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Childhood diet and behavioural problems: results from the ALSPAC cohort

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Abstract

Objective—To investigate whether a 'junk food' diet at 81 months of age is associated with the development of behavioural problems over the following 16 months.

Subjects/Methods—The study used data from the Avon Longitudinal Study of Parents and Children (ALSPAC) and 12,942 children were included. The main outcome measure was behavioural problems, measured using the Strengths and Difficulties Questionnaire (SDQ). SDQ scores were available at 81 and 97 months of age. Child-based dietary data were collected at 81 months by food frequency questionnaire; from this a 'junk food' score was derived, and mean weekly non-milk extrinsic sugar (NMES) intake estimated. Statistical analyses examined the associations between dietary exposures at 81 months and SDQ outcomes at 97 months. Children with SDQ scores suggesting behavioural problems at baseline were excluded in order to identify new cases. Adjustments were made for potential confounders such as socioeconomic status.

Results—Unadjusted analyses suggested associations between the 'junk food' score at 81 months and both total difficulties and pro-social behaviour at 97 months. However, adjustment for baseline SDQ scores attenuated these associations, with confidence intervals including the null for both total difficulties [OR(95% CI):1.05(0.92,1.21);P=0.45] and pro-social behaviour [1.13(1.00,1.26);P=0.04]. Adjustment for other potential confounders further attenuated the effects. Adjustment for confounders similarly attenuated modest associations between NMES intake and behavioural problems.

Conclusions—There was no evidence to support an association between a 'junk food' diet at 81 months of age and behavioural problems 16 months later.

Keywords

ALSPAC; child behaviour; diet

Introduction

Concerns have been raised about the association between an unhealthy diet and the development of behavioural problems in children. The subject has received much media attention in recent years, partly in response to celebrity chef Jamie Oliver, who investigated the nutritional quality of school dinners in the UK (BBC News 2004).

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Studies have examined the physical and mental health consequences of dietary intake. Poor nutrition in childhood is associated with increased levels of childhood obesity and later morbidity (Ebbeling et al. 2002; Must & Strauss 1999). In terms of behavioural problems, one randomised controlled trial found an association between the intake of artificial food colouring and preservatives, and parental ratings of hyperactivity in three year old children over the course of a week (Bateman et al. 2004). Thiamine deficiency has been linked with behavioural problems in adolescents (Benton 1997). However, studies have tended to focus on the addition or exclusion of specific chemicals or nutrients, and its effect on childhood behavioural problems (Hirayama et al. 2004), rather than examining overall dietary patterns, which may provide greater potential for public health interventions. Such studies have also generally examined only short-term effects of such additives. A narrative review has concluded that there is currently a lack of evidence from short-term experimental studies, for a causal relationship between sugar intake and behavioural problems (Bellisle et al. 2004). The review goes on to emphasise the importance of further understanding the contribution of diet to childhood hyperactivity.

Anecdotal news reports have suggested a reduction of short-term childhood behavioural problems with healthier diets (BBC News 2005). In response to some of this evidence, as well as concerns about increasing levels of childhood obesity, there have been tight restrictions placed on the advertising of 'junk-food' to children in the UK (BBC News 2007). Additionally, campaigns such as encouraging the consumption of at least five portions of fruit and vegetables a day (www.5aday.nhs.uk) have been launched, and attempts made to improve the nutritional quality of food served in schools. In terms of the latter, the government guidelines stated that a balanced diet is important for child development and in improving short-term concentration among children and young people (Department for Education and Skills 2005). A subsequent government regulatory impact assessment went further, and stated that 'even moderate under-nutrition can have lasting effects and compromise cognitive development and school performance' (Department for Education and Skills 2006). However, there remains little evidence about the longer-term effects of poor nutrition on behavioural problems, over months or years, which are arguably of greater public health importance than shorter transient effects seen over hours or days.

It has been shown that nutrition has the greatest effect on brain growth and development during the third trimester of pregnancy and in the first few months of life (Dobbing & Sands 1973). However, more recent research has suggested 'growth spurts' in brain development throughout the first decade of life, specifically between 2-4 years and between 6-8 years of age (Isaacs & Oates 2008).

The Avon Longitudinal Study of Parents and Children (ALSPAC) allows the investigation of effects of childhood diet on behaviour months or years later. Previous studies using ALSPAC data have shown associations between childhood dietary patterns at ages three, four and seven, and school attainment at ages 10-11 (Feinstein et al. 2008); and between diet at age four and hyperactivity at age seven (Wiles et al. 2009). However, evidence for the latter was weak, with the confidence interval only just excluding the null. Further, dietary data was not collected at the same time point as baseline behavioural scores. Given the evidence suggesting growth spurts in brain development at ages 2-4 and 6-8 it is possible that previous work 'missed' the main brain growth windows. It is important to understand the effects of diet during these key years on behaviour later in childhood. This study investigates the association between diet at 81 months (6 years 9 months), and the development of behavioural problems up to 97 months (8 years 1 month).

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Materials and methods

ALSPAC

This study used data from the ALSPAC. Full details can be found elsewhere (Golding et al. 2001). In short, all pregnant women in the former region of Avon, UK, with an expected delivery date between April 1991 and December 1992 were invited to participate. Ethical approval for the study was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committees.

Behavioural outcomes

Childhood behavioural problems were measured using the Strengths and Difficulties Questionnaire (SDQ, Goodman 1997), completed by mothers at 81 months and 97 months. The SDQ comprises 25 questions, split into five sub-scales: hyperactivity, emotional symptoms, conduct problems, peer problems, and pro-social behaviour. Scores for the sub-scales range from 0 to 10, and the first four sub-scales are combined to calculate a total difficulties score, ranging from 0 to 40. Subscale scores were pro-rated if 1 or 2 items were missing (www.sdqinfo.com/b4.html). A higher score indicates more problems, except for pro-social behaviour, where a lower score indicates more difficulties. The SDQ has been shown to have good reliability, in terms of internal consistency and retest stability (Goodman 2001). As the SDQ scores were highly skewed, and even with the application of transformations did not fit a normal distribution, the scores were dichotomised. For the overall score and each of the five subscales, children were classified as having a particular behavioural problem if categorised as ‘abnormal’ or ‘borderline’, according to cut-offs suggested by Goodman for each SDQ subscale (Goodman 1997). These cut-offs are shown in Table 1.

Dietary exposure

Child-based dietary data were collected at 81 months by food frequency questionnaire (FFQ) completed by the child's main carer. The FFQ enquired about the frequency of consumption ‘nowadays’ by the child of 90 different foods and drinks provided by the mother. Principal components analysis (PCA) with varimax rotation was performed on this dietary data, and is described in detail elsewhere (Northstone & Emmett 2005). Three patterns of dietary intake were obtained. The first pattern was labelled ‘junk’, and was associated with high intake of processed and snack foods, high in fat and/or sugar. The second pattern was labelled ‘health-conscious’, and was associated with vegetarian foods, rice, pasta, salad and fruit. Finally, a ‘traditional’ pattern was obtained which was associated with intake of meat, potatoes and vegetables. Scores were calculated for each pattern for each child. A higher score for a pattern indicates greater consumption of foods fitting that pattern. The ‘junk’ pattern was chosen as the main dietary exposure to investigate the effect of a poor diet on childhood behaviour. This dietary pattern encompassed foods more likely to contain additives and less likely to contain key vitamins.

Sugar intake was used as an additional dietary measure. The FFQ was used to estimate non-milk extrinsic sugar (NMES) intake for each child. The approximate weekly NMES intake was calculated by multiplying the weekly frequency of consumption of a food/food group (assigned as follows: ‘never or rarely’ = 0, ‘once in 2 weeks’ = 0.5, ‘1-3 times per week’ = 2, ‘4-7 times per week’ = 5.5, and ‘more than once a day’ = 10) by the NMES content (obtained from the 5th edition of the *McCance and Widdowson's Composition of foods* [Holland et al. 1991] and its supplements) of a standard portion of that food, and summing this for all foods consumed.

Analyses

Statistical analyses examined the associations between the ‘junk’ pattern score and mean weekly NMES intake at 81 months, and each SDQ score at 97 months. Children with scores above the cut-off (or below for pro-social behaviour), or missing, for each SDQ subscale at 81 months were excluded from that specific analysis in order to identify ‘new’ cases of behavioural problems. Logistic regression was used with adjustment for confounding variables (see below). Adjustment for IQ score was made for the subset with data on this variable.

Data was available, primarily via self-completion questionnaires or hospital records, for a number of potential confounding factors. These included child factors (gender, birth weight, gestational age, and IQ score at eight years of age [Wechsler et al. 1992]); maternal factors (smoking during pregnancy, maternal age at delivery, maternal depression and anxiety scores when the child was 6 years of age [Cox et al. 2004; Crown & Crisp 1979]); and markers of socioeconomic status (weekly income, financial strain, maternal education, parental social class, housing tenure, household overcrowding, and car use). All analyses were conducted using SPSS version 12 (SPSS Inc 2003) and Stata version 10 (StataCorp 2007).

Dataset

The full ALSPAC cohort comprises 14 541 pregnancies. For the purposes of the present analyses, multiple or premature births (defined as less than 37 weeks gestation), and children born with major congenital diseases, were excluded, as were those missing data on birth weight or gestational age. This left a cohort of 12 942 singleton term infants, of whom 7727 children had full dietary data available at 81 months. Almost all of these children had SDQ data available (n=7649 for total difficulties; 7678 for hyperactivity; 7685 for emotional; 7691 for conduct; 7684 for peer problems; 7690 for pro-social). Of these, between 10 and 24% of children were excluded for having SDQ scores above the cut-off at baseline, as shown in Table 1 (n remaining = 6802 for total difficulties; 6278 for hyperactivity; 6697 for emotional; 5846 for conduct; 6596 for peer problems; 6948 for pro-social). Just over 60% of these had full covariate data excluding IQ, and about 50% had full covariate data including IQ (see Tables 3 and 4 for the numbers in each analysis). A small number of children had data on NMES intake but not full dietary data; thus numbers were slightly higher for the sugar analyses.

Results

Childhood behavioural problems

Mean scores for each SDQ sub-scale and for total difficulties at 81 months are shown in Table 1. These are presented alongside results from a large study conducted by the office for National Statistics (ONS) in 1999 investigating mental health of children and adolescents in Great Britain, to enable comparisons (Meltzer et al. 2000). ALSPAC had lower total difficulties scores, and slightly lower hyperactivity, emotional and peer problems scores than the ONS study, although in the main, scores were fairly similar. Using the Goodman cut-offs, the number of children classed as having behavioural problems ranged between 10% and 14% for total difficulties and each subscale except for conduct problems, which had a prevalence of 24%.

Children's diet

Table 2 compares children in the top and bottom quintiles for the ‘junk’ pattern score in terms of how many were eating a variety of foods four or more times per week at 81 months. Children in the highest quintile had higher consumption of crisps, chocolate coated biscuits and fizzy drinks. Conversely, children in the lowest quintile had higher fruit and vegetable intake.

Mean weekly NMES intake was normally distributed, with a mean of 494g and a standard deviation of 185g. Mean NMES intake was consistent with that estimated in other UK studies (Rugg-Gunn et al. 2007; McNeill et al. 2009).

Diet and behaviour

Unadjusted analyses suggested associations between the ‘junk’ pattern score at 81 months and both total difficulties and pro-social behaviour at 97 months (Table 3). However, these associations attenuated substantially following adjustment for scores on these domains at 81 months, with the 95% confidence intervals including the null. Adjustment for other potential confounders further attenuated the effect (Table 3). Further adjustment for total IQ score did not alter the findings.

Adjustment for confounders similarly attenuated the modest associations observed between mean weekly NMES intake and behavioural problems (in particular, total difficulties and conduct problems) seen in unadjusted analyses (Table 4).

Just over half the cohort had complete data for the adjusted regression analyses. However, subjects with missing outcome data had similar baseline SDQ scores to those with outcome data available. Furthermore, there were few differences between those with or without outcome data in terms of other potential confounders such as socioeconomic status.

Discussion

Key findings

This study found little evidence to support an association between a “junk food” diet at age 6 ¾ years and behavioural problems 16 months later. Whilst, univariate analyses suggested an increase in behavioural problems at age 8 (as measured by the total SDQ score) for those consuming greater quantities of “junk food” (or sugar) at age 6 ¾ years, after adjusting for confounding variables, the odds ratios were substantially attenuated, with the confidence intervals including one. Similarly, there was no evidence to support an association between the individual subscale scores and diet after adjustment for potential confounders. These results show that although there is some evidence to suggest that poor diet is associated with greater levels of behavioural problems, it would appear that this association is due to confounding and there is little evidence supporting a causal link.

Comparison with existing literature

The findings of this study appear to conflict with some previous research, and with anecdotal reports of dietary influences on childhood behaviour. However, this study set out to examine longer term effects of diet on childhood behaviour over several months, as opposed to shorter transient effects examined by others (Bateman et al. 2004; Hirayama et al. 2004). Previous work using ALSPAC data suggested children with a higher score on the ‘junk’ pattern at age 4 were more likely to have higher hyperactivity scores at age 7 (Wiles et al. 2009). However, the magnitude of this association was small with confidence intervals only just excluding the null value. Furthermore, in addition to examining the association between dietary intake and total behavioural problems as measured by the SDQ, this analysis also examined the association with the various subscales of the SDQ and hence multiple analyses were carried out increasing the possibility of a Type I error. Importantly, the baseline diet and hyperactivity measures were not concurrent, and as such adjustments may not have been sufficient to eliminate all potential confounding. The findings of the

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current study would suggest that there is no association between a 'junk' pattern score or sugar intake, and hyperactivity in children or other behavioural problems.

Strengths and limitations of this work

A major strength of this study is the detailed data that has been collected over many years from a large prospective cohort. The collection of baseline SDQ data at the same time as the dietary data allowed exclusion of those with behavioural difficulties at baseline. This enabled the investigation of 'new' cases of behavioural problems, removing the potential effect of reverse causality; children with behavioural problems may well eat more junk food as parents find it harder to control their diet. Additionally, the wealth of data collected throughout the cohort permitted adjustment for a number of potential confounding factors.

A potential limitation of the study is the use of parentally completed SDQ scores. It is possible that behavioural problems have been underestimated by some parents, which would have increased the likelihood of finding no association. However, previous studies have found parental ratings more sensitive for detecting hyperactivity in children than independent clinic ratings (Bateman et al. 2004).

As the SDQ scores were highly skewed, the outcomes were dichotomised, using cut-offs suggested by Goodman (1997). These cut-offs were originally designed so that approximately 10% of the general population would be classed as 'abnormal', with a further 10% classed as 'borderline'. For the purposes of this study, children were categorised as having a behavioural problem if they were either abnormal or borderline according to the Goodman scales. For all but conduct problems, the actual numbers with each behavioural problem were in fact less than 15%. This could suggest that there is some bias in which ALSPAC participants returned the SDQ questionnaires. This explanation is supported by the slightly lower mean SDQ scores for all but conduct problems, when compared to a large ONS study (Meltzer et al. 2000). With regards conduct problems, it may be that a higher cut-off would be more appropriate for children at this particular age (about 7 years); the original Goodman scales were not age specific. Previous work has used tertiles to categorise the SDQ scores. However, this is difficult in practice, particularly with the subscales, due to having discrete data which cannot be split into exact thirds.

Whilst just over half the cohort had complete data for the present analyses, those with missing outcome data were similar in terms of both baseline SDQ scores and other potential confounders to those with outcome data. Hence, it is unlikely that the results have been biased by missing data.

Children categorised as having behavioural problems at baseline were excluded from the main analysis, in order to investigate 'new' cases of behavioural problems. Thus this study only examined those classified as developing behavioural problems between the start and end of this study, that is between 81 and 97 months of age. It is possible that behavioural problems, if related to poor nutrition, generally develop earlier than 81 months, explaining the null finding of this study. However, this explanation is not supported by research on brain development, which has demonstrated a spurt in human brain growth between 6 and 8 years of age (Isaacs & Oates 2008). Further, the proportion of children in this study developing behavioural problems between 81 and 97 months was as high as 12% for peer problems. This demonstrates that there were still a significant number of 'new' cases during the study period, which cannot be explained by diet.

It is possible that using PCA to determine underlying patterns in the diet may not be the optimum method for the study of this particular outcome. It is possible that using other dietary pattern methods such as cluster analysis or *a priori* scores such as the Health Eating

Index (Kennedy et al. 1995) may have provided more positive associations. However, PCA has the advantage of identifying underlying dietary patterns within the data rather than creating pre-defined dietary scores based on pre-conceptions of which food items constitute a healthy diet. In addition, dietary intake was assessed using FFQs, rather than the gold standard of weighed dietary records. However, studies comparing the results of PCA using FFQs and weighed dietary records (Hu et al. 1990; Khani et al. 2004; Togo et al. 2003) have found the resulting patterns to be comparable.

Conclusions

This study has shown that neither junk food diet nor NMES intake at 81 months increase the risk of development of behavioural problems over the next 16 months.

In response to public concern over the nutritional quality of children's diets, the UK government increased funding for meals provided in schools (BBC News 2005b) and there have been general health campaigns to encourage healthier eating habits at home, such as promoting eating at least five portions of fruit and vegetables a day (www.5aday.nhs.uk). Increased behavioural problems have been stated as one reason for needing to improve childhood diet. These interventions are likely to be justified in terms of reducing obesity and improving general physical health (Ebbeling et al. 2002; Must & Strauss 1999), but an effect on long-term childhood behaviour is not supported by this study.

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Table 1

Summary statistics for baseline SDQ scores at 81 months, and comparisons with ONS Child Mental Health Study (Meltzer et al. 2000)

		Present study sample			ONS study (5-10 year old children)	
Variable	**Binomial cut-off**	**n**	**Mean (SD)**	**n (%) with behavioural problems**	**n**	**Mean (SD)**
Total difficulties	≥14	7649	7.5 (4.8)	847 (11)	5855	8.6 (5.7)
Hyperactivity	≥6	7678	3.4 (2.4)	1400 (12)	5855	3.6 (2.7)
Emotional symptoms	≥4	7685	1.5 (1.7)	988 (13)	5855	1.9 (2.0)
Conduct problems	≥3	7691	1.6 (1.5)	1845 (24)	5855	1.6 (1.7)
Peer problems	≥3	7684	1.1 (1.4)	1088 (14)	5855	1.4 (1.7)
Pro-social behaviour	≤5	7690	8.2 (1.8)	742 (10)	5855	8.6 (1.6)

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Table 2

Comparison of dietary intake amongst children with diets high or low in “junk food” based on dietary intake at age 81 months (for all those with dietary data: n = 7727)

Frequency of consumption of food item at least 4 times per week	Children in lowest quintile of “junk food”		Children in highest quintile of “junk food”		Frequency of consumption of food item at least 4 times per week	Children in lowest quintile of “junk food”		Children in highest quintile of “junk food”	
	n	%	n	%		n	%	n	%
Crispy coated chicken/turkey	23	1.5	411	13.3	Sausages/burgers	2	0.1	67	2.2
Oven/Fried chips	67	4.4	1471	47.7	Pizza	3	0.2	62	2.0
Crisps	293	19.1	2126	69.0	Baked beans	15	1.0	267	8.7
Ice cream	17	1.1	669	21.7	Tinned pasta	7	0.5	209	6.8
Cake	108	7.0	844	27.4	Pasta	144	9.4	153	5.0
Chocolate coated biscuits	242	15.7	1857	60.3	Rice	43	2.8	80	2.6
Biscuits	211	13.7	1516	49.2	Fresh citrus fruit	392	25.5	821	26.6
Chocolate bars	21	1.4	919	29.8	Other fresh fruit	1024	66.6	1761	57.1
Sweets	20	1.3	744	24.1	Green leafy vegetables[1]	306	19.9	276	9.0
Cola/Other fizzy drinks	193	12.5	1809	58.7	Other green vegetables[2]	181	11.8	179	5.8
Ice lollies	5	0.3	474	15.4	Carrots	385	25.0	425	13.8
Milk-based puddings	12	0.8	258	8.4	Other root vegetables[3]	46	3.0	53	1.7

[1]Cabbage, brussel sprouts, spinach, broccoli and other dark green leafy vegetables

[2]Other green vegetables (cauliflower, runner beans, leeks, okra, courgettes etc)

[3]Other root vegetables (turnip, swede, parsnip etc)

Table 3

Association between junk food intake at 81 months and behavioural problems at 97 months

	Total difficulties *(n=4220 / 3441)*‡		Hyperactivity *(n=3909 / 3202)*‡		Emotional symptoms *(n=4130 / 3345)*‡		Conduct problems *(n=3651 / 2974)*‡		Peer problems *(n=4095 / 3338)*‡		Pro-social behaviour *(n=4266 / 3457)*‡	
	OR* (95% CI)	**P value**	**OR* (95% CI)**	**P value**	**OR* (95% CI)**	**P value**	**OR* (95% CI)**	**P value**	**OR* (95% CI)**	**P value**	**OR* (95% CI)**	**P value**
Predictor - junk factor score at 81 months:												
Unadjusted	1.16 (1.02,1.32)	0.03	1.03 (0.90,1.16)	0.69	1.02 (0.91,1.14)	0.75	1.10 (0.99,1.24)	0.09	1.04 (0.94,1.15)	0.41	1.13 (1.01,1.25)	0.03
Adjusted for baseline SDQ score	1.05 (0.92,1.21)	0.45	0.97 (0.85,1.10)	0.63	1.02 (0.91,1.15)	0.70	1.07 (0.95,1.20)	0.29	1.01 (0.91,1.12)	0.93	1.13 (1.00,1.26)	0.04
Adjusted for all confounders†	1.02 (0.88,1.19)	0.79	0.95 (0.82,1.09)	0.46	1.02 (0.90,1.15)	0.80	1.04 (0.92,1.18)	0.51	0.98 (0.88,1.10)	0.78	1.05 (0.93,1.19)	0.39
Adjusted for all confounders† *in subset with data on IQ*	1.03 (0.87,1.23)	0.70	1.01 (0.86,1.18)	0.30	1.04 (0.90,1.21)	0.56	1.05 (0.91,1.21)	0.49	0.97 (0.85,1.10)	0.61	1.04 (0.90,1.19)	0.61
Adjusted for all confounders† *and for IQ*	1.02 (0.85,1.21)	0.86	1.00 (0.85,1.17)	>0.99	1.01 (0.88,1.17)	0.86	1.05 (0.91,1.22)	0.48	0.95 (0.83,1.08)	0.41	1.02 (0.89,1.18)	0.74

*Odds ratio represents increase in odds of behavioural problems per one SD increase in food factor score

†Confounding variables in model are: baseline SDQ score; gender; weight and gestation at birth; maternal smoking status during pregnancy; maternal age at delivery; maternal education; parental social class; housing tenure and crowding; family car use; family income and financial difficulties score; single parent; maternal anxiety and depression scores

‡The higher n is for the first three rows; the lower n is for the bottom two rows including IQ

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Table 4

Association between weekly non-milk extrinsic sugar (NMES) intake at 81 months and behavioural problems at 97 months

	Total difficulties *(n=4242 / 3461)*‡		**Hyperactivity** *(n=3933 / 3221)*‡		**Emotional symptoms** *(n=4155 / 3366)*‡		**Conduct problems** *(n=3672 / 2991)*‡		**Peer problems** *(n=4116 / 3357)*‡		**Pro-social behaviour** *(n=4291 / 3478)*‡	
	OR* (95% CI)	**P value**	**OR* (95% CI)**	**P value**	**OR* (95% CI)**	**P value**	**OR* (95% CI)**	**P value**	**OR* (95% CI)**	**P value**	**OR* (95% CI)**	**P value**
Predictor – NMES intake at 81 months:												
Unadjusted	1.10 (1.03,1.17)	0.01	1.02 (0.95,1.09)	0.59	1.00 (0.94,1.06)	0.95	1.07 (1.01,1.13)	0.03	1.04 (0.99,1.10)	0.15	1.01 (0.95,1.07)	0.81
Adjusted for baseline SDQ score	1.05 (0.98,1.13)	0.15	1.01 (0.94,1.08)	0.87	0.99 (0.93,1.05)	0.73	1.05 (0.99,1.12)	0.12	1.03 (0.97,1.09)	0.31	1.01 (0.95,1.07)	0.80
Adjusted for all confounders†	1.04 (0.97,1.12)	0.29	0.99 (0.92,1.07)	0.86	0.98 (0.92,1.05)	0.57	1.04 (0.98,1.11)	0.21	1.01 (0.96,1.07)	0.66	0.98 (0.91,1.04)	0.48
Adjusted for all confounders† *in subset with data on IQ*	1.03 (0.94,1.12)	0.58	1.01 (0.93,1.10)	0.80	0.99 (0.92,1.07)	0.83	1.03 (0.95,1.11)	0.47	1.02 (0.95,1.09)	0.57	0.96 (0.89,1.04)	0.30
Adjusted for all confounders† *and for IQ*	1.02 (0.93,1.11)	0.66	1.01 (0.92,1.10)	0.87	0.98 (0.91,1.06)	0.61	1.03 (0.95,1.11)	0.47	1.01 (0.95,1.08)	0.71	0.95 (0.88,1.03)	0.24

* Odds ratio represents increase in odds of behavioural problems per 100g increase in weekly NMES intake

† Confounding variables in model are: baseline SDQ score; gender; weight and gestation at birth; maternal smoking status during pregnancy; maternal age at delivery; maternal education; parental social class; housing tenure and crowding; family car use; family income and financial difficulties score; single parent; maternal anxiety and depression scores

‡ The higher n is for the first three rows; the lower n is for the bottom two rows including IQ