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Psychosocial and educational outcomes of weight faltering in infancy in ALSPAC

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ABSTRACT

Objectives: To investigate whether infants with weight faltering have impaired psychosocial and educational outcomes in later childhood.

Design: Follow-up of infants with weight faltering in a large UK cohort study.

Setting: The Avon Longitudinal Study of Parents and Children (ALSPAC).

Participants: 11 534 term infants from ALSPAC with complete weight records. Weight gain (conditional on initial weight) was calculated for three periods: from birth to 8 weeks, 8 weeks to 9 months, and birth to 9 months. Cases of weight faltering were defined as those infants with a conditional weight gain below the 5th centile, and these were compared with the rest of the cohort as the control group.

Outcomes: Between 6 and 11 years, social, emotional and behavioural development was measured by direct assessment of the children and parental and teacher report. Educational outcomes included Standardised Assessment Test results at 7 and 11 years and Special Educational Needs status at age 11.

Results: Differences seen on univariate analysis in attention, non-verbal accuracy, educational attainment and special educational needs became non-significant after adjustment for confounding. Children with weight faltering in infancy did not differ from controls on any measures of self-esteem, peer relationships, experience of bullying, social cognition, antisocial activities, anxiety, depression or behavioural problems.

Conclusions: Weight faltering in early infancy was associated with poorer educational outcomes in later childhood, but these associations were explained by confounding. The subsequent psychosocial development of infants with slow weight gain was not different from that of their peers.

ARTICLE SUMMARY

Article focus

- Studies of clinically derived samples of children with failure to thrive have reported problems with psychosocial development and subsequent educational attainment.
- We have used a population-based study of weight faltering in 11 534 term infants to investigate whether children who grew slowly in the first 9 months had different psychological, behavioural and educational outcomes later in childhood compared with their peers.

Key messages

- Using a large birth cohort, weight faltering in infancy was associated with poorer educational outcomes in later childhood, but these associations were explained by confounding factors.
- Infants with slow weight gain who were otherwise well had similar psychosocial development to their peers at school age.

Strengths and limitations of this study

- This research utilised a large representative population-based cohort (Avon Longitudinal Study of Parents and Children, ALSPAC), on whom a wide range of psychological and educational outcomes were available.
- The main limitation is missing data in some of the outcome measures, due to loss to follow-up.
- ALSPAC is an observational research study, and we do not know which cases were identified by health and education services and subject to interventions which may have influenced the outcome.

INTRODUCTION

Failure to thrive (FTT) is a term describing children who fail to grow at the expected rate, with various definitions, including 'infants and young children whose growth is substantially less than that of their peers'.[1] A common factor is the identification of cases by weight gain, so the term weight faltering is preferred as it avoids the pejorative use of 'failure'. The development of conditional growth measures,[2] which take account of an infant's weight gain relative to their sex, initial weight and regression towards the mean, has enabled a standardised anthropometric approach to the identification of cases of weight faltering.

In view of the evidence for developmental delay[3 4] and poorer cognitive outcomes[5 6] associated with early growth faltering, one

may predict that adverse effects extend to psychosocial development and educational attainment. The link between growth problems and insecure attachment[7 8] adds further plausibility that early growth faltering could be causally related to disordered emotional development. Early studies on FTT based on clinically derived samples reported that growth faltering was associated with behavioural disturbances, poorer social skills, lower self-esteem, abnormal personalities, negative relationships, delayed social maturity, lower emotional stability, learning difficulties and school problems.[9–19] Recently, population-based cohort studies which define growth faltering on standardised anthropometric criteria[20–24] have challenged these traditional findings. Systematic reviews have highlighted the paucity of high-quality follow-up studies and recommended the investigation of a larger range of outcomes, including attention and emotional development.[5 25]

The Avon Longitudinal Study of Parents and Children (ALSPAC)[26] has been used to investigate the epidemiological factors,[27 28] the anthropometric outcomes[29] and the IQ[6] of children with weight faltering in infancy. The analysis of IQ showed that children whose weight faltered from birth to 9 months had a total IQ that was significantly lower by an average of 2.71 points at 8 years, equivalent to 0.17 SD. Weight gain from birth to 8 weeks had a positive linear association with child IQ at 8 years, but weight gain from 8 weeks to 9 months did not show an association with IQ.

We now report on the psychological and educational outcomes in later childhood of infants in ALSPAC who had weight faltering in the first 9 months.

METHODS

ALSPAC is a UK-based birth cohort study designed to examine the genetic and environmental determinants of child health and development. The study recruited 15 247 pregnant women resident in the former Avon Health Authority area with an expected date of delivery between 1 April 1991 and 31 December 1992, resulting in a total cohort of 14 775 live-births. Avon has a mixture of urban and rural communities with sociodemographic characteristics similar to the rest of the UK at the 1991 census. Methodological details of the study have been published elsewhere[26] and details on questionnaires and clinics can be found on the ALSPAC website.[30]

Definition of cases

Weight data collected by health professionals as part of routine child health surveillance were obtained from the Avon Child Health Computer system. Weights were taken at birth, 8 weeks (range 1–3 months), and 9 months (range 6–12 months) and converted to z scores adjusted for gender and age using the British 1990 Growth Reference.[31] If data were missing for any of these measures, children were not included in further analysis (n=1292). Infants were also excluded if they had a major congenital abnormality likely to affect growth (eg, Down syndrome; n=89), were non-singleton births (n=184) or were born preterm (<37 weeks) or post-term (>42 weeks; n=871). The number of children with a complete weight dataset available for this analysis was 11 534.

Growth was measured by calculating differences in z scores between two time points and adjusted for regression towards the mean using Cole's equation,[2] utilising regression coefficients derived from within the cohort. The resulting weight gain was 'conditional' on gender, age and initial weight. As in previous studies investigating weight faltering in ALSPAC, 'cases' were identified as infants with conditional weight gain below the 5th centile in the cohort (z score below −1.645). All other infants in the cohort with weight gain above the 5th centile comprised the control group. Three periods of weight faltering were compared: birth to 8 weeks (early group), 8 weeks to 9 months (late group) and birth to 9 months.

Outcomes

Between 6 and 11 years of age, psychosocial development was measured by direct assessment of the child at research clinics, and by parental and teacher report in questionnaires. The measures used are detailed in table 1. Childhood educational outcomes include Standardised Assessment Test (SAT) results for Key Stages 1 (KS1) and 2 (KS2), obtained from Local Education Authorities in England. These tests are compulsory for children in state-funded schools in England, but are optional for independent private schools. KS1 comprises years 1–2 at primary school (ages 5–7 years) and includes compulsory national tests at 7 years of age in Reading, Writing and Mathematics. KS2 comprises years 3–6 at primary school (ages 8–11 years) and includes compulsory national tests at 11 years of age in English, Mathematics and Science. Educational attainment is categorised into National Curriculum Levels 1–8. In this analysis, KS1 and KS2 summary scores were computed by adding together the National Curriculum Levels the child achieved in each component. Information on children receiving Special Educational Needs (SENs) support was collected from the Pupil Level Annual School Census, a survey which is completed annually by all state schools in England.

Confounders

Background sociodemographic and health data were obtained from postal questionnaires completed by the study mother and partner at various stages through pregnancy, infancy and childhood. Factors predictive of weight faltering identified in previous ALSPAC studies[27 28] were used as covariates for infant growth in the regression analyses. Covariates used in a previous ALSPAC study on weight faltering and cognitive development[6] were entered into regression analyses of educational outcomes, and covariates for psychosocial outcomes were the same as used in a previous ALSPAC

Table 1 Summary of measures used for psychosocial and educational outcomes

Age of child (years)	Measure	Derived from	Comments
6	Behaviour (Strengths and Difficulties Questionnaire, SDQ[41])	Parent report	Total Behavioural Difficulties score (/40) comprises sum of 4 prorated component scores (hyperactivity, emotional symptoms, conduct and peer problems)
7	Behaviour (Strengths and Difficulties Questionnaire, SDQ[41])	Teacher report	As above
	Mental health (Development and Well-Being Assessment, DAWBA[42])	Parent and teacher report	Various prorated scores used (anxiety, mood, attention/activity symptoms, awkward and troublesome behaviours)
	Social cognition (Social Communication Disorders Checklist, SCDC[43])	Parent report	Prorated score summarises 12 questions on the main features of social cognition behaviour (/24)
	SATs—Key Stage One (Reading/ Writing/Mathematics, KS1)	School/LEA records	Children are expected to achieve ≥ National Curriculum Level 2 in each subject at Key Stage 1
8	Attention (Tests of Everyday Attention for Children, TEACh[44])	Assessment of child	Time-dependent tasks measure selective attention, ability to divide attention between 2 tasks and attentional control
	Friends (Cambridge Hormones and Moods project Friendship questionnaire[45])	Assessment of child	Summary score (/15) comprising child's satisfaction with friends, frequency they see them outside school and if they can talk to friends about problems and they are understanding
	Bullying (Bullying and Friendship Interview Schedule[46])	Assessment of child	Summary measure comprises proportion of children receiving direct or indirect bullying, frequently or very frequently in the previous 6 months
	Antisocial activities (Self-reported antisocial behaviour for young children questionnaire[47])	Assessment of child	Summary measure comprises proportion of children who report ever undertaking ≥2 of 11 antisocial activities.
	Self-esteem (Harter's Self Perception Profile for Children[48])	Assessment of child	Scores generated for global self-worth and scholastic competence subscales (both/24)
	Non-verbal accuracy (Diagnostic Analysis of Nonverbal Accuracy, DANVA[49])	Assessment of child	Summary measure comprises proportion of children with ≥7 errors on facial expressions recognition task (Faces subtest)
9	Depression (Short Moods and Feelings Questionnaire, MFQ[50 51])	Parent report	Depression score (/26) comprises sum of 13 questions on the child's moods and feelings in the past 2 weeks
	Special Educational Needs (SEN)	School/PLASC records	Summary measure comprises proportion of children with SEN±statement of SEN
10	Depression (Short Moods and Feelings Questionnaire, MFQ[50 51])	Assessment of child	Summary measure comprises proportion of children with SEN±statement of SEN
	SEN	School/PLASC records	Summary measure comprises proportion of children with SEN±statement of SEN
11	Attention (Tests of Everyday Attention for Children, TEACh[44])	Assessment of child	Summary measure comprises proportion of children with SEN±statement of SEN
	SATs—Key Stage Two (English/ Mathematics/Science, KS2)	School/LEA records	Children are expected to achieve ≥ National Curriculum Level 4 in each subject at Key Stage 2

In all of the numerical outcomes, a higher score equates to a worse outcome except for the Harter's Self Perception Profile for Children where a higher score indicates better self-esteem. Full details on the measures can be found using the respective references.
PLASC, Pupil Level Annual School Census.

study on child behaviour.[32] These include: gender, the child's IQ, birthweight, breastfeeding, maternal age and education, maternal smoking, family size, housing tenure, a home facilities score at 6 months, paternal socioeconomic status at the time of pregnancy, Family Adversity Index (a cumulative index of adversity including housing quality, financial difficulties, partner relationships, maternal mental health, education, criminality, excess alcohol/drugs) and parenting attitudes at 6 months.

Statistical methodology

Analysis was undertaken using Stata V.11.1 (StataCorp 2009). For univariate analysis, normal distributions were

described using means and SD, and other distributions using medians and IQR. Simple cross-tabulations were undertaken for binary outcomes, using χ^2 or Fisher's exact test as appropriate. Differences in means were tested using the unpaired t test for two means or analysis of variance for several means, whereas the difference in medians was tested using the Mann-Whitney U test.

Multivariate multiple regression analyses for all three time periods of growth faltering were conducted with psychosocial and educational outcomes as dependent variables, using backwards stepwise models. Numeric scale outcomes were investigated with ordinal regression and binary outcomes with logistic regression. For all regression analyses, initial models were created excluding covariates with over 10% missing data, and then repeated with those covariates added back in to ascertain their effect and create final models. A p value of >0.01 was used for stepwise exclusion of covariates in view of the number of outcome variables investigated and the importance of a conservative approach to analysis. We took the approach of using available data for each outcome, as restricting the analysis to only those with complete data for all outcomes would reduce the numbers substantially.

RESULTS

Ascertainment

Of the 11 534 infants with complete infant weight data, 46–62% had data available on psychosocial outcomes from child-derived, parent-derived and teacher-derived measures, while educational outcome data were available for 82–87%.

Children attending research clinics and those with returned questionnaires were more likely to come from families of higher socioeconomic class, with a higher maternal educational level and secure housing tenure ($p \leq 0.01$ for all). In contrast, the response bias for educational outcomes was in the opposite direction ($p \leq 0.001$ for socioeconomic class and maternal education), attributable to missing data from independent schools since SATs were only compulsory in the state school system.

Infant growth

Weight z scores (corrected for gender and gestational age) at birth, 8 weeks and 9 months were normally distributed with a mean just above 0 and SD of ~1. Weight gain z scores were also normally distributed, centiles were constructed, and infants below the 5th centile were classified as cases of growth faltering. There were 517 (4.5%) cases of 'early' weight faltering between birth and 8 weeks, and 487 (4.2%) in the 'late' group between 8 weeks and 9 months. Only 30 infants were classed as cases in both the early and late periods.

The birth to 9-month weight faltering group consisted of 520 infants (4.5%) who were slow growing (<5th centile) over a longer period. Of those in the birth to 9-month group, only 97/520 (19%) were also in the birth to 8-week group, but 334/520 (64%) were also in the 8-week to 9-month group.

Psychosocial outcomes

Only 2 of the 14 psychosocial outcomes demonstrated statistically significant differences ($p<0.01$) on univariate analysis; at 8 years, children with a history of early weight faltering demonstrated worse attention in half of the TEACh tasks, and cases of weight faltering between birth to 6–8 weeks and birth to 9 months also made more errors on the DANVA facial emotions recognition task.

Table 2 demonstrates univariate results and regression analyses of psychosocial outcomes for early growth faltering. Differences in psychosocial outcomes present on univariate analysis became non-significant after adjustment, except for the TEACh tasks at 8 years, where cases with early growth faltering demonstrated worse divided attention than controls (OR 1.43, CI 1.13 to 1.80, $p \leq 0.01$). The regression model for this attention task showed independent effects of sex (worse in boys, OR 1.25, CI 1.14 to 1.38, $p \leq 0.001$) and IQ (worse with lower IQ, OR 0.97, CI 0.968 to 0.974, $p \leq 0.001$). No interaction effects were observed. When the attention tasks were repeated at a research clinic at 11 years, no association was observed with any period of growth faltering, even on univariate analysis, so the clinical importance of the finding at 8 years is questionable.

Online supplementary appendix 1 contains the univariate results and regression analyses of psychosocial outcomes for weight faltering between 8 weeks and 9 months and birth to 9 months, which did not show any consistent associations.

Although the correlation between the parent and teacher versions of the SDQ behavioural difficulties score was 0.33, ($p<0.0001$), univariate results showed that parents consistently rated their children as having more behavioural difficulties (median 7, IQR 4–10) than did teachers (median 4, IQR 2–9). Hyperactivity, as measured by DAWBA attention/activity scores, was significantly correlated between the parent and teacher versions (Spearman's $r=0.40$, $p<0.0001$), and teachers consistently scored children higher on the hyperactivity scale than did parents (median 3, IQR 0–10 vs median 2, IQR 0–7 for parental report).

Educational outcomes

Unadjusted results demonstrated poorer educational attainment and higher rates of SENs among cases of weight faltering. These differences were more pronounced at KS2 and in the early weight faltering group displayed in (table 3). On multivariate analysis, all these differences became non-significant, except for isolated disparities in achieving the expected levels in KS1 Mathematics for cases of late growth faltering, and KS1 Mathematics and KS2 English for those with growth faltering between birth to 9 months. Regression models for failing to achieve the expected levels in KS1

Table 2 Psychosocial outcomes in later childhood of weight faltering between birth to 8 weeks

		Weight faltering between birth to 8 weeks						
		Case			Control			
Age (years)	Psychosocial outcome	N	Median/ proportion	IQR/%	N	Median/ proportion	IQR/%	Adjusted OR† (95% CI's)
6	Behavioural difficulties score/40	268	7	4–11	5874	7	4–10	0.87 (0.67 to 1.12)
7	Behavioural difficulties score/40	237	4	2–9	5062	4	2–9	0.92 (0.68 to 1.24)
	Mental health (teacher report)							
	Attention/activity symptoms score/38	239	3	1–10	5062	3	0–10	1.01 (0.75 to 1.35)
	Awkward/troublesome behaviour score/40	239	0	0–1	5058	0	0–2	0.82 (0.55 to 1.22)
	Mental health (parent report)							
	General anxieties score/14	300	1	0–3	6866	0	0–2	1.11 (0.89 to 1.38)
	General anxiety symptoms score/12	300	0	0–2	6835	0	0–1	1.18 (0.92 to 1.51)
	Mood symptoms score/12	295	0	0–0	6758	0	0–0	1.19 (0.84 to 1.69)
	Attention/activity symptoms score/36	298	2	0–7	6859	2	0–7	0.93 (0.72 to 1.20)
	Awkward behaviours score/18	296	0	0–1	6820	0	0–1	0.84 (0.62 to 1.13)
	Troublesome behaviours score/14	299	0	0–1	6834	0	0–1	1.18 (0.88 to 1.58)
	Social cognition score/24	299	2	0–4	6820	2	0–4	0.87 (0.67 to 1.12)
8	Attention							
	Selective attention score (range −0.4 to 46.6)	273	4.9	4.1–6.1	5759	4.9	4.1–5.8	1.06 (0.83 to 1.35)
	Dividing attention score (range −1.0 to 270.9)	242	2.6*	1.0–7.4	5264	2.0	0.4–5.5	1.43 (1.13 to 1.80)**
	Attentional control-same worlds task (seconds)	274	13.0	11.5–14.5	5779	12.5	11.0–14.5	0.98 (0.79 to 1.22)
	Attentional control-opposite worlds task (seconds)	274	17.5*	15.0–20.0	5775	16.5	14.5–19.5	1.15 (0.93 to 1.43)
	Friends score/15	267	3	2–5	5721	3	2–5	1.26 (1.01 to 1.56)
	Bullying status							
	Victim of direct bullying	366	102/366	38%	5703	1989/5703	34%	1.17 (0.89 to 1.53)
	Victim of indirect bullying	252	43/252	17%	5576	915/5576	16%	0.97 (0.67 to 1.39)
	≥2 anti-social activities	269	20/269	7%	5716	426/5716	7%	1.08 (0.67 to 1.77)
	≥7 errors on non-verbal accuracy task	252	76/253*	30%	5456	1202/5456	22%	1.36 (1.00 to 1.83)
	Self-esteem							
	Scholastic competence score/24	259	17	15–19	5573	17	15–20	0.96 (0.77 to 1.20)
	Global self-worth score/24	261	19	17–21	5565	20	17–22	0.81 (0.65 to 1.01)
9	Depression score/26	304	2	0–4	6507	2	0–4	1.05 (0.83 to 1.34)
10	Depression score/26	273	3	1–6	5857	3	1–6	1.01 (0.79 to 1.30)
11	Attention							
	Selective attention score (range −1.9 to 25.7)	263	3.4	2.8–4.0	5644	3.4	2.8–4.1	1.11 (0.86 to 1.44)
	Dividing attention score (range −7.2 to 186.5)	258	0.4	−0.2–1.9	5593	0.4	−0.3–1.5	1.11 (0.87 to 1.41)
	Attentional control-same worlds task (seconds)	255	10	9–11	5443	10	9–11	1.12 (0.88 to 1.42)
	Attentional control-opposite worlds task (seconds)	255	12.5	11.5–14	5441	12.5	11–14	1.05 (0.82 to 1.33)

In all the numerical outcomes, a higher score equates to a worse outcome except for self-esteem scores where a higher score indicates better self-esteem.
*p<0.01 on univariate analysis.
**p<0.01 on multivariate analysis.
†Adjusted for (1) potential confounders for psychosocial outcomes: gender, the child's IQ, maternal education, housing tenure, maternal smoking, home facilities score, paternal socioeconomic status, family adversity index, parenting attitudes at 6 months; and (2) potential confounders for infant growth between birth and 6–8 weeks: time between weight measurements, maternal height, maternal age, use of a car, infant health before weight measurement and feeding difficulties (general and poor sucking) in the first weeks of life.

Table 3 Weight faltering in infancy and later educational outcomes

		Weight faltering in infancy								
		Birth to 8 weeks			8 weeks to 9 months			Birth to 9 months		
Educational outcome	Number with outcome (N=11 534)	Case N or median, (% or IQR)	Control N or median, (% or IQR)	Adjusted OR† (95% CI's)	Case N or median, (% or IQR)	Control N or median, (% or IQR)	Adjusted OR‡ (95% CI's)	Case N or median, (% or IQR)	Control N or median, (% or IQR)	Adjusted OR§ (95% CI's)
Key stage 1 (6–7 years)										
<Level 2 in reading	9454	84/434 (19%)*	1287/9020 (14%)	1.16 (0.81 to 1.66)	74/384 (19%)*	1297/9070 (14%)	1.39 (0.98 to 1.96)	74/417 (18%)	1297/9037 (14%)	1.08 (0.75 to 1.55)
<Level 2 in writing	9456	76/433 (18%)	1316/9023 (15%)	0.91 (0.62 to 1.34)	75/384 (20%)*	1317/9072 (15%)	1.41 (1.01 to 1.95)	81/417 (19%)*	1311/9039 (15%)	1.34 (0.96 to 1.85)
<Level 2 in Mathematics	9452	57/434 (13%)	900/9018 (10%)	1.10 (0.73 to 1.67)	62/417 (15%)*	895/9035 (10%)	1.74 (1.21 to 2.49)**	58/384 (15%)*	899/9068 (10%)	1.65 (1.15 to 2.37)**
KS1 summary score	9439	9 (6–12)*	10 (7–13)	0.87 (0.70 to 1.08)	9.5 (6.5–13)	10 (7–12)	0.90 (0.72 to 1.13)	9 (6–12)	10 (7–12)	0.81 (0.65 to 1.01)
Key stage 2 (10–11 years)										
<Level 4 in English	10 081	111/441 (25%)*	1784/9640 (19%)	1.29 (0.93 to 1.79)	90/404 (22%)	1805/9677 (19%)	1.19 (0.87 to 1.63)	118/448 (26%)*	1777/9633 (18%)	1.49 (1.12 to 1.97)**
<Level 4 in Mathematics	10 043	121/442 (27%)*	2012/9601 (21%)	1.45 (1.07 to 1.95)	95/398 (24%)	2038/9645 (21%)	1.30 (0.95 to 1.80)	124/444 (28%)*	2009/9599 (21%)	1.47 (1.09 to 1.97)
<Level 4 in Science	10 089	59/444 (13%)*	788/9645 (8%)	1.55 (1.05 to 2.31)	42/403 (10%)	805/9686 (8%)	1.15 (0.74 to 1.80)	54/447 (12%)*	793/9642 (8%)	1.22 (0.77 to 1.94)
KS2 summary score	9971	12 (11–14)*	13 (11–14)	0.77 (0.62 to 0.96)	13 (11–14)	13 (11–14)	0.89 (0.71 to 1.10)	12 (11–14)*	13 (11–14)	0.82 (0.66 to 1.01)
Special Educational Needs status										
SEN recorded at 9 years	9700	101/432 (23%)*	1709/9268 (18%)	1.04 (0.77 to 1.41)	84/387 (22%)	1726/9313 (19%)	0.89 (0.71 to 1.10)	102/434 (24%)*	1708/9266 (18%)	1.27 (0.94 to 1.71)
SEN recorded at 10 years	9764	88/439 (20%)	1476/9325 (16%)	1.27 (0.94 to 1.71)	79/389 (20%)	1485/9375 (16%)	1.19 (0.87 to 1.63)	90/436 (21%)*	1474/9328 (16%)	1.18 (0.88 to 1.58)

*p<0.01 on univariate analysis.
**p<0.01 on multivariate analysis.
†Adjusted for (1) age of the child at testing (not for SEN status); (2) potential confounders for educational outcomes: maternal education, paternal socioeconomic class, housing tenure, use of a car, family size, birth-weight, breastfeeding, hospital admissions over childhood and (3) potential confounders for infant growth between birth and 6–8 weeks: time between weight measurements, maternal height, maternal age, infant health before weight measurement and feeding difficulties (general and poor sucking) in the first weeks of life.
‡Adjusted for (1) age of the child at testing (not for SEN status); (2) potential confounders for educational outcomes: maternal education, paternal socioeconomic class, housing tenure, use of a car, family size, birth-weight, breastfeeding, hospital admissions over childhood and (3) Potential confounders for infant growth between 6–8 weeks and 9 months: time between weight measurements, maternal height, infant health before weight measurement and feeding difficulties (refusing non-breast milk and taking too small a quantity) in first months of life.
§Adjusted for (1) age of the child at testing (not for SEN status) (2) potential confounders for educational outcomes: maternal education, paternal socioeconomic class, housing tenure, use of a car, family size, birth-weight, breastfeeding, hospital admissions over childhood and (3) potential confounders for infant growth between birth and 9 months: time between weight measurements, maternal height, maternal body mass index and feeding difficulties (refusing non-breast milk and taking too small a quantity) in the first months of life.

Mathematics demonstrated independent effects of a number of factors other than weight faltering, such as the age of the child at testing, lower paternal socioeconomic class, low-maternal educational level and insecure housing tenure. The regression models of those who did not reach the expected levels for KS2 English demonstrated independent effects of age at testing, having non-breast milk at 6 months, low-paternal socioeconomic class, insecure housing tenure, low-maternal educational level and large families, with the latter four factors having a stronger effect than weight faltering between birth and 9 months.

DISCUSSION

This comprehensive, prospective study of early growth faltering investigated a wide range of psychological, social and educational outcomes in middle childhood. Although a proportionally small number of measures from the many tested appeared worse in children who had faltered in their growth in infancy, almost all became non-significant after adjustment for confounding factors, and the conclusion of this investigation is that growth faltering in infancy is not associated with poorer psychosocial and educational outcomes in later childhood.

The biggest limitation of this work, as with many large longitudinal cohort studies, is missing data, although the number of cases of weight faltering in this study is still large compared with that in the published literature. We acknowledge that response bias is present in the dataset but do not believe that it affects our conclusions, since a simulation study on behavioural disorders in ALSPAC found that the validity of regression models is only marginally affected despite the range restrictions after selective dropout.[33] Furthermore, the lack of effect is consistent across the range of outcomes despite educational data exhibiting the opposite response bias to clinic-derived and questionnaire-derived measures.

ALSPAC is an observational research study, and we do not know which cases were identified by health and education services and subject to interventions, which could potentially have attenuated the effects of growth faltering on later psychosocial and educational outcomes. However, considering that randomised trials of interventions for FTT have failed to demonstrate convincing effects in these areas,[34 35] it seems unlikely that clinical interventions have masked the impact on psychological development and educational attainment.

Despite these limitations, the study represents a comprehensive investigation into the later childhood outcomes of growth faltering in infancy, utilising a large population-based sample. This dataset benefits from extensive, prospectively collected information on relevant confounders, and the covariates entered into regression models were chosen on the basis of literature review and previous work on infant growth, cognitive and behavioural development in ALSPAC. Assessing the child's development directly in research clinics and from parental and teacher's perspectives provides triangulation of our findings and adds confidence to our conclusions. We have not been able to investigate outcomes against the *severity* of the infant growth faltering, but have looked at *chronicity*—and were able to compare early weight faltering over the first 8 weeks with longer faltering over 9 months. However, in view of the large number of outcomes investigated, a conservative approach to analysis was appropriate and we have been careful not to exaggerate our univariate findings.

The unadjusted educational outcomes are consistent with previously reported IQ data from this cohort,[6] in that poorer achievement was more evident in children with early rather than late growth faltering in infancy. However, the great majority of differences become non-significant after adjustment for confounding, suggesting that childhood educational attainment is more strongly influenced by other sociodemographic factors, especially maternal education and the quality of the home environment. Differences persisting after adjustment (eg, poorer ability at 8 years in divided attention) must be interpreted with caution in view of the small effect sizes and the large number of non-significant outcomes. The lack of adverse effects is in agreement with UK population-based studies where growth faltering was defined using similar conditional anthropometric criteria—for example, Drewett *et al*,[24 36] but differs from studies based on families from deprived backgrounds.[23] This study builds on those reports with a population-based sample, a greater number of cases and a wider range of outcomes, and provides clear messages for clinical practice.

Clinical implications

The message that children who grow slowly in infancy are unlikely to have adverse psychosocial and educational consequences will reassure parents and clinicians. A large proportion of weight faltering infants who are otherwise well will be 'slow normal', growing according to their genetic potential (hence, the strong influence of parental height[27 28]). The majority of these infants warrant a conservative and supportive approach unless additional symptoms or signs of illness are present. Recommendations for the management of weight faltering in developed countries should balance this finding with the increasing evidence for adverse consequences of rapid weight gain in infancy,[37] which implies that a policy of augmenting 'catch up' growth by giving extra calories is undesirable. In low-income settings, however, weight faltering is more often a consequence of undernutrition, with good evidence to suggest poorer psychological and cognitive outcomes and a greater need for intervention.[38 39]

CONCLUSIONS

Clinicians looking after infants showing weight faltering can have difficulty in containing parents' anxiety, even

when the child is otherwise well, since parents often fear slow growth is indicative of an underlying problem.[40] This study provides good evidence to reassure clinicians and families that, in a resource-rich society with a good educational system, slow weight gain is not associated with later disadvantages in psychosocial development or achievement at school.

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