Relationships between maternal overweight prior to pregnancy, feeding mode and infant feeding beliefs and practices

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Running head: Maternal overweight and infant feeding

Abstract

Aim: To examine whether pre-pregnancy weight status was associated with maternal feeding beliefs and practices in the early post-partum period.

Methods: Secondary analysis of longitudinal data from Australian mothers. Participants (N=486) were divided into two weight status groups based on self-reported pre-pregnancy weight and measured height: healthy weight (BMI <25kg/m^2; *n*=321) and overweight (BMI>25kg/m^2; *n*=165). Feeding beliefs and practices were self-reported via an established questionnaire that assessed concerns about infant overeating and undereating, awareness of infant cues, feeding to a schedule, and using food to calm.

Results: Infants of overweight mothers were more likely to have been given solid foods in the previous 24hrs (29% vs 20%) and fewer were fully breastfed (50% vs 64%). Multivariable regression analyses (adjusted for maternal education, parity, average infant weekly weight gain, feeding mode and introduction of solids) revealed pre-pregnancy weight status was not associated with using food to calm, concern about undereating, awareness of infant cues or feeding to a schedule. However feeding mode was associated with feeding beliefs and practices.

Conclusions: Although no evidence for a relationship between maternal weight status and early maternal feeding beliefs and practices was observed, differences in feeding mode and early introduction of solids was observed. The emergence of a relationship between feeding practices and maternal weight status may occur when the children are older, solid feeding is established and they become more independent in feeding.

Key Words: Feeding beliefs and practices; breastfeeding; maternal weight; infant cues

'What is already known on this topic'

- Maternal feeding beliefs and practices are modifiable risk factors for childhood obesity
- Overweight mothers use more inappropriate feeding practices with their children
- Little research has examined feeding beliefs and practices of overweight mothers in the early months

'What this paper adds'

- Overweight mothers did not differ from healthy weight mothers in their infant feeding beliefs and practices
- Overweight mothers were less likely to fully breastfeed and more likely to have given solid food in the previous 24 hours
- Breastfeeding was associated with infant feeding beliefs and practices

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Introduction

The World Health Organization has recognised childhood obesity as one of the most challenging public health issues of the 21st century[1]. Observational evidence from the US consistently confirms a strong correlation between maternal and child BMI[2-4], with maternal obesity identified as the strongest risk factor for childhood obesity[2]. A genetic predisposition towards obesity contributes to the strong association between child and maternal weight status[5], however not all children born to obese parents become obese. Thus, it is suggested that there is an environmental or "nurture" component to the development of childhood obesity that remains poorly understood.

Feeding mode (i.e., breastfeeding, formula feeding, or a combination) as well as feeding beliefs and practices have been associated with risk of childhood overweight and obesity. Breastfeeding is the recommended sole source of nutrition for infants up until six months of age[6, 7]. Breastfeeding confers a range of health benefits for both mothers and infants. For infants these include but are not limited to reduced risk of gastrointestinal, respiratory and ear infections; autoimmune diseases such as Type 1 diabetes, and importantly future overweight[7]. Maternal obesity is associated with an increased risk of lactation failure, and delay in establishing lactation post-delivery[8]. Failure to establish lactation and continue breastfeeding increases the likelihood of formula feeding, which further compounds the increased risk of childhood obesity in the children of obese mothers[9].

Feeding practices that are controlling (e.g., pressure or restriction) or that use food for reasons other than hunger (e.g., instrumental or emotional feeding) have been associated with obesogenic eating behaviours in children[10, 11] and the development of obesity[12]. Overweight mothers appear to exhibit greater concern about their own weight status, which has been associated with greater concern for child's weight and the use of more controlling

feeding practices in school aged children[9, 13, 14]. For instance, overweight, but not healthy weight mothers' concern about their child's (aged 5 years) weight has been significantly related to their use of restriction and pressure to eat[15]. During infancy, beliefs and practices have been cross-sectionally associated with one another. In a sample of mothers of infants aged 2 weeks to 6 months those who were more concerned about their baby becoming overweight and perceived their baby to have poor satiety regulation were more likely to use restriction. Conversely, those who were concerned their baby would become underweight and had poor appetite were more likely to use pressure[16]. However, to our knowledge differences in feeding beliefs (i.e., concerns) and practices of overweight and healthy weight mothers in the early months has not been explored.

Feeding mode as well as maternal feeding beliefs and practices are potentially modifiable risk factors for childhood obesity. Although there is evidence for differences in mode of feeding according to maternal weight status it is less clear whether feeding beliefs and practices in the first few months of life are also influenced by maternal weight. Moreover, the potential impact of feeding mode – independent of maternal weight status – on early feeding beliefs and practices is unclear. The aim of this paper was to examine whether pre-pregnancy weight status was associated with maternal feeding beliefs and practices at four months post-partum.

Materials and Methods

Study Design and Participants

The data analysed and reported here were collected as part of the prospective, observational *New Beginnings: Healthy Mothers and Babies* study[17]. The recruitment protocol has been described in detail elsewhere[17]. Women receiving antenatal care at the Royal Brisbane and Women's Hospital (RBWH) between August 2010 and January 2011 were consecutively approached for screening and consent to participate. Two recruitment methods were used. A study information sheet was sent by Maternity Outpatients administrative staff to all women receiving antenatal care at the RBWH. A consecutive sample of eligible women was also approached in the waiting room of the antenatal clinic by a researcher. Eligibility criteria included ≥18 years of age, no pre-existing type 1 or 2 diabetes and sufficient language skills to complete questionnaires in English. Of the 1059 eligible women approached 664 (63%) provided baseline data. Women who miscarried or went on to deliver a very preterm infant (≤32 weeks completed gestation) and/or with major health concerns were subsequently excluded. Characteristics of participants have been detailed elsewhere[18]. Privacy and ethical restrictions prevented gathering of information about those women who declined participation. However, participants were broadly representative of the Queensland obstetric population for age, marital status, ethnicity, parity and anthropometric characteristics[19]. Ethical approval was obtained from the RBWH (HREC/10/QRBW/139) and Queensland University of Technology (1000000558) Human Research Ethics Committee.

Data were collected at four time points: 16 weeks gestation (T1), 36 weeks gestation (T2), following delivery (T3) and four months postpartum (T4). T1, T2 and T4 consisted of self-administered questionnaires. Follow up calls were made to women who did not return a questionnaire within a 2-4 week period. T3 data were collected from an obstetric database.

Seventy-seven percent of mothers (n=513) provided at least some data at follow up four months postpartum (T4). Based on status at T4, non-completers were younger (28 vs 30 years, *P*=.002), less likely to have a university education (34% vs 47%, *P*=.025), more likely to be born overseas (22% vs 14%, *P*=.020) and less likely to be married or in a defacto relationship (88% vs 95%, *P*=.005) than completers. There were no differences between completers and non-completers in terms of maternal pre-pregnancy weight status (*P*=.91), other children (*P*=.74) or infant gender (*P*=.44).

Maternal Weight Status

Self-reported pre-pregnancy weight and measured height were used to calculate pre-pregnancy Body Mass Index (BMI). These figures were categorised as per the World Health Organization classifications (kg/m^2): underweight <18.5; healthy weight 18.5-24.99 and overweight ≥25.00 (comprising pre-obese 25-29.99 and obese ≥30.00)[20]. Self-reported pre-pregnancy weight in the first trimester of pregnancy has shown a correlation of r=.99, with a documented weight measured in the three months prior to pregnancy in 170 women.[21] Furthermore, the mean under-reporting rate of 1kg did not differ by weight, ethnicity or gestational age at enrolment.[21] There was a strong correlation (.96) between measured weight at the first hospital visit and self-reported pre-pregnancy weight in the current study providing further justification for its use.

Given that only a small proportion of women still active at follow up (T4) were underweight prior to pregnancy (4.5%), the categories of underweight and healthy weight were combined to create a not overweight 'healthy' group, and pre-obese and obese combined to create an 'overweight' category. Comparisons of groups who are overweight and not overweight are common in body weight literature[22, 23].

Infant Feeding Beliefs and Practices

Maternal feeding beliefs and practices at four months post-partum were assessed using the *Infant Feeding Questionnaire*[24]. The original 20-item questionnaire was tested in a sample of mothers when their infants were 11-23 months old to provide a retrospective measure of seven feeding beliefs and practices (factors) during the first year of life. A modified version of the questionnaire was used in the present study to allow concurrent assessment of feeding practices and to ensure appropriateness in the Australian setting. The modified version has been used previously in a different Australian sample of mothers of infants aged 4 months (range: 2-7 months)[25, 26].The modifications to the original *Infant Feeding Questionnaire* included change in tense from past to present, were adapted to Australian wording (e.g. "unsettled" rather than "fussiness"), and the addition of a "not applicable" option for those items (n=11) judged to be potentially irrelevant if the child was exclusively breastfed. Not applicable responses in the present sample ranged from 0.6-46.3% and were re-coded to missing data for analysis purposes. Consequently, two of the original factors were dropped from further analysis due to a large number of responses being re-coded as missing data (Concern about infant hunger – 2 of 3 items contained 30% and 46% missing data) and Social interactions with infant during feeding (1 of 2 items contained 37% missing data). Thus, the remaining five feeding factors included for analysis were: Concern about infant undereating or becoming underweight; Concern about infant over-eating and becoming overweight; Awareness of infant hunger and satiety cues; Using food to calm; and Feeding on a schedule. Response options for each item ranged from 0 (lowest) to 4 (highest). Mean scores were calculated for each factor.

Covariates

Extensive demographic data were collected at first participant contact (T1), including maternal age, marital status (married/defacto vs other), education level (university education vs no university education), country of birth (Australian vs other) and other children in the

household (no vs yes). Mothers reported the infant's last measured weight and the date at which this occurred. For analytical purposes, infant weight gain (g/week) was computed by subtracting the infant's birth weight (obtained from hospital records) from their weight at T4 (self-reported) and dividing by the infant's exact age in weeks at the reported date on which the infant's weight was measured. Infant weight-for-age Z scores were calculated based on infant gender, weight and age at the time of weight measurement using the software program WHO Anthro version 3.0.1[27]. For analytical purposes, current feeding mode at T4 was dichotomised into: "breastfeeding only" (exclusive or fully breastfeeding) vs "mixed/formula feeding". Mothers also reported on whether the child had been given solid or semi-solid food in the last 24 hours (no vs yes).

Statistical Methods

In preparation for inclusion in the multivariable analysis all feeding factors, with the exception of using food to calm, were dichotomised (low vs high) at the median due to skewed distributions. The using food to calm factor was left as a continuous variable and entered as the outcome variable in a linear regression model. The four other dichotomised feeding practice factors were entered as the outcome variable into binary logistic regression models. Pre-pregnancy weight status (healthy vs overweight) was included as the key predictor of interest. Potential covariates[1] associated (non-parametric bivariate analysis; $P<.10$) with one or more infant feeding factor outcomes were also adjusted for in the regression analyses. These included: maternal education, other children in the household, average change in infant weight/week, feeding mode, and whether solids had been consumed by the infant in the last 24 hours. All variables (maternal pre-pregnancy weight status and

[1] Birth country and infant weight Z score were excluded from analyses because the 'other' category for birth country was not homogenous (44 different countries of birth reported) and we reasoned that mothers are more likely to be aware of their baby's weight gain in the first few months rather than their weight Z score at any point in time.

196 covariates) were entered simultaneously into the regression models for each feeding practice.
197 Statistical analyses were completed using SPSS version 21.

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Results

Four hundred and eighty-six of the 513 mothers who remained active in the study at T4 (mean infant age 17, *SD*=3 weeks, range: 10-30 weeks), had usable pre-pregnancy BMI data. A comparison of healthy and overweight mothers on selected maternal and child characteristics are reported in Table 1. As shown, feeding mode differed between healthy and overweight mothers. Sixty-four percent of healthy weight mothers were fully breastfeeding their infant at T4 compared to 50% of overweight mothers. Infants of overweight mothers were more likely to be given solid foods in the previous 24 hours.

Table 2 shows internal reliability estimates of the five subscales of the IFQ as well as the correlation between the subscales and the mean/median responses. Cronbach's alpha values were >.65 for all scales except for concern about overeating (.59). On average, mothers reported low concern about undereating and overeating, high awareness of infant cues and moderate use of food to calm. Mothers tended to report feeding on demand rather than to a schedule (see Table 2). Concern about undereating and concern about overeating were positively correlated and both were negatively correlated with awareness of cues. Mothers who were concerned about their infant overeating were also more likely to use food to calm and feed to a schedule. Using food to calm was negatively correlated with both awareness of cues and feeding to a schedule (see Table 2).

The linear and logistic regression models testing the association between pre-pregnancy weight and maternal feeding beliefs/practices are presented in Table 3. The model explaining mothers' concern about their infant overeating was not significant so is not included in the table and will not be considered further. The four statistically significant regression models ($P \leq .001$) explained around 7-8% of the variance in each infant feeding factor (Table 3).

224 However, contrary to expectations pre-pregnancy weight status was not related to using food
225 to calm, concern about undereating, awareness of infant cues or feeding to a schedule.

226 The model predicting using food to calm (R^2=.088, *P*<.001) revealed that this practice was
227 higher among university educated mothers, mothers who were fully breastfeeding and those
228 who were yet to introduce their baby to solids.

229 Concern about undereating (Nagelkerke R^2=.077, *P*<.001) was also associated with education
230 – those with a university degree were more likely to be concerned. Mothers whose babies had
231 a lower weight gain were more concerned and those who were mixed/formula feeding were
232 also more concerned that those who were fully breastfeeding.

233 Awareness of infant cues (Nagelkerke R^2=.068, *P*=.001) was lower in first time mothers and
234 in those fully breastfeeding feeding.

235 Finally, the model for feeding to a schedule (Nagelkerke R^2=.082, *P*<.001) revealed only one
236 significant relationship: mothers who were mixed/formula feeding were more likely to feed to
237 a schedule than those fully breastfeeding (who were more likely to feed on demand).

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Discussion

To our knowledge, the current study is one of the largest to investigate associations between maternal weight status and concurrent infant feeding beliefs and practices prior to 6 months of age. It is well established in the literature that overweight/obese mothers are less likely to breastfeed at all or exclusively[28]. Maternal obesity has also been associated with feeding beliefs and practices that may promote later obesity in older children[9, 13, 14, 24]. It was therefore hypothesised that maternal weight status is also likely to play a role in early maternal feeding beliefs and practices. The results of this study did not support this hypothesis, indicating no significant differences in maternal feeding beliefs and practices reported by healthy weight and overweight women, independent of feeding mode (fully breastfeeding vs mixed/formula feeding only), during the first four months of life.

Congruent with other literature[9, 28], we found significant differences between feeding mode, with overweight mothers less likely to be exclusively or fully breastfeeding at four months. Feeding mode was significantly associated with four out of the five infant feeding factors. Mothers who were mixed feeding or formula feeding were more concerned about their infant undereating and becoming underweight. This association was significant in the model in which average weight gain per week was controlled for and is at odds with the more rapid weight gain typically observed in formula fed infants[29, 30]. This highlights the need to particularly provide formula feeding mothers with accurate information on infant energy requirements to support healthy infant growth. Greater concern about infant/child weight and hunger has been consistently correlated with higher levels of dietary control[24] and restriction[14, 31]. Mothers who were fully breastfeeding their infants were more likely to feed on demand rather than on a schedule and also reported feeding to comfort the infant. These practices which are responsive to the infant's cues (either for food or comfort) are consistent

with evidence that both exclusive breastfeeding at 6 months and duration of breastfeeding are prospectively associated with the use of less restrictive feeding practices at child age 1 year[32]. Surprisingly mothers who were fully breastfeeding reported lower awareness of infant cues of hunger and satiety. This finding is somewhat at odds with the finding that mothers who were fully breastfeeding were more likely to feed on demand and to settle the infant. It is important to note that awareness of cues was not correlated with feeding on schedule vs on demand and was negatively correlated with using food to calm. The absence of an association between awareness of cues and feeding on a schedule is somewhat surprising given – we would expect that mothers with a good awareness of their baby's hunger cues would be more likely to feed on demand rather than to a schedule. Secondly, the (small) negative correlation between awareness of cues and using food to calm may reflect that mothers who are fully breastfeeding do not readily distinguish between infant distress related to hunger or other factors and respond with feeding regardless. Taken together, it is unclear how well the awareness of cues subscale reflects accuracy in interpreting infant cues and thus findings related to this factor should be with interpreted with caution.

Strengths and Limitations

The study had a relatively large sample size, feeding mode and maternal feeding practices were collected concurrently to minimise recall bias and analyses were adjusted for a wide range of covariates. Retention bias at T4 was noted, thus the generalizability of results to younger, less educated, single mothers not born in Australia is unclear. The *Infant Feeding Questionnaire*[24], though the most appropriate tool available at the time, had a number of limitations and as such a modified version[25, 26] was used in the present study. Some of the factors exhibited inadequate variability and heavily skewed responses, therefore these could

not be treated as continuous measures. It may be that the some of the items in this questionnaire are not relevant until later in the first year of life and as noted, we identified a number of items (not included in the analysis) which were irrelevant to mothers who were fully breastfeeding. While the majority of data used in this analysis was self-reported, potentially introducing social desirability bias, self-reported pre-pregnancy weight has been shown to be a reasonable estimate of weight at conception[33]. While measured weight at a preconception visit is the ideal method to examine pre-pregnancy weight, it is often not practical, with recalled weight at the first antenatal visit considered the most feasible.[34]

Conclusion

Infant feeding mode but not maternal pre-pregnancy weight status was associated with maternal feeding beliefs and practices assessed using the IFQ at child age four months. Given previous studies have found evidence of associations between maternal weight status and feeding beliefs and practices in older children[24, 31, 35] as well as later obesity risk[2-5], it would be premature to conclude that explicitly promoting protective feeding practices from as early as possible to women who enter pregnancy overweight it is not warranted. Interventions designed to promote responsive feeding practices to mothers who are not fully breastfeeding should be priorities. Given that maternal weight is known to be a strong predictor for childhood obesity and feeding beliefs and practices are modifiable risk factors, longitudinal studies are still needed to explore whether, and when, differences in feeding beliefs and practices of healthy and overweight mothers emerge.

Acknowledgements

Data used in this paper is from the *New Beginnings Healthy Mothers and Babies Study* conducted at QUT and the RBWH. We would like to acknowledge co-investigators on the project: Prof Jan M. Nicholson LaTrobe University and A/Prof Leonie K. Callaway RBWH and the University of Queensland. We would like to thank Rebecca Byrne for her comments on an earlier draft of this paper. Finally, we are grateful to the women who participated.

The *New Beginnings: Healthy Mums and Babies* Study was funded by the RBWH Research Advisory and the RBWH Foundation. Authors were supported by the National Health and Medical Research Council (S J. de Jersey Postgraduate PhD Scholarship 1017169) and the Heinz Postdoctoral Research Fellowship funded by H.J. Heinz (K M. Mallan).

The authors have indicated that they have no personal financial relationship or conflict of interest relevant to this article to disclose.

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Table 1. Description of study sample (N=486) and comparison between healthy and overweight participants

Variable	Healthy Weight† (n=321)	Overweight† (n=165)	Difference (*P*)
	M (SD) or Percentage (count)		
Maternal age (years) n=485	30 (5)	30 (5)	.85
Education (university) n=485	52 (167)	37 (61)	.002
Marital Status (married/defacto) n=486	96 (307)	96 (159)	.81
Birth country (Australia) n=485	68 (217)	79 (131)	.008
Other children (yes) n=483	41 (131)	42 (95)	.85
Infant gender (male) n=482	52 (166)	51 (82)	.85
Infant age (weeks) n=474	17 (3)	17 (3)	.45
Change in infant weight (g) per week‡ n=430	208 (69)	225 (66)	.02
Infant weight-for-age Z score§ n=428	0.08 (1.05)	0.33 (1.00)	.02
Current feeding mode n=483			
Breastfeeding fully	64 (206)	50 (82)	.005
Mixed feeding	17 (53)	31 (50)	
Formula feeding only	19 (60)	20 (164)	
Solid or semi-solid food in last 24hrs (yes)	20 (64)	29 (47)	.039

Due to round percentage totals may equal >100%, n values indicate missing data.

† Based on pre-pregnancy self-reported weight and measured height; healthy weight: BMI <25kg/m^2 and overweight: BMI>25kg/m^2.

‡ Calculated by subtracting the infant's birth weight (obtained from hospital records) from their most recent weight and then divided by the infant's exact age (weeks) at time of most recent measurement.

§ Calculated based on infant gender, most recent weight and exact age (days) at time of weight measurement using WHO Anthro version 3.0.1[(27)].

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435 ***Table 2.*** Associations (Spearman's rho) between subscales of a modified version of the *Infant Feeding Questionnaire*[23]
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		Concern about undereating	**Concern about overeating**	**Awareness of infant cues**	**Using food to calm**	**Feeding to a schedule**
	Cronbach's α	n=475	n=475	n=474	n=475	n=471
Concern about undereating 4 items, e.g. *Do you worry that your baby is not feeding enough?*	.73	1.00	.21**	-.30**	.08	.06
Concern about overeating 3 items, e.g. *Do you get upset if your baby feeds too much?*	.59		1.00	-.22**	.09*	.14**
Awareness of infant cues 4 items, e.g. *I know when my baby is hungry*	.66			1.00	-.12**	-.05
Using food to calm 2 items, e.g. *Feeding my baby is the best way to stop him/her being unsettled*	.69				1.00	-.36**
Feeding to a schedule 2 items, e.g. *Do you let your baby feed whenever s/he wants to?*	.84					1.00
Median (IQR)		0.50 (0.00, 1.00)	0.33 (0.00, 1.00)	3.50 (3.25, 4.00)	2.00 (1.50, 3.00)	0.50 (0.00, 1.50)
Mean (SD)		0.65 (0.72)	0.60 (0.65)	3.45 (0.53)	2.07 (0.95)	0.97 (1.08)

437 **P*=<.05 (two tailed), ***P*=<.01 (two tailed)
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439 ***Table 3.*** Multivariable associations between maternal pre-pregnancy weight status, maternal and child covariates and infant feeding beliefs and

440 practices at age four months

Predictor	Using food to calm† n=422		Concern about undereating‡ n=422		Awareness of infant cues‡ n=421		Feeding to a schedule‡ n=418	
	β	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Pre-pregnancy BMI status (healthy vs overweight)	-.04	.45	1.18 (0.77, 1.83)	.45	1.32 (0.87, 2.02)	.19	0.85 (0.55, 1.31)	.46
Education (not university vs university)	.13	.009	1.73 (1.14, 2.63)	.011	0.82 (0.55, 1.23)	.33	0.80 (0.53, 1.21)	.29
Other children (no vs yes)	.06	.21	0.66 (0.44, 1.00)	.052	1.64 (1.09, 2.44)	.017	0.67 (0.46, 1.05)	.083
Change in infant weight (g) per week	-.06	.23	1.00 (0.99, 1.00)	.005	1.00 (1.00, 1.00)	.51	1.00 (1.00, 1.00)	.92
Breastfeeding only (exclusive/fully breastfeeding vs mixed/formula only)	-.15	.003	1.74 (1.11, 2.72)	.015	1.74 (1.13, 2.67)	.012	2.27 (1.47, 3.50)	<.001
Solid or semi-solid food in last 24hrs (no vs yes)	-.11	.023	0.71, 0.42, 1.19)	.19	1.23 (0.75, 2.03)	.41	1.32 (0.80, 2.16)	.28
Full model	R^2 =.088 (R^2_{Adj}=.075)	<.001	Nagelkerke R^2=.077	<.001	Nagelkerke R^2=.068	.001	Nagelkerke R^2=.082	<.001

441 β: standardized regression coefficient (beta); OR: odds ratio; CI: confidence interval

442 † Linear regression analysis with mean subscale score (measured on a five-point scale from 0 [lowest] to 4 [highest]) on a modified version of the *Infant Feeding*
443 *Questionnaire*[23].

444 ‡ Binary logistic regression analysis with subscale score on the *Infant Feeding Questionnaire*[23] dichotomised (low vs high) using a median split.
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