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## ORIGINAL ARTICLE

# The influence of maternal socioeconomic and emotional factors on infant weight gain and weight faltering (failure to thrive): data from a prospective birth cohort

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**Aims:** To study the influence of maternal socioeconomic and emotional factors on infant weight gain and weight faltering (failure to thrive) in the first year of life.

**Methods:** The Gateshead Millennium Baby Study is a population birth cohort in northeast England studied prospectively from birth, via parental questionnaires and a health check aged 13 months. Data were collected on maternal education, deprivation, eating attitudes, and depression, using the Edinburgh Postnatal Depression Scale (EPDS) at 3 months. Weight gain was assessed using change in weight SD score, conditional on birth weight (Thrive Index); weight faltering was defined as conditional weight gain below the 5th centile.

**Results:** Of 923 eligible infants born at term, 774 (84%) had both weight and questionnaire data. Replicating a previous finding, both the highest and the lowest levels of deprivation were associated with weight faltering; this was independent of the type of milk feeding. No relation was found with maternal educational status. Maternal eating restraint was unrelated to weight gain. Infants of mothers with high depression symptom scores (EPDS >12) had significantly slower weight gain and increased rates of weight faltering up to 4 months (relative risk 2.5), especially if they came from deprived families, but by 12 months they were no different from the remainder of the cohort.

**Conclusions:** In this setting, social and maternal characteristics had little influence on infants' weight gain, apart from a strong, but transient effect of postnatal depression.

Under-nutrition in childhood is still a major problem worldwide, and in developing countries is clearly related to poverty and maternal education.<sup>1</sup> In more affluent countries under-nutrition in early childhood tends to be called "failure to thrive" and in the past was assumed to be strongly related to poverty, maternal deprivation, and neglect.<sup>2–3</sup> However by the 1980s the link with neglect was being challenged,<sup>4–5</sup> and population based research over the last 15 years has shown that neglect plays a part in only a minority of cases,<sup>6–7</sup> leading to the recommendation that the less pejorative term "weight faltering" now be used instead and for the diagnosis to be based on objective evidence of subnormal weight gain or severe underweight.<sup>8</sup>

Feeding relies on a successful interaction between mother and child, making it likely that maternal characteristics and family conditions would have an important influence on infant growth, but research to date has produced equivocal results.<sup>9</sup> Our previous retrospective population based study did not find a direct relation with socioeconomic deprivation,<sup>10</sup> and this finding has recently been replicated in another large cohort.<sup>11</sup> Early studies found associations between weight faltering and mothers' unhappy childhoods,<sup>12–14</sup> but not with major mental health problems.<sup>15–17</sup> One recent study found an association between weight faltering and postnatal depression<sup>18</sup> but another did not,<sup>19</sup> while other studies have found an association with restrained eating.<sup>20–22</sup> A limitation of many of these studies was that the participants had already been referred for specialist assessment,<sup>12–13 16–18 20–22</sup> when we know that family characteristics themselves influence referral, with, for example, the growth of children from more prosperous families less likely to be labelled failure to thrive.<sup>23</sup>

The Gateshead Millennium Baby (GMB) Study thus set out to examine the correlates and antecedents of weight faltering, prospectively, in a population based birth cohort. This allowed us to examine the relation between deprivation, maternal education, maternal depression, and restrained eating, and weight gain and failure to thrive in a large group of unselected infants.

## METHODS

### Subjects

The GMB study recruited subjects shortly after birth between June 1999 and May 2000 in Gateshead, an urban district in northeast England, with a largely white British population. All infants born to mothers resident in Gateshead in 34 prespecified weeks were eligible for recruitment. Parents who agreed to participate received questionnaires at 6 weeks, and 4, 8, and 12 months, all of which asked a wide range of questions about feeding, while each individual questionnaire also asked about different aspects of the mother or child. The study was approved by the Gateshead local research ethics committee. For this analysis, infants born before 37 weeks gestation were excluded.

### Measures

All children in the UK are routinely weighed by primary care nurses in community based well-baby clinics and these weights are recorded in parent held child health records (PCHR); parents transcribed these weights onto each questionnaire. At the age of 13 months, research nurses weighed the infants and measured their length at a health check as well as retrieving a copy of the PCHR weight recording page. Maternal weight and height were also measured and used to

**Table 1** Demographic characteristics of subjects with weight and questionnaire data, compared to cohort as a whole (number, % of total relevant population)

Townsend score quintile*	Whole cohort	Demographic and weight data at 6 wk	Demographic and weight data at 12 mth	EPDS and weight data at 4 mth	Eating attitudes and weight data at 12 mth	No weight data at 6 wk or 12 mth
Total	917† (100%)	774 (84%)	772 (84%)	662 (72%)	564 (61%)	70 (8%)
1 (most affluent)	152 (100%)	143 (94%)	141 (93%)	124 (81%)	128 (84%)	6 (4%)
2	193 (100%)	174 (90%)	171 (89%)	138 (71%)	141 (73%)	12 (6%)
3	212 (100%)	174 (82%)	178 (84%)	154 (73%)	126 (59%)	16 (7%)
4	187 (100%)	150 (80%)	151 (81%)	121 (65%)	98 (52%)	16 (9%)
5 (most deprived)	173 (100%)	133 (77%)	131 (76%)	125 (72%)	71 (41%)	20 (12%)
p value‡		<0.0001	<0.0001	<0.0001	<0.0001	

\*Quintiles for UK Northern Region.

†Townsend scores missing for six subjects.

‡ $\chi^2$  test for trend, compared to those without those data at that time point.

calculate their body mass index ( $BMI = \text{weight (kg)}/\text{height (m)}^2$ ).

Demographic information was collected at recruitment, and the mother's and father's highest attained educational qualification was recorded. The child's postcode (zip code) at birth was linked to census data for the enumeration district, to provide a Townsend score, a well validated area based measure of socioeconomic deprivation.<sup>24</sup> The distribution of these scores in the Northern Region is known, so that the scores could then be divided into five categories corresponding to the quintiles for the general population. As part of routine care, when the baby was aged 2–3 months, mothers completed the Edinburgh Post Natal Depression Scale (EPDS) and this score was forwarded to the project office. The EPDS is a well validated screening tool,<sup>25</sup> comprising 10 questions, with a maximum score of 30 and a score of greater than 12 being the usual screening threshold. In the 12 month questionnaire mothers were asked to complete the English version of the Dutch Eating Behaviour Questionnaire (DEBQ). This is a self-report instrument<sup>26</sup> which is widely used and well validated for use in the UK;<sup>27</sup> its 32 items are used to generate three sub-scales: restraint, emotional (reliance on food to provide comfort or relieve stress), and external (the tendency to eat in response to external cues).

### Growth outcomes

The weight data were cleaned and cross-checked<sup>28</sup> and then all weights converted into standard deviation (SD) scores compared to the UK 1990 growth reference.<sup>29–30</sup> Growth outcomes were examined in terms of overall weight gain and the prevalence of weight faltering. For each child, all available weight SD scores within four age ranges (1–2, 3–6, 7–9, and 10–18 months) were identified and the average score per child for that time period calculated. These supplied SD scores at around the ages of 6 weeks, and 4, 8, and 12 months. Weight gain was then assessed using the Thrive Index (TI), a measure of change in weight SD over time, conditional on initial weight, to allow for regression to the mean.<sup>31</sup> The Thrive Index, which compares a child's actual weight SDS to their expected weight SDS, can be calculated for any time interval as follows:

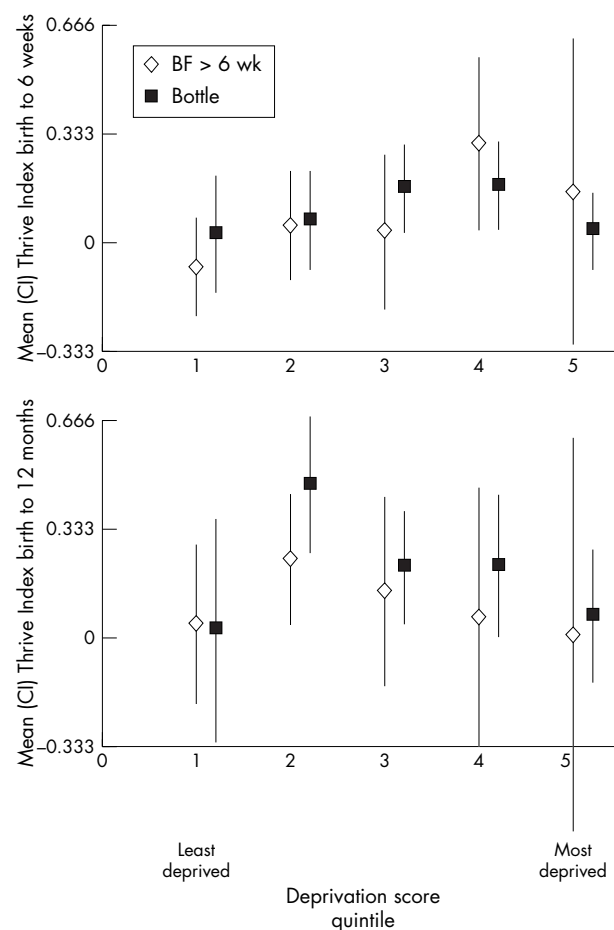
$$\bullet \text{ TI} = \text{SDS}_{\text{time2}} - r \times \text{SDS}_{\text{time1}}$$

where  $r$  is the regression coefficient for the whole population for that time interval. The regression coefficients and limits used were calculated from the cohort as a whole, since they represented a substantial normative population. The TI values used in this study and their equations were:

- $\text{TI birth to 6 weeks} = \text{SDS}_{6w} - 0.687 \times \text{SDS}_{\text{birth}}$
- $\text{TI birth to 4 months} = \text{SDS}_{4m} - 0.507 \times \text{SDS}_{\text{birth}}$

- $\text{TI birth to 8 months} = \text{SDS}_{8m} - 0.412 \times \text{SDS}_{\text{birth}}$
- $\text{TI birth to 12 months} = \text{SDS}_{12m} - 0.380 \times \text{SDS}_{\text{birth}}$

*Weight faltering* was defined, for any time interval, as weight gain (TI) below the 5th centile for that interval in this population, and this was defined as *sustained* if weight faltering was present in two or more of the four age bands. The 5th centile for the Thrive Index varied from a fall of 0.9 SDS (birth to 6 weeks) to 1.3 SDS (birth to 12 months).



**Figure 1** Relation between deprivation (Townsend score quintile), type of infant feeding (breast fed for 6 wk+ versus bottle fed), and weight gain (mean (CI) Thrive Index) to 6 weeks and 12 months.

**Table 2** Effect of deprivation and maternal education on weight gain (Thrive Index) and weight faltering

	Number	Cases of faltering weight once during first year Number (%)	Cases of sustained faltering weight during first year Number (%)	Thrive Index	
				Birth to 6 wk Mean (SD)	Birth to 12 mth Mean (SD)
<b>Whole cohort</b>	923	92 (10%)	36 (4%)	0.08 (0.65)	0.21 (0.95)
<b>Townsend score quintile</b>					
1 (most affluent)	152	24 (16%)	11 (7%)	-0.07 (0.62)	0.03 (1.01)
2	193	15 (8%)	2 (1%)	0.07 (0.63)	0.35 (0.89)
3	212	16 (7%)	8 (4%)	0.11 (0.68)	0.25 (0.89)
4	187	15 (8%)	7 (4%)	0.19 (0.64)	0.25 (1.0)
5 (most deprived)	173	22 (13%)	8 (5%)	0.06 (0.65)	0.09 (0.99)
Comparison across Townsend quintiles (p value)		0.04*	0.06*	0.01†	0.03†
<b>Maternal educational qualifications</b>					
Higher education	159	17 (11%)	9 (3%)	0.04 (0.69)	0.18 (0.93)
Beyond 16 years	111	9 (8%)	9 (4%)	0.11 (0.56)	0.29 (0.96)
GCSE‡	445	50 (11%)	22 (5%)	0.08 (0.65)	0.20 (0.97)
None	190	14 (7%)	4 (2%)	0.10 (0.66)	0.22 (0.95)
Other	16	2 (12%)	0 (0%)	0.03 (0.52)	-0.12 (0.73)
Comparison across educational categories (p value)		0.7*	0.4*	0.8†	0.5†

\* $\chi^2$  test for trend.

†F test from ANOVA, with a linear contrast.

‡General Certificate of Secondary Education, taken at age 16 years.

## Analysis

Categorical data were analysed using  $\chi^2$  and  $\chi^2$  for trend. Weight gain outcomes (Thrive Index) were assessed using ANOVA with a linear contrast and multiple linear regression. Multivariable models were usually constructed by entering all predictor variables with significant ( $p < 0.05$ ) univariate associations, except when analysing the DEBQ data, where all three sub-scales were entered together, as intended by the design of the scale. To explore the relation between postnatal depression, deprivation and weight gain, an interaction term (raised/normal EPDS  $\times$  Townsend score quintile) was included in the model; to explore the non-linear relation between deprivation and weight gain, a quadratic term (Townsend score quintile<sup>2</sup>) was used.

## RESULTS

The study recruited 1029 infants, 82% of eligible births. Of these, 68 infants were born before 37 weeks gestation and were excluded. There were 33 Ultra-Orthodox Jewish and eight Moslem infants who showed major differences both in sociodemographic characteristics and in weight gain patterns, which will be the subject of a future paper; they have not been included in this analysis.

This left 923 infants (915 mothers), of whom all but 7 (0.8%) were of white British origin. Of these, 85% had weight SD scores at mean (SD) ages 6.6 (0.83) weeks, 86% at 3.6 (0.52) months, and 84% at 12.9 (1.5) months. The mean (SD) weight SD scores for the whole cohort were -0.11 (1.01) at birth, +0.03 (0.94) at 6 weeks, and +0.16 (1.03) at 12 months. In total 92 children (10%) showed weight faltering at some time and 36 (4%) had sustained weight faltering in two or more of the four age bands. Of these, 22 were still faltering at 12 months, 10 had recovered, and 4 were lost to follow up.

Seventy one per cent of infants had mothers educated only to age 16 years and 24% lived in unwaged households. Families in the original cohort were fairly evenly distributed between the Townsend score quintiles; families who did not return questionnaires or have weights were significantly more deprived than the cohort as a whole, but all social strata remained well represented in the analyses (table 1). Fifty per

cent of infants were initially breast fed, and 25% remained so at 6 weeks.

## Socioeconomic factors

There was no relation between maternal or paternal education level and either overall weight gain or rates of weight faltering. There was no clear trend to poorer growth with higher deprivation quintiles (table 2). The mean Thrive Index tended to be highest in the intermediate quintiles and lowest in the most and least deprived. Regression analysis, using the Townsend scores as the independent variable, revealed a significant positive linear relation with the Thrive Index from birth to 6 weeks ( $p = 0.005$ ) and a trend to a U shaped relation, but the additional quadratic term was not significant ( $p = 0.1$ ). The Thrive Index from birth to 12 months showed a significant quadratic (U shaped) relation ( $p = 0.04$ ). This effect was not explained by differing rates and duration of breast feeding (fig 1).

## Postnatal depression

Both EPDS scores at 2–3 months and weights at age 4 months were obtained for 664 (72%) mothers, 82 (12%) of whom scored above 12 on the EPDS, the usual cut-off for primary care based intervention. Infants of these mothers showed slower weight gain overall and an increased rate of weight faltering from birth to 4 months the (table 3). However this trend did not persist and over the period to 12 months there was no difference in weight gain between these and the remainder of the cohort. Mothers from the most deprived areas were three times as likely to be depressed as those in the least deprived (% (number) depressed quintile: 1 = 7% (9), 2 = 9% (13), 3 = 12% (20), 4 = 10% (13), 5 = 21% (29);  $\chi^2$  trend,  $p = 0.001$ ).

We thus examined the association between level of deprivation, depression, and weight gain. As at 6 weeks, weight gain to 4 months was related to deprivation with a significant linear, but non-significant quadratic term. Figure 2 shows an interaction, with raised EPDS scores associated with a lower Thrive Index in the more deprived groups but not otherwise. In a regression of weight gain by level of deprivation and depression, the interaction term (level of

**Table 3** Relation between postnatal depression (EPDS) score, weight gain (Thrive Index), and weight faltering

EPDS score	Thrive Index Mean (SD)				Weight faltering Number (%)		
	n	Birth to 4 mth	n	Birth to 12 mth	Birth to 4 mth	Birth to 12 mth	Sustained faltering
≤ 12	584	0.17 (0.82)	561	0.22 (0.96)	24 (4%)	27 (5%)	26 (4%)
> 12	82	-0.052 (0.84)	72	0.08 (0.89)	8 (10%)	2 (3%)	3 (4%)
p value		0.02†		0.3†	0.046*	0.8*	1.0*

†† test.

\* $\chi^2$  test.

deprivation  $\times$  depression) was statistically significant at 4 months ( $p = 0.01$ ) but not at 12 months.

### Dutch Eating Behaviour Questionnaire

This was available for 569 mothers whose infants had also been weighed at the age of 12 months; maternal body mass index (BMI) was also available for 528, of whom 97 (18.4%) were obese ( $\text{BMI} > 30 \text{ kg/m}^2$ ) while only 37 (7%) had  $\text{BMI} < 20 \text{ kg/m}^2$ . All three sub-scores of the DEBQ were strongly inter-correlated; restraint and emotional eating, but not external eating, correlated strongly with maternal BMI (data not shown). There were no significant univariate correlations between mothers' scores and the weight gain of their infants to either 6 weeks or 12 months. However, when entered together in a regression analysis, emotional eating was associated positively with weight gain to 12 months ( $p = 0.04$ ), while external eating was associated negatively ( $p = 0.01$ ). Only 31 mothers (5.4%) were in both the top tertile for externality and the bottom tertile for emotionality, but their infants showed slower weight gain to age 6 weeks (mean difference in TI from rest of cohort  $-0.29$ ,  $p = 0.01$ ) and to age 12 months ( $-0.25$ ,  $p = 0.09$ ). Restrained eating was unrelated to infant weight gain at any age. None of the scales related to weight faltering.

### DISCUSSION

This study found only limited evidence that maternal characteristics influence infant weight gain or predispose infants to weight faltering. This seems surprising, given that infants rely so heavily on maternal responsiveness to meet their feeding needs. We measured weight gain and weight

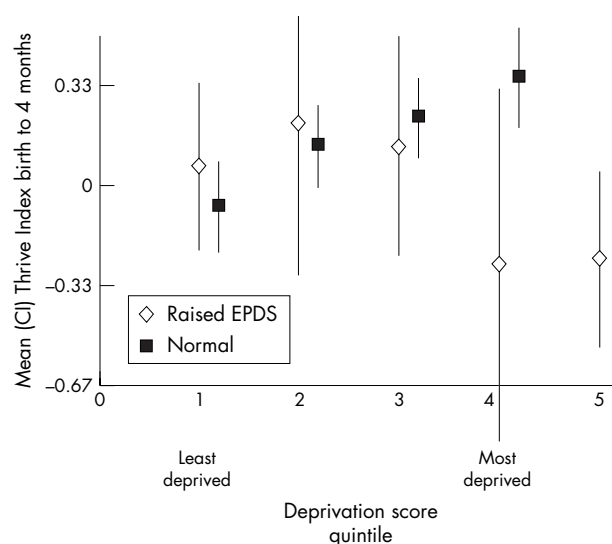
faltering using a conditional approach that reliably isolates postnatal from intrauterine weight gain and which has now been used successfully in a number of studies<sup>19 32 33</sup> and clinical tools.<sup>34 35</sup> The weights were mostly not collected in a research setting, but we have shown that such routine data collected in this<sup>28</sup> and earlier studies<sup>36</sup> correspond well to growth references. The risk of misclassification due to individual mis-measurements has been minimised by using the average SDS of multiple weights in most age bands, maximising the precision of estimates overall, though there would be reduced precision for under-attending subgroups, with fewer weight per age band, such as children from the most deprived quintile.

The study had limited power to detect risk factors for severe weight faltering since there were relatively few such infants in the cohort, but it had the potential to detect much smaller variations in weight gain in the cohort as a whole, which generally showed similar results. We achieved reasonable retention of subjects, even though the study was located in a deprived urban area. It is possible however that some of the most troubled mothers and families were lost to the study, reducing our power to detect the impact of extreme mental ill-health. As with almost all community based studies,<sup>37 38</sup> there were higher rates of attrition among the most deprived families, particularly for the eating behaviour questionnaire, which was not completed until 12 months, and this will have reduced the power of the study to assess possible effects in extremely deprived families. However the fact that a large number of the poorest families were available to be recruited for the study means that, even with attrition, we still have useable data for these often overlooked families.

### Socioeconomic status and disadvantage

This study again challenges the traditional assumption that failure to thrive in infancy is strongly linked to family poverty. This lack of association seems to contradict clinical experience, as infants referred for specialist assessment tend to show multiple adversities.<sup>39</sup> However this probably reflects a tendency for these sorts of families to be referred preferentially.<sup>23</sup> This lack of association presumably reflects the food safety net provided for young infants by the UK welfare foods scheme and the US Women Infants and Children (WIC) programme, since there is still evidence of association between deprivation and growth in older UK children, not eligible for the same level of food aid<sup>40</sup> and in US children eligible for but not actually receiving WIC.<sup>41</sup>

Compared with the middle category, about twice as many infants met the criterion for failure to thrive in both the most and the least deprived quintile; indeed the lowest mean Thrive Index was in the most affluent group, as was the highest proportion of cases. This is a replication of our own previous finding, also from a population based study,<sup>7</sup> with a similar, though non-significant trend seen in another UK population based study.<sup>11</sup> We previously speculated that this might relate to higher rates of breast feeding in the most affluent stratum, but the effect is present in both breast and in formula fed groups and it thus remains unexplained.



**Figure 2** Relation between maternal depression (raised EPDS score), deprivation (Townsend) score, and weight gain (mean (CI) Thrive Index) to 4 months.



## Postnatal depression

The association of weight gain with postnatal depression was striking, but relatively transient. A previous study by O'Brien and colleagues<sup>18</sup> found an association between weight faltering in the first two years with both raised maternal EPDS and higher rates of diagnosed depression. In contrast a large cohort study found no association between EPDS measured at age 8 weeks or 8 months with weight faltering over the first year.<sup>19</sup> The results reported here are arguably consistent with both, since they do suggest a transient effect of depression, but one that does not persist to the end of the first year. It should be noted that O'Brien and colleagues' study<sup>18</sup> relied on referred cases and there may thus have been some referral bias with, for instance, mothers who were also depressed being preferentially referred. A new aspect here is the observation that it was the infants of mothers who were both depressed and deprived who showed poorer weight gain. Studies in the developing world have consistently found associations between maternal depression and weight faltering,<sup>42–44</sup> suggesting that maternal depression may be a more important factor in disadvantaged populations.

## Eating attitudes

The absence of a relation between maternal dietary restraint and infant weight gain was surprising. Two other studies have found higher levels of restraint in mothers of infants with weight faltering<sup>20</sup> or with "feeding disorders",<sup>21</sup> while another found that infants of mothers with eating disorders were significantly thinner than normal controls.<sup>22</sup> The first two studies comprised relatively small numbers of referred children and used the interview based restraint scale of the Eating Disorders Interview. The scale used in our study was less clinically based, but has been shown to discriminate between UK subjects with and without eating disorders.<sup>27</sup> It must be remembered that while high restraint is a feature of eating disorders, which are comparatively rare, it is most characteristically associated with obesity, which was common in this cohort. Thus the main implication may be that mothers who are appropriately attempting to restrain their own eating, are not transferring this restraint into feeding their infants. In contrast high externality and low emotionality were associated with lower weight gain, though not weight faltering. The external eating scale measures the tendency to eat in response to external cues, such as seeing a delicious cake, while the emotional scale reflects the extent to which the respondent relies on food to provide comfort or relieve stress. However, since externality and emotionality are strongly positively correlated, this combination occurs only rarely, and thus would only apply to a small minority of cases. If this finding were replicated, future work might explore whether not responding emotionally to food and relying on external cues to eat, might lead a mother to give low priority to feeding her infant as well as herself.

In conclusion, we found that a range of well established measures of maternal social and emotional characteristics

## What this study adds

- There is no clear relation between weight faltering and maternal deprivation, educational level, or markers of eating disorders
- Infants of mothers with high depression symptom scores are more than twice as likely to have weight faltering up to 4 months, but are no different from the remainder of the cohort by the age of 1 year

showed few associations with weight gain in infants, apart from a transient effect of postnatal depression in deprived mothers and a relation with eating attitudes relevant to only a small minority of mothers. These findings further emphasise that, in the UK and similar populations, weight faltering is likely to be largely unrelated to poverty and that the explanation for weight faltering must rest either in child characteristics, or those of the maternal child feeding interaction. We have explored these factors in another paper.<sup>45</sup>

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Competing interests: none

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## What is already known on this topic

- In the past it was assumed that weight faltering (failure to thrive) was strongly related to poverty, maternal deprivation, and neglect, but many studies included only referred cases, when it is known that vulnerable, deprived families are more likely to be referred
- Recent population based research has questioned the influence of deprivation while evidence on the importance of maternal characteristics has been equivocal

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