Family and infant characteristics associated with timing of core and non-core food introduction in early childhood

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Abstract

Objective—To identify family and infant characteristics associated with timing of introduction of two food types: core foods (nutrient-dense) and non-core foods (nutrient-poor) in a population-based sample of mothers and infants.

Method—Participants were 1861 mothers and infants from the Gemini twin birth cohort (one child per family). Family and infant characteristics were assessed when the infants were around 8 months old. Timing of introducing core and non-core foods was assessed at 8 and 15 months. As the distributions of timing were skewed, three similar-sized groups were created for each food type: earlier (core: 1–4 months; non-core: 3–8 months), average (core: 5 months; non-core: 9–10 months), and later introduction (core: 6–12 months; non-core: 11–18 months). Ordinal logistic regression was used to examine predictors of core and non-core food introduction, with bootstrapping to test for differences between the core and non-core models.

Results—Younger maternal age, lower education level, and higher maternal BMI were associated with earlier core and non-core food introduction. Not breastfeeding for at least 3 months and higher birth weight were specifically associated with earlier introduction of core foods. Having older children was specifically associated with earlier introduction of non-core foods.

Conclusion—There are similarities and differences in the characteristics associated with earlier introduction of core and non-core foods. Successful interventions may require a combination of approaches to target both food types.

Keywords

Infant feeding; core foods; non-core foods

Introduction

The transition from milk feeding to complementary foods is a critical period during which the developmental and nutritional needs of the infant must be met[1]. Despite potential health implications, many caregivers introduce solid foods before the recommended age[2–4] or introduce non-recommended foods. By one year, a substantial proportion of infants consume foods high in fat, salt, or sugar, and low in nutrient density[5,6].

Since 2001, the World Health Organisation has recommended exclusive breastfeeding for the first 6 months of life, followed by introduction of complementary foods alongside continued breastfeeding for up to two years of age or beyond[7]. Introduction of solid foods before 4 months may result in inadequate nutrient or energy intake due to displacement of milk in the diet, and could impose stress on the immature gastrointestinal, immune, and renal system[8,9]. Another potential risk is rapid infant weight gain[10,11] and increased likelihood of obesity later in life[12,13].

Current guidelines recommend that foods high in fat, salt or sugar and low in nutritional value should not be given in the first year of life[14,15]. Such foods have been described as 'non-core' or superfluous to a balanced diet[16–18]. A diet based on foods from the five 'core' food groups (carbohydrate-rich; vegetables; fruits; dairy products; high protein) meets essential nutrient requirements, and 'non-core' foods such as confectionery or savoury snacks are unnecessary[18].

Studies to date have identified a range of family and infant characteristics associated with early solid food introduction, including socioeconomic status, education level, breastfeeding duration, perceived infant hunger, and infant temperament, size and gender[19–23]. However, relatively little attention has been paid to the timing of different food types. This is particularly relevant given the evidence that infancy is an important time for development of eating behaviours and infant dietary patterns track into childhood and beyond[24–26]. Foods given in this period can result in lasting taste preferences after as little as one exposure[27] and have been linked to later food preference and consumption[28–30].

Because infants' first foods tend to be cereals, fruits, and vegetables[2,31,32], which are core foods, studies of the timing of solid food introduction usually reflect introduction of core foods. In the few studies that have examined factors associated with non-core foods[33,34], earlier age of any solid food introduction and presence of older children in the home predicted earlier intake, but there have been no specific comparisons with timing of core foods. In older children there is evidence of differential predictors of core and non-core food consumption[35,36].

The aims of the present study were therefore to i) examine family and infant predictors of the timing of core and non-core food introduction, and ii) test whether different factors were associated with earlier introduction of core and non-core foods.

Methods

Sample

Data were from parent-infant dyads (one infant randomly selected per family) in the Gemini twin birth cohort (n=2402); a study of genetic and environmental influences on early weight gain[37]. The Gemini sample was recruited by the Office of National Statistics and included 36% of all eligible families with twin births in England and Wales during the recruitment period in 2007. Ethical approval was granted by the University College London Committee for the Ethics of non-National Health Service Human Research. The geographical

distribution of participating families reflects the UK population density and the cohort is representative of national twin statistics for sex, zygosity, birth weight, and gestational age at birth[37,38].

Family and infant characteristics were assessed when the children were on average 8.2 months old (SD=2.2, range 4–20). Questions on solid food timing were asked when the children were on average 8.2 and 15.8 months old (SD=1.1, range 14–27). The solid food questions were repeated in a second questionnaire because 55% of infants had not yet tried non-core foods at the time of the first questionnaire. Full data were available for 1861 parent-infant dyads.

Measures

Timing of core and non-core food introduction—In each questionnaire, parents were asked whether the infant had tried any of a list of foods and the age at which they first tried them. Core and non-core food groups were based on the Australian dietary guidelines[18]. Core foods were: baby rice, cereal, rusks or bread; fruit (fresh, frozen or tinned); vegetables (fresh, frozen or tinned); potatoes; meat (e.g. chicken, lamb, pork, beef); fish (fresh, frozen, or tinned); eggs; and dairy products (e.g. milk, cheese, yoghurt). Non-core foods were: savoury snacks (e.g. crisps, cheese biscuits); fried potatoes; processed meat (e.g. sausages, burger); sweet snacks (e.g. cakes, biscuits, ice cream); and confectionary (e.g. chocolate, fruit sweets). Age of core and non-core food introduction was taken as the earliest age (in months) that the infant had first tried each food type. Where available, responses were taken from the 8 month questionnaire. If responses were not available at baseline (e.g. if non-core foods had not been tried), data were from the 15 month questionnaire. This ensured that responses were given closer to the time of actual core and non-core food introduction. Using the two assessment points, mothers reported the timing of core food introduction on average 3.7 months (SD = 2.5, range = 0 – 16) after the event, and the timing of non-core food introduction on average 5.1 months (SD = 2.9, range = 0 – 18) after the event.

The distributions of timing of core and non-core food introduction were skewed, therefore three similar-sized groups were created for each food type: earlier (core: 1–4 months; non-core: 3–8 months), average (core: 5 months; non-core: 9–10 months) and later introduction (core: 6–12 months; non-core: 11– 18 months).

Potential predictors of timing—Family characteristics included maternal age, education, BMI, presence of older children in the home, and duration of breastfeeding. Maternal education was categorised as high (university education), intermediate (vocational or advanced high-school education), or low (no qualifications or basic high-school education). Self-reported height and weight were used to calculate maternal BMI (weight/ height^2). Presence of older children in the home was assessed using the question: 'How many other children live in the home with your twins?' This variable was categorised as none or one or more older children. Breastfeeding was assessed using two questions: 'Which feeding method did you use in the first three months' (response options: entirely breastfeeding, mostly breastfeeding with some bottle-feeding; equally breastfeeding and bottle-feeding; mostly bottle-feeding with some breastfeeding; almost entirely bottle-feeding; and entirely bottle-feeding); and 'If you are no longer breastfeeding, when did you stop' (response options: number of weeks after birth). Responses to the breastfeeding questions were categorised as: i) mothers who at least partly breastfed for at least 3 months and ii) mothers who never breastfed or stopped before 3 months.

Infant characteristics included birth weight, gender and a rating of appetite. Birth weights were taken by health professionals and recorded in the child's personal health record. Parents were asked to photocopy the relevant pages of the health records or copy available

measurements into the baseline questionnaire. Birth weight standard deviation scores (SDS) were calculated adjusting for exact age, sex and gestational age using British 1990 growth reference data and the LMS growth macro for excel[39,40]. Infant appetite was assessed using the item 'How would you rate your twin's appetite in the first 3 months'; measured on a 5-point scale (from 1=poor to 5=excellent). This measure was used to capture general appetite and has been validated against the Baby Eating Behaviour Questionnaire (BEBQ), a comprehensive measure of appetite during the milk feeding period[41].

Statistical analyses—Univariate ordinal logistic regression was used to assess relationships between each family/infant variable and the timing of core and non-core foods. All variables were included in the multivariate models to determine which were independently associated with timing of core and non-core foods. To ensure equal numbers in the core and non-core models, cases with missing data on any of the study variables were excluded. Bootstrapping with 9999 iterations was used to test for differences between the regression coefficients for each family/infant characteristic in the core and non-core models[42]. SPSS 18.0 for Windows (SPSS Inc., Chicago, IL, USA) was used for the ordinal logistic regression analyses, and Stata version 10.1 (Stata Corp., College Station, TX, USA) was used for the bootstrapping.

Results

The total Gemini sample was 2402 families; 541 were excluded due to missing values on one or more of the study variables. There were no significant differences between the full sample (n=2402) and the sample used for analysis (n=1861) on any study variables (data not shown).

Characteristics of the study sample are included in Table 1. Maternal characteristics only are included as in 99% of cases, the mother was the child's primary caregiver. Mothers had an average age of 33 years, a mean BMI of 25.1, 95% were married or cohabiting, and 45% were university educated. Almost a third of mothers had breastfed their babies for at least three months. Almost half (48%) had one or more older children. Infant characteristics are also shown in Table 1. Half the children were male, mean gestational age was 36.3 weeks, and mean birth weight SDS was –0.55; as expected for a twin population. The mean appetite score (3.5) was just above the mid-point of the scale.

The average age for introduction of core foods was 5.04 months (SD=1.03), and for non-core foods was 8.98 months (SD=2.34). On average, infants were introduced to non-core foods 3.9 months after being introduced to core foods; only 2.8% tried both at the same age; and less than 1% started non-core before core foods. At the time of the second questionnaire (average infant age=15.8 months), all infants had tried core food and 98.5% had tried non-core foods.

Almost a third of infants (30.5%) started core foods between 1 and 4 months, 34% at 5 months, and 35% after 6 months. Most of the infants who were introduced to core foods 'later' started at 6 months; only 3.5% started after 6 months. Almost half (46%) the infants were introduced to non-core foods between 3 and 8 months, 28% between 9 and 10 months, and 27% after 11 months. Figure 1 shows stronger clustering of the timing of core than non-core foods.

Predictors of core food introduction

Lower maternal age and education, higher maternal BMI, and less than 3 months breastfeeding were associated with earlier core food introduction. Presence of older children in the home was not associated with timing of core foods. Infant characteristics associated

with earlier core food introduction were: male gender, higher birth weight SDS, and a larger appetite. All characteristics associated with timing of core foods in univariate models remained significant in the multivariate model (see Table 2).

Predictors of non-core food introduction

Lower maternal age and education, higher maternal BMI, less than three months breastfeeding, and older children in the home were associated with earlier non-core food introduction. None of the infant characteristics were related to timing of non-core food introduction. All characteristics associated with timing of non-core food introduction in univariate models, except for breastfeeding, remained significant in the multivariate model (see Table 2).

Because starting core foods preceded but correlated with timing of non-core foods (r=0.28), the non-core multivariate model was repeated including timing of core foods as an additional predictor (see Table 3). In this model, maternal education became borderline significant, but other effects remained the same.

To examine the influence of postnatal growth on timing of core and non-core food introduction, the multivariate models were repeated replacing birth weight with 0–3 month weight gain. As for birth weight, greater 0–3 month weight gain was significantly associated with earlier core food introduction (OR=1.20, 95% CI=1.10–1.30, $p < 0.001$), and not with non-core food introduction (p=0.884). All other effects in the models remained the same as in the analyses using birth weight.

Differences between predictors of core and non-core food introduction

Bootstrapping was used to directly compare predictors of core and non-core food timing. Shorter duration of breastfeeding and higher birth weight SDS had significantly stronger associations with earlier core than non-core food introduction (p=0.030 and p=0.002, respectively). Presence of older children had a borderline significantly stronger association with earlier non-core than core food introduction (p=0.089). For other characteristics, there were no significant differences between the core and non-core models.

Discussion

This is the first study to directly compare family and infant characteristics associated with the timing of core and non-core food introduction. Consistent with recent surveys[3,4], a substantial proportion of infants were given core foods earlier than currently recommended (i.e. six months). Non-core foods were introduced on average four months later than core foods, but nonetheless, three quarters of infants had non-core foods in the first year of life; contrary to current guidelines[14,15].

The findings of this study are largely consistent with previous research on predictors of general solid food introduction[19–23]. Younger, less educated, heavier mothers who breastfed for less than three months introduced core foods earlier. Infants who were male, heavier, and had a heartier appetite were started on core foods earlier. This consistency with previous research is likely explained by the fact that the first foods introduced to infants tend to be core foods[31,32]; but given the potential role of non-core foods in excess weight, it is important to examine both food types.

Using bootstrapping, we could directly compare predictors of core and non-core food introduction and showed that higher maternal BMI and lower maternal age and education predicted earlier introduction of both core and non-core foods. Shorter breastfeeding duration and higher birth weight were associated with earlier core but not non-core food

introduction. The specific association between shorter breastfeeding and earlier core food introduction is perhaps unsurprising given that core foods tend to be the first foods following milk feeding[31,32]. We had anticipated that infant size would relate to both food types, particularly if it is reflected in general food-oriented behaviour[43,44]. The finding was confirmed using weight gain from birth to three months. It is possible that weight beyond three months is relevant to consumption patterns of non-core food but not to the timing of introduction. Having older children showed a trend towards a stronger association with non-core than core food introduction. This may be because older children in the home provide more opportunities for the infant to be exposed to non-core foods. In addition, siblings may be significant role models for development of food habits and preferences[26].

Understanding the similarities and differences in predictors of nutrient-dense and nutrient-poor foods may help to target infant feeding advice. For example, less educated families may need advice related to both core and non-core food introduction, but for infants who are breastfed for less than three months the risk of early introduction is primarily for core foods. Advising parents on how to deal with older children's non-core food consumption may benefit strategies targeting introduction of these foods.

The strengths of this study include having a large, population-based sample, a range of family and infant characteristics, examination of core and non-core foods, and birth weight measurements taken by health professionals. Although some evidence suggests that feeding practices can differ between twin and singleton infants[45], there is no direct evidence to suggest that the study findings would significantly differ in singletons. In contrast, research has shown that several factors associated with infant feeding practices, such as maternal age and education, are the same for twins and singletons[46], and the findings of this study replicate previous research using different samples[19–23]. Measures of timing of solid food introduction were self-report, as in other studies in this area. As the data were collected retrospectively, there may be memory errors and bias; although collecting data at two times meant that parents reported their feeding habits closer to the time that they began using new foods. Research has demonstrated the validity of infant feeding practices recalled at 18 months postpartum[47]; and studies using retrospective reports of solid food introduction have replicated findings from concurrent data[48]. The cut-offs used to create the different timing groups were based on the distributions in this dataset, rather than recommended guidelines for optimal timing. This was because the timings were skewed and creating three similar sized groups produced a more detailed outcome measure that took into account the range of responses. In practice, the groups are close to the existing guidance (delay any solid food introduction until six months and avoid non-core food introduction in the first year of life) and results do not differ from studies that used other cut-offs to examine predictors of general solid food introduction[3,22,23,49].

There is a still a need for clarification about the optimal timing of solid food introduction and the food types to be offered at different stages of weaning. This is important to ensure consistency for research purposes and so that caregivers can confidently use the guidelines in practice. In particular, high-quality randomised studies are needed to determine the long-term health outcomes of early introduction of core and non-core foods. There is evidence that early exposure to certain foods may increase preferences and later consumption[27–29], which would have long-term health consequences. However, while there is evidence linking health outcomes to the timing of general solid food introduction[10-13], few studies have focused on specific food groups, so it is unclear whether the health effects relate to core foods, non-core foods, or both. In terms of timing, adverse health outcomes have been associated with introduction to solid foods before four months; whereas evidence for adverse health outcomes with introduction between four and six months is limited[50]. This may be because few studies have considered a range of cut-offs or food types.

Conclusion

These findings suggest that parents who introduce core foods early into their infant's diet tend also to introduce non-core foods early. Common predictors of core and non-core food introduction include maternal demographics. Infant characteristics were more strongly associated with core food introduction, whereas the presence of older siblings may be relevant to non-core food introduction. To ensure that all infants get the best nutritional start in life, strategies will need to consider parents, infants, and siblings.

Acknowledgments

Abbreviations

OR   Odds ratio

CI   Confidence interval

SDS   Standard deviation score

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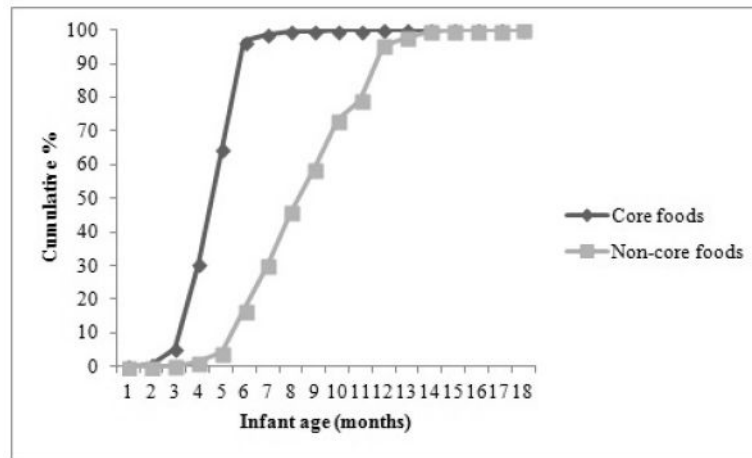
Figure 1.
Cumulative percentage of infants introduced to core and non-core foods by infant age.

Table 1

Characteristics of the total sample (N = 1861, mean (SD) unless stated otherwise)

Family characteristics	
Maternal age, yrs.	33.86 (5.08)
Marital status, n (%)	
Married or cohabiting	1774 (95.3)
Divorced or separated	16 (0.9)
Single	70 (3.8)
Unknown	1 (0.1)
Maternal educational level, n (%)	
High	831 (44.7)
Intermediate	665 (35.7)
Low	365 (19.6)
Maternal BMI	25.07 (4.70)
Breastfeeding, n (%)	
At least 3 months	581 (31.2)
Never or stopped before 3 months	1280 (68.8)
Number of older children, n (%)	
0	969 (52.1)
1 or more	892 (47.9)
Infant characteristics	
Gestational age, wks.	36.30 (2.37)
Gender, n (%)	
Female	928 (49.9)
Male	933 (50.1)
Birth weight SDS	−0.55 (0.94)
Appetite rating	3.52 (1.16)
Core food introduction	
1 – 4 months	567 (30.5)
5 months	638 (34.3)
6 – 12 months	656 (35.2)
Non-core food introduction	
3 – 8 months	854 (45.9)
9 – 10 months	511 (27.5)
11 – 18 months	496 (26.7)

Table 2

Multivariate analyses of family and infant characteristics associated with earlier core and non-core food introduction[1] (N = 1861)

	Core food introduction		Non-core food introduction	
	Adj OR	**95% CI (p value)**	**Adj OR**	**95% CI (p value)**
Family characteristics				
Maternal age, yrs.	0.93	0.91 – 0.95 (<0.001)	0.94	0.93 – 0.96 (<0.001)
Maternal education level				
High	1	–	1	–
Intermediate	1.26	1.03 – 1.54 (0.024)	1.27	1.04 – 1.56 (0.020)
Low	1.49	1.17 – 1.90 (0.001)	1.34	1.04 – 1.71 (0.022)
Maternal BMI (per unit increase)	1.05	1.03 – 1.07 (<0.001)	1.04	1.02 – 1.06 (<0.001)
Breastfeeding				
At least 3 months	1	–	1	–
Never or stopped before 3 months	1.48	1.21 – 1.80 (<0.001)	1.13	0.93 – 1.38 (0.206)
Number of older children				
0	1	–	1	–
1 or more	1.11	0.93 – 1.33 (0.228)	1.35	1.13 – 1.61 (0.001)
Infant characteristics				
Gender				
Female	1	–		
Male	1.26	1.06 – 1.50 (0.008)	1.11	0.93 – 1.32 (0.230)
Birth weight SDS	1.13	1.03 – 1.24 (0.009)	0.95	0.87 – 1.04 (0.298)
Appetite rating	1.09	1.01 – 1.18 (0.024)	1.03	0.96 – 1.11 (0.424)

[1] For the purposes of analyses, timing of core food introduction was coded as: 1 = later (6 – 12 months), 2 = average (5 months), and 3 = earlier (1 – 4 months). Timing of non-core food introduction was coded as: 1 = later (11 – 18 months), 2 = average (9 – 10 months), and 3 = earlier (3 – 8 months)

Adj OR = odds ratio adjusted for all listed variables; 95% CI = 95% confidence interval; 1 denotes the reference group; BMI = body mass index;

Birth weight SDS = Weight standard deviation scores at birth calculated using 1990 UK weight reference data [43]

Table 3

Family and infant characteristics associated with earlier non-core food introduction[1], including core food introduction as a covariate(N = 1861)

	Adj OR	95% CI (p value)
Family characteristics		
Maternal age, yrs.	0.96	0.94 – 0.98 (<0.001)
Maternal education level		
High	1	–
Intermediate	1.22	1.00 – 1.50 (0.055)
Low	1.24	0.96 – 1.59 (0.093)
Maternal BMI (per unit increase)	1.03	1.01 – 1.05 (0.005)
Breastfeeding		
At least 3 months	1	–
Never or stopped before 3 months	1.03	0.85 – 1.26 (0.758)
Number of older children		
0	1	–
1 or more	1.34	1.12 – 1.60 (0.001)
Infant characteristics		
Gender		
Female	1	–
Male	1.05	0.88 – 1.25 (0.598)
Birth weight SDS	0.92	0.84 – 1.02 (0.101)
Appetite rating	1.02	0.94 – 1.10 (0.670)
Core food introduction		
Later	1	–
Average	1.87	1.52 – 2.30 (<0.001)
Earlier	3.20	2.54 – 4.03 (<0.001)

[1] For the purposes of analyses, timing of core food introduction was coded as: 1 = later (6 – 12 months), 2 = average (5 months), and 3 = earlier (1 – 4 months). Timing of non-core food introduction was coded as: 1 = later (11 – 18 months), 2 = average (9 – 10 months), and 3 = earlier (3 – 8 months)

Adj OR = odds ratio adjusted for all listed variables; 95% CI = 95% confidence interval; 1 denotes the reference group