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Dietary patterns in infancy: the importance of maternal and family influences on feeding practice

Siân Robinson[1]*, Lynne Marriott[1], Jason Poole[1], Sarah Crozier[1], Sharon Borland[1], Wendy Lawrence[1], Catherine Law[2], Keith Godfrey[1], Cyrus Cooper[1], Hazel Inskip[1] and The Southampton Women's Survey Study Group[1]

[1]*MRC Epidemiology Resource Centre, University of Southampton, Southampton General Hospital, Southampton SO16 6YD, UK*
[2]*Centre for Paediatric Epidemiology and Biostatistics, Institute of Child Health, University College London, 30 Guilford Street, London WC1N 1EH, UK*

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It is not known what constitutes an optimal diet in infancy. There are relatively few studies of weaning practice in the UK, and there is a need for prospective data on the effects of infant diet and nutrition on health in later life. We describe the dietary patterns, defined using principal components analysis of FFQ data, of 1434 infants aged 6 and 12 months, born between 1999 and 2003. The two most important dietary patterns identified at 6 and 12 months were very similar. The first pattern was characterised by high consumption of fruit, vegetables and home-prepared foods ('infant guidelines' pattern). The second pattern was characterised by high consumption of bread, savoury snacks, biscuits and chips ('adult foods' pattern). Dietary pattern scores were correlated at 6 and 12 months (r 0·46 'infant guidelines'; r 0·45 'adult foods'). These patterns, which reflect wide variations in weaning practice, are associated with maternal and family characteristics. A key influence on the infant diet is the quality of the maternal diet. Women who comply with dietary recommendations, and who have high intakes of fruit and vegetables, wholemeal bread and rice and pasta, are more likely to have infants who have comparable diets – with high 'infant guidelines' pattern scores. Conversely, women whose own diets are characterised by high intakes of chips, white bread, crisps and sweets are more likely to have infants who have high 'adult foods' pattern scores. The effects of these patterns on growth and development, and on long-term outcomes need to be investigated.

Infant diet: Weaning: Dietary patterns

It is not known what constitutes an optimal diet in infancy that is sufficient in amount and quality to meet nutrient requirements and to allow an infant to grow and develop to its potential. The most recent national survey of infant feeding in the UK indicates wide variations in practice[1], but whether these differences have implications for current or future health is unknown. Since there is now observational evidence that links specific patterns of infant growth to differences in risk of adult disease[2], we need to understand more about the determinants of infant growth and development, and in particular the role of diet in the first year of life.

Studies of infant feeding commonly focus on differences in milk feeding during early infancy. Although first foods eaten and the age of introduction of solid foods are reported, the process of weaning – that is, the gradual transition from a milk-based diet to a diet based on solid foods – is not well described[3]. Differences in some adult outcomes have been reported between breast-fed and formula-fed infants in developed countries[4,5], but there is little other information about the influence of qualitative differences in the infant diet, and in the nature of the weaning process, on long-term health outcomes.

This limited evidence base is reflected in fairly general weaning guidance given to mothers. In the UK, the main guidelines are to introduce solid foods from the age of 6 months, to provide a varied diet that includes starchy foods, fruit and vegetables and meat and fish, and to encourage the use of home-prepared rather than commercial baby foods[6]. Additionally there are specific guidelines that include the delayed introduction of allergenic foods, and the avoidance of added salt and sugar. With the exception of the age of introduction of solid foods, the current guidelines are based on the recommendations of the COMA Working Group on the Weaning Diet[7]. In 2003, the recommended duration of exclusive milk feeding was increased from between 4 and 6 months, to 6 months, in response to new guidance[8]. It is not yet known what impact this latest advice has had on weaning age in the UK.

We describe the dietary patterns of a general population sample of infants who were born to women in the

Abbreviations: PCA, principal components analysis; SWS, Southampton Women's Survey.
* **Corresponding author:** Dr Siân Robinson, fax +44 2380 704021, email smr@mrc.soton.ac.uk

Southampton Women's Survey (SWS) between 1999 and 2003[9]. Using principal components analysis (PCA), we identify the most important patterns of diet at 6 and 12 months of age, and we consider maternal and family factors that are associated with these patterns.

Subjects and methods

The Southampton Women's Survey

The SWS is a study of a population sample of non-pregnant women aged 20–34 years, resident in the city of Southampton, UK[9]. The SWS was started in 1998. The aim of the SWS is to identify the maternal influences acting before and during pregnancy that determine fetal growth, and to characterise how maternal and intra-uterine influences interact with the offspring's genes and postnatal environment to determine subsequent growth, development and health. Each child born to a woman in the SWS is followed up at 6 and 12 months of age, when they are visited by trained research nurses. Infants who are visited within 2 weeks of their 6-month birthday, or within a period 2 weeks before and 3 weeks after their 12-month birthday have a dietary assessment, and details of the milk-feeding history over the preceding 6 months are ascertained. The study was approved by Southampton and South West Hampshire Local Research Ethics Committee.

Participants

There were 1981 singleton live births to women in the SWS up to the end of 2003. After exclusion of infants with major congenital abnormalities (*n* 2), and neonatal deaths (*n* 6), there were 1973 SWS infants for postnatal follow up. A total of 1886 of these infants (96 %) were followed up at 6 months of age. Of these infants, 1645 (83 %) were visited within 2 weeks of their 6-month birthday. A total of 1815 of the infants born up to the end of 2003 were followed up at 12 months of age (92 %). Of these infants, 1618 (82 %) were visited within a period 2 weeks before and 3 weeks after their 12-month birthday, when diet was assessed. The data presented in the present study are for 1434 infants (73 %) whose diets were assessed at both 6 and 12 months of age.

Dietary assessment

Diet was assessed at 6 and at 12 months using FFQs. The FFQs were developed for use in the SWS using a variety of sources of dietary information. We compiled lists of foods to be included after review of data collected from a nationally representative sample of children aged 18 months[10], the weighed food diaries of a group of preterm infants aged 6 and 12 months[11], infant-feeding literature, and adult dietary data collected from women living in Southampton[12]. The food lists were then reviewed following collection of 24 h recall data from a sample of infants recruited from a health visitor clinic. Final amendments were made to the FFQ in the piloting phase of the study. At 6 months of age, the FFQ included thirty-four food items. It was administered by a trained research nurse. The average frequency of consumption and amounts consumed of the listed foods over the 7 d preceding the visit were recorded. In addition a 24 h diet recall was administered by the nurse. At 12 months, the FFQ included seventy-eight food items. It was administered by a trained research nurse. The average frequency of consumption and amounts consumed of the listed foods during the month preceding the interview were recorded. At both interviews, prompt cards were used to show the foods included in each food group, to ensure standardised responses to the FFQ. Portion size was described using household measures, and with the aid of food models. At the end of each FFQ, an open section in the same format was included, to record frequencies of consumption and amounts of any foods that were not listed on the FFQ, if they were consumed once per week or more. Breast milk intake was estimated from the reported duration of breast-feeding at each feed[13]. The age at which solid foods were introduced into the infant's diet was recorded.

Dietary patterns analysis

Dietary patterns were defined using PCA[14]. This is a multivariate statistical technique that produces new variables that are uncorrelated linear combinations of the dietary variables that maximise the explained variance. Before the PCA of the 6-month FFQ data, the thirty-four foods listed on the FFQ were grouped on the basis of similarity of type of food into twenty-eight food groups. All additional foods recorded at the end of the FFQ were put into fifteen further groups, and milks were combined into three groups. This provided a total of forty-six food groups to be entered into the 6-month PCA. A separate PCA was carried out on the 24 h recall data, after allocating each food and drink recorded to one of forty-six equivalent FFQ food groups. Before the PCA of the 12-month FFQ data, the seventy-eight foods listed on the FFQ were grouped into forty-six food groups. Seven further groups were created for the additional foods recorded at the end of the FFQ, and milks were combined into three groups. A total of fifty-six food groups were entered into the 12-month PCA.

PCA was performed on the reported weekly frequencies of consumption for the forty-three food groups, and the daily intake of the three types of milk consumed at 6 months of age, and similarly for the fifty-three food groups and daily intakes of the three types of milk consumed at 12 months of age. The PCA was based on the correlation matrix in order to adjust for unequal variation of the food group variables. For each component, individual infants were allocated a score that was derived from the component's coefficients for the food groups and the reported frequencies of consumption. The distributions of these scores were then standardised, to have zero mean and unit variance, using Fisher–Yates normal scores[15].

Mother and infant data

Details of mother's age, number of children, educational attainment, time spent watching television (h per week) and lifestyle were obtained at the pre-pregnant interview, and height was measured. Educational attainment was defined in six groups according to the woman's highest academic

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qualification. GCSE (General Certificate of Secondary Education) examinations are usually taken at the age of 16 years, A-levels (advanced level) at 18 years, and HND (higher national diploma) qualifications and degrees thereafter. Mother's smoking status was ascertained at the infant's 6-month interview, and her body weight was measured. BMI was calculated using the mother's weight at the 6-month interview, and her height. Mother's diet was assessed by FFQ before the pregnancy (median interval between dietary assessment and the birth of the child was 20·8 (interquartile range 13·9–30·2) months). A PCA of the mothers' pre-pregnant dietary data yielded a component that was characterised by high intakes of fruit, vegetables, wholemeal bread, rice and pasta, but low intakes of white bread, added sugar, and tinned vegetables, and describes a pattern of foods that reflects recommendations for a healthy diet, called a 'prudent' diet[12]. Prudent diet scores were available for each mother.

Statistical analysis

Associations between dietary component scores and a range of maternal and family factors (mother's educational attainment, BMI, age, smoking status, time spent watching television, prudent diet score, infant birth order, age of introduction of solid foods) were investigated in univariate and multivariate linear regression models. Resultant β coefficients, associated 95 % CI and t statistics were used to assess the strength of association between predictor and outcome, and the relative influence between models.

A χ^2 test was used to test for a difference in two proportions. Pearson correlation coefficients (r) were derived to compare two normally distributed variables. Spearman correlation coefficients were derived to compare two variables where one or both were non-normal. A Wilcoxon rank-sum test was used to test for differences in non-normal variables between two groups. Statistical analysis was performed in Stata 9·0[16].

Table 1. Characteristics of the women and infants studied (n 1434)

	n	%
Women		
Age (years)*	1432	
Median	31	
Range	21–38	
BMI (kg/m²)	1407*	
Median	25·5	
Range	16·4–49·2	
Smoking status*		
No	1156	81
Less than ten per d	96	7
Ten or more per d	170	12
Educational level†		
None	34	2
GCSE grade D or below	140	10
GCSE grade C or above	409	29
A-level or equivalent	424	30
HND or equivalent	104	7
Degree	317	22
Time spent watching television (h per d)‡		
None	17	1
Less than 1	126	9
1 to 2	346	24
2 to 3	464	32
3 to 4	275	19
4 to 5	152	11
More than 5	51	4
Infants		
Sex		
Boys	760	53
Girls	674	47
Birth order		
First	672	47
Second	543	38
Third	156	11
Fourth or later	60	4
Age solid foods introduced (months)		
Less than 2	23	2
2 to <3	68	5
3 to <4	431	30
4 to <5	772	54
5 or more	136	10

GCSE, General Certificate of Secondary Education; A-level, advanced level; HND, higher national diploma.
* At 6-month infant interview.
† Highest qualification attained.
‡ In 3-month period preceding pre-pregnant interview.

Results

Characteristics of the women and their infants are shown in Table 1. The median age at which solid foods were introduced to the infants was 4·0 (range 0·7–6·0) months. A total of 1173 (82 %) of the infants were born before the change in the recommended age of introduction of solid foods from 4–6 months, to 6 months, in May 2003. Amongst the infants born before this date, 38 % were introduced to solid foods before 4 months of age, and the remaining 62 % by 6 months. A total of 261 infants were born between May and the end of 2003. The proportion of these infants introduced to solid foods before the age of 4 months was lower (30 %; $P=0·02$). Only three (1 %) of the 261 infants born after the change in guidance were not introduced to solid food until 6 months.

Table 2 shows the coefficients for the first three components defined by the PCA of the FFQ data at 6 months. The first component was characterised by a high frequency of consumption of vegetables, fruit, meat and fish, other home-prepared foods and greater breast milk consumption, but by a low frequency of consumption of commercial baby foods in jars and lower consumption of formula milk. The only commercial baby food that characterised this component was baby rice. The component describes a pattern of foods that conforms to infant feeding guidelines as recommended in feeding manuals, and was called the 'infant guidelines' pattern. At 6 months of age, the second component was characterised by a high frequency of consumption of bread, savoury snacks, biscuits, squash, breakfast cereals and chips, but by low frequency of consumption of breast milk, baby rice and cooked and tinned fruit. Since this component was characterised by frequent consumption of foods found in the adult diet, and by low consumption of early weaning foods, we called it the 'adult foods' pattern.

The third component identified at 6 months was characterised by a high frequency of consumption of 'wet' commercial baby foods, most commonly available in jars, but by a low

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Table 2. Coefficients for the first three principal components identified in food-frequency questionnaire data at 6 months of age

	Component*				Component*		
	1	2	3		1	2	3
Breast milk (g)	0·14	−0·21†	0·09	Crackers or breadsticks	0·02	0·10	−0·06
Formula milk (g)	−0·16†	0·14	−0·10	Biscuits	−0·04	0·27†	−0·09
Cows' milk and other non-baby milks (g)	0·04	0·19†	0·04	Baby fruit and herbal juice	−0·10	0·14	0·01
Baby rice	0·18†	−0·17†	0·00	Squash and diet squash	−0·03	0·19†	−0·10
Other dried baby breakfast cereals	−0·01	−0·10	−0·21†	Tea	−0·02	0·06	0·06
Baby rusks	−0·08	0·11	−0·04	Water	0·09	−0·01	0·03
Baby dried meat- or fish-based meals	−0·12	0·07	−0·43†	Rice cakes	0·05	0·01	0·06
Baby dried vegetable-, pasta- or rice-based meals	−0·09	0·01	−0·35†	Baby biscuits	−0·03	0·08	0·06
Baby dried desserts	−0·11	0·04	−0·42†	Cheese	0·16†	0·14	0·06
Baby jar breakfast meals such as porridge	−0·15	0·02	0·27†	Eggs and egg dishes	0·07	0·08	0·01
Baby jar meat- or fish-based meals	−0·24†	0·06	0·30†	Meat substitutes (including soya and Quorn)	0·08	−0·01	0·01
Baby jar vegetable-, pasta- or rice-based meals	−0·18†	−0·01	0·30†	Marmite	−0·01	0·21†	−0·01
Baby jar milk-, cereal- or fruit-based desserts	−0·21†	0·05	0·24†	Chips	−0·02	0·22†	−0·01
Baby pure fruit purée	−0·12	−0·05	0·25†	Chocolate	−0·04	0·19†	0·03
Weetabix and other breakfast cereals	0·12	0·25†	0·02	Puddings and ice cream	0·03	0·20†	0·01
Potatoes and sweet potatoes	0·35†	0·03	0·01	Gravy and savoury sauces	0·10	0·10	0·02
Rice	0·12	0·01	0·03	Spreading fats	0·04	0·22†	0·06
Pasta	0·16†	0·24†	0·02	Sugar and sweet spreads	0·00	0·12	−0·01
Meat and fish	0·28†	0·17†	0·06	Savoury snacks	−0·01	0·29†	−0·01
Beans and pulses	0·19†	0·13	0·04	Fruit juice	0·03	0·01	0·04
Vegetables	0·41†	−0·07	0·02	Miscellaneous‡	0·03	0·05	0·00
Yoghurt and fromage frais	0·07	0·19†	0·11				
Cooked, dried and tinned fruit	0·31†	−0·14	−0·02	Proportion of variation explained (%)	8·9	6·7	5·0
Fresh fruit	0·26†	0·01	0·05				
Bread or toast	0·05	0·33†	0·01				

* Component 1, 'infant guidelines'; component 2, 'adult foods'; component 3, 'baby jar foods'.
† Coefficients > 0·15.
‡ Includes foods such as cakes or soup that were consumed by very few infants.

frequency of consumption of dried commercial baby foods. The remaining foods in the infant diet did not contribute to the component. We called this component the 'baby jar foods' pattern. We considered a further two components identified by the PCA at 6 months – but these did not provide meaningful or interpretable patterns of foods and they explained less of the variance in the dietary data (3·9 and 3·3 %). When we examined the first three components defined by the PCA of the 24 h recall data, we found very similar patterns of foods as in the PCA of the FFQ data (data not shown). Spearman rank correlations between pattern scores calculated from the FFQ and the 24 h recall data were 0·81 for the 'infant guidelines' pattern, 0·73 for the 'adult foods' pattern and 0·51 for the 'baby jar foods' pattern (all $P<0·001$).

Table 3 shows the first two components defined by the PCA of the 12-month data. The first component was characterised by a high frequency of consumption of fruit and vegetables, rice and pasta, fish, cheese and meat, but by a low frequency of consumption of commercial jar baby foods. This component is indicative of an infant diet that is based on home-prepared 'family' foods. It describes a pattern of foods that conforms to infant feeding guidelines, and is very similar to the first component described at 6 months – the 'infant guidelines' pattern. This first component in the PCA of the 12-month data was therefore called the '12-month infant guidelines' pattern. The second component identified at 12 months was characterised by a high frequency of consumption of crisps and savoury snacks, processed meat, fruit squash, chips and roast potatoes, and white bread, but by low frequency of consumption of commercial baby foods and formula milk. This component is similar to the second component described at 6 months – the 'adult foods' pattern. This second component in the PCA of the 12-month data was therefore called the '12-month adult foods' pattern.

We considered a further three components identified by the PCA – but (in common with the fourth and fifth components at 6 months) they did not provide meaningful or interpretable patterns of foods and explained less of the variance in the dietary data than the first two components (3·6, 3·2 and 2·9 %).

Since the first two dietary patterns identified by the PCA were so similar at 6 and 12 months, we examined the relationship between infants' pattern scores at the two ages for the 'infant guidelines' and the 'adult foods' patterns. The pattern scores were highly correlated (r 0·46 'infant guidelines', r 0·45 'adult foods'; both $P<0·001$). Two-thirds of both the 'infant guidelines' and the 'adult foods' pattern scores at 6 and 12 months were within 1 SD of each other. This consistency in the ranking of infant dietary pattern scores is indicative of tracking of the dietary patterns over the second half of infancy.

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Table 3. Coefficients for the first two principal components identified in food-frequency questionnaire data at 12 months of age

	Component*			Component*	
	1	2		1	2
Breast milk (g)	0·10	−0·08	Eggs and egg dishes	0·16†	0·03
Baby formula milk (g)	−0·12	−0·16	Cheese	0·21†	−0·05
Cows' milk and other non-baby milks (g)	0·02	0·24†	Gravy and savoury sauces	0·21†	−0·10
Baby dried cereals	−0·09	−0·16†	Tinned and cooked fruit	0·13	−0·02
Baby dried savoury meals	−0·09	−0·04	All fresh fruit except citrus	0·26†	−0·08
Baby dried desserts	−0·05	−0·01	Citrus fruits	0·12	0·01
Baby breakfast jar meals (such as porridge)	−0·13	−0·09	Yoghurt and fromage frais	0·02	0·02
Baby savoury jars	−0·27†	−0·14	Puddings and ice cream	0·12	0·16
Baby dessert jars	−0·21†	−0·12	Cakes (including pancakes, fruit breads)	0·08	0·12
Baby pure fruit purée	−0·07	−0·16†	Biscuits	−0·03	0·23†
White bread	0·02	0·26†	Chocolate and sweets	−0·07	0·24†
Brown bread	0·18†	−0·15	Crisps and savoury snacks	−0·08	0·32†
Savoury biscuits and breadsticks	0·08	−0·09	Marmite and Bovril	0·12	0·03
Breakfast cereals	0·15	0·06	Sweet spreads (including peanut butter)	0·09	0·05
Potatoes and sweet potatoes	0·24†	0·02	Spreading fats	0·16†	0·18†
Chips, roast and potato shapes	−0·05	0·25†	Sugar	−0·02	0·19†
Rice, pasta (including couscous and other grains)	0·24†	−0·05	Fruit juice (including baby juices)	−0·01	−0·06
Processed meat products	0·08	0·28†	Fruit squashes (including diet squash)	−0·06	0·27†
Roast meat and meat dishes	0·22†	0·02	Fizzy drinks (including diet drinks)	−0·02	0·10
Offal	0·06	0·01	Tea and coffee	−0·03	0·16
White fish and fish products	0·21†	0·00	Water	0·10	−0·09
Oily fish	0·23†	−0·09	Rusks	−0·07	−0·03
Tinned vegetables	0·01	0·19†	Rice cakes	0·08	−0·10
Vegetables (except for tinned and salad)	0·25†	−0·05	Baby biscuits	0·01	−0·11
Salad vegetables	0·19†	−0·07	Dried fruit	0·13	−0·06
Beans and pulses (including hummus)	0·19†	0·05	Other bread-type products	0·00	−0·02
Meat substitutes (including soya and Quorn)	0·08	−0·04	Other drinks	−0·01	0·04
Pizza and quiche	0·10	0·12	Miscellaneous foods‡	−0·01	0·02
			Proportion of variation explained (%)	7·0	6·4

* Component 1, '12-month infant guidelines'; component 2, '12-month adult foods'.
† Coefficients > 0·15.
‡ Includes foods such as soup, Yorkshire pudding and cream that were consumed by very few infants.

We examined the influence of a range of maternal and family characteristics on the dietary pattern scores. At 6 months, all the factors considered were related to the 'infant guidelines' pattern in univariate analyses (data not shown). Mothers of infants with high scores were more likely to have a higher level of educational attainment, to be older, of lower BMI, to be a non-smoker, to watch less television and to have a high prudent diet score (all $P<0·001$). High 'infant guidelines' scores were associated with lower birth order and with later introduction of solid foods (both $P<0·001$). In a multivariate analysis that considered the effects of these factors together (Table 4), there were no longer independent influences of smoking, time spent watching television, or age of introduction of solid foods on the 'infant guidelines' score. At 6 months, the most important influences on the 'infant guidelines'

Table 4. Regression analysis of the factors associated with the 'infant guidelines' pattern scores at 6 and 12 months

	6 months†			12 months†		
	β	95 % CI	*t*	β	95 % CI	*t*
Mother‡						
Educational level	0·130	0·089, 0·172	6·13**	0·057	0·015, 0·100	2·67*
Age (years)	0·018	0·004, 0·032	2·57*	0·001	−0·013, 0·015	0·10
BMI (kg/m^2)	−0·017	−0·026, −0·007	−3·34*	−0·009	−0·019, 0·001	−1·75
Smoking status	−0·056	−0·133, 0·022	−1·41	−0·033	−0·111, 0·045	−0·83
Time spent watching television (h/week)	−0·025	−0·065, 0·015	−1·23	−0·058	−0·098, − 0·018	−2·83*
Prudent diet score§	0·196	0·135, 0·257	6·32**	0·282	0·220, 0·343	8·97**
Infant‡						
Age of introduction of solid foods	0·019	−0·044, 0·083	0·60	−0·034	−0·099, 0·030	−1·05
Birth order	−0·145	−0·209, −0·081	−4·46**	−0·142	−0·206, −0·077	−4·29**

* $P<0·05$; ** $P<0·001$.
† Results at 6 months are mutually adjusted in a multivariate regression model; similarly for the 12-month results.
‡ For definitions of maternal and infant predictor terms, see Table 1.
§ Defined from principal components analysis of mother's pre-pregnant diet.

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score were the prudent diet score of the mother and her educational attainment.

At 12 months, with the exception of age of introduction of solid foods, univariate analyses showed similar associations to those seen at 6 months between the maternal and family factors considered and the '12-month infant guidelines' scores. The multivariate analysis showed that in addition to the age of introduction of solid foods, mother's age, BMI and smoking status no longer had independent influences on the '12-month infant guidelines' score. The influences of mother's prudent diet score, birth order, mother's educational attainment, and time spent watching television all remained, although the relative importance of the influence of mother's educational attainment was less than at 6 months. The most important influence on the '12-month infant guidelines' score was the prudent diet score of the mother (Fig. 1).

'Adult foods' pattern scores at 6 and 12 months were related to all of the maternal and family factors considered in univariate analyses (data not shown). At both ages, mothers of infants with high 'adult foods' pattern scores were more likely to have a lower educational attainment, to be younger, of higher BMI, to smoke, to watch more television and to have a lower prudent diet score (all $P<0·001$). Infants with higher 'adult foods' pattern scores were more likely to be of higher birth order, and to have been introduced to solid foods earlier (both $P<0·001$). Infants in the top quarter of the distribution of 'adult foods' pattern scores at 6 months were introduced to solid foods at a mean age of 3·6 months compared with 4·2 months for infants in the bottom quarter ($P<0·001$). A multivariate analysis that considered these factors together (Table 5) showed that, with the exception of time spent watching television, all factors remained independent predictors of the 'adult foods' pattern score at 6 months. The most important influences at this age were age of introduction of solid foods and mother's educational attainment. At 12 months, the multivariate analysis showed that the relative importance of the influences had changed. The most important influences on the '12-month adult foods' score were the infant's birth order (Fig. 2), mother's prudent diet score and age of introduction of solid foods.

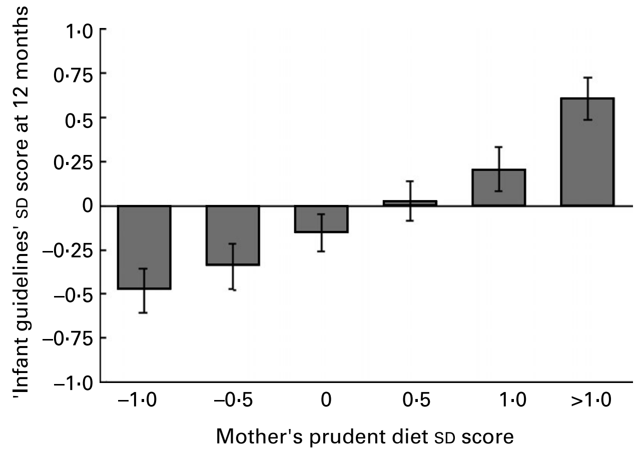

Fig. 1. 'Infant guidelines' scores at 12 months by prudent diet score of the mother. Values are means, with 95 % CI represented by vertical bars.

In contrast to the first two dietary patterns, the 'baby jar foods' pattern identified at 6 months was not associated with as many of the maternal and family characteristics considered. Univariate analyses showed that mothers of infants with high scores were more likely to have a higher educational attainment, to be older, to be a non-smoker, to watch less television and to have a higher prudent diet score (all $P<0·05$), but the effects were small (data not shown). There was no association with mother's BMI, age of introduction of solid foods or birth order. In a mutually adjusted analysis, only maternal age had an independent influence on 'baby jar' score at 6 months (baby jar score increased by 0·02 (95 % CI 0·008, 0·038) per year of maternal age; $P=0·004$).

Discussion

We have described the dietary patterns of a large population sample of infants at 6 and 12 months of age. The patterns, which reflect wide variations in contemporary infant feeding and weaning practice, have not been described before. The two

Table 5. Regression analysis of the factors associated with the 'adult foods' pattern scores at 6 and 12 months

	6 months†			12 months†		
	β	95 % CI	*t*	β	95 % CI	*t*
Mother‡						
Educational level	−0·168	−0·208, −0·128	−8·27**	−0·107	−0·145, −0·069	−5·53*
Age (years)	−0·030	−0·043, −0·017	−4·38**	−0·040	−0·053, −0·027	−6·14**
BMI (kg/m^2)	0·021	0·012, 0·030	4·45**	0·013	0·004, 0·022	2·83*
Smoking status	0·132	0·058, 0·206	3·49**	0·071	0·001, 0·141	1·98*
Time spent watching television (h/week)	0·023	−0·015, 0·061	1·19	−0·003	−0·040, 0·033	−0·19
Prudent diet score§	−0·074	−0·132, −0·015	−2·48*	−0·215	−0·270, −0·160	−7·63**
Infant‡						
Age of introduction of solid foods	−0·266	−0·327, −0·205	−8·56**	−0·221	−0·279, −0·163	−7·50**
Birth order	0·073	0·012, 0·134	2·35*	0·285	0·227, 0·343	9·64**

* $P<0·05$; ** $P<0·001$.
† Results at 6 months are mutually adjusted in a multivariate regression model; similarly for the 12-month results.
‡ For definitions of maternal and infant predictor terms, see Table 1.
§ Defined from principal components analysis of mother's pre-pregnant diet.

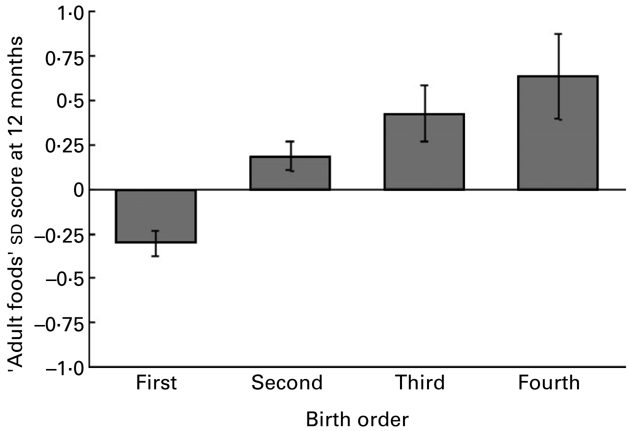

Fig. 2. 'Adult foods' scores at 12 months by birth order of the infant. Values are means, with 95 % CI represented by vertical bars.

most important patterns identified at 6 months were still evident at 12 months, and the pattern scores were correlated – indicating tracking of diet over the second half of infancy.

Study population

The infants we studied were born to women in the SWS, a general population sample of women living in Southampton[9]. Full dietary information was obtained at both 6 and 12 months for 73 % of infants born to the end of 2003. The infants come from a wide range of backgrounds, and many of their maternal and family characteristics are comparable with those of the wider community[9,17]. The dietary patterns we identified should therefore have relevance beyond Southampton. We assessed diet using FFQ that were administered by trained research nurses. As diet changes very rapidly in infancy, the questionnaires assessed intake over relatively short time periods when compared with adult assessments[12,18]. Whilst there is concern that FFQ can be prone to measurement error[19], they have been shown to identify similar patterns of diet as weighed diet records[18]. In the present study, the first three patterns of foods defined by the PCA of the FFQ and the 24 h recall data collected at 6 months were very similar, and pattern scores were highly correlated.

Dietary patterns in infancy

The first ('infant guidelines') pattern identified by the PCA at 6 months and 12 months is interpretable as a pattern that indicates compliance with infant feeding guidelines, and is characterised by greater consumption of fruits, vegetables and home-prepared foods. Infants with high pattern scores are more likely to be breastfed at 6 months than infants with lower scores. The second ('adult foods') pattern seen at 6 and 12 months is suggestive of infants being 'fast-tracked' through the weaning process and is characterised by high consumption of chips, savoury snacks and biscuits – foods that characterise poor adult diets. Although we have yet to determine how these dietary patterns relate to nutrient intake, there are obvious concerns about the diets of infants with high 'adult foods' pattern scores, as the early introduction of foods with high energy, but low micronutrient density, may have implications for micronutrient intakes. The significance of the third ('baby jar foods') dietary pattern identified at 6 months of age is uncertain. There is a clear preference for wet or dry commercial baby foods, but considerably less variability among the rest of the foods in the diet. This pattern appears to be a feature of an early stage in the weaning process and is no longer evident by 12 months.

The first two components explained 15·6 and 13·4 % of the variation in the food groups at 6 and 12 months respectively. The proportion of variation explained by a set of components is dependent on the number of variables entered into the PCA and the number of components retained. Although we are not aware of any other published PCA of infant data to compare with the present study, the proportion of variation explained is comparable with analyses of adult data that used a similar number of variables and components[20].

Influences on infant dietary patterns

The dietary patterns are influenced by maternal and family characteristics. A key determinant of the nature of the infant diet is the quality of the mother's diet. This is more marked at 12 months of age – which coincides with the stage when the infant diet is increasingly based on family foods. Thus, infants of mothers who have high prudent diet scores and 'healthier' dietary patterns before pregnancy, characterised by high intakes of fruit and vegetables, wholemeal bread, rice and pasta[12], are more likely to have a comparable diet, and are fed in accordance with infant feeding guidelines. Conversely, mothers who have low prudent diet scores and whose diets are characterised by high intakes of chips and roast potatoes, white bread, processed meat, crisps, sweets and soft drinks[12] are more likely to provide a diet for their infant that is also characterised by these foods. Whilst it might be expected that women who conform to adult dietary recommendations also comply with infant feeding guidelines, we were surprised to see the parallels between poor maternal diets and the 'adult foods' pattern in the infants we studied. Children's diets and food preferences have been shown to be influenced by their food environment, and by observing the eating behaviours of their parents[21–23]. The present study provides evidence that influences of the food environment on children's diet operate very early – as soon as infants start to eat solid food.

In addition to maternal food choices, we found important influences of maternal educational attainment and birth order on dietary patterns in infancy. The positive influence of education on dietary habits has been shown in a variety of studies of adult populations[12,24,25] – although it is not clear exactly how higher educational attainment influences food choices. There is also evidence of beneficial effects of mothers' educational attainment on children's diets in both the developed[23,26,27] and in the developing world[28]. In the study of Vereecken *et al.*[23], the effects of maternal education on children's fruit and vegetable consumption were largely explained by differences in mothers' fruit and vegetable consumption. In the present study, an independent influence of maternal educational attainment on infant diet remained after allowing for the effects of mother's diet. It is possible that maternal knowledge has a greater influence on infant feeding and the weaning process, when compared with the feeding of older children. This is supported by the observation of a relatively greater influence of maternal education on dietary pattern scores at 6 months compared with 12 months of age.

There were clear effects of birth order on the dietary patterns of infants in the present study. When compared with infants who had older siblings, those born first were more likely to have a diet that conforms with feeding guidelines, and less likely to have a diet that is characterised by energy-dense low-micronutrient foods. This influence was evident at both 6 and 12 months of age for both patterns, but its effect on the 'adult foods' pattern was particularly marked at 12 months. This may provide some insight into the factors that impact on a family's ability to follow dietary guidelines – such as the competing priorities of the needs and food preferences of older children. A negative effect of family size on diet has also been shown in older children. In children aged 4 and 7 years in the Avon Longitudinal Study of Parents and Children, high scores for a 'junk food' pattern, characterised by biscuits, chips and ice cream, were found in children who had greater numbers of siblings[29]. An influence of family size on dietary habits may not only apply to children. In non-pregnant women in the SWS, we have previously reported that women who share the home with children are more likely to have a diet of poorer quality when compared with women who do not live with children[12].

There were smaller additional effects of maternal age, BMI and age of introduction of solid foods on dietary patterns in infancy, such that poorer-quality diets were more common in families where the mother was younger, of higher BMI, where solid foods were introduced at an earlier age, and where more television was watched. These factors were more consistently predictive of the 'adult foods' pattern – and their influences were independent of the effects of maternal education and maternal diet. Associations between early introduction of solid feeding and younger maternal age with poorer infant feeding practice have been described before, most commonly in relation to breast-feeding incidence and duration[1]. The effect of maternal BMI on infant feeding practice has not been reported before and needs to be replicated.

Tracking of dietary patterns

The tracking of the 'infant guidelines' and 'adult foods' patterns between 6 and 12 months suggests stability in eating habits that we might expect to persist beyond infancy. In children in the Avon Longitudinal Study of Parents and Children, consistent dietary patterns have been described at 3, 4 and 7 years of age, indicating that dietary patterns are stable in early childhood[29,30]. Whilst our understanding of how early eating behaviour influences lifelong food preferences is limited, it is of concern that infants in our population whose diets are already poor may continue to have a poor diet throughout childhood and into their adult life. With continued follow up of the SWS infants we will be able to address how dietary patterns evolve in childhood, and to determine how dietary patterns in early life relate to growth and development, and to functional outcomes in later childhood.

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