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Are the differences in adulthood ill-health across the North-South divide and between Scotland and England also evident in early childhood health indicators?

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ABSTRACT

Regional differences in adult morbidity and mortality within England (i.e., north-south divide or gradient) and between England and Scotland (i.e., Scottish effect) are only partly explained by adult levels of socioeconomic status or risk factors. This suggests variation in early life, and is supported by the fetal origins and life-course literature which posits that birth outcomes and subsequent, cumulative exposures influence adult health. However, no studies have examined the north-south gradient or Scottish effect in health in the earliest years of life. The aims of the study were: i) to examine health indicators in English and Scottish children at birth and age three to establish whether regional differences exist; and ii) to establish whether observed changes in child health at age three were attributable to birth and/or early life environmental exposures. Respondents included 10,639 biological Caucasian mothers of singleton children recruited to the Millennium Cohort Study (MCS) in the year 2000. Outcome variables were: gestational age and birth weight, and height, body mass index (BMI), and externalising behavioural problems at age three. Region/country was categorised as: South (reference), Midlands, North (England), and Scotland. Respondents provided information on child, maternal, household, and socioeconomic characteristics. Results indicated no significant regional variations for gestational age or birth weight. At age three there was a north-south gradient for externalising behaviour and a north-south divide in BMI which attenuated on adjustment. However, a north-south divide in height was not fully explained by adjustment. There was also evidence of a 'Midlands effect', with increased likelihood of shorter stature and behaviour problems. Results showed a Scottish effect for height and BMI in the unadjusted models, and height in the adjusted model, but a decreased likelihood of behaviour problems. Findings indicated no regional differences in health at birth, but some regional variation at age three supports the cumulative life-course model.

Keywords: England, Scotland, north-south divide, Scottish effect, health inequalities, child health, life-course

INTRODUCTION

The north-south divide in adult health within England is a well documented, persistent phenomena of worse health outcomes for those living in the north of England compared to those in the south, and has also been observed as a *gradient* of increasingly worse health from the south, through the midlands, to the north of England (Doran, Drever, & Whitehead, 2004; Hacking, Muller, & Buchan, 2011; Leyland, 2004; Wells & Gordon, 2008). These differences are somewhat, but not entirely explained by variations in socioeconomic status (SES) or other factors such as lifestyle or social composition within regions (Doran et al., 2004; Hacking et al., 2011).

Similarly, Scotland exhibits higher mortality rates than England that go back to at least 1925, and have been increasing since the middle of the 20th century, especially for men (Campbell, Ballas, Dorling, & Mitchell, 2013). Even compared to similarly deprived areas in other parts of Britain, Scotland has a history of higher mortality rates (Hanlon et al., 2005). These findings have led to the term 'the Scottish effect', and as with the north-south divide in England, the higher mortality risk in Scotland is only partially explained by differences in deprivation levels (Hanlon et al., 2005) or variations in lifestyle or risk factor levels (Mitchell, Fowkes, Blane, & Bartley, 2005). More recently, Shelton (2009) has also identified evidence of a Scottish effect in the prevalence of risk factors for cardiovascular disease in a comparison of Scottish and English regions. However, the relationship between area and risk factor was complex, and varied in strength and direction according to gender and risk factor.

Research investigating the north-south divide and the Scottish effect has typically focused on *adult* mortality and morbidity. However, it seems plausible to examine patterns of regional differences in early life health indicators as these may be the precursors to regional differences in later life health outcomes. We know from the fetal origins and life-course literature (Barker, 1992; Ben-Shlomo & Kuh, 2002; Power & Hertzman, 1997) that birth and

early life outcomes are associated with a range of adverse health outcomes in the adult years. For example, associations that are independent of the effects of birth weight have been established between preterm birth and cardiovascular disease, hypertension, and glycaemic dysregulation (Dalziel, Parag, Rodgers, & Harding, 2007; Doyle, 2008). Similarly, substantive literature has documented relationships between low birth weight and cardiovascular disease (Eriksson, Forsén, Tuomilehto, Osmond, & Barker, 2001; Kaijser et al., 2008; Rich-Edwards et al., 2005), hypertension (Eriksson, Forsén, Tuomilehto, Osmond, & Barker, 2000; Ramadhani et al., 2006), and metabolic syndrome (Eriksson et al., 2000; Newsome et al., 2003; Ramadhani et al., 2006) in adulthood. Evidence suggests an inverse association between height and cardiovascular disease (Paajanen, Oksala, Kuukasjärvi, & Karhunen, 2010; The Emerging Risk Factors Collaboration, 2012), height and cardiorespiratory disease (Davey Smith et al., 2000; McCarron, Okasha, McEwen, & Davey Smith, 2002), and an association between high body mass index (BMI) in childhood and the development of type 2 diabetes, hypertension, and coronary heart disease in adulthood (Park, Falconer, Viner, & Kinra, 2012; Reilly & Kelly, 2011). Finally, evidence indicates that behavioural problems in childhood are associated with increased risk in a number of health-related areas in adulthood including: obesity, substance misuse, risky sexual behaviour (e.g., multiple partners; teen pregnancy/parenthood), injury, hospitalisation due to road traffic accidents, chronic widespread pain, long-term illness, psychological ill health, mortality (by midlife), and criminal behaviour (von Stumm et al., 2011; Fergusson, Horwood, & Ridder, 2005; Timmermans, van Lier, & Koot 2008; Jokela, Power, & Kivimäki, 2009; Redelmeier, Chan, & Lu, 2010; Pang, Jones, Power, & Macfarlane, 2010; Clark, Rodgers, Caldwell, Power, & Stansfeld, 2007; Jokela, Ferrie, & Kivimäki, 2009; Murray, Irving, Farrington, Colman, & Bloxsom, 2010). Finally, evidence indicates that behavioural problems in childhood are associated with increased risks in a number of health-related areas in adulthood

including: obesity (von Stumm, Deary, Kivimäki, et al., 2011), substance misuse (von Stumm, Deary, Kivimäki, et al. 2011; Fergusson, Horwood, Ridder, 2005), risky sexual behaviour (e.g., multiple partners; teen pregnancy/parenthood) (Fergusson, Horwood, Ridder, 2005), injury (Jokela, Power, Kivimäki, 2009), hospitalisation due to road traffic accidents (Redelmeier, Chan, Lu, 2010), chronic widespread pain (Pang, Jones, Power, et al., 2010), long-term illness (von Stumm, Deary, Kivimäki, et al., 2011), psychological ill health (Fergusson, Horwood, Ridder, 2005; Clark, Rodgers, Caldwell, et al., 2007), mortality (by midlife) (Jokela, Ferrie, Kivimäki, 2009), and criminal behaviour (Fergusson, Horwood, Ridder, 2005; Murray, Irving, Farrington, et al., 2010).

Therefore, there is a rationale for examining early life health indicators in order to understand patterns of regional differences that may be present at birth, or that may emerge during the first few years of life. Moreover, if regional differences in health are present at birth and in the early years, important policy implications are imminent. For example, if the origins of chronic disease are largely determined in the fetal and early life periods, public health interventions should target this important life-stage. Moreover, whilst the impact of birth characteristics (Barker, 1992; Gluckman, Hanson, Spencer, & Bateson, 2005) and the accumulation of subsequent and varied early life environmental exposures on adult health is well-established (Power & Hertzman, 1997), there is little research focused directly towards the impact of such variables on health outcomes in the shorter term (i.e., during the first few years of life).

To date, there are no studies that have explicitly examined the north-south divide (or gradient) or the Scottish effect in health in the earliest years of life. Therefore, the aims of this study were twofold. First, we aimed to examine health indicators in English and Scottish children at birth and at three years of age in order to establish whether regional differences exist – it was hypothesised that if the antecedents of regional variations in adult health are

determined at an early stage then similar variations should be present, and will be evident as markedly worse health at birth or during the infancy/early childhood period for those living in the north of England (compared to the south of England), and for those living in Scotland (compared to the south of England). The five health indicators examined were: gestational age and weight at birth, and height, BMI, and externalising behaviour problems at three years of age. The second aim of the present study was to establish whether observed changes in health at age three were attributable to birth characteristics and/or early life environmental factors.

METHODS

Sample Population

Respondents were the biological mothers of singleton children enrolled in the Millennium Cohort Study (MCS), a nationally representative birth cohort study of children born across the UK in the year 2000 (see cohort profile by Connelly & Platt, 2014). The present study is concerned with data collected in waves 1 (baseline) and 2 (second stage of data collection) of the MCS in England and Scotland when the cohort child was aged nine months and three years respectively. It should be noted that attrition rates at wave 2 for families with lower (or no) education was higher in Scotland than in England, thus affecting the representativeness of the Scottish sample at wave 2. Children of non-biological mothers (1.8% of total sample), and from non-singleton pregnancies (1.4% of total sample) were excluded because of their potential to confound results. There were also a small numbers of cases that had incomplete data for maternal age, maternal ethnicity, mother's employment, number of siblings, tenure, and car availability (N=20) which were also excluded from analysis. These exclusions left a sample size of 13365. Frequency analysis showed the proportion of non-white ethnicities in Scotland was small (2.2%) compared to the other

regions (see Table 1), therefore, children of non-white/non-Caucasian mothers were excluded from further analysis. The final sample sizes for analysis with valid data on each of the five outcome variables were as follows: gestational age, N=10575; birth weight, N=10512; height, N=8233; BMI, N=8143; and externalising behaviour N=8576. Ethical approvals for the MCS waves 1 and 2 were granted by the South West Multicentre Research Ethics Committee (MREC) and London MREC respectively.

Measurements

Outcome variables

All outcome variables were coded as binary. Gestational age comprised a preterm (25^{+0}-37^{+0} weeks) versus term group (37^{+1}-43^{+0} weeks). Birth weight comprised a low birth weight (LBW) (0.500-2.500 kgs) versus normal group (>2.500 kgs). Height comprised a 'short for age and gender' (at age three) versus normal group. The Center for Disease Control (CDC) standardised (z-scores) norms for height (by age and gender) were used as a reference (Kuczmarski et al., 2002), with a height of ≥1 standard deviation below the mean being the cut-off. Child BMI was available as a 4-category derived variable; for the purpose of the present analysis this variable was further aggregated to comprise an 'overweight/obese' versus an 'underweight/normal' group (at age three). Externalising behaviour comprised two groups; 'behaviour problems' and 'no behaviour problems' (at age three) which was derived by summing scores on the hyperactivity and conduct disorders scales of the parent-completed Strengths and Difficulties Questionnaire (SDQ; Goodman, Ford, Simmons, Gatward, & Meltzer, 2000; Goodman, Renfrew, & Mullick, 2000; Goodman, Lamping, & Ploubidis, 2010). Children were identified as having problem behaviour (i.e., 'caseness') if they scored ≥90^{th} percentile (based on the England and Scotland MCS sample percentiles) on the externalising scale.

Primary covariate

Region was the primary covariate and included England and Scotland. England was disaggregated into the following three regions reflecting the north-south divide: the South (London and the south, east, south-east, and south-west of England; reference); the Midlands (east and west Midlands); and the North (north-east and north-west of England, Yorkshire, and Humberside).

Confounding variables

Child characteristics were birth weight (except where birth weight and gestational age were the outcome variables), gestational age (except where gestational age was the outcome variable), gender, parity (except where BMI and behaviour were the outcome variables), and breastfeeding status (except where gestational age and birth weight were the outcome variables). Birth weight comprised five categories: 1.500-2.500 kgs, 2.501-3.000 kgs, 3.001-3.500 kgs (reference), 3.501-4.000 kgs, and 4.001-4.600 kgs. Gestational age comprised three categories: 25^{+0}-37^{+0} weeks (preterm), 37^{+1}-41^{+0} weeks (normal term; reference), and 41^{+1}-43^{+0} weeks (late term). Gender comprised male and female (reference). Parity comprised two categories: multiparous and nulliparous (reference). Breastfeeding comprised two categories: never and ever (reference).

Maternal characteristics included mother's current age, her BMI and employment status. Mother's age comprised three categories: 16-29, 30-39 (reference), and 40+. Mother's pre-pregnancy BMI was calculated using height and pre-pregnancy weight measurements that were available in the dataset. Respondents were allocated to the standard WHO BMI groupings (i.e., underweight [<18 kg/m^2], normal weight [reference; 18-24.99 kg/m^2], overweight [25-29.99 kg/m^2], obese [≥30 kg/m^2]) based on their individual BMI levels. Mother's employment status included not working and working (reference). No distinction was made between full- or part-time employment. For analyses with gestational age and

birthweight as the outcome variables, mother's pre-pregnancy employment status was used; for the analyses with height, BMI, and externalising behaviour as the outcome variable, mother's current employment status was used (i.e., when the child was aged three years).

Household characteristics included having a partner in the household (no partner; partner [reference]) and whether the child had any siblings (except where gestational age, birth weight, and height were the outcome variables) (one sibling; two or more siblings; no siblings [reference]). The presence of siblings in the household was included as a possible confounder for BMI and behaviour problems at age three in preference to parity as interaction between siblings could influence both outcomes.

Socioeconomic characteristics included household social class, mother's educational level, housing tenure, and car availability. In households where two caregivers were resident, household social class was derived from whichever of the two caregivers had the highest NS-SEC classification (5-category; highest [ref] through to lowest). In single-parent households, the household social class was derived from the single parent. For analyses where height, BMI, and behaviour were the outcome variables, social class at age three years was the preferred social class variable. However, if social class data was missing at age three years, but available at age nine months, the nine-month social class data was used in order to counteract the missing data for social class at age three years. Mother's highest educational level comprised secondary education and higher education (reference). Housing tenure comprised tenant and owner (reference). The tenant category included respondents who indicated living rent-free, living with parents, or squatting. Car availability comprised no availability and availability (reference).

Statistical analysis

A series of binary logistic regressions were conducted with birth weight, gestational age, child height, child BMI, and externalising behaviour as the outcome variable in each

instance. Regressions were conducted with and without adjustment for child characteristics, maternal, household, and socioeconomic characteristics. A 'missing' category was included for all covariates/confounding variables where there were larger amounts of missing data.

RESULTS

Frequency analyses of the five health outcome variables indicated that 7.6% of the total sample was born ≤37 weeks gestation, 5.5% weighed ≤2.500 kgs at birth, and 12.4% had a height ≥1 SD below the CDC standardised recommended height for age and gender at age three. Further, 23.3% were in the overweight or obese weight category at age three, and 10.1% scored at or above the 90th percentile on the SDQ externalising behaviour scale at age three.

Table 1 shows child, maternal, household, and socioeconomic characteristics cross tabulated by region for the baseline sample at wave 1. There was no evidence of a north-south gradient or Scottish effect for either gestational age or birth weight. There was the anticipated north-south gradient for proportions of younger mothers (52.8%, 47.0%, 40.5%), mothers with lower educational levels (61.2%, 57.6%, 56.0%), unemployed mothers (36.9%, 33.8%, 29.7%), mothers in the lowest social class (49.5%, 43.9%, 36.5%), and mothers with no access to a vehicle (19.3%, 14.3%, 12.3%). There were also North and South differences for mothers without a resident partner (17.3% vs 11.5%), mothers who were tenants (40.1% vs 35.5%), and mothers who did not breastfeed the cohort child (53.3% vs 31.5%). There was evidence of a Scottish effect for those who were not breastfeeding (49.0% vs 31.5% in South), and younger motherhood (44.5% vs 40.5% in South). Patterns of BMI were comparable across the regions, as were the number of siblings in the household. The highest proportion of non-white ethnicities was in the South (14.2%); proportions in the Midlands and North were comparable (10%). However, Scotland had notably lower proportions of non-

white ethnicities (2.2%), thus supporting the decision to exclude all non-white ethnicities from further analyses.

< INSERT TABLE 1 >

Table 2 summarises the results of a series of unadjusted and adjusted binary logistic regressions examining the effects of region on each health indicator (see Supplementary tables S1-S5 showing detailed results of the unadjusted, sequential, and fully adjusted models for each indicator). Results indicated that children in the North were 13% (CIs 0.95-1.35) more likely to be born preterm than children in the South, an effect that attenuated when adjusted for maternal characteristics (OR1.07; CIs 0.89-1.28). A similar pattern was observed for birth weight, with effects for the North in the unadjusted model (OR 1.16; CIs 0.95-1.43) that attenuated when adjusted for maternal characteristics (OR 1.03; CIs 0.80-1.33).

< INSERT TABLE 2 >

Although all regions had higher proportions of short stature children compared to the South, the region with the largest proportion was the Midlands (13.9% vs 11.0% in the South). This was reflected in an OR of 1.40 (CIs 1.16-1.69) that remained largely un-attenuated in the adjusted model (OR 1.39; CIs 1.14-1.68), suggesting an effect very similar to a north-south divide or Scottish effect. Although there was no north-south gradient for height, children in the North were 22% (CIs 1.03-1.44) more likely than those in the South to be of short stature. This effect attenuated somewhat on adjustment for child characteristics (OR 1.15; CIs 0.97-1.37), in particular, birth weight and parity.

All regions had higher proportions of children with high BMI compared to the South, with Scotland showing the highest (25.0% vs 21.6% in the South). Although children in the North were 14% (CIs 1.00-1.30) more likely than those in the South to have high BMI, these effects attenuated on adjustment. Children in the Midlands were more likely than those in the South to have high BMI (OR 1.17; CIs 1.01-1.36), and this effect remained largely unaffected

by adjustment (OR 1.14; CIs 0.98-1.33). Similarly, Scottish children were more likely than those in the South to have high BMI (OR 1.19; CIs 1.04-1.37), an effect that was only marginally affected by adjustment (OR 1.12; CIs 0.97-1.29).

Externalising behaviour was the only health indicator that showed a clear north-south gradient, with children in the Midlands and the North being 33% (CIs 1.09-1.62) and 50% (CIs 1.27-1.77) more likely (respectively) than children in the South to have behaviour problems. These effects attenuated on adjustment, leaving no gradient; however, children in the Midlands were still 13% (CIs 0.92-1.39) more likely than those in the South to exhibit behaviour problems. Contrary to there being a Scottish effect, the adjusted model indicated that children in this region were less likely (OR 0.77; CIs 0.62-0.95) than those in the South to have behaviour problems.

DISCUSSION

The hypothesis that there would be a north-south gradient within the regions of England and evidence of a Scottish effect between Scotland and England was not supported for either gestational age or birth weight. The hypothesized north-south gradient was partially supported at age three for height, BMI, and behaviour. However, there also appeared to be evidence of a 'Midlands effect' in height, and to a lesser extent in BMI and behaviour which was not hypothesized. The hypothesis that there would be a Scottish effect at age three was supported for height in both the unadjusted and adjusted models, and for BMI in the unadjusted model (though the CIs only just straddled 1 in the adjusted model). However, any effect that was evident for behaviour problems in Scottish children was in the opposite direction to that predicted: the adjusted model showed that Scottish children were 23% less likely than children in the South to have behaviour problems. Therefore, the findings of the present study do little to suggest that the established geographic variations in adult morbidity

and mortality patterns within England and between England and Scotland are mirrored by similar patterns in health at birth. However, there was evidence of geographic variations in health by the age of three. Although these variations do not all follow a distinct north-south gradient or Scottish effect, they provide evidence for the cumulative model of life-course epidemiology proposed by Power and Hertzman (1997).

The literature suggests some possible explanations for these findings. For example, recent studies suggest the presence of a 'Scottish effect' in the north of England, meaning this region holds higher morbidity and/or mortality rates, comparable to those seen in Scotland, which cannot be explained entirely by socioeconomic disadvantage (Whynes, 2009). Of particular interest is a study that examined mortality rates from age 0-85+ within fifty four of the most persistently disadvantaged constituencies across the UK (Tunstall, Mitchell, Gibbs, Platt, & Dorling, 2007). Results indicated that for the 0-4-year-old age group, there were higher rates of mortality in the Midlands than in the North. Moreover, the mortality rates for Scotland for the 0-4-year-olds were lower than for either the Midlands or the North. This is particularly relevant to the findings of the present study which found increased likelihood of short stature, high BMI, and behaviour problems in children in the Midlands (compared to the South) than either the North or Scotland.

Tunstall et al.'s (2007) study also illustrated that mortality rates varied across the lifespan. This may support the argument that a north-south divide/gradient and/or Scottish effect in health may only become evident at older ages, and is congruent with the 'accumulation of risk' and 'pathways' models of life-course epidemiology which argue that it is not only the accumulation of exposure to risk factors across the life-course, but also the interactions between risk factors, situated with the context of the individual's sociodemographic and environmental characteristics, that ultimately determine health outcomes (Kuh, Ben-Shlomo, Lynch, Hallqvist, & Power, 2003; Power & Hertzman, 1997).

There was very little variation in our data to suggest gradients or regional effects for either gestational age or birth weight. However, there was some evidence of the effects of birth weight, coupled with breastfeeding and parity in attenuating the ORs for height in the North. There was also evidence for the effects of breastfeeding in attenuating the ORs for BMI and externalising behaviour problems in the Midlands and the north of England at age three. These findings highlight the influence of early life factors on short-term future health outcomes, and provide some support for the second hypothesis, and the pathways model (Power & Hertzman, 1997) which observed that changes in health outcomes at age three can be attributed (in part) to birth outcomes and early life exposures. However, on the basis of the study design we cannot definitely conclude that the kinds of regional differences that we currently see at age three are going to continue into adulthood, or that they are predictors of future/adult health problems. In addition, it is possible that the cohort of children growing up now differs significantly in early life factors from the generation that is currently demonstrating differing levels of chronic disease in later adulthood.

The strengths of the present study are the large and predominantly nationally representative sample that allowed for the adjustment of a number of possible confounding variables. Moreover, to our knowledge there have been no previous studies that have explicitly examined the north-south divide/gradient and Scottish effect in infant and early childhood health. Therefore, the present findings provide a valuable contribution to both the infant/child health and life-course epidemiology literatures. A possible limitation is the lack of representativeness of the Scottish sample at age three; it could be argued that the lack of (or counterintuitive) Scottish effects in the present study can be attributed to this. However, this is not a valid argument as it is hypothesised that the Scottish effect is evident across all socioeconomic groupings. Moreover, all models were adjusted for a range of indicators of socioeconomic position.

CONCLUSION

It is evident from the findings of the present study that there are differences in child health indicators within England, and between Scotland and England, some of which are explained by SES and some of which are not. However, none of these differences are apparent at birth, but rather are emerging over time, suggesting that they are the result of the accumulation and interaction of multiple factors. It is also evident in the present study that the established geographic variations in adult morbidity are not mirrored in child health outcomes, but that alternative types of regional variation exist in the early years. This represents an important contribution to the fetal origins/life-course literature which has tended to focus on the impact of fetal/birth outcomes on adult morbidity and mortality rather than on emerging morbidity at an earlier stage of the life-course. Whether these findings are a true reflection of regional differences in early life indicators, simply a cohort effect, or whether they are indicative of changes in regional health disparities is a topic for future studies. Ongoing research is currently examining whether patterns of regional differences observed in the present study at age three continue into middle and late childhood, while further assessing the impact of early life factors on health outcomes in later childhood.

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Table 1. Child, maternal, household, and socioeconomic characteristics of the sample at Wave 1 (unweighted n; weighted %)

				South	Midlands	North	Scotland
Total N			Total N (%)	4246	1572	2596	2225
Maternal characteristics	Age	16-29	6572 (51.5)	2507 (40.5)	1158 (47.0)	1840 (52.8)	1067 (44.5)
		30-39	6334 (44.9)	3005 (55.5)	927 (49.8)	1279 (44.5)	1123 (51.5)
		40+	459 (3.6)	236 (4.0)	60 (3.2)	77 (2.7)	86 (4.1)
	Ethnicity	White	10641 (89.5)	4246 (85.8)	1573 (89.1)	2597 (89.9)	2225 (97.8)
		Other	2724 (10.5)	1502 (14.2)	572 (10.9)	599 (10.1)	51 (2.2)
	Pre-pregnancy BMI	Underweight	770 (5.0)	325 (5.0)	111 (4.0)	213 (5.9)	121 (4.9)
		Normal	8117 (63.1)	3485 (63.2)	1264 (62.1)	1899 (62.0)	1469 (65.1)
		Overweight	2453 (18.5)	1030 (18.3)	416 (19.2)	589 (18.3)	418 (18.4)
		Obese	1105 (8.2)	477 (8.3)	198 (9.6)	259 (7.9)	171 (7.4)
		Missing	920 (5.2)	431 (5.2)	156 (5.2)	236 (5.9)	97 (4.3)
	Education	Higher	3271 (28.4)	1708 (32.4)	426 (26.6)	499 (20.0)	638 (30.3)
		Secondary	7538 (57.3)	3109 (56.0)	1204 (57.6)	1944 (61.2)	1281 (55.8)
		Missing	2556 (14.3)	931 (11.6)	515 (15.8)	753 (18.8)	357 (13.9)
	Employment	Working	8258 (68.2)	3694 (70.3)	1187 (66.2)	1792 (63.1)	1585 (71.0)
		Not working	5107 (31.8)	2054 (29.7)	958 (33.8)	1404 (36.9)	691 (29.0)
Household characteristics	Partner	Has partner	11220 (86.5)	4924 (88.5)	1831 (87.5)	2557 (82.7)	1908 (85.5)
		No partner	2145 (13.5)	824 (11.5)	314 (12.5)	639 (17.3)	368 (14.5)
	Siblings	None	5653 (43.1)	2472 (43.7)	827 (40.1)	1323 (42.2)	1031 (45.0)
		1 or more	7712 (56.9)	3276 (56.3)	1318 (59.9)	1873 (57.8)	1245 (55.0)
	Household social class	Highest	2572 (22.8)	1338 (26.3)	347 (22.8)	395 (15.7)	492 (23.0)
		2	1587 (13.1)	741 (14.1)	210 (11.0)	327 (11.6)	309 (14.0)
		3	1078 (8.7)	550 (10.3)	156 (8.1)	212 (7.2)	160 (7.5)
		4	1268 (9.8)	536 (9.5)	194 (9.6)	295 (9.6)	243 (11.0)
		Lowest	6010 (41.5)	2266 (36.5)	1061 (43.9)	1674 (49.5)	1009 (42.0)
		Missing	850 (4.1)	317 (3.4)	177 (4.7)	293 (6.4)	63 (2.5)
	Tenure	Owner	7657 63.5)	3300 (64.5)	1225 (65.9)	1749 (59.9)	1383 (63.5)
		Tenant	5708 (36.5)	2448 (35.5)	920 (34.1)	1447 (40.1)	893 (36.5)
	Car	Has car	10810 (85.4)	4783 (87.7)	1700 (85.7)	2418 (80.7)	1909 (85.6)
		No car	2555 (14.6)	965 (12.3)	445 (14.3)	778 (19.3)	367 (14.4)
Child characteristics	Gestational age	Preterm	1043 (7.6)	454 (7.8)	146 (6.3)	274 (8.2)	169 (7.5)
		Normal	9453 (70.5)	4078 (70.5)	1568 (73.3)	2234 (70.2)	1573 (69.0)
		Postterm/late	2732 (21.1)	1151 (20.8)	402 (19.8)	658 (20.8)	521 (22.9)
		Missing	137 (0.8)	65 (0.8)	29 (0.6)	30 (0.8)	13 (0.6)
	Birthweight	1.500-2.500	816 (5.3)	357 (5.2)	149 (5.5)	206 (5.9)	104 (4.4)
		2.501-3.000	2292 (15.3)	971 (15.2)	421 (17.1)	610 (17.1)	290 (12.4)
		3.001-3.500	4817 (36.2)	2101 (36.6)	757 (36.2)	1131 (35.5)	828 (36.0)
		3.501-4.000	3936 (31.1)	1626 (29.7)	598 (30.3)	940 (31.3)	772 (34.5)
		4.001-4.600	1242 (10.3)	576 (11.3)	188 (9.8)	239 (8.2)	239 (10.7)
		Missing	262 (1.9)	117 (2.0)	32 (1.1)	70 (2.1)	43 (2.0)
	Gender	Female	6493 (48.5)	2783 (48.5)	1060 (48.6)	1564 (49.3)	1086 (47.5)
		Male	6872 (51.5)	2965 (51.5)	1085 (51.4)	1632 (50.7)	1190 (52.5)
	Breastfed	Ever	7605 (58.5)	3925 (68.5)	1164 (56.0)	1414 (46.7)	1102 (51.0)
		Never	5760 (41.5)	1823 (31.5)	981 (44.0)	1782 (53.3)	1174 (49.0)

Ethnicity is included in frequency table for completeness; however, ethnicity was excluded from regression models owing to small proportions of ethnic minorities in Scotland

Table 2. Summary of results of unadjusted and fully adjusted binary logistic regressions examining effects of region on gestational age and weight at birth, and height, BMI, and externalising behaviour problems at three years of age

			South	Midlands		North		Scotland	
			Ref	OR	95% CIs	OR	95% CIs	OR	95% CIs
Birth outcomes	Gestational age	n/N (wtd%)	321/4215 (7.7)	103/1568 (6.2)		220/2580 (8.3)		168/2212 (7.7)	
	(preterm)	Unadjusted	1.00	0.85	0.68, 1.07	1.13	0.95, 1.35	1.00	0.82, 1.21
		Adjusted[1]	1.00	0.84	0.66, 1.05	1.07	0.89, 1.28	0.97	0.80, 1.18
	Birthweight	n/N (wtd%)	238/4203 (5.4)	85/1557 (5.0)		167/2556 (6.4)		114/2196 (5.1)	
	(≤2.5kg)	Unadjusted	1.00	0.96	0.75, 1.24	1.16	0.95, 1.43	0.91	0.73, 1.15
		Adjusted[2]	1.00	1.06	0.78, 1.45	1.03	0.80, 1.33	0.85	0.64, 1.12
Age 3 outcomes	Height	n/N (wtd%)	372/3346 (11.0)	192/1287 (13.9)		263/1989 (13.0)		221/1611 (13.7)	
	(≤1SD below mean)	Unadjusted	1.00	1.40	1.16, 1.69***	1.22	1.03, 1.44*	1.27	1.06, 1.52**
		Adjusted[3]	1.00	1.39	1.14, 1.68***	1.15	0.97, 1.37	1.33	1.11, 1.60**
	BMI	n/N (wtd%)	726/3311 (21.6)	316/1278 (24.6)		476/1967 (24.0)		398/1587 (25.0)	
	(overweight/obese)	Unadjusted	1.00	1.17	1.01, 1.36*	1.14	1.00, 1.30§	1.19	1.04, 1.37*
		Adjusted[4]	1.00	1.14	0.98, 1.33	1.08	0.94, 1.23	1.12	0.97, 1.29
	Externalising	n/N (wtd%)	347/3487 (9.4)	171/1334 (11.4)		292/2053 (12.6)		150/1702 (8.0)	
	behaviour	Unadjusted	1.00	1.33	1.09, 1.62**	1.50	1.27, 1.77***	0.87	0.72, 1.07
	(≥90th %ile on SDQ)	Adjusted[5]	1.00	1.13	0.92, 1.39	1.08	0.90, 1.29	0.77	0.62, 0.95*

[1] Model adjusted for: child characteristics (gender, parity); maternal characteristics (age, pre-pregnancy BMI, educational level, pre-pregnancy employment status); household characteristics (partner in household); socioeconomic status (household social class, housing tenure, availability of a car)

[2] Model adjusted for: child characteristics (gestational age, gender, parity); maternal characteristics (age, pre-pregnancy BMI, educational level, pre-pregnancy employment status); household characteristics (partner in household); socioeconomic status (household social class, housing tenure, availability of a car)

[3] Model adjusted for: child characteristics (gestational age, birthweight, ever breastfed, parity); maternal characteristics (age, educational level, current employment status); household characteristics (partner in household); socioeconomic status (household social class, housing tenure, availability of a car)

[4] Model adjusted for: child characteristics (gestational age, birthweight, ever breastfed, number of siblings); maternal characteristics (age, educational level, current employment status); household characteristics (partner in household); socioeconomic status (household social class, housing tenure, availability of a car)

[5] Model adjusted for: child characteristics (gestational age, birthweight, gender, ever breastfed, number of siblings); maternal characteristics (age, educational level, current employment status); household characteristics (partner in household); socioeconomic status (household social class, housing tenure, availability of a car)

* $p<0.05$; ** $p<0.01$; *** $p\leq0.001$; § $p=.057$

RESEARCH HIGHLIGHTS

- Few studies have examined UK regional differences in early childhood health
- This study found no regional differences in birth weight and gestational age
- Some regional differences, including a ‘Midlands effect’ were evident by age three
- These findings support the cumulative effects of birth and infancy factors
- Results make important contribution to the life-course literature and health policy

Table S1. Results of unadjusted, sequential, and fully adjusted models examining regional differences in gestational age

			Unadjusted						Fully adjusted	
		N	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs
Region	South England	4215	1.00		1.00		1.00		1.00	
	Midlands	1568	0.85	0.68, 1.07	0.86	0.68, 1.08	0.84	0.66, 1.05	0.84	0.66, 1.05
	North England	2580	1.13	0.95, 1.35	1.13	0.95, 1.36	1.07	0.89, 1.29	1.07	0.89, 1.28
	Scotland	2212	1.00	0.82, 1.21	0.99	0.82, 1.21	0.98	0.81, 1.19	0.97	0.80, 1.18
Gender	Female	5124	1.00		1.00	0.00, 0.00	1.00	0.00, 0.00	1.00	
	Male	5451	1.21	1.05, 1.40**	1.21	1.05, 1.40**	1.21	1.04, 1.39*	1.21	1.04, 1.39*
Parity	Multiparous	4641	1.00		1.00	0.00, 0.00	1.00	0.00, 0.00	1.00	
	Nulliparous	5934	0.88	0.76, 1.01	0.88	0.76, 1.01	0.78	0.66, 0.91**	0.77	0.65, 0.90***
Maternal age	16-29	5006	1.09	0.94, 1.26			0.91	0.78, 1.07	0.87	0.73, 1.03
	30-39	5214	1.00				1.00	0.00, 0.00	1.00	
	40+	355	1.16	0.79, 1.71			1.20	0.81, 1.77	1.20	0.81, 1.78
Maternal pre-pregnancy BMI	Underweight	550	1.56	1.17, 2.08**			1.40	1.05, 1.88*	1.38	1.03, 1.85*
	Normal	6693	1.00				1.00	0.00, 0.00	1.00	
	Overweight	1958	1.08	0.89, 1.31			1.08	0.89, 1.31	1.07	0.88, 1.30
	Obese	890	1.16	0.90, 1.50			1.16	0.89, 1.50	1.14	0.88, 1.47
	Missing	484	1.57	1.16, 2.12**			1.46	1.07, 1.98*	1.45	1.07, 1.97*
Maternal education	Higher	2743	1.00				1.00	0.00, 0.00	1.00	
	Secondary	6260	1.30	1.08, 1.56**			1.28	1.06, 1.55**	1.18	0.96, 1.45
	Missing	1572	1.68	1.34, 2.11***			1.55	1.21, 1.99***	1.40	1.06, 1.86*
Maternal employment	Working	7266	1.00				1.00	0.00, 0.00	1.00	
	Not working	3309	1.28	1.10, 1.48***			1.24	1.05, 1.47*	1.24	1.03, 1.48*
Partner	Has partner	8952	1.00						1.00	
	No partner	1623	1.21	1.00, 1.46*					1.02	0.82, 1.28
Household social class	Highest	2225	1.00						1.00	
	2	1320	1.24	0.95, 1.62					1.16	0.87, 1.54
	3	843	1.15	0.84, 1.57					1.10	0.80, 1.52
	4	1053	1.24	0.93, 1.65					1.14	0.84, 1.54
	Lowest	4724	1.44	1.18, 1.77***					1.23	0.96, 1.57
	Missing	410	1.16	0.77, 1.76					0.80	0.50, 1.28
Tenure	Owner	6452	1.00						1.00	
	Tenant	4123	1.28	1.11, 1.48***					1.05	0.87, 1.28
Car availability	Has car	8854	1.00						1.00	
	No car	1721	1.30	1.09, 1.56**					1.05	0.85, 1.30

*p<0.05; **p≤0.01; ***p≤0.001

Table S2. Results of unadjusted, sequential, and fully adjusted models examining regional differences in birthweight

			Unadjusted						Fully adjusted	
		N	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs
Region	South England	4203	1.00		1.00		1.00		1.00	
	Midlands	1557	0.96	0.75, 1.24	1.08	0.80, 1.46	1.04	0.76, 1.41	1.06	0.78, 1.45
	North England	2556	1.16	0.95, 1.43	1.14	0.89, 1.45	1.03	0.80, 1.32	1.03	0.80, 1.33
	Scotland	2196	0.91	0.73, 1.15	0.90	0.69, 1.18	0.85	0.65, 1.12	0.85	0.64, 1.12
Gestational age	Preterm	810	34.47	28.25, 42.07***	36.05	29.43, 44.17***	37.70	30.58, 46.47***	37.84	30.66, 46.70***
	Normal	7388	1.00		1.00		1.00		1.00	
	Postterm/late	2251	0.34	0.21, 0.54***	0.33	0.21, 0.52***	0.34	0.22, 0.55***	0.34	0.21, 0.54***
	Missing	63	3.97	1.69, 9.31**	4.32	1.83, 10.18***	3.63	1.51, 8.73**	3.50	1.46, 8.44**
Gender	Female	5114	1.00		1.00		1.00		1.00	
	Male	5398	0.81	0.69, 0.96*	0.63	0.52, 0.77***	0.63	0.51, 0.77***	0.63	0.51, 0.77***
Parity	Multiparous	4620	1.00		1.00		1.00		1.00	
	Nulliparous	5892	0.71	0.60, 0.84***	0.66	0.54, 0.80***	0.51	0.41, 0.64***	0.49	0.39, 0.62***
Maternal age	16-29	4987	1.19	1.01, 1.41*			0.82	0.66, 1.03	0.72	0.57, 0.92**
	30-39	5170	1.00				1.00		1.00	
	40+	355	1.75	1.19, 2.58**			2.12	1.32, 3.42**	2.18	1.35, 3.53***
Maternal pre-pregnancy BMI	Underweight	551	2.28	1.73, 3.02***			2.01	1.41, 2.86***	1.89	1.32, 2.70***
	Normal	6667	1.00				1.00		1.00	
	Overweight	1938	0.93	0.74, 1.17			0.86	0.66, 1.13	0.86	0.65, 1.12
	Obese	878	0.88	0.64, 1.22			0.77	0.52, 1.13	0.74	0.50, 1.08
	Missing	478	1.02	0.68, 1.53			0.63	0.39, 1.02	0.60	0.37, 0.97*
Maternal education	Higher	2721	1.00				1.00		1.00	
	Secondary	6211	1.51	1.21, 1.90***			1.47	1.12, 1.92**	1.21	0.90, 1.63
	Missing	1580	2.81	2.17, 3.64***			2.86	2.04, 3.99***	2.19	1.50, 3.19***
Maternal employment	Working	7211	1.00				1.00		1.00	
	Not working	3301	1.47	1.25, 1.75***			1.32	1.05, 1.67*	1.23	0.96, 1.58
Partner	Has partner	8888	1.00						1.00	
	No partner	1624	1.35	1.10, 1.67**					0.90	0.67, 1.20
Household social class	Highest	2204	1.00						1.00	
	2	1306	1.28	0.91, 1.80					1.17	0.77, 1.77
	3	834	1.55	1.07, 2.25*					1.51	0.97, 2.36
	4	1042	1.71	1.22, 2.40**					1.59	1.04, 2.42*
	Lowest	4713	2.01	1.56, 2.57***					1.49	1.05, 2.11*
	Missing	413	1.64	1.03, 2.62*					0.87	0.47, 1.63
Tenure	Owner	6384	1.00						1.00	
	Tenant	4128	1.75	1.49, 2.07***					1.43	1.09, 1.88**
Car availability	Has car	8787	1.00						1.00	
	No car	1725	1.62	1.33, 1.97***					1.05	0.78, 1.39

*p<0.05; **p<0.01; ***p≤0.001

Table S3. Results of unadjusted, sequential, and fully adjusted models examining regional differences in height at age 3

			Unadjusted								Fully adjusted	
		N	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs
Region	South England	3346	1.00		1.00		1.00		1.00		1.00	
	Midlands	1287	1.40	1.16, 1.69***	1.39	1.15, 1.68***	1.38	1.14, 1.68***	1.38	1.14, 1.68***	1.39	1.14, 1.68***
	North England	1989	1.22	1.03, 1.44*	1.16	0.98, 1.39	1.15	0.97, 1.38	1.16	0.97, 1.38	1.15	0.97, 1.37
	Scotland	1611	1.27	1.06, 1.52**	1.31	1.09, 1.58**	1.33	1.11, 1.60**	1.33	1.11, 1.59**	1.33	1.11, 1.60**
Gestational age	Preterm	613	1.95	1.58, 2.40***	1.20	0.94, 1.53	1.20	0.94, 1.54	1.20	0.94, 1.54	1.20	0.94, 1.54
	Normal	5800	1.00		1.00		1.00		1.00		1.00	
	Postterm/late	1781	0.84	0.71, 0.99*	1.07	0.90, 1.28	1.08	0.90, 1.28	1.08	0.90, 1.29	1.08	0.90, 1.28
	Missing	39	3.16	1.59, 6.26***	2.75	1.37, 5.54**	2.64	1.31, 5.34**	2.67	1.32, 5.38**	2.63	1.30, 5.33**
Birthweight	1.500-2.500	394	2.01	1.57, 2.57***	1.85	1.38, 2.47***	1.82	1.36, 2.43***	1.82	1.36, 2.44***	1.82	1.36, 2.43***
	2.501-3.000	1190	1.28	1.07, 1.54**	1.27	1.06, 1.53**	1.26	1.05, 1.52*	1.26	1.05, 1.52*	1.26	1.05, 1.52*
	3.001-3.500	2990	1.00		1.00		1.00		1.00		1.00	
	3.501-4.000	2666	0.53	0.44, 0.62***	0.51	0.43, 0.61***	0.51	0.43, 0.61***	0.51	0.43, 0.61***	0.51	0.43, 0.61***
	4.001-4.600	845	0.31	0.23, 0.43***	0.30	0.22, 0.42***	0.31	0.22, 0.43***	0.31	0.22, 0.43***	0.31	0.22, 0.43***
	Missing	148	1.48	0.98, 2.24	1.39	0.91, 2.12	1.38	0.90, 2.11	1.37	0.90, 2.10	1.38	0.90, 2.11
Breastfed	Ever	4625	1.00		1.00		1.00	0.00, 0.00	1.00		1.00	
	Never	3608	1.18	1.04, 1.35*	1.07	0.93, 1.22	1.00	0.87, 1.16	1.01	0.87, 1.16	1.00	0.87, 1.16
Parity	Multiparous	3584	1.00		1.00		1.00	0.00, 0.00	1.00		1.00	
	Nulliparous	4649	1.24	1.09, 1.42***	1.36	1.19, 1.56***	1.36	1.18, 1.57***	1.35	1.17, 1.56***	1.36	1.17, 1.57***
Maternal age	16-29	2517	1.14	0.99, 1.31			1.07	0.91, 1.25	1.08	0.92, 1.27	1.06	0.90, 1.25
	30-39	4946	1.00				1.00	0.00, 0.00	1.00		1.00	
	40+	770	0.97	0.76, 1.22			0.94	0.74, 1.19	0.94	0.74, 1.19	0.93	0.74, 1.19
Maternal education	Higher	2337	1.00				1.00	0.00, 0.00	1.00		1.00	
	Secondary	4864	1.19	1.02, 1.39*			1.05	0.89, 1.24	1.05	0.89, 1.24	1.06	0.89, 1.27
	Missing	1032	1.60	1.30, 1.98***			1.18	0.93, 1.50	1.20	0.94, 1.53	1.17	0.90, 1.52
Maternal employment	Working	4645	1.00				1.00	0.00, 0.00	1.00		1.00	
	Not working	3588	1.26	1.11, 1.43***			1.13	0.98, 1.29	1.13	0.98, 1.30	1.10	0.95, 1.28
Partner	Has partner	6989	1.00						1.00		1.00	
	No partner	1244	1.10	0.92, 1.31					0.92	0.76, 1.11	0.84	0.68, 1.04
Household social class	Highest	2289	1.00								1.00	
	2	1024	1.01	0.80, 1.27							0.98	0.77, 1.25
	3	939	1.09	0.87, 1.38							0.98	0.77, 1.25
	4	846	1.10	0.86, 1.40							0.89	0.69, 1.16
	Lowest	2992	1.23	1.04, 1.45*							0.97	0.79, 1.18
	Missing	143	1.95	1.27, 2.99**							1.41	0.87, 2.28
Tenure	Owner	5546	1.00								1.00	
	Tenant	2687	1.27	1.11, 1.45***							1.05	0.87, 1.27
Car availability	Has car	7118	1.00								1.00	
	No car	1115	1.35	1.14, 1.61***							1.10	0.88, 1.37

*p<0.05; **p≤0.01; ***p≤0.001

Table S4. Results of unadjusted, sequential, and fully adjusted models examining regional differences in BMI at age 3

			Unadjusted								Fully adjusted	
		N	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs
Region	South England	3311	1.00		1.00		1.00		1.00		1.00	
	Midlands	1278	1.17	1.01, 1.36*	1.15	0.99, 1.34	1.15	0.98, 1.34	1.15	0.98, 1.34	1.14	0.98, 1.33
	North England	1967	1.14	1.00, 1.30	1.10	0.96, 1.26	1.10	0.96, 1.26	1.10	0.96, 1.25	1.08	0.94, 1.23
	Scotland	1587	1.19	1.04, 1.37*	1.14	0.99, 1.31	1.13	0.98, 1.30	1.13	0.98, 1.30	1.12	0.97, 1.29
Gestational age	Preterm	604	0.87	0.71, 1.07	1.15	0.91, 1.46	1.15	0.91, 1.46	1.15	0.91, 1.46	1.15	0.91, 1.46
	Normal	5746	1.00		1.00		1.00		1.00		1.00	
	Postterm/late	1756	1.21	1.07, 1.37**	1.06	0.93, 1.20	1.06	0.93, 1.20	1.06	0.93, 1.20	1.06	0.93, 1.21
	Missing	37	0.93	0.42, 2.03	0.97	0.44, 2.15	0.98	0.44, 2.17	0.97	0.44, 2.15	0.94	0.43, 2.09
Birthweight	1.500-2.500	389	0.71	0.53, 0.95*	0.65	0.47, 0.89**	0.64	0.47, 0.89**	0.64	0.47, 0.89**	0.64	0.46, 0.88**
	2.501-3.000	1184	0.83	0.70, 0.98*	0.81	0.68, 0.97*	0.81	0.68, 0.97*	0.81	0.68, 0.97*	0.81	0.68, 0.96*
	3.001-3.500	2961	1.00		1.00		1.00		1.00		1.00	
	3.501-4.000	2628	1.34	1.18, 1.52***	1.34	1.19, 1.52***	1.34	1.18, 1.52***	1.34	1.18, 1.52***	1.35	1.19, 1.53***
	4.001-4.600	835	1.93	1.63, 2.29***	1.97	1.66, 2.34***	1.96	1.65, 2.33***	1.97	1.65, 2.34***	1.97	1.66, 2.34***
	Missing	146	1.52	1.05, 2.19*	1.49	1.02, 2.17*	1.49	1.02, 2.18*	1.50	1.03, 2.19*	1.49	1.02, 2.18*
Breastfed	Ever	4581	1.00		1.00		1.00		1.00		1.00	
	Never	3562	1.26	1.14, 1.40***	1.29	1.16, 1.44***	1.29	1.16, 1.45***	1.29	1.15, 1.44***	1.26	1.12, 1.41***
Maternal age	16-29	2486	1.03	0.92, 1.15			1.00	0.88, 1.13	0.99	0.87, 1.12	0.94	0.82, 1.07
	30-39	4894	1.00				1.00		1.00		1.00	
	40+	763	1.07	0.90, 1.28			1.08	0.90, 1.29	1.08	0.90, 1.29	1.10	0.91, 1.31
Maternal education	Higher	2318	1.00				1.00		1.00		1.00	
	Secondary	4808	1.04	0.92, 1.17			1.01	0.89, 1.15	1.01	0.89, 1.14	0.96	0.84, 1.10
	Missing	1017	1.10	0.92, 1.30			1.07	0.88, 1.29	1.05	0.86, 1.27	0.95	0.77, 1.17
Maternal employment	Working	4593	1.00				1.00		1.00		1.00	
	Not working	3550	0.93	0.84, 1.03			0.93	0.83, 1.03	0.92	0.82, 1.03	0.91	0.80, 1.02
Partner	Has partner	6920	1.00						1.00		1.00	
	No partner	1223	1.08	0.94, 1.24					1.10	0.95, 1.29	1.04	0.87, 1.23
Siblings	None	2086	1.00						1.00		1.00	
	1	4006	1.03	0.91, 1.16					1.02	0.89, 1.16	1.02	0.89, 1.16
	2 or more	2051	1.05	0.91, 1.22					1.02	0.87, 1.19	1.00	0.86, 1.17
Household social class	Highest	2268	1.00								1.00	
	2	1007	1.07	0.90, 1.28							1.04	0.86, 1.25
	3	927	1.00	0.83, 1.21							1.01	0.84, 1.23
	4	838	1.21	1.01, 1.46*							1.22	1.00, 1.49*
	Lowest	2965	1.18	1.04, 1.34*							1.15	0.99, 1.35
	Missing	138	1.41	0.96, 2.07							1.44	0.95, 2.20
Tenure	Owner	5494	1.00								1.00	
	Tenant	2649	1.08	0.97, 1.20							1.06	0.92, 1.23
Car availability	Has car	7043	1.00								1.00	
	No car	1100	1.09	0.94, 1.26							1.04	0.87, 1.25

*p≤0.05; **p<0.01; ***p<0.001

Table S5. Results of unadjusted, sequential, and fully adjusted models examining regional differences in behaviour problems at age 3

			Unadjusted								Fully adjusted	
		N	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs
Region	South England	3487	1.00		1.00		1.00		1.00		1.00	
	Midlands	1334	1.33	1.09, 1.62**	1.17	0.96, 1.43	1.14	0.93, 1.40	1.13	0.92, 1.39	1.13	0.92, 1.39
	North England	2053	1.50	1.27, 1.77***	1.22	1.03, 1.45*	1.14	0.96, 1.36	1.13	0.95, 1.35	1.08	0.90, 1.29
	Scotland	1702	0.87	0.72, 1.07	0.76	0.62, 0.93**	0.79	0.64, 0.97*	0.80	0.65, 0.99*	0.77	0.62, 0.95*
Gestational age	Preterm	638	1.28	1.01, 1.62*	0.99	0.75, 1.32	1.04	0.78, 1.38	1.02	0.76, 1.36	1.03	0.77, 1.38
	Normal	6036	1.00		1.00		1.00		1.00		1.00	
	Postterm/late	1863	0.93	0.78, 1.10	1.03	0.86, 1.23	1.05	0.88, 1.26	1.07	0.90, 1.29	1.07	0.89, 1.28
	Missing	39	1.75	0.77, 3.98	1.59	0.69, 3.68	1.28	0.55, 3.02	1.18	0.50, 2.77	1.07	0.45, 2.54
Birthweight	1.500-2.500	413	1.46	1.10, 1.95**	1.44	1.03, 2.00*	1.30	0.93, 1.83	1.34	0.95, 1.88	1.30	0.92, 1.84
	2.501-3.000	1233	1.29	1.06, 1.56*	1.29	1.05, 1.58*	1.21	0.99, 1.49	1.22	0.99, 1.51	1.19	0.97, 1.47
	3.001-3.500	3105	1.00		1.00		1.00		1.00		1.00	
	3.501-4.000	2776	0.87	0.73, 1.02	0.87	0.73, 1.03	0.91	0.77, 1.08	0.90	0.76, 1.07	0.91	0.77, 1.09
	4.001-4.600	893	0.70	0.53, 0.91**	0.70	0.53, 0.92**	0.78	0.59, 1.03	0.77	0.58, 1.01	0.79	0.60, 1.05
	Missing	156	1.08	0.66, 1.77	1.07	0.64, 1.77	1.03	0.61, 1.73	1.02	0.61, 1.73	1.03	0.61, 1.74
Gender	Female	4214	1.00		1.00		1.00		1.00		1.00	
	Male	4362	1.55	1.35, 1.77***	1.64	1.43, 1.89***	1.66	1.44, 1.92***	1.69	1.46, 1.95***	1.71	1.48, 1.97***
Breastfed	Ever	4825	1.00		1.00		1.00		1.00		1.00	
	Never	3751	2.45	2.13, 2.81***	2.38	2.06, 2.74***	1.61	1.38, 1.88***	1.57	1.34, 1.83***	1.44	1.23, 1.68***
Maternal age	16-29	2609	2.61	2.27, 3.00***			1.78	1.53, 2.07***	1.81	1.54, 2.11***	1.49	1.26, 1.76***
	30-39	5167	1.00				1.00		1.00		1.00	
	40+	800	1.02	0.77, 1.34			1.05	0.79, 1.39	1.03	0.78, 1.37	1.08	0.81, 1.43
Maternal education	Higher	2445	1.00				1.00		1.00		1.00	
	Secondary	5066	2.52	2.06, 3.10***			1.69	1.36, 2.10***	1.61	1.29, 2.00***	1.36	1.08, 1.72**
	Missing	1065	6.60	5.24, 8.31***			3.29	2.55, 4.25***	2.86	2.20, 3.71***	2.05	1.54, 2.72***
Maternal employment	Working	4848	1.00				1.00		1.00		1.00	
	Not working	3728	2.25	1.96, 2.59***			1.56	1.35, 1.81***	1.38	1.18, 1.61***	1.23	1.05, 1.45*
Partner	Has partner	7278	1.00						1.00		1.00	
	No partner	1298	2.67	2.29, 3.11***					1.64	1.38, 1.95***	1.22	1.01, 1.49*
Siblings	None	2190	1.00						1.00		1.00	
	1	4227	1.03	0.87, 1.22					1.30	1.08, 1.56**	1.31	1.09, 1.58**
	2 or more	2159	1.47	1.22, 1.77***					1.64	1.33, 2.02***	1.53	1.24, 1.89***
Household social class	Highest	2395	1.00								1.00	
	2	1068	1.30	0.97, 1.74							0.97	0.72, 1.32
	3	1000	1.32	0.98, 1.77							1.00	0.74, 1.36
	4	876	2.45	1.89, 3.19***							1.41	1.06, 1.87*
	Lowest	3095	3.35	2.75, 4.08***							1.46	1.15, 1.85**
	Missing	142	8.28	5.61, 12.24***							1.71	1.10, 2.67*
Tenure	Owner	5784	1.00								1.00	
	Tenant	2792	3.38	2.94, 3.87***							1.44	1.19, 1.74***
Car availability	Has car	7405	1.00								1.00	
	No car	1171	3.54	3.04, 4.13***							1.40	1.15, 1.70***

*p≤0.05; **p≤0.01; ***p≤0.001