**ONLINE SUPPLEMENT**

# The Avon Longitudinal Study of Parents and ChildrenALSPAC is a population-based prospective birth cohort study from southwest England. Full details can be found on the study website ([www.alspac.bris.ac.uk](http://www.alspac.bris.ac.uk)). Briefly, 14,541 pregnancies to women resident in a defined area of the South West of England, with an expected delivery date between 1st April 1991 and 31st December 1992 were enrolled into the cohort. There were 13,988 live-born children who were still alive at age 1 year.

**Dietary Assessment** *Food frequency questionnaires*Mothers and partners were posted self-completion questionnaires at intervals from their enrolment into the study. Once the child was born, parents were asked to fill in parental-report postal questionnaires about the child’s health and development. These included a section about their child’s diet at age 4 weeks and 6, 15 and 24 months. Each questionnaire contained a range of questions with a section about eating, including the frequency of consumption of specific foods and drinks. As the child grew a full FFQ, adapted from the parental one, was included at ages 3, 4, 7 and 9 years. Each questionnaire was posted to the mother with a reply envelope and if it was not returned within 3 weeks, a postal reminder was sent followed by a second reminder 2 weeks later. A telephone prompt was then given if there was no response after a further month. This has helped with maintaining the response rate to maternal and child questionnaires. The FFQ was used to calculate approximate nutrient intakes by multiplying the weekly frequency of consumption of each food, food group or drink by the nutrient content of a standard portion of that food or drink and summing that for all of the foods and drinks in the questionnaire.(1) The portion sizes and types of foods included in each group were appropriate to the age of the person covered by the questionnaire and for the children no differentiation was made between genders. The original questionnaire covered 43 main food groups with additional questions about the types of bread, milk and fats used and amounts of tea and coffee drunk. As experience was gained in using the FFQ to estimate nutrient intakes, adaptations were made to the questionnaire to enhance the calculations. These included an expansion of the list of food groups to 56 and drink groups to 12, thus providing better assessment of vegetarian foods, milk, soft drinks and alcohol intake. Furthermore, 3-day food diaries collected on the 3.5-year olds gave insight into foods and drinks consumed in more detail; this information was used to decide the proportion of individual foods to use when estimating the nutrient intake of a food group. For example, 37% (by weight) of fruit eaten was apples and another 37% was bananas with other fruit accounting for 26%, and these proportions were used to calculate the nutrient content of ‘fruit’ in the FFQ administered at ages 3 and 4 years. Further adaptations were made to the FFQ to accommodate the fact that breaded fish and poultry were eaten more frequently by the children than plain forms. The assessment of what children ate at school was tackled in the FFQ by asking parents to consider in one section ‘only food provided by themselves’ and in another section, ‘food provided by the school’. We suggested that they discussed with the child what had been eaten at school. Additionally, we wrote to schools in the area to obtain copies of menus and serving sizes, so that we could more accurately estimate the nutrient content of the average school meal in the area. When suitable equipment became available, the FFQ was redesigned to allow direct scanning of the data, thus saving time and possible transcription errors. The following number of individuals reported implausible intakes by FFQ and were therefore removed during the data cleaning process: n=329 at age 3 years; n=223 at age 4 years; n=263 at age 7 years and n=233 at age 9 years.

*3-day food diaries*A randomly selected subsample of around 10% of the study children, known as Children in Focus, were invited to attend research clinics regularly from age 4 months to 5 years. The child’s diet was assessed at 4, 8, 18 months, 3.5 and 5 years. The parents were invited, by post, to record in a structured diary all foods and drinks their child consumed over three individual days (1 only at 4 months): 1 weekend day and 2-week days. They were asked to bring the completed diaries to the clinic where, when funds allowed, they were interviewed briefly by a member of the nutrition team to clarify any anomalies in the diary. Foods and drinks consumed were recorded in household measures on separate pages of the diary to allow specific questions to be answered. For drinks, details of the amount of concentrate used in diluted drinks, additions such as sugar, total volume offered and amount left over were recorded. For foods, a full description of the food and the amount offered was requested with a separate section for description of leftovers. From 3.5 years onwards a short questionnaire was also included; this asked about the use of vitamin supplements, types of spread normally used on bread, types of milk used and other details of diet to aid dietary coding. The questionnaire was developed in the light of experience gained when interviewing the parent in the previous sweep and proved very successful in giving confidence to the coding of commonly eaten foods. For school meals, parents were instructed to ask the child what they had eaten and to obtain menus, which are often available from schools, to help them. For packed lunches, they were instructed to record everything put into the lunch box and to ask the child to bring back leftover items in the box to be recorded later. The same type of diary was distributed for parental completion for the whole cohort at age 7 years. However, for the data collection at age 10 and 13 years, the diary was redesigned and aimed directly at the child for self-completion with parental help. An accompanying questionnaire was used to elicit help from the parents and gain further information about the foods eaten. The clinic interview, which lasted around 15 minutes, with the child and parent, was vital to obtain additional information and improve the quality of the data obtained. At each age from 18 months onwards, the diet records were coded using the computer programme DIDO (Data In, Diet Out) originally developed by the Dunn Nutrition Unit in Cambridge and shown to improve accuracy and save time compared with other dietary assessment systems.(2) When necessary, the portion sizes used were based on data on average portion sizes for children derived from weighed dietary intakes (3) from two national samples of British children.(4;5) Otherwise portion sizes were based on the manufacturers’ information or by adapting adult portion sizes.(6) Nutrient content was calculated for each food and drink consumed and combined to produce average daily nutrient and food group intakes. The coding of all the records was checked against the original, and the errors were corrected and finally records that produced very high or very low estimates of intake for selected nutrients were rechecked to ensure the quality of the data. No implausible nutrient intakes were reported by food diaries at any measurement occasion.

**Choosing a ‘knot point’ for our models**A priori, it was decided that we would only fit “knot points” (i.e. the points at which the linear relationship between age and energy intake change to have a different slope) at ages at which there was an energy intake measurement, to ensure availability of sufficient data at and around the knot point. Initial examination of the mean energy intake at each measurement occasion in males and females revealed that energy intakes increased rapidly in earlier childhood, and then at a slower rate during later childhood and early adolescence. Therefore, we tested alternative models with either one or two knot points placed at different ages in childhood, chosen around the ages at which the observed mean energy intake appeared to change, and compared the model fit (assessed by likelihood) between these different models. Initially, we explored models with two knot points: one in earlier childhood (5, 7 or 9 years) and one in later childhood (9 or 10 years). These models with two knot points result in three linear splines (or slopes); however the rates of change in intake in the last two age periods (i.e. the second and third slopes) were very similar. Moreover, these models were all estimating four parameters (one intercept and three slopes) from a median of five measures per child, and so were not substantially reducing the dimensionality of the data. Models with two knot points did not produce appreciably better model fit than models with a single knot point. Thus, we explored models with a single knot point in earlier childhood (i.e. 5, 7 or 9 years). The best model fit, judged by the maximum-likelihood value and differences between observed and predicted measurements, was obtained with a single knot point at age 7 years, i.e. estimating the intercept (energy intake at three years) and two different slopes (change in energy intake between three and seven years, and change in energy intake (with a different slope) between 7 and 13 years.

**Plausibility of reporting covariable**

The plausibility of reporting covariable is a ratio of reported energy intake (EI) to estimated energy requirements (EERs). It is a time varying covariable, so each individual has a ratio at each measurement occasion, and at each measurement occasion they are classified as being an over-reporter, under-reporter, or plausible reporter. EERs are comprised of total energy expenditure (TEE) and energy that is required for growth (EG), thus:

EER = TEE + EG

Equations to calculate TEE are different for males and females, but are standard for those aged 1-18 years (7)

Males -TEE (kJ/day) = 1.298 + (0.265 x weight in kg) – (0.0011 x weight in kg2) x 1000

Females - TEE (kJ/day) = 1.102 + (0.273 x weight in kg) – (0.0019 x weight in kg2) x 1000

For this equation, weight data from the clinic closest to the time of the diet assessment was used for each individual at each measurement occasion. Weight data were not available for the FFQs since these were questionnaire measures. Therefore, we used a linear spline multilevel model of weight gain (two levels: measurement occasion and individual) with knot points at 3, 12, 36 and 84 months to predict weight at the time of completing the FFQ, and also exact age of clinic attendance for participants with missing weight data at the time of completing the food diaries.

Individual estimates of TEE are added to EG. EG is calculated for each individual by multiplying an age and sex specific average weight gain per day (Table 9 in Torun, 2005) by 8.6 kJ/g; the average energy cost per gram of weight gain:

EG = mean weight gain (g/day) \* 8.6 (KJ/g)

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| --- | --- | --- |
| Boys -  |  | Girls -  |
| 1-1.9 years | = 6.6 x 8.6 |  | 1-1.9 years | = 6.6 x 8.6 |
| 2-2.9 years | = 5.5 x 8.6 |  | 2-2.9 years | = 6.0 x 8.6 |
| 3-3.9 years | = 5.8 x 8.6 |  | 3-3.9 years | = 5.2 x 8.6 |
| 4-4.9 years | = 5.5 x 8.6 |  | 4-4.9 years | = 4.7 x 8.6 |
| 5-5.9 years | = 5.5 x 8.6 |  | 5-5.9 years | = 4.9 x 8.6 |
| 6-6.9 years | = 6.0 x 8.6 |  | 6-6.9 years | = 6.3 x 8.6 |
| 7-7.9 years | = 6.6 x 8.6 |  | 7-7.9 years | = 8.2 x 8.6 |
| 8-8.9 years | = 7.7 x 8.6 |  | 9-8.9 years | = 10.1 x 8.6 |
| 9-9.9 years | = 9.0 x 8.6 |  | 9-9.9 years | = 11.0 x 8.6 |
| 10-10.9 years | = 10.7 x 8.6 |  | 10-10.9 years | = 12.3 x 8.6 |
| 11-11.9 years | = 12.3 x 8.6 |  | 11-11.9 years | = 12.3 x 8.6 |
| 12-12.9 years | = 14.2 x 8.6 |  | 12-12.9 years | = 12.6 x 8.6 |
| 13-13.9 years | = 15.9 x 8.6 |  | 13-13.9 years | = 11.5 x 8.6 |
| 14-14.9 years | = 16.2 x 8.6 |  | 14-14.9 years | = 9.3 x 8.6 |
| 15-15.9 years | = 14.8 x 8.6 |  | 15-15.9 years | = 6.0 x 8.6 |

The ratio of EI to EER is then calculated for each individual as: Reported daily kJ intake / EER. The overall coefficient of variation (CVt) of EI/EER is to establish the accuracy of reported EI. This is calculated from the number of days diet recorded (i.e. 3), the CV for the measurement of EE (CVEE = 19%, the average from doubly-labelled water studies on which the EER equations are based,(8) and the CV for the measurement of EI (CVEI = 17.61 at aged 10 years obtained from current sample).



If reported EI is valid then EI/EER should equal one or 100%, so to establish the lower and upper cut offs for accurate reporters, CVt is added and subtracted from 100% accordingly. Therefore, based on these calculations any reported EI less than 78.45% or above 121.55% can be classified as under-reporting or over-reporting respectively.

**Random and fixed effects structure in the multilevel linear spline energy intake trajectories**In all models, measurement source, reporting individual and the plausibility of reporting covariables were included as fixed effects, allowing the model to predict the average difference in reported energy intake between FFQs when compared to food diaries, children reporting compared to parents reporting, and over/under-reporters compared to plausible reporters. The intercept and both linear splines were included as level 2 (individual) random effects, allowing individuals to have different predicted energy intake trajectories. The intercept, age in weeks and the measurement source indicator were included as level one (occasion) random effects to account for changing scale with age (energy intakes increase with age, and therefore the measurement error is larger for older children), and also the differential variance between FFQs and food diaries.

**Distribution of the individual-level and occasion-level residuals from energy intake trajectories

Figure 1: A normal quantile plot showing the distribution of the individual-level residuals for the intercept (energy intake at age 3 years)
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**Figure 2: A normal quantile plot showing the distribution of the individual-level residuals from slope 1 (change in energy intake from age 3-7 years)

Figure 3: A normal quantile plot showing the distribution of the individual-level residuals from slope 2 (change in energy intake from age 7-13 years)
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**Figure 4: A normal quantile plot showing the distribution of the occasion-level residuals for the intercept (energy intake at age 3 years)
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**Figure 5: A normal quantile plot showing the distribution of the occasion-level residuals from slope 1 (change in energy intake from age 3-7 years)
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**Figure 6: A normal quantile plot showing the distribution of the occasion-level residuals from slope 2 (change in energy intake from age 7-13 years)
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**The equation for modelling energy intake (kcal) at 3 years, and change in energy intake from 3-7 years and 7-17 years for a given value of maternal BMI, adjusted for plausibility of reporting, measurement source, reporting individual, gender, maternal education, social class, maternal age and parity.**

Kcalij = (β0+u0j+e0ij) + (β1+u1j)(S1ij) + (β2+u2j)(S2ij) + β3(malej) + β4(malej\*S1ij) + β5(malej\*S2ij) + β6(maternal BMIij) + β7(maternal BMI\*S1ij) + β8(maternal BMI\*S2ij) + (β9+e0ij)(sourceij) + β10(reporting individualij) + β11(under-reporterij) + β12(over-reporterij) + β13 (O-level educationij) + β14(O-level educationij\*S1ij) + β15(O-level educationij\*S2ij) + β16(A-level educationij) + β17(A-level educationij\*S1ij) + β18(A-level educationij\*S2ij) + β19(≥university educationij) + β20(≥university educationij\*S1ij) + β21((≥university educationij\*S2ij) + β22 (manual social classij) + β23 (manual social classij\*S1ij) + β24 (manual social classij\*S2ij) + β25(no childrenij) + β26(no childrenij\*S1ij) + β27(no childrenij\*S2ij) + β28(2 childrenij) + β29 (2 childrenij\*S1ij) + β30(2 childrenij\*S2ij) + β31(3 childrenij) + β32 (3 childrenij\*S1ij) + β33(3 childrenij\*S2ij) + β34(4+ childrenij) + β35 (4+ childrenij\*S1ij) + β36(4+ childrenij\*S2ij) + β37(maternal ageij) + β38(maternal ageij\*S1ij) + β39(maternal ageij\*S2ij) + eij(agewkij) + eij(sourceij)

Where, for individual j at measurement occasion i, β0 is the average predicted daily energy intake at 3 years in females measured by a food diary; β1 is the average predicted linear changes in daily energy intake per year in the first period (S1=3 to 7 years) in females measured by a food diary; β2 is the average predicted linear changes in daily energy intake per year in the second period (S2=7 to 13 years) in females measured by a food diary; β3-5 are the differences between males and females (male is coded 0=female, 1=male) in energy intake measured by a food diary at 3 years and linear changes in energy intake between 3-7 and 7-13 years respectively, β6-8 are the average associations between maternal pre-pregnancy BMI and energy intake at 3 years, and linear change in energy intake between 3-7 years and 7-13 years, respectively. β9 is the average difference in reported energy intake between FFQs and food diaries (source is coded 0=food diary, 1=food frequency questionnaire), β10 is the average difference between child- and parent-reported energy intake (reporting individual is coded 0=parent completion, 1=child completion), β11 is the average difference in reported energy intake between under- and plausible reporters (under-reporter is coded 0=not under-reporter, 1=under-reporter), β12 is the average difference in reported energy intake between over- and plausible reporters (over-reporter is coded 0=not over-reporter, 1= over-reporter), β13-15 are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are O-level educated and children of mothers who are educated below O-level (O-level is coded 0=below O-level education, 1=O-level education), β16-18 are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are A-level educated and children of mothers who are educated below O-level (A-level is coded 0=below O-level education, 1=A-level education), β19-21 are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are university educated or above and children of mothers who are educated below O-level (≥university education is coded 0=below O-level education, 1= ≥university education), β22-24 are the differences between children from a non-manual and manual social class (manual social class is coded 0=non-manual, 1=manual) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β25-27 are the differences between children of mothers with no other children and children of mothers with 1 other child (no children is coded 0=1 other child, 1=no other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β28-30 are the differences between children of mothers with 2 other children and children of mothers with 1 other child (2 children is coded 0=1 other child, 1=2 other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β31-33 are the differences between children of mothers with 3 other children and children of mothers with 1 other child (3 children is coded 0=1 other child, 1=3 other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β34-36 are the differences between children of mothers with 4 or more other children and children of mothers with 1 other child (4+ children is coded 0=1 other child, 1=4+ other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β37-39 are the average associations between maternal age and energy intake at 3 years, and linear changes in energy intake from 3-7 and 7-13 years respectively. ‘u’ represents individual level random effects and ‘e’ occasion level random effects. ‘Agewks’ (age in weeks) and ‘source’ (measurement source) were fitted as random-effects at the occasion level (i) in order to allow for the variance of energy intake to change linearly with age and measurement source.

**The bivariate multilevel model equation for the association between energy intake (kcal) at 3 years, and change in energy intake from 3-7 years and 7-17 years with offspring BMI at mean age 15 years, adjusted for plausibility of reporting, measurement source, reporting individual, gender, maternal education, maternal pre-pregnancy BMI, social class, maternal age and parity.**

Equation 1: Kcalij = (β0+u0j+e0ij) + (β1+u1j)(S1ij) + (β2+u2j)(S2ij) + β3(malej) + β4(malej\*S1ij) + β5(malej\*S2ij) + β6(maternal BMIi) + β7(maternal BMIj\*S1ij) + β8(maternal BMIj\*S2ij) + (β9+e0ij)(sourceij) + β10(reporting individualij) + β11(under-reporterij) + β12(over-reporterij) + β13(O-level educationij) + β14(O-level educationij\*S1ij) + β15(O-level educationij\*S2ij) + β16(A-level educationij) + β17(A-level educationij\*S1ij) + β18(A-level educationij\*S2ij) + β19(≥university educationij) + β20(≥university educationij\*S1ij) + β21((≥university educationij\*S2ij) + β22(manual social classij) + β23(manual social classij\*S1ij) + β24(manual social classij\*S2ij) + β25(no childrenij) + β26(no childrenij\*S1ij) + β27(no childrenij\*S2ij) + β28(2 childrenij) + β29(2 childrenij\*S1ij) + β30(2 childrenij\*S2ij) + β31(3 childrenij) + β32(3 childrenij\*S1ij) + β33(3 childrenij\*S2ij) + β34(4+ childrenij) + β35(4+ childrenij\*S1ij) + β36(4+ childrenij\*S2ij) + β37(maternal ageij) + β38(maternal ageij\*S1ij) + β39(maternal ageij\*S2ij) + eij(agewkij) + eij(sourceij)
Equation 2: Offspring BMI = (β40+u0j) + β41(age at BMI assessmentij) + β42(maleij)

Where, for individual j at measurement occasion i, β0 is the average predicted daily energy intake at 3 years in females measured by a food diary; β1 is the average predicted linear changes in daily energy intake per year in the first period (S1=3 to 7 years) in females measured by a food diary; β2 is the average predicted linear changes in daily energy intake per year in the second period (S2=7 to 13 years) in females measured by a food diary; β3-5 are the differences between males and females (male is coded 0=female, 1=male) in energy intake measured by a food diary at 3 years and linear changes in energy intake between 3-7 and 7-13 years respectively, β6-8 are the average estimates for the associations between maternal pre-pregnancy BMI and energy intake at 3 years, and linear change in energy intake between 3-7 years and 7-13 years, respectively. β9 is the average difference in reported energy intake between FFQs and food diaries (source is coded 0=food diary, 1=food frequency questionnaire), β10 is the average difference between child- and parent-reported energy intake (reporting individual is coded 0=parent completion, 1=child completion), β11 is the average difference in reported energy intake between under- and plausible reporters (under-reporter is coded 0=not under-reporter, 1=under-reporter), β12 is the average difference in reported energy intake between over- and plausible reporters (over-reporter is coded 0=not over-reporter, 1= over-reporter), β13-15 are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are O-level educated and children of mothers who are educated below O-level (O-level is coded 0=below O-level education, 1=O-level education), β16-18 are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are A-level educated and children of mothers who are educated below O-level (A-level is coded 0=below O-level education, 1=A-level education), β19-21are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are university educated or above and children of mothers who are educated below O-level (≥university education is coded 0=below O-level education, 1= ≥university education), β22-24are the differences between children from a non-manual and manual social class (manual social class is coded 0=non-manual, 1=manual) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β25-27are the differences between children of mothers with no other children and children of mothers with 1 other child (no children is coded 0=1 other child, 1=no other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β28-30 are the differences between children of mothers with 2 other children and children of mothers with 1 other child (2 children is coded 0=1 other child, 1=2 other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β31-33 are the differences between children of mothers with 3 other children and children of mothers with 1 other child (3 children is coded 0=1 other child, 1=3 other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β34-36are the differences between children of mothers with 4 or more other children and children of mothers with 1 other child (4+ children is coded 0=1 other child, 1=4+ other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β37-39 are the average estimates for associations between maternal age and energy intake at 3 years, and linear changes in energy intake from 3-7 and 7-13 years respectively. β40 is the average offspring BMI at mean age 15 years in females. β41 is the average estimate for the association between the age at which BMI is assessed and BMI at mean age 15 years, β42 is the average difference in BMI at 15 years in males (male is coded 0=female, 1=male),‘u’ represents individual level random effects and ‘e’ occasion level random effects. ‘Agewks’ (age in weeks) and ‘source’ (measurement source) were fitted as random-effects at the occasion level (i) in order to allow for the variance of energy intake to change linearly with age and measurement source.

The beta coefficients for the associations between energy intake (kcal) at 3 years, and change in energy intake from 3-7 years and 7-17 years with offspring BMI at mean age 15 years are calculated from the individual-level random effects variance- covariance matrix.

 **The trivariate multilevel model equation for the role of offspring energy intake in mediating the association between maternal BMI and offspring BMI at mean age 15 years, adjusted for plausibility of reporting, measurement source, reporting individual, gender, maternal education, social class, maternal age and parity.**

Equation 1: Maternal BMIij = (β0+u0j)
Equation 2: Kcalij = (β1+u0j+e0ij) + (β2+u1j)(S1ij) + (β3+u2j)(S2ij) + β4(malej) + β5(malej\*S1ij) + β6(malej\*S2ij) + (β7+e0ij)(sourceij) + β8(reporting individualij) + β9(under-reporterij) + β10(over-reporterij) + β11(O-level educationij) + β12 (O-level educationij\*S1ij) + β13(O-level educationij\*S2ij) + β14(A-level educationij) + β15(A-level educationij\*S1ij) + β16(A-level educationij\*S2ij) + β17(≥university educationij) + β18((≥university educationij\*S1ij) + β19(≥university educationij\*S2ij) + β20 (manual social classij) + β21(manual social classij\*S1ij) + β22(manual social classij\*S2ij) + β23(no childrenij) + β24(no childrenij\*S1ij) + β25(no childrenij\*S2ij) + β26(2 childrenij) + β27(2 childrenij\*S1ij) + β28(2 childrenij\*S2ij) + β29(3 childrenij) + β30(3 childrenij\*S1ij) + β31(3 childrenij\*S2ij) + β32(4+ childrenij) + β33(4+ childrenij\*S1ij) + β34(4+ childrenij\*S2ij) + β35(maternal ageij) + β36(maternal ageij\*S1ij) + β37(maternal ageij\*S2ij) + eij(agewkij) + eij(sourceij)
Equation 3: Offspring BMI = (β38+u0j) + β39(age at BMI assessmentij) + β40(maleij)

Where, for individual j at measurement occasion i, β0 is the average maternal pre-pregnancy BMI. β1 is the predicted daily energy intake at 3 years in females measured by a food diary; β2 is the average predicted linear changes in daily energy intake per year in the first period (S1=3 to 7 years) in females measured by a food diary; β3 is the average predicted linear changes in daily energy intake per year in the second period (S2=7 to 13 years) in females measured by a food diary; β4-6 are the differences between males and females (male is coded 0=female, 1=male) in energy intake measured by a food diary at 3 years and linear changes in energy intake between 3-7 and 7-13 years respectively, β7 is the average difference in energy intake reported by FFQs and food diaries (source is coded 0=food diary, 1=food frequency questionnaire), β8 is the average differences between child- and parent-reported (reporting individual is coded 0=parent completion, 1=child completion) energy intake, β9 is the average difference between under- and plausible reporters (under-reporter is coded 0=not under-reporter, 1=under-reporter), β10 is the average difference between over- and plausible reporters (over-reporter is coded 0=not over-reporter, 1= over-reporter), β11-13 are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are O-level educated and children of mothers who are educated below O-level (O-level is coded 0=below O-level education, 1=O-level education), β14-16 are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are A-level educated and children of mothers who are educated below O-level (A-level is coded 0=below O-level education, 1=A-level education), β17-19 are the differences in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, between children of mothers who are university educated or above and children of mothers who are educated below O-level (≥university education is coded 0=below O-level education, 1= ≥university education), β20-22 are the differences between children from a non-manual and manual social class (manual social class is coded 0=non-manual, 1=manual) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β23-25are the differences between children of mothers with no other children and children of mothers with 1 other child (no children is coded 0=1 other child, 1=no other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β26-28 are the differences between children of mothers with 2 other children and children of mothers with 1 other child (2 children is coded 0=1 other child, 1=2 other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β29-31 are the differences between children of mothers with 3 other children and children of mothers with 1 other child (3 children is coded 0=1 other child, 1=3 other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β32-34 are the differences between children of mothers with 4 or more other children and children of mothers with 1 other child (4+ children is coded 0=1 other child, 1=4+ other children) in energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years, respectively, β35-37 are the average estimates for associations between maternal age and energy intake at 3 years, and linear changes in energy intake from 3-7 and 7-13 years respectively. β38 is the average offspring BMI at mean age 15 years in females. Β39 is the average estimate for the association between the age at which BMI is assessed and BMI at mean age 15 years, β40 is the average difference in BMI at 15 years in males (male is coded 0=female, 1=male),‘u’ represents individual level random effects and ‘e’ occasion level random effects. ‘Agewks’ (age in weeks) and ‘source’ (measurement source) were fitted as random-effects at the occasion level (i) in order to allow for the variance of energy intake to change linearly with age and measurement source.

The beta coefficients for the total effect and direct effect of maternal BMI on offspring BMI were calculated from the variance-covariance matrix of the individual-level random effects. The indirect effect of maternal BMI on offspring BMI (i.e. that is mediated through offspring energy intake from 3-13 years) was calculated by subtracting the direct effect from the total effect.

**Calculation and interpretation of path analysis parameters**

 The ‘total effect’ of maternal BMI on offspring BMI through all possible pathways is calculated from unadjusted analyses of the covariance between the individual-level random effects for these variables, divided by the variance of the maternal BMI random effect. The ‘direct effect’, i.e. the association not mediated by offspring energy intake trajectories, is calculated from analyses adjusted for the terms in the random effects covariance matrix relating to energy intake at 3 years and linear changes in energy intake between 3-7 and 7-13 years. The ‘indirect effect’, i.e. the portion of the association between maternal and offspring BMI that is mediated by offspring energy intake trajectories, is estimated by subtracting the direct effect from the total effect.

**Figure A – Individual predicted energy intake trajectories from 3 to 13 years of age in a random sample of 600 participants**



**Table A – Average difference in energy intake for categories of the three covariables included in all models (measurement source, reporting individual and plausibility of reporting)**

|  |  |
| --- | --- |
|  | **Mean overall difference in energy intake in kcal (SE)**  |
| **FFQ** (compared to food diary) | 74 (2) |
|  |  |
| **Child completion** (compared to parent completion) | -81 (7) |
| **Under-reporters**(compared to plausible reporters) | -448 (3) |
| **Over-reporter**s(compared to plausible reporters) | 502 (2) |

**Table B– Characteristics of the participants included in the association analyses, compared to those excluded from the analyses due to missing data.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Characteristic** | **N (%) with data**  | **Participants with dietary intake trajectoriesN = 12,032** |  | **N (%) with data** | **Participants included in association analyses N = 4,197** |
| Mean predicted energy intake at 3 years, (SD) (kcal) | 12,032 (100%) | 1131 (74) |  | 4,197 (100%) | 1125 (75) |
| Mean predicted change in energy intake from 3-7 years, (SD) (kcal/year) | 12,032 (100%) | 136 (16) |  | 4,197 (100%) | 136 (17) |
| Mean predicted change in energy intake from 7-13 years, (SD) (kcal/year) | 12,032 (100%) | 97 (20) |  | 4,197 (100%) | 97 (22) |
| Mean Maternal pre-pregnancy BMI (SD) (kg/m2) | 10,177 (85%) | 22.96 (3.81) |  | 4,197 (100%) | 22.80 (3.60) |
| Mean Offspring BMI at age 15 (SD) (kg/m2) | 5338 (44%) | 21.43 (3.55) |  | 4,197 (100%) | 21.33 (3.41) |

BMI, body mass index; g, grams

**Table C: Analysis using raw data - Unadjusted associations of reported energy intake at 3 years, and change in reported energy intake per year from 3-7 years and 7-13 years with body mass index at age 15 years, restricted to food diaries only (n=403)**

|  |  |  |
| --- | --- | --- |
|  | **Unadjusted** |  |
| **Observed energy intake (kcal) and change in energy intake (kcal/year)** | **B** | **95% CI** | **P value** |  |
| 3 years | 0.01 | -0.01, 0.03 | 0.204 |  |
| 3-7 years | 0.02 | -0.02, 0.06 | 0.302 |  |
| 7-13 years | -0.07 | -0.12, -0.03 | 0.001 |  |

Results are presented as the increase in offspring BMI per 10 kcal increase in reported energy intake at age 3 years, and change in reported energy intake per year from 3-7 and 7-13 years

**Table D: For comparison with analysis using raw data - Unadjusted associations of predicted energy intake at 3 years, and change in predicted energy intake per year from 3-7 years and 7-13 years (from a multilevel model using data from food diaries only and not adjusting for other covariables) with body mass index at age 15 years, using the two-step process (n=403)**

|  |  |  |
| --- | --- | --- |
|  | **Unadjusted** |  |
| **Predicted energy intake (kcal) and change in energy intake (kcal/year)** | **B** | **95% CI** | **P value** |  |
| 3 years | 0.05 | 0.004, 0.09 | 0.030 |  |
| 3-7 years | 0.14 | -0.05, 0.33 | 0.135 |  |
| 7-13 years | -0.27 | -0.49, -0.05 | 0.015 |  |

Results are presented as the increase in offspring BMI per 10 kcal increase in predicted energy intake at age 3 years, and change in predicted energy intake per year from 3-7 and 7-13 years

**Table E: Mediation of the association between maternal BMI and offspring BMI at age 15 years by energy intake at 3 years and linear changes in energy intake from 3-7 and 7-13 years, using a trivariate multilevel model (n=4,197).**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Adjusted for gender, dietary intake measurement source, and plausibility of dietary intake measurements** |  | **Adjusted for gender, dietary intake measurement source, plausibility of dietary intake measurements and confounders \***  |
|  | **Coefficient** | **95% CI for the coefficient** | **% of the total effecta** | **P**  |  | **Coefficient** | **95% CI for the coefficient** | **% of the total effecta** | **P** |
| **Total effect** | 0.32 | 0.30, 0.35 | - | <0.001 |  | 0.33 | 0.30, 0.35 | - | <0.001 |
| **Direct effect**  | 0.24 | 0.22, 0.27 | - | <0.001 |  | 0.24 | 0.21, 0.27 | - | <0.001 |
| **Indirect effect**  | 0.08 | - | 25% |  |  | 0.09 | - | 27% |  |

The total effect is a linear regression coefficient representing the total association between maternal BMI and offspring BMI through all possible pathways, i.e. for a one unit (one kg/m2) increase in maternal pre-pregnancy BMI, offspring BMI at 15 years is on average 0.330kg/m2 higher. The direct effect is the effect of maternal BMI on offspring BMI that is not mediated through offspring energy intake, but could be confounded or mediated by other factors not included in our model. The total indirect effect represents the proportion of the association between maternal BMI and offspring BMI that is mediated through offspring energy intake from 3 to 13 years. Confounders adjusted for are: age at the time offspring BMI was assessed, maternal education, parity, maternal age and social class.
aThis is the proportion of the association between maternal pre-pregnancy BMI and offspring BMI at 15 years that is mediated through offspring energy intake from 3-13 years and is calculated by dividing the coefficient for the total indirect effect by the coefficient for the total effect, and multiplying by 100.

**SENSITIVITY ANALYSIS RESULTS**

 **Table F: Predicted energy intake at 3 years and change in energy intake from 3-7 years, and 7-13 years in males and females who had at least two measures of reported energy intake from 3-13 years (n=10,872)**

|  |  |  |
| --- | --- | --- |
|  | **Mean(SD) predicted intercept (energy intake in kcal at 3y) and slopes (change in energy intake in kcal per year from 3-7y and 7-13y) in males (n=6,184)** | **Mean(SD) predicted intercept (energy intake in kcal at 3y) and slopes (change in energy intake in kcal per year from 3-7y and 7-13y) in females (n=5,848)** |
| 3 years | 1176 (61) | 1080 (66) |
| 3-7 years | 139 (18) | 134 (16) |
| 7-10 years | 106 (15) | 88 (12) |

 SD, standard deviation

 **Table G: Predicted energy intake at 3 years and change in energy intake from 3-7 years, and 7-13 years in males and females that had at a measure of reported energy intake at 3 years, and a least one measure between 3-7 years and at least one measure between 7-13 years (n=7,954)**

|  |  |  |
| --- | --- | --- |
|  | **Mean(SD) predicted intercept (energy intake in kcal at 3y) and slopes (change in energy intake in kcal per year from 3-7y and 7-13y) in males (n=6,184)** | **Mean(SD) predicted intercept (energy intake in kcal at 3y) and slopes (change in energy intake in kcal per year from 3-7y and 7-13y) in females (n=5,848)** |
| 3 years | 1177 (61) | 1084 (68) |
| 3-7 years | 138 (19) | 133 (15) |
| 7-10 years | 106 (15) | 88 (12) |

 SD, standard deviation

**Figure B – Individual predicted energy intake trajectories from 3 to 13 years of age in a random
sample of 600 participants from the multilevel model restricted to food diaries (n=9,204)**

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**Figure C – Individual predicted energy intake trajectories from 3 to 13 years of age in a random
sample of 600 participants from the multilevel model restricted to FFQs (n=11,086)**

****

**Table H: A summary of measurements included and model fit for energy intake trajectories when the model is restricted to data from food diaries only (n=9,204).**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Summary of measurements** |  | **Model fit for energy intake trajectories** |
|  | **Number of children with at least one dietary intake measurement** | **Total number of measures** | **Median (IQR) measures per child** | **Mean (SD) predicted intercept and slopesa** | **Mean predicted energy intake in kcal (SD)b** | **Mean observedenergy intake in kcal (SD)** | **Mean difference between observed and predicted energy intake in kcal (SD)** | **95% level of agreement (kcal)\*\*\*\*** |
| Overall | 9204 | 22,490 | 6 (3 to 7) | - | - | - | - | - |
| 3 years\* | 863 | 863 | 1 (0 to 1) | 1187 (60) | 1339 (250) | 1349 (258) | 10 (130) | -243, 244 |
| 3-7 years\*\* | 999 | 1638 | 2 (0 to 2) | 122 (19) | 1536 (259) | 1515 (293) | -21 (134) | -285, 240 |
| 7-13 years\*\*\* | 9047 | 20,852 | 3 (2 to 4) | 101 (19) | 1828 (316) | 1828 (421) | 0 (201) | -392, 392 |

SD, standard deviation.
a The data at age 3 years relate to predictions from the multilevel model at exactly age 3 years (i.e. the intercept).
b The data at age 3 years relate to the FD carried out at mean age 3.91 years
\*The data for 3 years relate to the FD from the 3 year assessment (mean (SD) age 3.91 years (0.03 years)).
\*\*The data from 3 to 7 years relate to dietary intake assessments taken when the child was between 3 and 7 years, excluding the FFQ from mean age 3.
\*\*\*The data from 7 to 13 years relate to dietary intake assessments taken when the child was over 7 years
\*\*\*\*Range within which 95% of the differences between observed energy intake measurements and those predicted by the multi-level model lie

**Table I: A summary of measurements included and model fit for energy intake trajectories when the model is restricted to data from food frequency questionnaires only (n=11,806).**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Summary of measurements** |  | **Model fit for energy intake trajectories** |
|  | **Number of children with at least one dietary intake measurement** | **Total number of measures** | **Median (IQR) measures per child** | **Mean (SD) predicted intercept and slopesa** | **Mean predicted energy intake in kcal (SD)b** | **Mean observedenergy intake in kcal (SD)** | **Mean difference between observed and predicted energy intake in kcal (SD)** | **95% level of agreement (kcal)\*\*\*\*** |
| Overall | 11,086 | 35,271 | 5 (3 to 7) | - | - | - | - | - |
| 3 years\* | 9805 | 9805 | 1 (1 to 1) | 1196 (76) | 1250 (292) | 1257 (316) | 7 (129) | -245, 259 |
| 3-7 years\*\* | 10,021 | 17,183 | 2 (1 to 2) | 139 (26) | 1604 (378) | 1601 (434) | -4 (150) | -296, 289 |
| 7-13 years\*\*\* | 7937 | 8283 | 2 (1 to 4) | 97 (8) | 1905 (357) | 1906 (468) | 1 (192) | -374, 375 |

SD, standard deviation.
a The data at age 3 years relate to predictions from the multilevel model at exactly age 3 years (i.e. the intercept).
b The data at age 3 years relate to the FFQ carried out at mean age 3.21 years
\*The data for 3 years relate to the FFQ from the 3 year assessment (mean (SD) age 3.21 years (0.12 years)).
\*\*The data from 3 to 7 years relate to dietary intake assessments taken when the child was between 3 and 7 years, excluding the FFQ from mean age 3.
\*\*\*The data from 7 to 13 years relate to dietary intake assessments taken when the child was over 7 years
\*\*\*\*Range within which 95% of the differences between observed energy intake measurements and those predicted by the multi-level model lie

**Table J: Associations of energy intake at 3 years, and linear changes in energy intake from 3 to 7 years and 7 to 13 years with body mass index at age 15 years using the two-step process, restricting to food diaries only (n=4,125).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Adjusted for gender, individual reporting dietary intake, and plausibility of dietary intake measurements** |  | **Adjusted for gender, individual reporting dietary intake, plausibility of dietary intake measurements and confounders \***  |  | **Adjusted for gender, individual reporting dietary intake, plausibility of dietary intake measurements, confounders\* and previous energy intakes** |
| **Energy intake** | **B1** | **95% CI** | **P value** |  | **B1** | **95% CI** | **P value** |  | **B1** | **95% CI** | **P value** |
| 3 years | 0.29 | 0.26, 0.31 | <0.001 |  | 0.26 | 0.24, 0.28 | <0.001 |  | - | - | - |
| Change from 3-7 years\*  | 0.69 | 0.64, 0.74 | <0.001 |  | 0.64 | 0.59, 0.68 | <0.001 |  | 0.43 | 0.33, 0.53 |  <0.001 |
| Change from 7-13 years\* | -0.53 | -0.62, -0.43 | <0.001 |  | -0.48 | -0.57, -0.38 | <0.001 |  | -0.24 | -0.53, 0.05 | 0.109 |

Results are presented as the increase in offspring BMI per increase of 10 kcal at age 3 years and per 10 kcal change in energy intake per year from 3-7 years, and from 7-13 years
\*confounders adjusted for are: age at the time offspring BMI was assessed, maternal education, parity, maternal age, social class and pre-pregnancy maternal BMI

**Table K: Associations of energy intake at 3 years, and linear changes in energy intake from 3 to 7 years and 7 to 13 years with body mass index at age 15 years using the two-step process, restricting to FFQs only (n=4,140).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Adjusted for gender and plausibility of dietary intake measurements** |  | **Adjusted for gender, plausibility of dietary intake measurements and confounders \***  |  | **Adjusted for gender, plausibility of dietary intake measurements, confounders\* and previous energy intakes** |
| **Energy intake** | **B1** | **95% CI** | **P value** |  | **B1** | **95% CI** | **P value** |  | **B1** | **95% CI** | **P value** |
| 3 years | 0.16 | 0.15, 0.18 | <0.001 |  | 0.14 | 0.13, 0.16 | <0.001 |  | - | - | - |
| Change from 3-7 years\*  | 0.14 | 0.13, 0.16 | <0.001 |  | 0.31 | 0.27, 0.34 | <0.001 |  | 0.10 | 0.05, 0.15 | <0.001 |
| Change from 7-13 years\* | -0.08 | -0.21, 0.06 | 0.25 |  | -0.08 | -0.20, 0.05 | <0.23 |  | 0.29 | 0.02, 0.55 | 0.03 |

Results are presented as the increase in offspring BMI per increase of 10 kcal at age 3 years and per 10 kcal change in energy intake per year from 3-7 years, and from 7-13 years
\*confounders adjusted for are: age at the time offspring BMI was assessed, maternal education, parity, maternal age, social class and pre-pregnancy maternal BMI

**Online Supplement Reference List**

 **1. Rogers I, Emmett P. Diet during pregnancy in a population of pregnant women in South West England. ALSPAC Study Team. Avon Longitudinal Study of Pregnancy and Childhood. Eur J Clin Nutr 1998;52:246-50.**

 **2. Price GM, Paul AA, Key FB et al. Measurement of diet in a large national survey: comparison of computerized and manual coding of records in household measures. Journal of Human Nutrition and Dietetics 1995;8:417-28.**

 **3. Wrieden WL, Longbottom PJ, Adamson AJ et al. Estimation of typical food portion sizes for children of different ages in Great Britain. British Journal of Nutrition 2008;99:1344-53.**

 **4. Gregory J, Lowe S, Bates CJ et al. National Diet and Nutrition Survey: young people aged 4 to 18 years. Volume I: Report of the diet and nutrition survey. London: The Stationery Office 2000.**

 **5. Gregory JR, Collins DL, Davies PSW, Hughes JM, Clarke PC. The Diet and Nutrition Survey: children aged 1½–4½ years. Vol. 1, Report of the diet and nutrition survey. London: The Stationery Office 1995.**

 **6. Ministry of Agriculture Fisheries and Food. Food Portion Sizes. London: The Stationery Office, 1993.**

 **7. Torun B. Energy requirements of children and adolescents. Public Health Nutr 2005;8:968-93.**

 **8. Black AE, Cole TJ. Within- and between-subject variation in energy expenditure measured by the doubly-labelled water technique: implications for validating reported dietary energy intake. Eur J Clin Nutr 2000;54:386-94.**

 **9. Merrill A, Watt. Energy value of foods: basis and derivation. Agricultural handbook 74. Washington DC: US Department of Agriculture, Agricultural Research Service 1973.**