Neighbourhood deprivation and child behaviour across childhood and adolescence

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Abstract

Children living in deprived areas tend to show greater problem behaviour relative to children in more advantaged areas. We explored the effect of different forms of area deprivation (e.g., income, education and health) on the development of child problem behaviour (emotional and behavioural problems) from early childhood to middle adolescence. Using data from the Millennium Cohort Study, we modelled trajectories of child problem behaviour depending upon the level of deprivation in the neighbourhood, across ages 3 to 14 years, in England (*n* = 6,127). We explored seven types of social, economic and environmental deprivation in small standard areas, using the Index of Multiple Deprivation. Child problem behaviour was measured with the Strengths and Difficulties Questionnaire. Most types of deprivation were moderately predictive of child problem behaviour at around age 8 years (where we set the intercept), when explored in separate models, even after adjustments to reduce area selection bias. However, they were not related to longitudinal changes in problem behaviour. Socio-economic aspects of area deprivation – education, income and employment - were most consistently related to child problem behaviour – and were robust to adjustments for other domains of area deprivation including crime and living environment.

Key words: Area effects, child behaviour, Millennium Cohort Study, multilevel modelling, IMD indexes of neighbourhood deprivation

Over the past three decades, a growing body of research has investigated the relationship between deprivation in the neighbourhood and adult ratings of children's emotional and behavioural problems ('child problem behaviour'). Neighbourhood deprivation refers to the level of unmet need among residents brought on by a lack of resources of all types, not only financial: 'People can be said to be *deprived* if they lack the types of diet, clothing, housing, household facilities and fuel and environmental, educational, working and social conditions, activities and facilities which are customary…' (Townsend, 1987, p. 131). Such research can be traced back to Wilson's (1987) treatise about a rise in poverty in U.S. urban neighbourhoods in the 1970s and 1980s that isolated disadvantaged children and families from opportunities. Deprived or disadvantaged neighbourhoods are thought to have a negative impact on child behaviour due to the relative lack of role models (e.g., University-educated adults or those working in managerial or professional occupations) (Brooks-Gunn et al., 1993). Such high status adults may, in turn, affect positively children's behaviour by helping to maintain social control in neighbourhoods, thereby promoting opportunities and minimising bad behaviour (Jencks & Mayer, 1990). Moreover, in less deprived neighbourhoods residents are more likely to be working together towards common goals (Sampson et al., 1999, 2002), share similar behavioural norms (Brooks-Gunn et al., 1993; Kohen et al., 1998; Stafford et al., 2003), or monitor more closely and support the local children (Froiland et al., 2014; Leventhal & Brooks-Gunn, 2000; Sampson et al., 1999). Neighbourhood disadvantage may also impact on child problem behaviour via more proximal risk factors such as stressful life events and experiences (Evans, 2004) or parental depression (Lorant et al., 2003), which in turn seems to affect children both directly and via parenting (Gershoff, Aber, Raver, & Lennon, 2007). Of course, neighbourhood advantage could also be linked to positive emotional and behavioural outcomes in children simply because of its association with health-enhancing resources such as material benefits (Alegria et al., 2014).

The research to date finds that the effects of neighbourhood disadvantage are, typically, modest in size and smaller than those of family risk factors (Leventhal & Brooks-Gunn, 2000). Nevertheless, much it also shows that they are significant and robust to adjustment

for various aspects of family disadvantage (Andersen et al., 2014; Brooks-Gunn et al., 1993; Chase-Lansdale et al., 1997; Duncan et al., 1994; Flouri et al., 2013; Flouri et al., 2012; Edwards & Bromfield, 2009; Jeon et al., 2014; Leventhal & Brooks-Gunn, 2000; Midouhas et al., 2014). For example, after attempts to reduce selection bias through similar adjustments, research also using data from the UK Millennium Cohort Study (MCS), found that neighbourhood deprivation, measured with a general composite index of various forms of area disadvantage was related positively to trajectories of emotional and behavioural problems in early and middle childhood (Flouri et al., 2015; 2016).

In the present study, we analysed data from the first six sweeps of MCS to examine the trajectories, from ages 3 to 14, of child problem behaviour in England by level of area deprivation. We used the English Index of Multiple Deprivation (IMD, Noble, Wright, Smith, & Dibben, 2006), a measure of multiple deprivation at the small area level (described in detail in 'Measures'), to assess seven different domains of deprivation including income deprivation, employment deprivation, health deprivation and disability, education skills and training deprivation, barriers to housing and services, living environment deprivation and crime. We looked at England only because the IMD is not equivalent across the four UK countries, and, breaking tradition with the majority of UK 'area effects' research to date which uses the overall IMD score (a weighted area-level aggregation of these forms of deprivation), we looked at the different domains of area deprivation separately. In both the UK and elsewhere, most of the research into neighbourhood deprivation and child problem behaviour has either measured deprivation using aggregate measures of multiple forms of deprivation including, for example, income, employment, education and health, or a single measure of socio-economic disadvantage (Aneshensel & Sucoff, 1996; Caspi, Taylor, Moffitt, & Plomin, 2000; Edwards & Bromfield, 2009; Flouri et al., 2013; Flouri et al., 2012; Leventhal & Brooks-Gunn, 2000; Xue, Leventhal, Brooks-Gunn, & Earls, 2005). It is less common for studies to address individually multiple dimensions of deprivation in the neighbourhood. In addition to socio-economic deprivation, however, neighbourhoods may be characterised in terms of other forms of disadvantage, including crime or poor physical environment, likely also important for children's behaviour and development. The relative contributions of these forms of deprivation have been largely unexplored in the 'neighbourhood effects'

literature in general, and specifically with regard to their influence on child emotional and behavioural problems.

One of the reasons why, in the UK 'area effects' research, the overall IMD is so widely used is that some of its individual domains are too highly correlated - income and employment deprivation for example (Liverani, Lavigne, & Blangiardo, 2016). Hence, these may be difficult to differentiate conceptually, and including them in the same regression model introduces multicollinearity problems. On the other hand, not all the domain components of the IMD are collinear. For example, an area can be low in terms of income deprivation but high in terms of barriers to housing and services. Thus, it is important to consider domain-specific effects too. In the present study, we explored the IMD's component dimensions of area deprivation separately, starting with separate regression models for each domain of deprivation. Then, for those that showed consistent associations with child problem behaviour, we ran additional models adjusting for other forms of deprivation (not collinear) to check whether associations were robust. Moreover, we tested whether deprivation domains predicted behaviour longitudinally across our study period. In all our models we attempted to control for selection bias. In the context of modelling 'area effects', this occurs when the selection mechanism into areas is not independent from the outcome studied. We attempted to control for the bias caused by families' selective sorting into areas by adjusting for mother's educational attainment, family poverty, family structure and ethnicity. We also adjusted for urbanicity. Rural England has lower deprivation levels and higher mean gross income (Commission for Rural Communities, 2008), with incomes varying dramatically within the heavily populated urban areas (Pateman, 2010).

Methods

Study sample

We used analysis of secondary data from the Millennium Cohort Study (MCS) (www.cls.ioe.ac.uk/mcs), a longitudinal survey of children born in the UK over 12 months from 1 September 2000. To date, six sweeps (waves) of data are available for analysis. A total of 19,519 children participated in at least one of these six sweeps. The MCS sample is disproportionately stratified, firstly by country, and then type of electoral ward[i]. The sample

design over-represented families living in areas of high child poverty, areas with high proportions of ethnic minority populations across England and the three smaller UK countries. Children and their families were sampled from 398 electoral wards across the UK. Ethical approval was gained from NHS Multi-Centre Ethics Committees, and parents (and children after age 11 years) gave informed consent before interviews took place. MCS children were around 9 months old at Sweep 1, and 3, 5, 7, 11 and 14 years old at Sweeps 2-6, respectively. We analysed data from Sweeps 2-6 (the sweeps with data on both child behaviour and area deprivation) using records for one child per family (the first-born where there were twins or triplets). Our analytic sample included children with available information on area deprivation in England, measured with the IMD at Sweeps 2-6 (*n* = 6,127).

Measures

a) *Area deprivation.* (Low) area deprivation was measured with the 2004 English IMD which provides a set of relative measures of types of deprivation for small areas (Lower-layer Super Output Areas [LSOAs]) across England. LSOAs contain 1500 people on average (Office for National Statistics, 2012) with boundaries drawn to maximise social homogeneity. The IMD has information on seven domain indices (Neighbourhood Renewal Unit, 2004) that capture different types or dimensions of deprivation. IMD ranks (based on the IMD scores) for each domain were exponentially transformed and then converted to deciles across all LSOAs, with a higher decile representing less deprived areas.

   The seven domains of the IMD are as follows:

- *Income Deprivation,* which measures the proportion of the area population experiencing deprivation relating to low income;
- *Employment Deprivation,* which measures the proportion of people who are unable to work due to unemployment, sickness or disability, or caring responsibilities;
- *Education, Skills and Training Deprivation,* which measures educational disadvantage within an area. The indicator comprises two sub-domains, one relating to lack of

attainment among children and young people[ii] and the other one relating to adults' lack of qualifications in terms of skills[iii];

- *Health Deprivation and Disability,* which captures morbidity, disability and premature mortality in the area;
- *Crime,* which measures the local-level risk of personal and material victimisation;
- *Barriers to Housing and Services,* which combines two sub-domains: 'Geographical barriers', which measures the physical proximity of local services, and 'wider barriers' which provides information about access to housing such as affordability.
- *Living Environment Deprivation,* which measures the quality of the local environment comprising two subdomains: 'Indoors' living environment measures the quality of housing whereas 'outdoors' living environment contains measures of air quality and road traffic accidents.

As an illustration of what these area measures capture, the Health Deprivation and Disability domain, for example, 'identifies areas with relatively high rates of people who die prematurely or whose quality of life is impaired by poor health or who are disabled, across the whole population'. This domain is calculated from the following information:
• Years of Potential Life Lost (1997-2001); • Comparative Illness and Disability Ratio (2001); • Measures of emergency admissions to hospital (1999-2002); • Adults under 60 suffering from mood or anxiety disorders (1997-2002).

In our study, all children were attributed with the IMD2004 scores of the English LSOA they found themselves in at each sweep. Their IMD could change over sweeps but only for movers and only if there was sufficient upward or downward area move to cross into another decile.

b) Emotional and behavioural problems were measured at ages 3, 5, 7, 11 and 14 with the parent-reported Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). The SDQ is a short, reliable and widely-used behavioural screening tool. It consists of 20 items (grouped in 4 scales) about difficulties. Each item is scored on a 3-point scale of 0 (*not true*), 1 (*somewhat true*), and 2 (*certainly true*). The scales (of 5 items each) are: emotional

symptoms, conduct problems, hyperactivity/inattention and peer problems. Scores for each scale may range 0-10. In our sample, Cronbach's alphas across sweeps ranged .69 to .75 for emotional symptoms, .75 to .80 for conduct problems, .81 to .85 for hyperactivity and .70 to .77 for peer problems. Thus, internal consistency was in line with other SDQ research (Stone, Otten, Engels, Vermulst, & Janssens, 2010).

c) Our *covariates* were both time-invariant and time-varying, where available. The time-invariant covariates were: *Ethnicity* (white, Indian, Pakistani/Bangladeshi, black, mixed, and other), *gender*, *maternal education* (whether the mother achieved a university degree or not by Sweep 6) and *IQ* which in MCS was derived at age 5 from three subscales of the British Ability Scales (BAS) (Elliott, Smith, & McCulloch, 1996). The time-varying covariates (across sweeps 2-6) were: *Age* in years; *maternal mental health*, assessed with the 6-item Kessler scale (Kessler at al., 2003); *family structure* (two natural parents at home or not); *family poverty* (below the study-defined poverty line or not); *urbanicity* (living or not in an urban LSOA, i.e., within a settlement with a population greater than 10,000, and *family residential mobility* (whether the family had the same address as at the previous sweep).

Statistical analysis

As the first step of our analysis, we explored the differences between the analytic sample (*n*=6,127) and the non-analytic sample (*n*=13,117) on the selected variables of our study. Continuous variables were compared using one-way analysis of variance tests and categorical variables using chi-square tests. Next, we inspected the correlations between the IMD domains and the SDQ domains (i.e., the SDQ scales). Finally, in order to model the associations between area deprivation and trajectories of child emotional/behavioural problems, whilst adjusting for the clustering of children within areas, we fitted three-level growth curve models. This allowed us to avoid the underestimation of standard errors due to the hierarchical nature of our data (Goldstein, 2003) by having repeated measures (at ages 3, 5, 7, 11 and 14) of each SDQ scale scores (Level 1) nested in children (Level 2) nested in areas (wards of initial residence) (Level 3). To allow for changes in problems across time to vary between children, we specified a random slope on the child's age, which was grand-mean-centred at 8.09 years. We had a fixed effect for age as well as age^2 to account for the

shape of the average trajectory for each SDQ domain. We accounted for area clustering at the level of pre-2001 electoral ward on which the MCS survey design was built (we had a total of 233 wards in the analytic sample). In all models, we adjusted for the MCS 'stratum' to reflect the stratified sample design. In each of the four UK countries, MCS families were oversampled from wards with high child poverty ('disadvantaged') and from wards with high proportions of ethnic minorities ('ethnic'). As our sample included only children from England, we adjusted for three strata: 1) England-advantaged, 2) England-disadvantaged and 3) England-ethnic (Plewis, 2007). LSOAs, for which IMD measures of deprivation are defined, are different and generally smaller than the electoral wards used in the MCS sampling design.

All regression analyses were conducted in *MLwiN* 3.01.

Results

Descriptive statistics

Comparing those in the analytic sample (*n* = 6,127) with those in the non-analytic sample (*n* = 13,117), on average, one can see that children in the analytic sample had fewer conduct and hyperactivity problems but did not differ in emotional symptoms or peer problems. They were also from more advantaged backgrounds. For example, proportionally fewer of the analytic sample lived in deprived neighbourhoods or were from poor backgrounds. Moreover, as expected since it was confined to England, the analytic sample had greater proportions of ethnic minorities and urban residents compared to the non-analytic sample (results available on request).

Correlations at the child's age 7 (the MCS sweep closest to our intercept; Table 1) between most of the IMD domains (income, employment, education, health and disability, crime, living environment) were moderate to strong, ranging .44 to .94. Barriers to housing and services was either not statistically or very weakly (-.13 to .03) associated with all other domains of IMD. It was also negatively related to some (e.g., crime) and positively to others (e.g., living environment). Other than barriers to housing and services (which was only related to conduct problems and hyperactivity but in the opposite direction that one might expect), all other forms of deprivation were related consistently, and in the expected

direction, to all SDQ domains. These were however weak throughout (they ranged -.21 to -.08). The strongest correlations were found between peer problems and income, employment, health and disability, and education deprivation (-.12 to -.21).

<Table 1 here>

Multilevel models

Effects of area deprivation

In unadjusted models (Table 2), low deprivation in all domains was predictive of fewer problems across all SDQ domains (evaluated at age 8), with two exceptions: Barriers to housing and services did not predict any problem domains, and living environment deprivation did not predict hyperactivity/inattention.

After adjusting for child and family confounders (Table 3), low education deprivation was the only domain that continued to predict fewer problems across *all* SDQ domains (at age 8). Low deprivation in terms of income, employment and crime predicted fewer conduct problems, emotional symptoms and peer problems but not less hyperactivity. Health deprivation and disability was associated with conduct problems and peer problems. Low living environment deprivation was related to fewer peer problems. [Tables A1-A7 in the Appendix present the results of the fully adjusted model (fixed and random effects) for each of the IMD domains on each SDQ outcome. For a discussion on effect sizes see also Appendix and Table A8.]

We also explored whether area deprivation was associated with the annual rate of change in problems by adding interaction terms based on the product of deprivation and age (e.g., deprivation x age and deprivation x age^2). These were not statistically significant so they were left out of the models presented here.

<Table 2 here>

<Table 3 here>

Illustrating the trajectories of problems by area deprivation

To illustrate some of the differences in problem behaviour for children living in high and low deprivation areas, we plotted the predicted values for the trajectories of conduct, emotional, hyperactivity and peer problems, based on the adjusted model results, for two illustrative cases of children living in high and low education deprived areas (Figures 1-4). High deprivation was defined by the lowest decile (1) and low deprivation was defined by the highest decile (10).

Conduct problems across ages 3 to 14 (Figure 1) appear to follow a trajectory where parents report their children as having more problems (around 2.5 points on the scale potentially ranging 0-10) at age 3, with a drop to around 1-1.25 points on the scale around age 10. Problems increase slightly on average as children enter adolescence. The trajectories are roughly parallel for the child living in an area with low education deprivation and the child in a high education deprivation area. The gap in these trajectories is around .25 points (Figure 1).

<Figure 1 here>

Hyperactivity scores (Figure 2) for children tend to start higher at age 3 (compared to the other problem scores) and steadily reduce with time by about one point by age 14. The consistent gap between the child in the high and the child in the low deprivation area is around .20 points on the scale.

<Figure 2 here>

Emotional symptoms start out quite low at age 3 and steadily increase but only slightly from just above 1 to around 2 points by age 14. A very small gap remains over time between the child in the high deprivation area and the child in the low deprivation area (Figure 3).

<Figure 3 here>

Peer problems (Figure 4) follow a flat trajectory, on average, with a small dip around 7-8 years of age. The child in the high education deprivation area and the child in the low education deprivation area are differentiated by a gap of around .40 points in peer problems across ages.

<Figure 4 here>

Random effects

In models with only age and age^2 as predictors, the intra-class correlations (ICCs) at ward-level range 2-4% across problem types and the ICCs at child-level range 44-58% across problem types. When adding area deprivation, the ICCs reduce to a range of .5-1% at ward-level and change to a range of 43-55% at child-level, across problem types. Hence, the differences in children's emotional and behavioural problems between wards in the models unadjusted for individual and family characteristics were mostly explained by area deprivation differences.

Modelling multiple domains jointly

Lastly, we attempted to explore whether the effect of education, skills and training deprivation, which we found to be significant for all four problem domains, was robust to the adjustment for the other domains of deprivation. We carried out additional models of all problem domains adjusting for the IMD domains of crime, health and disability, barriers to housing and services and living environment. We left out income and employment deprivation as they were too highly correlated with education, skills and deprivation (.80-.82) based on variance inflation factor[iv] (VIF) values.

Therefore, we fitted, for each problem domain, a regression model including all five domains: education, skills and training, barriers to housing and services, crime, health and disability, and living environment. The VIF values ranged from 1.029 to 3.477, suggesting that multicollinearity was not a concern. The results show that, when modelling these five domains jointly, the education, skills and training deprivation effect remains, but only for conduct problems, hyperactivity and peer problems (not emotional problems). What is

more, the effects we found in the main models for the other individual domains (health and disability, living environment and crime) were no longer significant.

We also tested a set of models with only the income, living environment, crime and barriers to housing and services domains. Income deprivation remained a significant predictor (but none of the other domains did) of emotional problems, conduct problems and peer problems. The same result was found when replacing income deprivation with employment deprivation, which is not surprising given the high correlation, between the two types of deprivation (.91).

Discussion

US and UK studies that find associations between neighbourhood deprivation and child problem behaviour typically measure deprivation either with an aggregate index of disadvantage or with a single measure of socio-economic deprivation (e.g., Minh, Muhajarine, Janus, Brownell, & Guhn, 2017). The present study explored individually the role of multiple dimensions of deprivation in the neighbourhood in the development of emotional and behavioural problems across childhood and adolescence. In models exploring deprivation domains separately, with adjustments for important confounders including those capturing selection of families into neighbourhoods, all domains of deprivation were related concurrently to at least one domain of child problem behaviour, except for barriers to housing and services. No single domain however was related to the rate of change in problem behaviour across childhood and adolescence.

In our study, socio-economic aspects of deprivation, including income, employment and education deprivation, were most consistently related to emotional and behavioural problems - in terms of the number of problem domains they affected- , which is in line with much previous evidence about the role of area-level socio-economic disadvantage in child outcomes (Andersen et al., 2014; Brooks-Gunn et al., 1993; Chase-Lansdale et al., 1997; Duncan et al., 1994; Edwards & Bromfield, 2009; Flouri et al., 2013; Flouri et al., 2012; Jeon et al., 2014; Leventhal & Brooks-Gunn, 2000; Midouhas et al., 2014). Income and employment deprivation were related to more emotional, conduct and peer problems (but

not more hyperactivity). Education deprivation was the only domain associated with more problems across *all* problem types. The education, skills and training domain captures an area's poor school attainment as well as absence of adult qualifications. The former could be a proxy for peer academic effects, for which the evidence available shows some support with regard to behavioural outcomes (Flouri & Midouhas, 2016; Humphrey & Wigelsworth, 2012). Lack of adult qualifications among neighbours has been largely unexplored in the 'neighbourhood effects' literature with regard to its influence on child emotional and behavioural problems. One study, however, also using the MCS, has found that a low proportion of university-educated adult residents was related positively to conduct problems during primary school (Midouhas, Kuang, & Flouri, 2014). It may be that being surrounded by educationally high status peers and adults is positive for one's behaviour broadly, over and above one's own ability, which we adjusted for in our analyses. This would provide support for the theory that good role models in the neighbourhood (Brooks-Gunn et al., 1993) may benefit children's behaviours by helping to maintain social control locally (Jencks & Mayer, 1990). The adverse impact of income and employment deprivation, which are highly associated with each other, is also aligned with the theory of the importance of the local presence of high status adults.

Although in models looking separately at deprivation domains, low crime levels, low health deprivation and disability and low living environment deprivation were each related to low scores in at least some SDQ scales, when modelling domains jointly these relationships were no longer significant. Education deprivation, however, remained significantly associated with hyperactivity, conduct problems and peer problems, although the link with emotional symptoms was attenuated. Moreover, in separate models exploring income/employment deprivation (but not education) - whilst adjusting for crime levels, barriers to housing and services as well as living environment deprivation - income/employment deprivation remained significantly related to emotional symptoms, conduct problems and peer problems (but not hyperactivity). Future research might explore the reasons why education (but not income or employment) deprivation predicts hyperactivity and why income/employment (but not education) deprivation predicts emotional symptoms. In general however, it appears that socio-economic aspects of deprivation are most relevant

for child emotional and behavioural outcomes. Yet it is important to note that, in comparison to the education, income and employment domains (which are based on rates), some of the other domains, including the crime and living environment domains, are based on modelled estimates which may be less reliable measures (Liverani, Lavigne, & Blangiardo, 2016).

A finding that merits discussion is the association of barriers to housing and services both with other deprivation domains and with child behaviour. Speficically, we found, along with others (Liverani, Lavigne, & Blangiardo, 2016), that the barriers to housing and services domain is negatively correlated with the other deprivation domains (except for the living environment domain). We also showed here that it behaves differently in terms of its association with child behaviour (it was unrelated to it). This may be partly because of the different (even conflicting) focuses it has (Office for National Statistics, 2009). The measure of barriers to housing and services comprises indicators of access to affordable housing as well as services including GPs and supermarkets. Given the density of services in urban areas, neighbourhoods considered to be deprived in this way are not over-represented among urban areas in the UK. Rural areas in the UK are in fact more deprived in terms of access to services. On the other hand, many London neighbourhoods and others in the Southeast are deprived in access to affordable housing, largely due to the high cost of housing in these areas (Office for National Statistics, 2009).

Another finding that warrants some discussion is that the differences in emotional and behavioural problems of children from higher and lower deprivation areas were stable over time, showing that these children tended to follow parallel paths. Behavioural and emotional problems do not appear to get worse over time for children in more deprived areas compared to their counterparts in less deprived areas. Furthermore, differences in child behaviour due to area deprivation were small, which reflects the wider literature showing rather modest effects of neighbourhood disadvantage on child development (). Our study's modest 'neighbourhood effect' was also evidenced by the small percentage of variation in problem behaviour at around age 8 years (2-4% in unadjusted models) that was attributed to the neighbourhoods (wards) our sample lived in at Sweeps 1 and 2 (at ages 9

months and 3 years, respectively). Loss of clustering of MCS children within neighbourhoods as they grow older, due to home moves, is an issue that needs to be acknowledged.

This study is not without its limitations. First, other unmeasured individual and family characteristics may be associated with a family's choice of neighbourhood, thus accounting for associations between neighbourhood deprivation and child problem behaviour. Second, we were unable to account for change in the characteristics of a neighbourhood over the course of the study period. Although areas could change over time in resident composition, employment opportunities, cultures of poverty, social capital, collective action or local policies, the only IMD available was measured at 2004. This study had to apply it to areas where families lived up to around 2015. Our implicit assumption that UK areas did not change in terms of IMD-relevant composition for our entire study period has some justification. What UK research there is suggests that few neighbourhoods change relative ranking much over the short term (Lupton & Power, 2004; Gambaro et al., 2016). In our study, an individual's IMD decile could change, but only for movers and only if there was a change of decile in IMD in either direction. Thus, we allow for changed environments for (some) movers but not for stayers. Third, the IMD is available for a pre-defined geographic unit, a LSOA. Although LSOA boundaries are drawn in order to maximise social homogeneity within areas and to take into account geographical barriers and edges of settlements, it is unclear to what extent such geographical units correspond to what residents refer to as 'neighbourhood'. Fourth, it is possible that the allowance for advantaged vs. disadvantaged stratum attenuates the estimates of IMD effects. Fifth given our outcome measure (parent-reported SDQ) we cannot tell if our estimates simply pick up the parent's perception or the child's behaviour. Last, the reasons for the associations between child behaviour and neighbourhood-level education or income/employment deprivation were unexplored here. This is worth pursuing in future research to uncover empirically the causal mechanisms that yield these relationships. Area-level education deprivation, for example, may be connected to children's behavioural and emotional outcomes simply because children may be attending schools that are under-resourced relative to the needs and challenges they face.

Identifying neighbourhood effects, or at least getting closer to understanding the role of area context, has implications for public policy, and our findings suggest that policies should target both 'place' and 'people' in order to reduce any child mental health inequalities. Our study showed clearly that socio-economic aspects of area deprivation (including employment, income and education deprivation), rather than area deprivation related to crime levels, the physical environment or access to services and affordable housing, appear to be related to emotional and behavioural problems of children in England followed from the preschool years to middle adolescence. Future research should explore the causal mechanisms explaining this risk specificity as well as examine histories of exposure to specific types of deprivation. In particular, it would be important to model the effects of moving to and from neighbourhoods with more and less socio-economic deprivation, separately for education and income/employment.

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[i] Electoral wards are the key building block of UK electoral geography (http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/administrative/england/electoral-wards-divisions/index.html). The average population is around 5,500, though counts can vary substantially.

[ii] Indicators include school-level achievement (average Key Stage 2, 3, and 4 scores) and absence rates, the proportion of young people not staying on in school/further education above 16 and the proportion under 21 not entering higher education.

[iii] The proportion of adult residents with no or low qualifications.

[iii] The general rule of thumb is that VIF values exceeding 4 warrant further investigation and VIF values exceeding 10 are signs of serious multicollinearity.

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Tables and figures

Table 1
Pearson's r correlations between area deprivation domains and emotional and behavioural problems in the analytic sample at age 7 (Sweep 4)

	1	2	3	4	5	6	7	8	9	10
1.Income	1									
2.Employment	.91**	1								
3.Health and Disability	.86**	.94**	1							
4.Barriers to Housing and Services	.01	-.09**	-.10**	1						
5.Education Skills and Training	.82**	.80**	.79**	-.13**	1					
6.Crime	.67**	.66**	.69**	-.07**	.59**	1				
7.Living Environment	.62**	.57**	.58**	.03*	.44**	.59**	1			
8.Emotional problems	-.14**	-.13**	-.11**	-.01	-.14**	-.11**	-.08**	1		
9.Conduct problems	-.17**	-.17**	-.16**	.03*	-.18**	-.13**	-.08**	.37**	1	
10.Hyper-activity	-.15**	-.14**	-.14**	.04*	-.17**	-.10**	-.08**	.28**	.54**	1
11.Peer problems	-.20**	-.18**	-.18**	-.01	-.21**	-.15**	-.12**	.42**	.34**	.32**

Note. *p<.05, **p<.01.

Table 2

Estimates of fixed effects (unstandardized regression coefficients with standard errors) for deprivation indices in unadjusted multilevel models of problem behaviour

IMD domain	Emotional problems	Conduct problems	Hyperactivity	Peer problems
Income	-0.051(0.006)**	-0.054(0.005)**	-0.054(0.008)**	-0.055(0.005)**
Employment	-0.045(0.006)**	-0.051(0.006)**	-0.043(0.008)**	-0.052(0.005)**
Health Deprivation and Disability	-0.043(0.006)**	-0.051(0.006)**	-0.051(0.009)**	-0.055(0.006)**
Barriers to Housing and Services	0.006(0.005)	0.009(0.005)	0.013(0.007)	0.002(0.005)
Education, Skills and Training	-0.051(0.006)**	-0.062(0.005)**	-0.068(0.008)**	-0.065(0.005)**
Crime	-0.032(0.006)**	-0.030(0.005)**	-0.021(0.008)**	-0.027(0.005)**
Living Environment	-0.020(0.006)**	-0.017(0.005)**	-0.013(0.008)	-0.020(0.005)**

Note: IMD=Index of Multiple Deprivation.*** p<.01*

Table 3

Estimates of fixed effects (unstandardized regression coefficients with standard errors) for deprivation indices in fully-adjusted multilevel models of problem behaviour

IMD domain	Emotional problems	Conduct problems	Hyperactivity	Peer problems
Income	-0.018(0.006)**	-0.027(0.005)**	-0.015(0.008)	-0.031(0.005)**
Employment	-0.013(0.006)*	-0.023(0.006)**	-0.002(0.008)	-0.030(0.006)**
Health Deprivation and Disability	-0.011(0.006)	-0.025(0.006)**	-0.009(0.009)	-0.034(0.006)**
Barriers to Housing and Services	-0.002(0.005)	0.004(0.005)	0.010(0.007)	0.005(0.005)
Education, Skills and Training	-0.015(0.006)**	-0.029(0.005)**	-0.020(0.008)*	-0.039(0.005)**
Crime	-0.015(0.006)*	-0.016(0.006)**	0.005(0.008)	-0.021(0.005)**
Living Environment	-0.004(0.005)	-0.008(0.005)	-0.003(0.007)	-0.013(0.005)*

Note: IMD=Index of Multiple Deprivation. *p<.05,** p<.01*

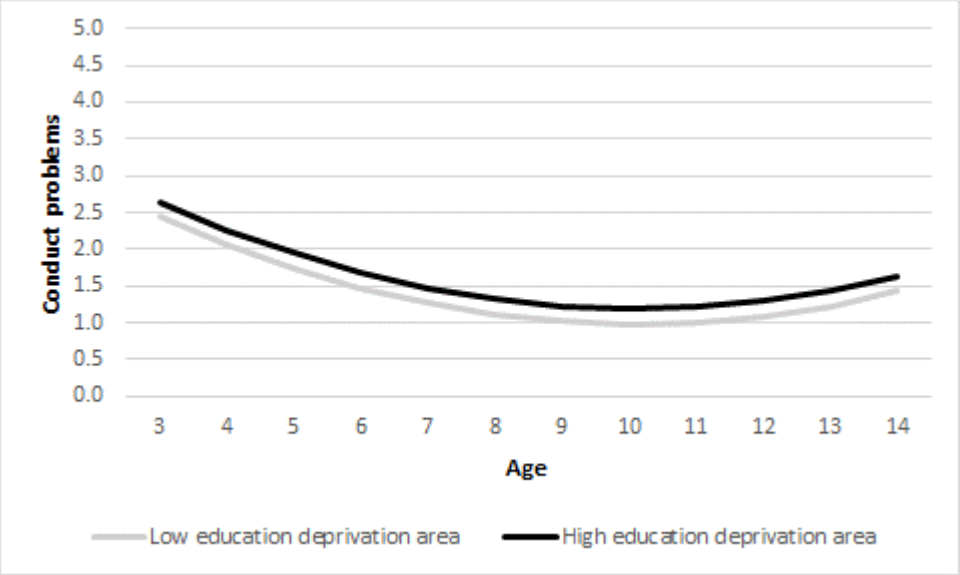

Figure 1. Predicted conduct problem trajectories by area education deprivation level (high vs. low)
Notes. Predictions are plotted for the reference group for each categorical variable and at the mean for each continuous variable. High deprivation is defined by the lowest decile (1) and low deprivation is defined by the highest decile (10).

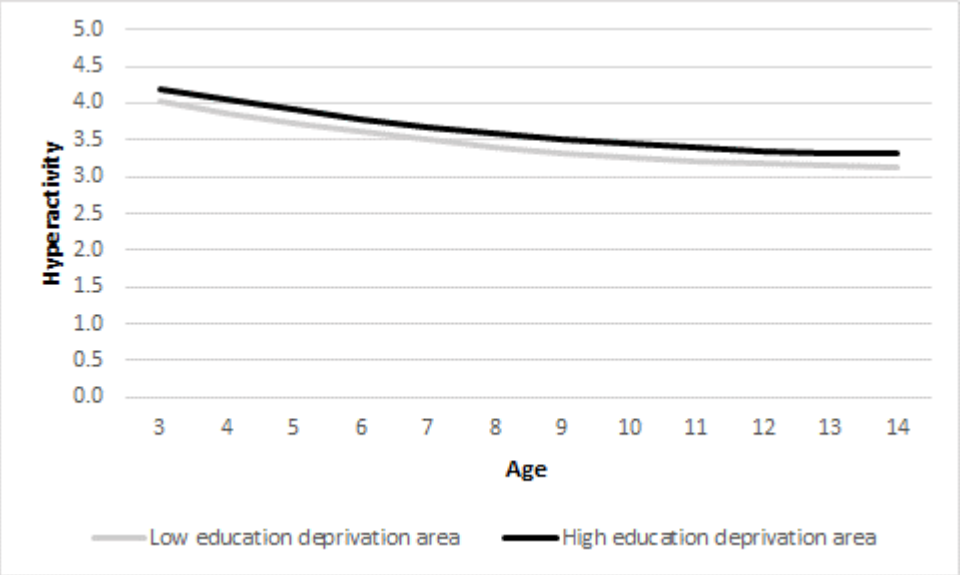

Figure 2. Predicted hyperactivity/inattention trajectories by area education deprivation level (high vs. low)
Notes. See Figure 1.

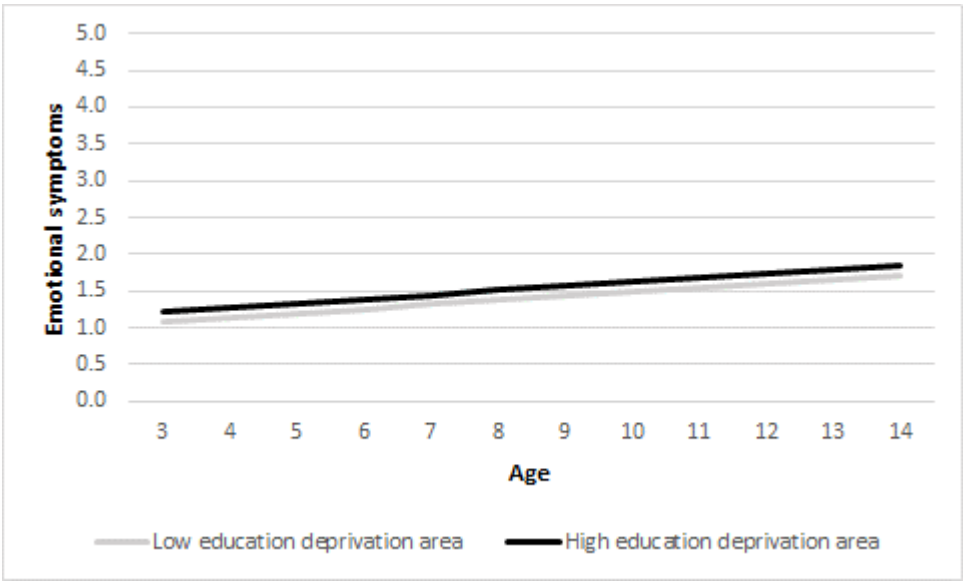

Figure 3. Predicted emotional symptom trajectories by area education deprivation level (high vs. low)
Notes. See Figure 1.

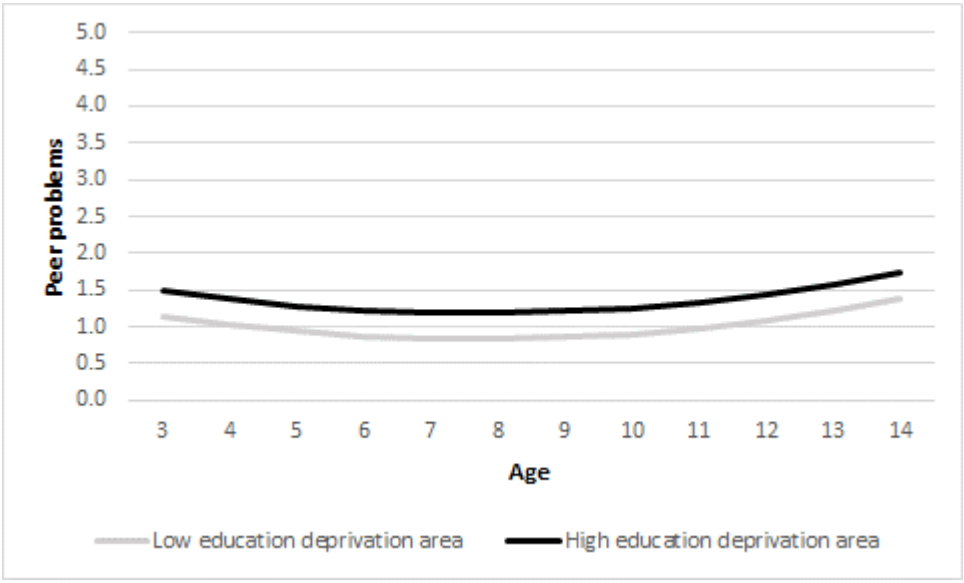

Figure 4. Predicted peer problem trajectories by area education deprivation level (high vs. low)
Notes. See Figure 1.

APPENDICES

A. Tables A1-S7 present the results of the fully-adjusted multilevel model (fixed and random effects) for each of the IMD domains on each SDQ outcome.

Table A1. Fixed and random effect estimates for adjusted multilevel model with IMD Income

	Emotional problems (n=5,918)		Conduct problems (n=5,919)		Hyperactivity (n=5,915)		Peer Problems (n=5,918)	
	Coeff.	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***
Fixed effects								
IMD Income†	**-0.01****	**0.00**	**-0.02****	**0.00**	**-0.01**	**0.00**	**-0.03****	**0.00**
Constant	2.44**	0.13	2.31**	0.12	6.30**	0.19	2.10**	0.12
Age (gm) †	0.05**	0.00	-0.12**	0.00	-0.08**	0.00	0.00**	0.00
Age (gm^2) †	0.00	0.00	0.02**	0.00	0.00**	0.00	0.01**	0.00
Maternal mental health †	0.09**	0.00	0.06**	0.00	0.07**	0.00	0.05**	0.00
Family poverty†	0.07*	0.03	0.09**	0.02	0.05	0.03	0.09**	0.02
Urbanicity†	-0.01	0.03	0.02	0.03	0.01	0.05	-0.02	0.03
Residential mobility†	0.05*	0.02	0.12**	0.02	0.03	0.02	0.04*	0.02
England advantaged	0.07	0.03	0.15**	0.03	0.16**	0.05	0.13**	0.03
England ethnic	0.05	0.06	0.10	0.06	0.10	0.10	0.10	0.06
Female	0.10**	0.03	-0.20**	0.02	-0.67**	0.04	-0.16**	0.02
Ethnicity-Mixed	-0.03	0.08	-0.05	0.08	-0.11	0.12	0.00	0.07
Ethnicity-Indian	-0.03	0.09	-0.16	0.08	-0.10	0.13	0.30**	0.08
Ethnicity-Pakistani & Bangladeshi	0.24**	0.07	-0.18*	0.07	-0.10	0.11	0.45	0.07
Ethnicity-Black	-0.27**	0.09	-0.32**	0.08	-0.49**	0.13	-0.01	0.08
Ethnicity-Other	0.04	0.13	-0.28*	0.12	-0.31	0.18	0.36**	0.11
IQ	-0.01**	0.00	-0.01**	0.00	-0.02**	0.00	-0.00**	0.00

Mother university educated	-0.09**	0.03	-0.25**	0.03	-0.57**	0.05	-0.13	0.03
Natural parents†	-0.20**	0.03	-0.20**	0.03	-0.27**	0.04	-0.17**	0.03
Random effects								
Level 3 (ward) Intercept	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Level 2 (child) Intercept	1.05	0.02	0.96	0.02	2.47	0.05	0.86	0.02
Level 2 (child) Slope	0.07	0.00	-0.01	0.00	0.01	0.00	0.04	0.00
Level 2 (child) Intercept/slope covariance	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.00
Level 1 (occasion) Intercept	1.50	0.01	1.12	0.01	2.00	0.02	1.17	0.01
Note: Coeff.=(Unstandardised) regression coefficient; S.E.=Standard error; gm=grand mean centred; IMD=Index of Multiple Deprivation; † time varying ** p<.01; * p<.05								

Table A2. Fixed and random effect estimates for adjusted multilevel model with IMD Employment

	Emotional problems (n=5,918)		Conduct problems (n=5,919)		Hyperactivity (n=5,915)		Peer Problems (n=5,918)	
	Coeff.	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***
Fixed effects								
IMD Employment†	**-0.01***	**0.01**	**-0.02****	**0.01**	**0.00**	**0.01**	**-0.03****	**0.01**
Constant	2.43**	0.13	2.31**	0.13	6.25**	0.19	2.11**	0.12
Age (gm) †	0.06**	0.00	-0.12**	0.00	-0.09**	0.00	0.01**	0.00
Age (gm^2) †	0.00	0.00	0.03**	0.00	0.01**	0.00	0.01**	0.00
Maternal mental health†	0.09**	0.00	0.07**	0.00	0.08**	0.00	0.06**	0.00
Family poverty†	0.08*	0.03	0.10**	0.03	0.06	0.04	0.10**	0.03
Urbanicity†	-0.01	0.04	0.02	0.04	0.02	0.05	-0.03	0.04
Residential mobility†	0.05*	0.03	0.12**	0.02	0.03	0.03	0.05*	0.02
England advantaged	0.08*	0.04	0.16**	0.04	0.19	0.06	0.13**	0.04

England ethnic	0.07	0.07	0.12*	0.06	0.14	0.10	0.12	0.06
Female	0.10**	0.03	-0.21**	0.03	-0.68	Ll.05	-0.16**	0.03
Ethnicity-Mixed	-0.03	0.08	-0.04	0.08	-0.10	0.12	0.02	0.08
Ethnicity-Indian	-0.03	0.09	-0.16	0.09	-0.11	0.14	0.31**	0.08
Ethnicity-Pakistani & Bangladeshi	0.25**	0.08	-0.18*	0.07	-0.10	0.11	0.46**	0.07
Ethnicity-Black	-0.26**	0.09	-0.31**	0.09	-0.48**	0.14	0.00	0.09
Ethnicity-Other	0.05	0.13	-0.26*	0.12	-0.31	0.19	0.38**	0.12
IQ	-0.01**	0.00	-0.01**	0.00	-0.03**	0.00	-0.01**	0.00
Mother university educated	-0.10*	0.04	-0.26**	0.04	-0.59**	0.06	-0.14**	0.03
Natural parents†	-0.21**	0.03	-0.21**	0.03	-0.28**	0.04	-0.17**	0.03
Random effects								
Level 3 (ward) Intercept	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Level 2 (child) Intercept	1.05	0.02	0.96	0.02	2.47	0.05	0.86	0.02
Level 2 (child) Slope	0.07	0.00	-0.01	0.00	0.01	0.00	0.04	0.00
Level 2 (child) Intercept/slope covariance	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.00
Level 1 (occasion) Intercept	1.50	0.01	1.12	0.01	2.00	0.02	1.17	0.01

Note: Coeff.=(Unstandardised) regression coefficient; S.E.=Standard error; gm=grand mean centred; IMD=Index of Multiple Deprivation; † time varying
** p<.01; * p<.05

Table A3. Fixed and random effect estimates for adjusted multilevel model with IMD Health Deprivation and Disability

	Emotional problems (n=5,918)		Conduct problems (n=5,919)		Hyperactivity (n=5,915)		Peer Problems (n=5,918)	
	Coeff.	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***

Fixed effects								
IMD Health deprivation and disability†	**-0.01**	**0.01**	**-0.03****	**0.01**	**-0.01**	**0.01**	**-0.03****	**0.01**
Constant	2.42**	0.13	2.34**	0.13	6.29**	0.20	2.16**	0.12
Age (gm) †	0.06**	0.00	-0.12**	0.00	-0.09**	0.00	0.01**	0.00
Age (gm^2) †	0.00	0.00	0.03**	0.00	0.01**	0.00	0.01**	0.00
Maternal mental health†	0.09**	0.00	0.07**	0.00	0.08**	0.00	0.06**	0.00
Family poverty†	0.08*	0.03	0.10**	0.03	0.06	0.04	0.10**	0.03
Urbanicity†	-0.02	0.04	0.01	0.04	0.01	0.05	-0.05	0.04
Residential mobility†	0.05*	0.03	0.12**	0.02	0.03	0.03	0.05*	0.02
England advantaged	0.09*	0.04	0.16**	0.04	0.18**	0.06	0.12**	0.04
England ethnic	0.08	0.07	0.12	0.06	0.12	0.10	0.11	0.06
Female	0.10**	0.03	-0.21**	0.03	-0.68**	0.05	-0.16**	0.03
Ethnicity-Mixed	-0.03	0.08	-0.04	0.08	-0.10	0.12	0.02	0.08
Ethnicity-Indian	-0.03	0.09	-0.16	0.09	-0.10	0.14	0.31**	0.08
Ethnicity-Pakistani & Bangladeshi	0.25**	0.08	-0.18*	0.07	-0.10	0.11	0.46**	0.07
Ethnicity-Black	-0.26**	0.09	-0.31**	0.09	-0.48**	0.14	0.00	0.09
Ethnicity-Other	0.05	0.13	-0.26*	0.12	-0.31	0.19	0.39**	0.12
IQ	-0.01**	0.00	-0.01**	0.00	-0.03**	0.00	-0.01**	0.00
Mother university educated	-0.10**	0.04	-0.26**	0.04	-0.58**	0.06	-0.13**	0.03
Natural parents†	-0.21**	0.03	-0.21**	0.03	-0.28**	0.04	-0.17**	0.03
Random effects								
Level 3 (ward) Intercept	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Level 2 (child) Intercept	1.05	0.02	0.96	0.02	2.47	0.05	0.86	0.02

Level 2 (child) Slope	0.07	0.00	-0.01	0.00	0.01	0.00	0.04	0.00
Level 2 (child) Intercept/slope covariance	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.00
Level 1 (occasion) Intercept	1.50	0.01	1.12	0.01	2.00	0.02	1.17	0.01

Note: Coeff.=(Unstandardised) regression coefficient; S.E.=Standard error; gm=grand mean centred; IMD=Index of Multiple Deprivation; † time varying
** p<.01; * p<.05

Table A4. Fixed and random effect estimates for adjusted multilevel model with IMD Barriers to Housing and Services

	Emotional problems (n=5,918)		Conduct problems (n=5,919)		Hyperactivity (n=5,915)		Peer Problems (n=5,918)	
	Coeff.	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***
Fixed effects								
IMD Barriers to housing and services†	**0.00**	**0.01**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Constant	2.37**	0.13	2.17**	0.13	6.19**	0.19	1.93**	0.12
Age (gm) †	0.06**	0.00	-0.12**	0.00	-0.09**	0.00	0.01*	0.00
Age (gm^2) †	0.00	0.00	0.03**	0.00	0.01**	0.00	0.01**	0.00
Maternal mental health†	0.09**	0.00	0.07**	0.00	0.08**	0.00	0.06**	0.00
Family poverty†	0.09**	0.03	0.11**	0.03	0.06	0.04	0.11**	0.03
Urbanicity†	0.00	0.04	0.04	0.04	0.00	0.05	-0.01	0.04
Residential mobility†	0.05	0.03	0.12**	0.02	0.03	0.03	0.04	0.02
England advantaged	0.11**	0.03	0.22**	0.03	0.20**	0.05	0.21**	0.04
England ethnic	0.11	0.06	0.20**	0.06	0.16	0.10	0.21**	0.06
Female	0.10**	0.03	-0.21**	0.03	-0.68**	0.05	-0.16**	0.03
Ethnicity-Mixed	-0.03	0.08	-0.03	0.08	-0.09	0.13	0.03	0.08
Ethnicity-Indian	-0.04	0.09	-0.17*	0.09	-0.10	0.14	0.30**	0.09

Ethnicity-Pakistani & Bangladeshi	0.26**	0.08	-0.17*	0.07	-0.10	0.11	0.48**	0.07
Ethnicity-Black	-0.26**	0.09	-0.29**	0.09	-0.45**	0.14	0.02	0.09
Ethnicity-Other	0.04	0.13	-0.27*	0.12	-0.30	0.19	0.38**	0.12
IQ	-0.01**	0.00	-0.01**	0.00	-0.03**	0.00	-0.01**	0.00
Mother university educated	-0.11**	0.04	-0.28**	0.04	-0.59**	0.06	-0.16**	0.03
Natural parents†	-0.22**	0.03	-0.22**	0.03	-0.28**	0.04	-0.19**	0.03
Random effects								
Level 3 (ward) Intercept	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Level 2 (child) Intercept	1.05	0.02	0.96	0.02	2.47	0.05	0.87	0.02
Level 2 (child) Slope	0.07	0.00	-0.01	0.00	0.01	0.00	0.04	0.00
Level 2 (child) Intercept/slope covariance	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.00
Level 1 (occasion) Intercept	1.50	0.01	1.12	0.01	2.00	0.02	1.17	0.01

Note: Coeff.=(Unstandardised) regression coefficient; S.E.=Standard error; gm=grand mean centred; IMD=Index of Multiple Deprivation; † time varying
** p<.01; * p<.05

Table A5. Fixed and random effect estimates for adjusted multilevel model with IMD Education Skills and Training

	Emotional problems (n=5,918)		Conduct problems (n=5,919)		Hyperactivity (n=5,915)		Peer Problems (n=5,918)	
	Coeff.	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***
Fixed effects								
IMD Education Skills and Training†	**-0.02***	**0.01**	**-0.03****	**0.01**	**-0.02***	**0.01**	**-0.04****	**0.01**
Constant	2.42**	0.13	2.31**	0.13	6.32**	0.19	2.13**	0.12
Age (gm) †	0.06**	0.00	-0.12**	0.00	-0.09**	0.00	0.01**	0.00

Age (gm^2) †	0.00	0.00	0.03**	0.00	0.01**	0.00	0.01**	0.00
Maternal mental health†	0.09**	0.00	0.07**	0.00	0.08**	0.00	0.06**	0.00
Family poverty†	0.08	0.03	0.09**	0.03	0.06	0.04	0.09**	0.03
Urbanicity†	-0.02	0.04	0.01	0.04	0.00	0.05	-0.05	0.04
Residential mobility†	0.05*	0.03	0.12**	0.02	0.03	0.03	0.05*	0.02
England advantaged	0.08*	0.04	0.16**	0.04	0.15*	0.06	0.12**	0.03
England ethnic	0.08	0.06	0.13*	0.06	0.11	0.10	0.13*	0.06
Female	0.10**	0.03	-0.21**	0.03	-0.68**	0.05	-0.16**	0.03
Ethnicity-Mixed	-0.03	0.08	-0.04	0.08	-0.11	0.12	0.02	0.08
Ethnicity-Indian	-0.02	0.09	-0.15	0.09	-0.09	0.14	0.33**	0.08
Ethnicity-Pakistani & Bangladeshi	0.25**	0.08	-0.18*	0.07	-0.11	0.11	0.46**	0.07
Ethnicity-Black	-0.25*	0.09	-0.30**	0.09	-0.48**	0.14	0.02	0.08
Ethnicity-Other	0.06	0.13	-0.25	0.12	-0.30	0.19	0.40	0.12
IQ	-0.01**	0.00	-0.01**	0.00	-0.03**	0.00	-0.01**	0.00
Mother university educated	-0.09*	0.04	-0.23**	0.04	-0.56**	0.06	-0.11**	0.03
Natural parents†	-0.21**	0.03	-0.21**	0.03	-0.28**	0.04	-0.17**	0.03
Random effects								
Level 3 (ward) Intercept	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Level 2 (child) Intercept	1.05	0.02	0.96	0.02	2.47	0.05	0.86	0.02
Level 2 (child) Slope	0.07	0.00	-0.01	0.00	0.01	0.00	0.04	0.00
Level 2 (child) Intercept/slope covariance	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.00
Level 1 (occasion) Intercept	1.50	0.01	1.12	0.01	2.00	0.02	1.17	0.01

Note: Coeff.=(Unstandardised) regression coefficient; S.E.=Standard error; gm=grand mean centred; IMD=Index of Multiple Deprivation; † time varying
** p<.01; * p<.05

Table A6. Fixed and random effect estimates for adjusted multilevel model with IMD Crime								
	Emotional problems (n=5,918)		Conduct problems (n=5,919)		Hyperactivity (n=5,915)		Peer Problems (n=5,918)	
	Coeff.	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***
Fixed effects								
IMD Crime†	**-0.02***	**0.01**	**-0.02****	**0.01**	**-0.01**	**0.01**	**-0.02****	**0.01**
Constant	2.47**	0.14	2.31**	0.13	6.27**	0.20	2.10**	0.13
Age (gm) †	0.06**	0.00	-0.12**	0.00	-0.09**	0.00	0.01*	0.00
Age (gm^2) †	0.00	0.00	0.03**	0.00	0.01**	0.00	0.01**	0.00
Maternal mental health†	0.09**	0.00	0.07**	0.00	0.08**	0.00	0.06**	0.00
Family poverty†	0.08*	0.03	0.10**	0.03	0.06	0.04	0.11**	0.03
Urbanicity†	-0.03	0.04	0.01	0.04	0.01	0.05	-0.04	0.04
Residential mobility†	0.05*	0.03	0.12**	0.02	0.03	0.03	0.04*	0.02
England advantaged	0.08*	0.04	0.19**	0.04	0.19**	0.06	0.17**	0.04
England ethnic	0.07	0.06	0.15*	0.06	0.13	0.10	0.15*	0.06
Female	0.10**	0.03	-0.21**	0.03	-0.68**	0.05	-0.16**	0.03
Ethnicity-Mixed	-0.03	0.08	-0.04	0.08	-0.11	0.12	0.02	0.08
Ethnicity-Indian	-0.03	0.09	-0.17*	0.09	-0.11	0.14	0.30**	0.09
Ethnicity-Pakistani & Bangladeshi	0.25**	0.08	-0.17*	0.07	-0.10	0.11	0.47**	0.07
Ethnicity-Black	-0.27**	0.09	-0.32**	0.09	-0.48**	0.14	0.00	0.09
Ethnicity-Other	0.05	0.13	-0.27*	0.12	-0.32	0.19	0.38**	0.12
IQ	-0.01**	0.00	-0.01**	0.00	-0.03**	0.00	-0.01**	0.00
Mother university educated	-0.11**	0.04	-0.27**	0.04	-0.59**	0.06	-0.15**	0.03

Natural parents†	-0.21	0.03	-0.22**	0.03	-0.28**	0.04	-0.18**	0.03
Random effects								
Level 3 (ward) Intercept	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Level 2 (child) Intercept	1.05	0.02	0.96	0.02	2.47	0.05	0.86	0.02
Level 2 (child) Slope	0.07	0.00	-0.01	0.00	0.01	0.00	0.04	0.00
Level 2 (child) Intercept/slope covariance	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.00
Level 1 (occasion) Intercept	1.50	0.01	1.12	0.01	2.00	0.02	1.17	0.01
Note: Coeff.=(Unstandardised) regression coefficient; S.E.=Standard error; gm=grand mean centred; IMD=Index of Multiple Deprivation; † time varying ** p<.01; * p<.05								

Table A7. Fixed and random effect estimates for adjusted multilevel model with IMD Living Environment

	Emotional problems (n=5,918)		Conduct problems (n=5,919)		Hyperactivity (n=5,915)		Peer Problems (n=5,918)	
	S.E.	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***	***S.E.***	***Coeff.***
Fixed effects								
IMD Living environment†	**0.00**	**0.01**	**-0.01**	**0.01**	**0.00**	**0.01**	**-0.01***	**0.01**
Constant	2.38**	0.13	2.24**	0.13	6.26**	0.20.	2.03**	0.12
Age (gm) †	0.06**	0.00	-0.12**	0.00	-0.09**	0.00	0.01*	0.00
Age (gm^2) †	0.00	0.00	0.03**	0.00	0.01**	0.00	0.01**	0.00
Maternal mental health†	0.09**	0.00	0.07**	0.00	0.08**	0. I .00	0.06**	0.00
Family poverty†	0.09**	0.03	0.11**	0.03	0.06	0..04	0.11**	0.03
Urbanicity†	0.00	0.04	0.04	0.04	0.02	0.05	-0.01	0.04
Residential mobility†	0.05	0.03	0.12**	0.02	0.03	0.03	0.04	0.02

England advantaged	0.11**	0.04	0.21**	0.04	0.19**	0.06	0.19**	0.04
England ethnic	0.10	0.06	0.17*	0.06	0.14	0.10	0.17*	0.06
Female	0.10**	0.03	-0.21**	0.03	-0.68**	0.05	-0.16**	0.03
Ethnicity-Mixed	-0.03	0.08	-0.04	0.08	-0.11	0.13	0.02	0.08
Ethnicity-Indian	-0.04	0.09	-0.17**	0.09	-0.11	0.14	0.29**	0.09
Ethnicity-Pakistani & Bangladeshi	0.25**	0.08	-0.18*	0.07	-0.10	0.11	0.46**	0.07
Ethnicity-Black	-0.26**	0.09	-0.31**	0.09	-0.48**	0.14	0.00	0.09
Ethnicity-Other	0.04	0.13	-0.28*	0.12	-0.32	0.19	0.37**	0.12
IQ	-0.01**	0.00	-0.01**	0.00	-0.03**	0.00	-0.01**	0.00
Mother university educated	-0.11**	0.04	-0.28**	0.04	-0.59**	0.06	-0.16**	0.03
Natural parents†	-0.22**	0.03	-0.22**	0.03	-0.28**	0.04	-0.19**	0.03
Random effects								
Level 3 (ward) Intercept	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Level 2 (child) Intercept	1.05	0.02	0.96	0.02	2.47	0.05	0.86	0.02
Level 2 (child) Slope	0.07	0.00	-0.01	0.00	0.01	0.00	0.04	0.00
Level 2 (child) Intercept/slope covariance	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.00
Level 1 (occasion) Intercept	1.50	0.01	1.12	0.01	2.00	0.023	1.17	0.01
Note: Coeff.=(Unstandardised) regression coefficient; S.E.=Standard error; gm=grand mean centred; IMD=Index of Multiple Deprivation; † time varying ** p<.01; * p<.05								

B. We fitted our multilevel models in MLwiN which provides only unstandardised coefficients. But to give an idea of how meaningful our results are, we present below a table showing the results from two sets of multilevel models. For each set, we report the t-statistic for the effect of the IMD domain [‘income’ (Set A) and ‘education’ (Set B)] alongside the t-statistic for the effect of the family level ‘equivalent’ variable (family poverty and maternal education, respectively), produced after full adjustment for all covariates. We present the results only for income and education as these are

the IMD domains with clear family-level equivalents in our data. As can be seen in the table: 1) both area effects seem larger for peer problems than the family-level equivalent effects, 2) area poverty seems to affect children's externalising problems (conduct problems and hyperactivity) more than their own family's poverty does, and 3) as expected, the education of the mother appears to have a much stronger effect than the education of her neighbours on her child's externalising problems.

Table A8. T-test statistics of area and individual effects in 2 sets of (fully-adjusted) multilevel models

	Emotional problems	Conduct problems	Hyperactivity	Peer problems
Set A				
Area: IMD Income Domain	3	5.4	1.8	6.2
Family: below poverty line	2.5	3.4	0.4	3.4
Set B				
Area: IMD Education, Skills and Training	2.5	5.8	2.5	7.8
Family: mother is university-educated	2.4	7.2	9.9	3.1