.54	100.32	34.99	625.57	1.00
Proximal mediating factors:					
Psychological functioning					
Average maternal depression/anxiety score	11.51	6.26	0	41.50	1.00
Average maternal weighted life events	2.87	1.91	0	18.92	1.00
Average financial difficulties score	3.12	3.20	0	15	0.99
Parental relationship: affection	14.99	2.88	0	18	0.96
Parental relationship: aggression	3.92	2.82	0	14	0.93
Parental relationship: shared activities	5.98	2.54	0	15	0.93
Frequency of smacking at age 3	2.29	0.72	1	4	0.87
Maternal social networks score	23.39	3.64	3	29	0.98
Maternal social support score	20.28	4.62	1.5	30	0.96
Maternal locus of control score	4.20	2.13	0	12	0.83
Pre-school childcare					
Non-maternal childcare age 0-2:					
% Partner 1-15 hrs pwk	0.49	0.50	0	1	0.99
% Partner > 15 hrs pwk	0.42	0.49	0	1	0.99
% Friend/relative 1-15 hrs pwk	0.33	0.47	0	1	1.00
% Friend/relative > 15 hrs pwk	0.08	0.27	0	1	1.00
% Childminder 1-15 hrs pwk	0.06	0.24	0	1	1.00
% Childminder > 15 hrs pwk	0.11	0.31	0	1	1.00
% Nanny 1-15 hrs pwk	0.06	0.23	0	1	1.00
% Nanny > 15 hrs pwk	0.05	0.21	0	1	1.00
% Nursery 1-15 hrs pwk	0.08	0.28	0	1	1.00
% Nursery > 15 hrs pwk	0.04	0.19	0	1	1.00
% Other 1-15 hrs pwk	0.02	0.15	0	1	1.00
% Other > 15 hrs pwk	0.01	0.09	0	1	1.00
Non-maternal childcare age 3-school entry:					
% Partner/friend/relative 1-15 hrs pwk	0.15	0.35	0	1	0.89
% Partner/friend/relative > 15 hrs pwk	0.06	0.23	0	1	0.89
% Childminder 1-15 hrs pwk	0.06	0.23	0	1	0.89
% Childminder > 15 hrs pwk	0.05	0.22	0	1	0.89
% Nanny 1-15 hrs pwk	0.02	0.13	0	1	0.89
% Nanny > 15 hrs pwk	0.02	0.15	0	1	0.89
% Playgroup 1-15 hrs pwk	0.35	0.48	0	1	0.89
% Playgroup > 15 hrs pwk	0.01	0.12	0	1	0.89
% Nursery 1-15 hrs pwk	0.32	0.47	0	1	0.89
% Nursery > 15 hrs pwk	0.13	0.34	0	1	0.89
% Other 1-15 hrs pwk	0.05	0.22	0	1	0.89
% Other > 15 hrs pwk	0.19	0.39	0	1	0.89

Continued overleaf

Table A7: Descriptive statistics for all variables (continued)

Variable	Mean	Std. Dev.	Min	Max	% Non-missing [1]
Health behaviours and health at birth					
Birth weight (kg)	3.42	0.55	0.65	5.64	0.99
% Gestation < 37 weeks	0.05	0.22	0	1	1.00
% Low birth weight (<2.5kg) and not pre-term	0.02	0.14	0	1	0.99
% Mother smoked in pregnancy	0.25	0.43	0	1	0.95
% Smoker in household age 4	0.38	0.49	0	1	0.89
% Never initiated breadtfeeding	0.25	0.43	0	1	0.98
% Breastfed < 3 months	0.24	0.43	0	1	0.98
% Breastfed 3-6 months	0.17	0.37	0	1	0.98
% Breastfed 6-12 months	0.24	0.43	0	1	0.98
% Breastfed > 12 months	0.10	0.30	0	1	0.98
Junk food score at age 3	-0.09	2.95	-7.43	29.96	0.76
Healthy food score at age 3	-0.05	2.72	-6.46	22.80	0.76
Traditional food score at age 3	0.01	2.51	-7.93	17.01	0.76
Snack food score at age3	0.07	1.95	-9.31	12.16	0.76
Home learning environment					
% Child first owned 10+ books at 6 months	0.19	0.39	0	1	1.00
% Child first owned 10+ books at 18 months	0.47	0.50	0	1	1.00
% Child first owned 10+ books at 30months	0.20	0.40	0	1	1.00
% Child first owned 10+ books at 42 months	0.07	0.26	0	1	1.00
% Child never owned 10+ books by 42 months	0.06	0.24	0	1	1.00
Toy score at age 2	15.21	2.22	1	20	0.90
Maternal teaching score	27.32	2.47	11	30	0.92
Maternal reading and singing score at 18 mths	7.02	1.42	0	8	0.94
Maternal reading and singing score at 42 mths	6.28	1.89	0	8	0.92
Partner's reading and singing score at 18 mths	4.55	2.28	0	8	0.90
Partner's reading and singing score at 42 mths	4.35	2.05	0	8	0.86
Outings to library score	1.42	1.60	0	6	0.83
Outings to museums/places of interest score	2.01	1.86	0	6	0.84
Physical home environment					
% Ever without access to car	0.11	0.32	0	1	0.99
% Ever without garden	0.07	0.26	0	1	0.99
% Noise ever serious problem	0.08	0.26	0	1	0.98
Average crowding index (persons per room)	0.79	0.31	0.19	9.0	0.98
% Damp/mould/condensation ever serious problem	0.13	0.33	0	1	0.99
Average within-school scores [4]					
Average IQ in school	99.42	2.61	88.55	107.62	0.48
Average Key Stage 1 score in school	100.48	2.57	65.23	108.35	0.79
Average locus of control score in school	100.36	2.16	89.57	108.17	0.46
Average self esteem score in school	99.97	1.73	92.19	106.57	0.50
Average behaviour score in school	99.86	2.38	90.65	110.79	0.26
Average fat mass score in school	100.10	1.62	94.28	108.11	0.52

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Table A7: Descriptive statistics for all variables (continued)

Variable	Mean	Std. Dev.	Min	Max	% Non-missing [1]
Family characteristics:					
Family structure and life cycle					
% Non-resident partner by age 4	0.14	0.35	0	1	1.00
% Younger sibling by age 4	0.41	0.49	0	1	0.92
Number of older siblings at age 4	0.95	1.11	0	3	0.92
Mother's age at birth	28.57	4.70	15	44	1.00
Parental labour market status					
% Mother not employed preschool	0.25	0.43	0	1	0.87
% Mother employed part-time only	0.55	0.50	0	1	0.87
% Mother ever employed full time	0.20	0.40	0	1	0.87
% Partner continuously employed	0.81	0.39	0	1	0.66
% Partner out of work at 1 date	0.10	0.30	0	1	0.66
% Partner out of work > 1 date	0.09	0.29	0	1	0.66
Mother's occupational class	2.85	1.07	1	6	0.81
Partner's occupational class	3.00	1.31	1	6	0.88
Family educational attainment					
Mother's highest qualification	2.37	0.92	1	4	0.97
Partner's highest qualification	2.44	1.04	1	4	0.94
Grandmother's highest qualification	1.76	0.78	1	3	0.72
Grandfather's highest qualification	2.00	1.02	1	4	0.68
Local environment					
Rank of IMD score for ward at birth	4536	2523	0	8379	0.91
% Tenure: owner-occupied throughout	0.75	0.43	0	1	0.99
% Tenure: ever rented not social housing	0.09	0.28	0	1	0.99
% Tenure: ever in social housing	0.16	0.37	0	1	0.99
% Child is non-white	0.04	0.19	0	1	0.95

1. Statistics defined over the full sample with non-missing income and at least one child outcome measure (N = 9476).
2. Outcomes are standardised to mean 100, SD 10 on the full sample of observations available. Differences in the mean and SD of the working samples are due to the dropping of cases with missing household income. For locus of control, behaviour and fat mass higher scores indicate more adverse outcomes.
3. Equivalised. 1995 prices.
4. Defined only for children with at least 4 other non-missing peers' scores. For illustrative purposes only, school dummies are used in multivariate analysis.

Table A2: Pairwise correlations between explanatory variables, household income and child outcomes

	Log income	IQ	Key Stage 1	Locus of control	Self esteem	Behavioural problems	Fat mass
Proximal mediating factors:							
Psychological functioning							
Anxiety/depression	-0.18 *	-0.08 *	-0.11 *	-0.06 *	-0.08 *	-0.13 *	-0.02
Weighted life events	-0.11 *	0.03	-0.02	-0.00	-0.05 *	-0.12 *	-0.02
Financial difficulties	-0.47 *	-0.16 *	-0.18 *	-0.09 *	-0.08 *	-0.12 *	-0.06 *
Parental affection	0.13 *	0.08 *	0.08 *	0.04 *	0.05 *	0.08 *	-0.01
Parental aggression	-0.15 *	-0.07 *	-0.09 *	-0.04 *	-0.03	-0.06 *	-0.03
Parental shared activities	0.15 *	-0.02	0.00	-0.02	0.03	0.05 *	0.01
Frequency of smacking	-0.09 *	-0.13 *	-0.09 *	-0.10 *	-0.08 *	-0.08 *	-0.03
Maternal social networks	0.25 *	0.15 *	0.17 *	0.08 *	0.07 *	0.13 *	0.06 *
Maternal social support	0.18 *	0.09 *	0.11 *	0.05 *	0.07 *	0.16 *	0.04 *
Maternal locus of control	0.36 *	0.26 *	0.27 *	0.16 *	0.06 *	0.15 *	0.09 *
Pre-school childcare							
Childcare age 0-2							
Partner: none	-0.14 *	-0.05 *	-0.08 *	-0.03	-0.02	-0.06 *	-0.04 *
Partner: 1-15 hrs	0.06 *	0.03	0.04 *	0.02	-0.01	0.04	0.04 *
Partner: > 15 hrs	0.02	0.00	0.01	-0.00	0.02	0.00	-0.02
Friend/relative: none	0.03 *	0.02	0.05 *	0.02	0.02	0.02	0.01
Friend/relative: 1-15 hrs	-0.03	0.00	-0.03	-0.01	-0.02	0.00	-0.00
Friend/relative: > 15 hrs	-0.01	-0.04 *	-0.04 *	-0.02	0.00	-0.03	-0.02
Childminder: none	-0.26 *	-0.13 *	-0.13 *	-0.09 *	0.00	0.01	-0.05 *
Childminder: 1-15 hrs	0.09 *	0.06 *	0.05 *	0.04 *	-0.02	-0.03	0.03
Childminder: > 15 hrs	0.25 *	0.11 *	0.12 *	0.08 *	0.01	0.01	0.04 *
Nanny: none	-0.18 *	-0.12 *	-0.07 *	-0.09 *	0.00	-0.00	-0.04 *
Nanny 1-15 hrs	0.07 *	0.05 *	0.03 *	0.04 *	-0.02	-0.02	0.02
Nanny: > 15 hrs	0.19 *	0.12 *	0.07 *	0.08 *	0.01	0.02	0.04 *
Nursery: none	-0.17 *	-0.09 *	-0.07 *	-0.08 *	-0.02	-0.02	-0.03
Nursery: 1-15 hrs	0.10 *	0.05 *	0.04 *	0.05 *	0.00	-0.00	0.03
Nursery: > 15 hrs	0.15 *	0.09 *	0.07 *	0.06 *	0.04 *	0.04	0.00
Other: none	0.00	-0.04 *	-0.01	-0.03	0.02	0.03	-0.02
Other: 1-15 hrs	0.00	0.04 *	0.01	0.04 *	-0.02	-0.04	0.02
Other: > 15 hrs	0.01	0.01	0.00	0.00	-0.01	0.01	0.01

Continued overleaf

Table A8: Pairwise correlations between explanatory variables, household income and child outcomes (continued)

	Log income	IQ	Key Stage 1	Locus of control	Self esteem	Behavioural problems	Fat mass
Childcare 3-school entry							
Ptr/friend/relative: none	-0.03 *	0.02	-0.01	0.01	0.00	0.00	0.01
Ptr/friend/relative: 1-15 hrs	0.02	-0.02	0.03	0.01	-0.01	0.01	-0.01
Ptr/friend/relative: > 15 hrs	0.03 *	0.00	-0.02	-0.03	0.00	-0.03	0.00
Childminder: none	-0.21 *	-0.09 *	-0.09 *	-0.04 *	0.03	0.00	-0.02
Childminder: 1-15 hrs	0.13 *	0.07 *	0.06 *	0.03	-0.02	0.01	0.02
Childminder: > 15 hrs	0.16 *	0.05 *	0.06 *	0.03	-0.03	-0.01	0.01
Nanny: none	-0.15 *	-0.09 *	-0.05 *	-0.08 *	-0.01	0.00	-0.03
Nanny 1-15 hrs	0.04 *	0.03	0.01	0.05 *	0.01	0.00	0.03
Nanny: > 15 hrs	0.16 *	0.09 *	0.06 *	0.06 *	0.00	0.00	0.02
Nursery: none	-0.13 *	-0.08 *	-0.05 *	-0.05 *	-0.03	0.03	-0.01
Nursery: 1-15 hrs	0.03 *	0.04 *	0.03	0.01	0.01	0.00	0.01
Nursery: > 15 hrs	0.15 *	0.06 *	0.03 *	0.06 *	0.03	-0.04	0.01
Playgroup: none	-0.06 *	-0.06 *	-0.10 *	-0.01	-0.03	-0.02	-0.03
Playgroup: 1-15 hrs	0.06 *	0.06 *	0.10 *	0.01	0.03	0.03	0.02
Playgroup: > 15 hrs	0.02	0.00	0.01	-0.02	-0.01	-0.01	0.01
Other: none	-0.05 *	-0.07 *	-0.05 *	-0.02	0.03	0.01	-0.02
Other: 1-15 hrs	0.01	0.04 *	0.02	-0.00	0.00	-0.02	0.02
Other: > 15 hrs	0.06 *	0.05 *	0.04 *	0.03	-0.03	0.00	0.01
Health at birth and health behaviours							
Birth weight	0.05 *	0.08 *	0.09 *	0.04 *	0.02	0.03	-0.03
Gestation < 37 wks	-0.03	-0.04 *	-0.05 *	-0.01	0.00	-0.01	0.01
Low birthweight not preterm	-0.03 *	-0.06 *	-0.04 *	-0.02	-0.02	-0.03	-0.01
Mother smoked in pregnancy	-0.26 *	-0.10 *	-0.16 *	-0.08 *	-0.04 *	-0.13 *	-0.09 *
Smoker in household at 4	-0.26 *	-0.11 *	-0.18 *	-0.09 *	-0.04 *	-0.12 *	-0.09 *
Breastfed: never	-0.21 *	-0.20 *	-0.19 *	-0.10 *	-0.03	-0.07 *	-0.06 *
Breastfed: < 3 months	-0.01	-0.07 *	-0.03 *	-0.06 *	0.00	-0.02	-0.06 *
Breastfed: 3-6 months	0.07 *	0.02	0.04 *	0.01	0.01	0.00	0.00
Breastfed: 6-12 months	0.14 *	0.15 *	0.14 *	0.11 *	0.02	0.07 *	0.08 *
Breastfed: > 12 months	0.04 *	0.10 *	0.07 *	0.05 *	-0.01	0.03	0.04 *
Junk food at 3	-0.26 *	-0.24 *	-0.25 *	-0.13 *	-0.04 *	-0.06 *	-0.09 *
Healthy food at 3	0.13 *	0.16 *	0.11 *	0.10 *	0.03	0.00	0.07 *
Traditional food at 3	0.04 *	0.00	-0.01	0.03	0.02	0.01	-0.01
Snack food at 3	0.16 *	0.07 *	0.09 *	0.04 *	0.02	0.06 *	0.04 *
Home learning environment							
Owned 10+ books at 6 mths	0.13 *	0.11 *	0.09 *	0.04 *	0.03	0.01	0.01
Owned 10+ books at 18 mths	0.14 *	0.11 *	0.13 *	0.07 *	0.04 *	0.05 *	0.02
Owned 10+ books at 30 mths	-0.09 *	-0.11 *	-0.05 *	-0.06 *	-0.03	-0.02	-0.02
Owned 10+ books at 42 mths	-0.13 *	-0.10 *	-0.11 *	-0.06 *	-0.03 *	-0.02	-0.02
Never owned 10+ books	-0.21 *	-0.15 *	-0.20 *	-0.06 *	-0.07 *	-0.10 *	-0.01
Toys at age 2	0.13 *	0.11 *	0.12 *	0.05 *	0.03	0.10 *	0.01
Maternal teaching score	0.11 *	0.12 *	0.14 *	0.04 *	0.06 *	0.07 *	-0.02
Maternal reading at 18 mths	0.14 *	0.12 *	0.15 *	0.07 *	0.05 *	0.07 *	0.03
Maternal reading at 42 mths	0.18 *	0.12 *	0.15 *	0.07 *	0.03	0.05 *	0.03
Ptr's reading at 18 mths	0.17 *	0.15 *	0.19 *	0.10 *	0.07 *	0.06 *	0.02
Ptr's reading at 42 mths	0.16 *	0.11 *	0.16 *	0.05 *	0.06 *	0.04	0.01
Trips to library	0.09 *	0.17 *	0.15 *	0.08 *	0.03	0.04	0.06 *
Trips to places of interest	0.29 *	0.20 *	0.15 *	0.12 *	0.06 *	0.04	0.05 *

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Table A8: Pairwise correlations between explanatory variables, household income and child outcomes (continued)

	Log income	IQ	Key Stage 1	Locus of control	Self esteem	Behavioural problems	Fat mass
Physical home environment							
Lack of car	-0.36 *	-0.12 *	-0.19 *	-0.07 *	-0.03	-0.11 *	-0.01
Lack of garden	-0.19 *	-0.08 *	-0.11 *	-0.04 *	-0.01	-0.05 *	-0.03
Noise is serious problem	-0.18 *	-0.06 *	-0.11 *	-0.04 *	-0.02	-0.08 *	-0.02
Crowding index	-0.36 *	-0.19 *	-0.19 *	-0.10 *	-0.04 *	-0.05 *	-0.04 *
Damp is serious prooblem	-0.22 *	-0.05 *	-0.10 *	0.00	-0.02	-0.04	0.01
Within-school average scores							
IQ at 8	0.19 *	0.28 *	0.17 *	0.14 *	0.04	0.01	0.06 *
Key Stage 1 at 7	0.18 *	0.17 *	0.29 *	0.11 *	0.05 *	0.04	0.06 *
Locus of control at 8	0.14 *	0.17 *	0.14 *	0.23 *	0.05 *	-0.02	0.05 *
Self esteem at 8	0.08 *	0.05 *	0.07 *	0.06 *	0.18 *	0.04	0.01
Behaviour at 7	0.04 *	0.02	0.03 *	-0.02	0.03	0.28 *	-0.01
Fat mass at 9	0.10 *	0.10 *	0.09 *	0.07 *	0.01	0.00	0.17 *
Family characteristics:							
Family structure and life cycle							
Non-resident ptr	-0.33 *	-0.08 *	-0.13 *	-0.06 *	-0.05 *	-0.11 *	-0.03
Younger sib by 4	0.01	0.06 *	0.05 *	-0.01	0.04 *	0.02	0.05 *
# older sibs	-0.21 *	-0.12 *	-0.13 *	-0.02	-0.06 *	0.02	-0.01
Mother's age	0.27 *	0.18 *	0.16 *	0.14 *	0.00	0.08 *	0.05 *
Parental labour market status							
Mother not emp	-0.16 *	0.01	-0.05 *	0.00	0.00	-0.00	-0.01
Mother emp PT	-0.04 *	-0.05 *	0.02	-0.02	0.01	0.02	0.02
Mother emp FT	0.22 *	0.05 *	0.03	0.02	-0.02	-0.02	-0.01
Ptr always emp	0.29 *	0.05 *	0.09 *	0.03	0.01	0.02	0.05 *
Ptr out work once	-0.07 *	-0.01	-0.02	-0.02	0.02	-0.00	-0.03
Ptr out work > once	-0.32 *	-0.06 *	-0.10 *	-0.03	-0.04	-0.03	-0.03
Mother's occupation	-0.36 *	-0.25 *	-0.24 *	-0.17 *	-0.05 *	-0.07 *	-0.08 *
Partner's occupation	-0.40 *	-0.28 *	-0.28 *	-0.16 *	-0.05 *	-0.09 *	-0.07 *
Family educational attainment							
Mother's quals	0.43 *	0.37 *	0.33 *	0.21 *	0.06 *	0.10 *	0.10 *
Partner's quals	0.44 *	0.35 *	0.32 *	0.20 *	0.07 *	0.10 *	0.10 *
G'mother's quals	0.20 *	0.20 *	0.17 *	0.09 *	0.02	0.03	0.07 *
G'father's quals	0.23 *	0.23 *	0.19 *	0.12 *	0.04	0.08 *	0.09 *
Local environment							
IMD rank	0.33 *	0.18 *	0.20 *	0.09 *	0.01	0.04	0.07 *
Always owner-occupier	0.41 *	0.15 *	0.23 *	0.08 *	0.04 *	0.13 *	0.07 *
Ever rented (not social)	-0.06 *	0.02	0.01	-0.00	0.00	-0.04	-0.01
Ever in social housing	-0.44 *	-0.20 *	-0.28 *	-0.10 *	-0.06 *	-0.13 *	-0.07 *
Child non-white	-0.05 *	-0.01	-0.01	0.03	0.03	-0.01	-0.01

For all outcomes higher scores indicate more favourable outcomes.
* indicates significance at the 1% level