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Original Article

Association between maternal education and diet of children at 9 months is partially explained by mothers' diet

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Abstract

Infants of mothers of low educational background display consistently poorer outcomes, including suboptimal weaning diets. Less is known about the different causal pathways that relate maternal education to infants' diet. The present study aimed to test the hypothesis that the relationship between maternal education and infants' diet is mediated by mothers' diet. The analyses included 421 mother–infant pairs from the Melbourne Infant Feeding Activity and Nutrition Trial (InFANT) Program. Dietary intakes were collected from mothers when infants were aged 3 months, using a validated food frequency questionnaire relating to the past year, and in infants aged 9 months using 3 × 24-h recalls. Principal component analysis was used to derive dietary pattern scores, based on frequencies of 55 food groups in mothers, and intakes of 23 food groups in infants. Associations were assessed with multivariable linear regression. We tested the product 'ab' to address the mediation hypothesis, where 'a' refers to the relationship between the predictor variable (education) and the mediator variable (mothers' diet), and 'b' refers to the association between the mediator variable and the outcome variable (infants' diet), controlling for the predictor variable. Maternal scores on the 'Fruit and vegetables' dietary pattern partially mediated the relationships between maternal education and two infant dietary patterns, namely 'Balanced weaning diet' [ab = 0.11; 95% confidence interval (CI): 0.04; 0.18] and 'Formula' (ab = –0.08; 95% CI: –0.15; –0.02). These findings suggest that targeting pregnant mothers of low education level with the aim of improving their own diet may also promote better weaning diets in their infants.

Keywords: dietary patterns, infants, mothers, education, mediation.

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Introduction

The positive association between socio-economic status and health is well recognised (Braveman *et al*. 2005). This is likely to involve different dimensions of socio-economic status over time and may act at different levels (e.g. individual, family and neighbourhood). This association has been described as strong and consistent throughout the life course (Irwin *et al*. 2007). With regard to infancy, a growing body of evidence has demonstrated that families of lower socio-economic status display poorer health outcomes, such as lower birthweights (Kramer *et al*. 2000), the absence or reduced length of breastfeeding (van Rossem *et al*. 2009) and suboptimal weaning diets (Robinson *et al*. 2007; Ystrom *et al*. 2009; Smithers *et al*. 2012). However, less is known concerning the underlying mechanisms, i.e. the different causal pathways that relate socio-economic status to a given outcome.

The benefits of healthy diets in infancy extend beyond childhood, with some patterns such as lower duration of breastfeeding and higher protein intake purported to exert a negative influence on weight status (Owen *et al*. 2005; Gunther *et al*. 2007; Koletzko *et al*. 2009) and cardiovascular health (Barker *et al*. 2005) in later life. In addition, it has been suggested that dietary patterns emerge early (Smithers *et al*. 2012) and track through infancy (Robinson *et al*. 2007) into later childhood (Northstone & Emmett 2008), and from childhood to adulthood (Mikkila *et al*. 2005). The family is a major influence on the development of the behaviours and habits of children. Parents play an important role in food provision and feeding practices, and serve as role models for eating behaviour and food intakes (van der Horst *et al*. 2007; Savage *et al*. 2007; Pearson *et al*. 2009; Campbell *et al*. 2010). In particular, research has shown that as early as infancy and toddlerhood, child and maternal diets are already correlated (Brekke *et al*. 2007; Robinson *et al*. 2007).

It is also well recognised that maternal education is positively associated with healthier diets, not only in the women themselves (Groth *et al*. 2001; Robinson *et al*. 2004; Vereecken *et al*. 2004; Northstone & Emmett 2005) but also in their children – both under 2 years (Robinson *et al*. 2007; Ystrom *et al*. 2009; Smithers *et al*. 2012) and older (North & Emmett 2000; Vereecken *et al*. 2004; Northstone & Emmett 2005; Fisk *et al*. 2011). Whether the diet of mothers is also associated with their children's diet independent of maternal education level has not been well-established and is a question of some interest, particularly as mothers' diet is likely to be more amenable to change than is their educational status. It may be that a focus on the diet of mothers in the planning and implementation of prevention initiatives is an effective strategy for improving the diet of children under 2 years because the link between maternal education and infants' diet is mediated by what mothers eat. A previous study involving slightly older children (2.5–7 years) suggested that this was indeed the case, although this study was cross sectional and involved a simple food frequency questionnaire (FFQ) in children (Vereecken *et al*. 2004). Therefore, the current study aimed to assess the hypothesis that the relationship between maternal education and infants' diet is mediated by mothers' diet, using a longitudinal design with dietary intake collected in infants using 3×24-h recalls.

Methods

Study design and participants

The Melbourne Infant Feeding Activity and Nutrition Trial (InFANT) Program was a cluster randomised controlled trial involving first-time mothers from when infants were 3 to 181 months of age (Campbell *et al*. 2008). The intervention was conducted in 2008–2010 within Greater Melbourne, Victoria, Australia, across areas displaying a wide range of socio-economic circumstances. Briefly, a two-stage random sampling design was used to include English-speaking primary caregivers attending first-time parents' groups, a free and universal service provided by Maternal and Child Health nurses in Victoria. Eighty-six per cent of eligible parents consented to participate ($n = 542$). We excluded child–mother dyads when mothers were not first-time mothers ($n = 15$, including one child–father dyad); had an incomplete FFQ at baseline (i.e. mothers 3 months post-partum, $n = 20$); were lost to first follow-up (6 months after baseline, i.e. children aged 9 months, $n = 14$); had missing data for body mass index (BMI) ($n = 10$); when infants had less than two complete dietary recalls at the first follow-up ($n = 58$); and when data were considered outliers for energy and water intakes according to

Key messages

- Infants of mothers of low educational background display consistently poorer outcomes, including suboptimal weaning diets.
- Our study confirmed that distinct dietary patterns emerge as early as infancy.
- The positive association between maternal education and infants' diet is partially mediated by mothers' diet.
- Targeting pregnant mothers of low education level may promote better weaning diets in infants.

the criterion of mean ± 3 standard deviation (SD) ($n = 4$). Given that the intervention did not significantly affect infants' diet at the first follow-up (Campbell *et al*. 2013), children from the intervention arm were not excluded, although we controlled for treatment arm in our analyses. This resulted in a sample of 421 mother–infant dyads.

Ethical approval for this study was obtained from the Deakin University Human Research Ethics Committee (ID number: EC 175-2007) and the Victorian Office for Children (Ref: CDF/07/1138).

Measurements

Self-administered questionnaires were utilised to collect demographic and socio-economic data at baseline, including parents' and children's dates of birth, parents' country of birth, main language spoken at home and education level. Education was defined in two categories: low (secondary school or below) or intermediate (trade and certificate qualifications), and high (university degree or higher). Mother's weight (pre-pregnancy) and height, child's birthweight and age of first introduction to solid foods were also reported. Children's height/length and weight without clothes were measured at 9 months by trained staff.

Assessment of infants' diet at first follow-up

The children's dietary intakes were assessed by trained nutritionists when they were 9 months of age by telephone-administered multi-pass 24-h recall with parents (Blanton *et al*. 2006). Purpose-designed booklets, including photographs of common portion sizes and examples of measures (e.g. teaspoons, cups), were provided to parents to aid estimation of food consumption. Two or three non-consecutive days of dietary data were collected, including one weekend day. Calls were unscheduled where possible (>95% of all calls). Nutrient intakes were evaluated using the 2007 AUSNUT Database (Food Standards Australia New Zealand 2008, http://www.foodstandards.gov.au). Data were checked for accuracy by a dietitian. Breastfeeding was recorded as minutes of time spent breastfeeding and then converted to volume consistent with previous studies (Emmett *et al*. 2000).

Assessment of mothers' diet at baseline

Dietary data were collected from mothers 3 months post-partum using the FFQ (Ireland *et al*. 1994; Hodge *et al*. 2000). This tool is an updated version of the semi-quantitative FFQ specifically developed for the Melbourne Collaborative Cohort Study (Ireland *et al*. 1994) and was previously validated using 7-day food diaries (Hodge *et al*. 2000). Correlation coefficients for energy-adjusted nutrient intakes ranged from 0.28 (vitamin A) to 0.78 (carbohydrate). Mothers were asked to indicate how often they had consumed each food or beverage item over the preceding 12 months. The FFQ has 10 response options for 98 food items, ranging from 'never' to 'three or more times per day'. These data were converted into daily equivalent frequencies according to the Cancer Council Victoria protocol (Ireland *et al*. 1994). The FFQ also included 11 additional questions relating to the type and amount of milk consumed (number of glasses per day); the amount of diet and non-diet soft drinks consumed (number of glasses per day); the type and amount of bread consumed (number of slices per day); the number of eggs per week; and the frequency of consumption per week of both alcoholic and hot beverages.

Statistical analyses

Based on the assessment of the similarities in food type, energy density and context of consumption, all foods and beverages were assembled into 23 groups for infants (Appendix 1) and 55 groups for mothers (Lioret *et al*. 2012a). Intakes in grams (infants) and frequencies of consumption (mothers) of foods within each group were summed. Dietary data were then standardised by subtracting the mean and dividing by the SD within each of these food groups.

Dietary patterns in infants were derived using principal component analysis with varimax rotation using the 23 food group variables (standardised intakes, in grams) (Kline 1994). The number of patterns were selected considering eigenvalues >1.0, the scree plot and the interpretability of the patterns (Cattell 1966). To both interpret the results and calculate the scores, we retained the items (food groups) most strongly related to each pattern, i.e. those for which the absolute value of the loading coefficient was >0.15, and pattern labels were allocated accordingly. The factor scores for each pattern were then calculated at the individual level by summing the observed standardised intakes per food group, weighed according to the loading coefficients.

The same method was applied previously to this data set for the derivation of dietary patterns in first-time mothers (Lioret *et al*. 2012a). In that paper, four patterns were identified in mothers at baseline, accounting for 24% of the explained variance: (1) 'Fruits and vegetables', characterised by the consumption of vegetables, legumes, non-fried fish, and fruits; (2) 'High-energy snack and processed foods', characterised by high consumption of processed foods, such as pizzas, savoury pastries, crisps, ketchup, etc.; (3) 'High-fat foods', characterised by consumption of potatoes cooked with added fat, fat added to vegetables, white bread, fried fish, fat spreads and full-cream milk; (4) 'Cereals and sweet foods', characterised by consumption of cereals, reduced-fat milk and sweets (ice cream, confectionery other than chocolate-based).

To address the mediation hypothesis, we used the method developed by MacKinnon *et al*. (2007), which involves the following steps (Fig. 1): path c corresponds to the overall association between the predictor (i.e. maternal education) and the outcome variable (each infant dietary pattern); path c′, the coefficient relating the predictor variable to the outcome variable controlled for the mediator variable (each mother dietary pattern), is the non-mediated or direct effect; the action theory test (path a) refers to the relationship between the predictor variable and the mediator variable; the conceptual theory test (path b) refers to the association between the mediator variable and the outcome variable, controlling for the predictor variable. The product of these two parameters 'ab' is the mediated or indirect effect (which is equivalent to c-c′). It is noteworthy that the main effect (i.e. path c) does not need to be significant when mediation is assessed using the product

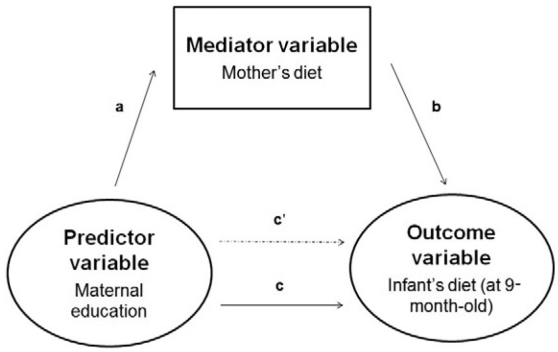

Fig. 1. Mediator model: (a) association between predictor and potential mediator; (b) association between potential mediator and outcome variable, accounting for predictor variable; (c) overall association between predictor variable and outcome variable; (c′) direct effect (unmediated) of predicted variable and outcome variable.

of coefficient test, i.e. 'ab' (MacKinnon *et al*. 2007). Random effect linear regression models, estimated using maximum likelihood, were run controlling for age and gender of the child; mother's age and pre-pregnancy BMI; treatment arm and clustering by first-time parents' group. In order to check that our results were not impacted by the intervention, the analyses were also performed including mother–infant dyads of the control arm only, using dietary pattern loadings estimated in infants of the control arm (results not shown).

The significance level was set at 5%. Analyses were conducted using STATA software (Release 11; StataCorpLP, College Station, TX, USA).

Results

Sample characteristics

Demographic characteristics of the sample are shown in Table 1. It should be noted that the 121 children excluded from the analyses due to loss at follow-up, missing data, or based on exclusion criteria, came from families where the mothers were less likely to have achieved a high education level compared with those retained in the analysis (33.9% vs. 59.4%).

Characteristics of infants' dietary patterns

Three dietary patterns were identified in infants, accounting for 25% of the explained variance

Table 1. Characteristics of the sample ($n = 421$)

	%	95% CI
Mother		
Age at baseline (years), mean (SD)	32.3 (4.1)*	
BMI† before pregnancy (kg m^{-2}), mean (SD)	24.4 (5.1)*	
Education level		
Low (secondary school or below) or intermediate (trade and certificate qualifications)	40.6	34.3; 46.9
High (university degree or higher)	59.4	53.1; 65.7
Country of birth		
Australia	78.9	74.2; 83.5
Other	21.1	16.5; 25.8
Language spoken at home		
English	93.8	91.2; 96.4
Other	6.2	3.6; 8.8
Child		
Sex		
Male	52.0	47.1; 56.9
Female	48.0	43.1; 52.9
Birthweight (kg), mean (SD)	3.4 (0.6)*	
Age when first introduced to solid foods (months), mean (SD)	5.3 (0.9)*	
First follow-up		
Age (months), mean (SD)	9.4 (1.1)*	
Weight (kg), mean (SD)	8.9 (1.1)*	
Currently breastfed		
Yes	44.4	38.0; 50.8
No	55.6	49.2; 62.0
Number of 24-h recalls		
2	6.2	3.8; 8.5
3	93.8	91.5; 96.2

CI, confidence interval. *Mean (SD) (all such values). †Body mass index (BMI) was calculated as weight/height^2 (kg m^{-2}).

Table 2. Factor loadings for the rotated patterns in infants aged 9 months ($n = 421$)

Food groups	Pattern 1	Pattern 2	Pattern 3
Bread and breakfast cereals	–0.001	–0.099	**0.332**
Pasta and rice	**0.306**	0.031	0.099
Vegetables	**0.413**	–0.058	–0.037
Fruits	**0.337**	**–0.161**	0.068
Animal products	**0.313**	0.102	0.053
Fish	**0.364**	0.058	–0.145
Processed meats	–0.108	–0.044	**0.383**
Pasta and vegetables meals (home-made)	–0.046	–0.046	0.133
Meat and vegetables meals (home-made)	0.052	0.040	0.018
Yoghurts	0.040	0.072	0.108
Cheese	0.129	–0.023	**0.276**
Fats	–0.020	0.121	**0.275**
Spreads	**0.225**	0.112	0.034
Savoury biscuits and crisps	–0.131	–0.059	**0.334**
Savoury takeaway	0.022	0.075	**0.202**
Sweet biscuits and cakes	–0.084	–0.008	**0.304**
Confectionery, ice creams and custards	**–0.204**	0.140	**0.164**
Infant dinners in jars	**–0.242**	0.043	0.046
Milk	**0.186**	0.018	**0.336**
Formula	–0.056	**0.657**	–0.109
Breast milk	–0.049	**–0.665**	–0.010
Sweet beverages	**–0.256**	–0.004	**0.164**
Water	**0.275**	0.046	**0.296**
% variance explained	8.6	8.2	7.7
Label	Balanced weaning diet	Formula	High-energy snack and processed foods

In bold: loading above 0.15.

(Table 2). The first pattern was positively correlated with intakes of vegetables, fish, fruits, animal products, pasta and rice, water, spread, and milk, and inversely correlated with intakes of sweet beverages, infant dinners in jars, and confectionery, ice cream and custards. This pattern was labelled 'Balanced weaning diet'. The second pattern, labelled 'Formula', was mainly characterised by high consumption of formula and negative loadings for breast milk and fruits. The third pattern had high positive loadings for processed meats, milk, savoury biscuits and crisps, bread and breakfast cereals, sweet biscuits and cakes, water, cheese, fats, savoury take-away foods, confectionery, ice cream and custards, and sweet beverages. This pattern was named 'High-energy and processed foods'.

Prediction of infants' dietary patterns by maternal education (path c)

There was an inverse relationship between maternal education and the 'Formula' dietary pattern identified in infants ($P < 0.001$) (Table 3). No significant relationship was observed between maternal education and scores in the 'Balanced weaning diet' and the 'High-energy snack and processed foods' patterns.

Table 3. Results from the mediation analysis, i.e. linear regression coefficients* and 95% confidence interval, with maternal education as the predictor variable in all mediation models ($n = 421$)

Mediator variable (mothers' dietary pattern scores assessed at baseline)	Outcome variable (infants' dietary pattern scores assessed at follow-up)	Total effect c	Direct effect c′ (full model)	Path a	Path b (full model)	Mediated effect a × b
Fruit and vegetables	Balanced weaning diet	0.04 (–0.23; 0.30)	–0.07 (–0.34; 0.20)	**0.69 (0.38; 0.99)**	**0.16 (0.07; 0.24)**	**0.11 (0.04; 0.18)**
	Formula	**–0.52 (–0.76; –0.27)**	**–0.43 (–0.68; –0.19)**	**0.69 (0.38; 0.99)**	**–0.12 (–0.20; –0.05)**	**–0.08 (–0.15; –0.02)**
	High-energy snack and processed foods	–0.18 (–0.40; 0.05)	–0.17 (–0.40; 0.06)	**0.69 (0.38; 0.99)**	–0.01 (–0.08; 0.06)	0 (–0.05; 0.04)
High-energy snack and processed foods	Balanced weaning diet	0.04 (–0.23; 0.30)	0.04 (–0.23; 0.31)	0.08 (–0.16; 0.33)	–0.03 (–0.13; 0.07)	0 (–0.01; 0.01)
	Formula	**–0.52 (–0.76; –0.27)**	**–0.53 (–0.77; –0.28)**	0.08 (–0.16; 0.33)	**0.09 (0; 0.19)**	0.01 (–0.02; 0.03)
	High-energy snack and processed foods	–0.18 (–0.40; 0.05)	–0.18 (–0.40; 0.04)	0.08 (–0.16; 0.33)	0.03 (–0.05; 0.12)	0 (–0.01; 0.01)
High-fat foods	Balanced weaning diet	0.04 (–0.23; 0.30)	0.03 (–0.24; 0.30)	–0.20 (–0.46; 0.06)	–0.04 (–0.13; 0.06)	0.01 (–0.02; 0.03)
	Formula	**–0.52 (–0.76; –0.27)**	**–0.52 (–0.77; –0.27)**	–0.20 (–0.46; 0.06)	–0.01 (–0.10; 0.08)	0 (–0.02; 0.02)
	High-energy snack and processed foods	–0.18 (–0.40; 0.05)	–0.17 (–0.39; 0.06)	–0.20 (–0.46; 0.06)	0.04 (–0.04; 0.12)	–0.01 (–0.03; 0.01)
Cereal and sweet foods	Balanced weaning diet	0.04 (–0.23; 0.30)	0.02 (–0.25; 0.29)	**0.34 (0.09; 0.59)**	0.05 (–0.05; 0.15)	0.02 (–0.02; 0.05)
	Formula	**–0.52 (–0.76; –0.27)**	**–0.53 (–0.78; –0.28)**	**0.34 (0.09; 0.59)**	0.05 (–0.05; 0.14)	0.02 (–0.02; 0.05)
	High-energy snack and processed foods	–0.18 (–0.40; 0.05)	–0.17 (–0.39; 0.06)	**0.34 (0.09; 0.59)**	–0.03 (–0.11; 0.06)	–0.01 (–0.04; 0.02)

*Random effect linear regression models, estimated using maximum likelihood, were controlled for age and gender of the child; mother's age and pre-pregnancy body mass index; treatment and clustering by first-time parents' group. **In bold**: statistically significant associations. Path a = association between the predictor variable (i.e. maternal education) and the mediator variable (mother's scores for a given pattern); path b = association between the mediator variable and the outcome variable (infant's scores for a given pattern), controlled for the predictor variable (maternal education); path c = overall association between predictor variable and outcome variable; path c′ = direct effect (unmediated) of predicted variable and outcome variable.

Prediction of mothers' dietary patterns by education (path a)

Consistent with what has been reported in a previous paper on the Melbourne InFANT Program sample at baseline (Lioret *et al.* 2012a), a higher maternal education was associated with higher scores in both the 'Fruit and vegetables' and the 'Cereal and sweet foods' patterns ($P < 0.05$) (Table 3). No significant relationship was observed between maternal education and scores in the 'High-energy snack and processed foods' and the 'High-fat foods' patterns.

Prediction of infants' dietary patterns by mothers' dietary patterns (path b)

After accounting for education level, analyses showed that a higher adherence of the mothers to the pattern labelled 'Fruits and vegetables' predicted higher scores for their children in the 'Balanced weaning diet' pattern, and lower scores in the 'Formula' pattern ($P < 0.05$) (Table 3). No other significant relationship was observed with regard to path b.

Mediation effects of mothers' dietary patterns for the relationship between maternal education and infants' dietary patterns

Among the four dietary patterns identified in mothers, only the scores for the 'Fruit and vegetables' pattern mediated the relationships between maternal education and two infants' dietary patterns, namely 'Balanced weaning diet' [ab = 0.11; 95% confidence interval (CI): 0.04; 0.18] and 'Formula' (ab = –0.08; 95% CI: –0.15; –0.02) (Table 3). Similar results were observed when dietary pattern loading estimation and mediation analyses were undertaken including mother–infant dyads of the control arm only (data not shown).

Discussion

This study provides insights into the mechanism underlying the association between maternal education and infants' dietary patterns. To our knowledge, this has not been examined before using longitudinal data collected in mother–infant dyads.

Our study suggests that distinct dietary patterns emerge as early as infancy, confirming the findings of other studies involving infants and toddlers (Robinson *et al.* 2007; Ystrom *et al.* 2009; Smithers *et al.* 2012). Given the predominant contact with their mother at this stage of life, it was expected that infant's diet would be associated with maternal characteristics, such as education (Robinson *et al.* 2007; Ystrom *et al.* 2009; Smithers *et al.* 2012). It has been suggested that parental education may influence literacy and knowledge about nutrition, thus promoting healthier eating behaviours (path a of the mediator model) (Braveman *et al.* 2005). In addition, while other studies have already reported that diets of mothers and children under 2 years were correlated (Brekke *et al.* 2007; Robinson *et al.* 2007), the longitudinal nature of the current study suggests that this relationship is causal and is independent of confounders such as maternal education and pre-pregnancy BMI (path b of the mediator model). This suggests the important role of mothers as models for their children's eating behaviours (van der Horst *et al.* 2007; Savage *et al.* 2007; Campbell *et al.* 2010). Parents who are aware of the importance of positive eating behaviours are more likely to model positive behaviours in the presence of their child, which, in turn, is likely to impact favourably on dietary patterns of the whole family (van der Horst *et al.* 2007; Savage *et al.* 2007; Haire-Joshu *et al.* 2008; Campbell *et al.* 2010). Role modelling at this age is likely to be particularly important because of the near-complete dependency of children on their mothers. The simple fact of sharing a meal with their child may be part of the explanation for this effect. This hypothesis supposes that maternal diet, measured retrospectively (previous year) in this paper when infants were aged 3 months, did not change 6 months later. While this could not be verified, other analyses have shown that dietary patterns estimated in these mothers when children were aged 18 months were very similar to the dietary patterns estimated at baseline (when infants were aged 3 months), suggesting stability of maternal dietary choices from pregnancy to early motherhood (Lioret *et al.* 2012b).

Furthermore, the mediation analyses undertaken in this work provided evidence for the hypothesis that differences in some aspects of infants' diet by maternal education are explained by the adherence of the mothers to a healthier dietary pattern (i.e. the 'Fruits and vegetables' pattern). These findings have important implications for public health prevention initiatives. While maternal education is difficult to modify, mothers' diet may be more amenable to change. By targeting the diet of pregnant mothers of low education level, the dual outcomes of improved mothers' diet as well as better weaning diets in their infants may be achieved. As suggested by our results, improvement in infant dietary patterns may include increased diversity of healthy foods. Furthermore, given that dietary patterns have been shown to emerge early and to track over childhood (Robinson *et al*. 2007; Northstone & Emmett 2008), such interventions may promote healthier dietary trajectories even beyond infancy. Additional mediators not assessed in the current study include fathers' diet, parental attitudes and feeding practices (e.g. pressure to eat, restriction of foods) (Vereecken *et al*. 2004). These may impact on the development of children's food preferences and eating behaviours (Savage *et al*. 2007) and need further investigation.

Strengths and limitations

Particular strengths of the study include the collection of dietary data in infants using repeated 24-h recalls; the longitudinal design; and the assessment of overall diet in both mothers and infants through the dietary pattern approach. Compared with the traditional single-food group approach, this data-driven method accounts for colinearity among all dietary components (Newby & Tucker 2004). Despite subjective choices inherent to factor analysis, Newby & Tucker (2004) reported in their review that some reproducibility has been observed between most studies which have identified patterns in adults. There is also consistency in dietary patterns of infants and young children among international studies despite the different food classifications and methods used to assess food intake. Although the Melbourne InFANT study was based on repeated 24-h recalls, similar dietary patterns were seen in the Avon Longitudinal Study of Pregnancy And Childhood (Smithers *et al*. 2012), the Southampton Women's Survey (Robinson *et al*. 2007), and the Norwegian Mother and Child Cohort Study (Ystrom *et al*. 2009), which all used FFQs.

However, in interpreting the findings of the present study, it is important to account for the following limitations. We acknowledge that the factor loadings reported in our study are not very high, as compared with many (Newby *et al*. 2006; Northstone *et al*. 2008; Touvier *et al*. 2009; Mishra *et al*. 2010; Northstone & Emmett 2010), but not all (e.g. Crozier *et al*. 2006), studies in the broader literature. Absolute values of the factor loadings are not easily comparable between studies as they depend on several methodological issues, such as the type of method used to collect food intake, the number of days of report, the units used to determine the amounts eaten and the number of food groups entered in the analysis. The value of 0.15 was chosen consistent with similar thresholds cited in the literature (Crozier *et al*. 2006; Newby *et al*. 2006; Knudsen *et al*. 2008; Northstone *et al*. 2008; Touvier *et al*. 2009; Mishra *et al*. 2010; Northstone & Emmett 2010); the overall range of loadings observed in our data (i.e. the ranking of foods in the pattern); and both the interpretability and the differentiation of each pattern. We also acknowledge that the percentage of variance estimated is low, but the latter is close to those estimated in the studies cited earlier.

As our underlying hypothesis was maternal modelling, we hypothesised that mediation pathways would involve patterns in mothers and children characterised by common foods (i.e. foods with high factor loadings in both infants and mothers). The two significant mediation pathways observed in our data fit this assumption, with fruits, vegetables and fish having high loadings in both the 'Fruit and vegetable' pattern in mothers and the 'Balanced weaning diet' pattern in children. Similarly, fruits received a relatively high loading (in absolute value) in both the 'Fruit and vegetable' pattern in mothers and the 'Formula' pattern in children. Importantly, the results presented here for the mediation pathways not found to be significant are nevertheless in the hypothesised directions (e.g. 'High-energy snack and processed foods' pattern in mothers with the 'High-energy snack and processed foods' pattern in infants; 'High-fat foods' pattern in mothers with the 'High-energy snack and processed foods' pattern in infants). In these two examples, common foods load relatively high in both maternal and children patterns. Owing to the data-driven nature of dietary pattern analysis, it is possible that in a sample including a higher proportion of mothers from lower educational backgrounds, these unhealthy dietary patterns would be the first to emerge from principal component analysis, not only in mothers but in their children too.

Finally, overall, the effect sizes in our models are higher for path a, relative to path b. This could come from different levels of precision of the variables involved in the models. Measurement errors – both precision and bias – are more likely for dietary measures than for education. Relationships measured through paths b, where the dependent and independent variables are both dietary measures, are therefore more likely to be attenuated (or biased) than those involved in paths a, in which the dependent variable of interest is maternal education level. In addition, each dietary pattern captures only a small part of the variability in the sample, addressing only partially our mediation hypothesis and limiting power for the observation of larger effect sizes. These limitations could potentially be minimised with a larger sample, including mothers with more diversity in education level and behaviours (mothers from lower socio-economic position were somewhat under-represented in our sample).

Despite these limitations, we were able to find two significant mediation pathways. The fact that consistent results were observed when analyses were run on half the sample (including controls only) supports our contention that these findings are not simply due to chance. Even if the effect sizes observed are rather small, as is often the case for behavioural data, they nonetheless support the hypothesis of the paper.

Conclusion

While we know that maternal education is likely to predict infant dietary intakes, our results suggest that mothers' diet, a potentially modifiable factor, partially mediates this association, thus providing a clear focus for family-based interventions aiming to improve infant diet. As these findings are hypothesis-generating, rather than confirmatory in nature, further research assessing the complexity of the multi-factorial pathways between maternal education and early childhood diet on large samples would be of interest.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

SL conducted the statistical analysis, contributed to interpretation of results, drafted and edited the manuscript, and had primary responsibility for final content. AJC contributed to the statistical analysis and interpretation of results, drafted and edited the manuscript. SAM managed the dietary data collection, guided the statistical analysis, contributed to interpretation of results, drafted and edited the manuscript. DC guided the statistical analysis, contributed to interpretation of results, drafted and edited the manuscript. ACS contributed to the dietary data collection, drafted and edited the manuscript. KH designed and led The Melbourne InFANT Program, guided the statistical analysis, contributed to interpretation of results, drafted and edited the manuscript. KJC was the principal investigator on The Melbourne InFANT Program. She designed and led that study, managed the dietary data collection, guided the statistical analysis, contributed to interpretation of results, drafted and edited the manuscript. All authors have read and approved the final manuscript.

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Appendix 1

Food classification used for infants

Bread and breakfast cereals	White bread and non-white grain; low- and high-fibre breakfast cereals; porridge
Pasta and rice	
Vegetables	Raw and cooked vegetables; soup; potatoes cooked without fat; starchy vegetables; legumes
Fruits	Fruits; dried fruits; preserve fruits; and mixed dishes where fruit is the major component
Animal products	Meat, poultry, eggs. Excludes fish and processed meats.
Fish	Fish (all cooking forms); recipe containing fish essentially; sea food
Processed meats	Sausages; ham; bacon; corned beef
Pasta and vegetables meals (home-made)	Mixed dishes containing pasta and vegetables essentially
Meat and vegetables meals (home-made)	Mixed dishes containing meat and vegetables essentially
Yogurts	
Cheese	Includes ricotta, cottage and feta cheeses
Fats	Butter and margarine
Spreads	Sweet spreads such as honey and jams; savoury sauces and dressings; yeast extracts
Savoury biscuits and crisps	
Savoury takeaway	Fast-food savoury dishes (such as pizzas, sandwiches, hamburgers); savoury snacks; potatoes cooked in fat
Sweet biscuits and cakes	Includes infant biscuits
Confectionary, ice creams and custards	Includes infant foods in jars
Infant dinners in jars	Infant dinners in commercial jars containing animal products and/or vegetables
Milk	Cow, sheep and goat milks
Formula	Cow's milk or soy-based
Breast milk	A feed of 10 min or greater was estimated at 100 mL and for feeds less than 10 min, a conversion factor of 10 mL min^{-1} was used. If breast milk was expressed, volumes estimated by parental report were used (Emmett *et al.* 2000).
Sweet beverages	Fruit juices; cordials; soft drinks; and flavoured mineral waters
Water	Plain water (tap or bottled)