

ORIGINAL COMMUNICATION

Do early infant feeding patterns relate to breast-feeding continuation and weight gain? Data from a longitudinal cohort study

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Objectives: To describe the first-week feeding patterns for breast- vs bottle-fed babies, and their association with sustained breast-feeding and infant weight gain at 6 weeks.

Design: A longitudinal cohort study.

Setting: Feeding diaries were completed by mothers in an urban UK community shortly after birth; follow-up weight and feeding data were collected at routine health checks.

Subjects: Mothers of 923 full-term infants born during the recruiting period agreed to join the study. In all, 502 usable diaries were returned from 54% of the cohort.

Results: Breast-fed infants were fed more frequently (2.71 h between feeds) than bottle-fed infants (3.25 h between feeds) and mixed-fed infants (3.14 h between feeds) ($P < 0.001$) in the first week of life, while duration of feeds was similar. Only exclusive breast-feeding in the first week ($P < 0.001$) and maternal education ($P = 0.004$) were related to continued breast-feeding at 6 weeks. Greater first-week feeding frequency (as measured by feed-to-feed interval, h) was associated with higher weight gain at 6 weeks for breast-feeders, but no analysed factors were associated with higher weight gain for bottle-feeders.

Conclusions: This large-scale study of first-week feeding patterns sheds light on the important and complicated issues of breast-feeding continuation and infant weight gain, with implications for the feeding advice given to mothers. Supplementary bottle feeds were clearly associated with discontinued breast-feeding at 6 weeks. Over that period, higher weight gain was associated with more frequent feeding for breast-fed infants only.

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Introduction

Owing to the many widely recognised benefits of breast-feeding, the World Health Organization recommends exclusive breast-feeding for 6 months (World Health Organization, 2001). Yet this pattern of sustained breast-feeding is uncommon in industrialised countries like the UK (Foster *et al*, 1995). Successful milk feeding, whether breast or bottle, is critical in the early weeks of life when infants are in their most rapid phase of growth. A large body of literature discusses what advice should be given to promote healthy feeding habits (Millard, 1990; Health Education Authority, 1998; Mozingo *et al*, 2000) and discusses the impact of breast- vs bottle-feeding on early growth (Nelson *et al*, 1989; Dewey *et al*, 1992). However, very little documentation exists

to show what patterns of feeding new mother–infant pairs actually adopt, or how these patterns in turn relate to the continuation of breast-feeding and weight gain.

Detailed feeding data may be obtained from observational studies such as sucking technique evaluations (Righard, 1998), videotaping feeds (Wright *et al*, 1980), and measuring milk consumption by weighing the infant before and after a feed (Wright, 1981, 1986; Hillervik-Lindquist *et al*, 1991). Unfortunately, such studies involve cumbersome processes, which interrupt normal regimes and rarely supply enough subjects to explore covariance within the cohort. Experimental work has shed important light on critical influences on feeding (Salaria *et al*, 1978) but is not informative about what happens in ‘free living’ infants.

As part of a large longitudinal study of feeding and growth, mothers were asked to keep a feeding diary, recording the pattern of milk feeding during the first week of life in order to:

- (1) Describe the first-week feeding patterns and how they vary for breast- and bottle-fed infants.
- (2) Test whether any aspect of the feeding patterns (interval between feeds or duration of feeding, or bottle supplementation) or maternal characteristics was related to the continuance of breast-feeding.
- (3) Test whether any aspect of the first-week feeding patterns (breast- vs bottle-feeding, interval between feeds, duration, amount per feed, and feeding rate), or maternal characteristics was related to infant weight gain over the first 6 weeks.

Methods

Study population

The Millennium Baby Study recruited mothers in a deprived, urban, northeastern UK community shortly after the birth of their infant (usually in hospital on the first or second day following delivery) to study patterns of feeding and growth in early life. All babies born to residents of the study community in preset recruiting weeks were eligible for the study. For this analysis we excluded 68 preterm infants (gestation less than 37 weeks), 38 infants from religious minorities with very different feeding norms from the majority population and 141 whose diaries did not cover the requisite time period, leaving 502 diaries for analysis. Ethical approval was obtained from the Local Research Ethics Committee.

The mothers who agreed to join the study completed a recruitment questionnaire that included socio-demographic data. They were issued with a personal child health record, which included weight-recording forms to be completed by health professionals, and a feeding diary that they were asked to complete for 3 days after recruitment and within the child’s first week of life. The diary included columns for the date and time of each feed, type of feed (eg, breast or formula), length of feed and (for bottle feeds) volume of feed.

Diaries were collected by the mothers’ midwives at a routine screening visit and sent back to the project office.

As mothers only reported feeds during the period of diary recording, we have no information on whether formula, water, or breast-milk may have been given before the recording period, but it was hospital ward policy then as now not to offer supplementary feeds to breast-fed infants. Rooming-in was the normal ward practice for both breast- and bottle-fed infants, although this information was not specifically recorded in the diaries either.

Infant weight data collected at the first health-visitor (a public-health nurse with statutory responsibility for pre-school children check) at around 12 days were also sent to the project office. All weights were measured using standard scales in clinical use. At 6 weeks, parents were sent the first of a series of self-completion questionnaires on which they reported current infant milk feeding status as ‘breast’, ‘bottle’ or ‘both’, and transcribed weights from the infant’s routine medical check at 6 weeks of age. At the end of the study (13 months), a duplicate of the weight data from the child health record was also retrieved and used for crosschecking.

Analyses

Three feeding groups were identified from records in the diaries: exclusively breast-fed (BREAST), exclusively bottle-fed (BOTTLE), and both breast- and bottle-fed (MIXED). For each infant, the date and time at the start and end of the diary was entered, and the number of feeds recorded, from which the feed-to-feed interval (defined as the average time from the start of one feed to the start of the next feed) was calculated as a measure of feeding frequency, by dividing the amount of time covered by the diary by the number of inter-feed intervals. Feed duration (min) and, for bottle-feeders, amount (ml) were also recorded for each feed, from which the feeding rate (ml/min) per feed was calculated. In order to characterise the feeding schedule, these variables were averaged over the diary for each mother–infant pair. In addition, they were computed for the first five feeds only, describing feeding patterns on the starting day of the diary. One feed was defined as one entry in the diary.

Outcomes studied at the time the diaries were completed were group differences in the feeding frequencies and feed duration of BREAST, BOTTLE, and MIXED feeders, explored by analysis of variance (ANOVA) with least-significant difference (LSD) post hoc tests, or Kruskal–Wallis tests. The covariance of factors related to feed-to-feed interval and weight gain were determined by stepwise linear regression.

Outcomes assessed at 6 weeks were feeding mode and weight gain. These were related to feeding mode and to feeding characteristics at the time of the diary using ANOVA.

Socio-demographic predictors of breast feeding at the time of the diary and at 6 weeks were also assessed using logistic regression (using the Statistical Package for Social Scientists SPSS, version 10.0). Infant sex and age, in days, at the start of the diary, maternal age and education, gestation, parity and

deprivation were included in all regressions to control for these variables.

Levels of socio-economic deprivation were assessed by two methods. At recruitment, demographic information was collected and used to dichotomise families into *affluent* (homeowner, car owner, and one or more employed parent) and *deprived* (one or more of: rented housing, no car, or no employed parent), for use in logistic regressions. In addition, the child's postcode at birth was used to identify their census enumeration district and the Townsend score (a summary measure using 1991 census data, Townsend *et al*, 1988) for that enumeration district was recorded. These scores were then divided into five categories corresponding to the quintiles for the Northern region, to provide a finer grained classification for linear regressions. Maternal educational information was also collected; for analysis in logistic regression this was dichotomised into those with and without education beyond the age of 16y. Variables with skewed distributions (feed duration, feeding rate and amount of feed) were log transformed for parametric analyses.

Measures of weight gain

Once data collection was completed all weights available for each infant were collated and duplicates deleted. Weights were converted to s.d. scores compared to the UK 1990 growth reference (Freeman *et al*, 1995). All extreme s.d. scores were checked against other weights held on the infant, corrected where possible, or deleted if plainly erroneous (eg where one value was inconsistent with other weights for that infant around the same age). For each infant the weights nearest to the two target ages (12 days, 6 weeks) and within a pre-stated range (9–21, 30–69 days, respectively) were identified. Weight gain was measured using the Thrive Index (TI), which is a measure of change in weight conditional on the baseline (Wright *et al*, 1994). The TI was

calculated as follows:

$$TI = SDS_{\text{time2}} - SDS_{\text{time1}}$$

r being the regression coefficient for the whole survey population for that time interval. The TI equations used in this study were:

$$12 - \text{day TI} = 12 - \text{day SDS} - (0.866 \times \text{birth weight SDS})$$

$$6 - \text{week TI} = 6 - \text{week SDS} - (0.65 \times \text{birth weight SDS})$$

Results

A total of 1254 babies were born in the 34 recruiting weeks. The mothers of 1029 (82%) babies agreed to join the study, of whom 68 preterm, 33 (3%) ultra orthodox Jewish, and five (0.5%) Muslim infants were excluded, leaving 923 participants. Of these, 643 (70%) returned diaries. A total of 47 diaries were excluded where mothers began recording after the infant was over a week old. A total of 19 were completed continuously for less than 12 h, 48 for 12–24 h and 27 for longer than 78 h. Only diaries covering periods of more than 24 h contained enough feeds to be useful, while diaries kept for longer than 78 h were insufficiently detailed. This meant that 502 diaries were used for this analysis, from 54% of the cohort. Mothers returning diaries were less deprived and more likely to breast-feed, but were otherwise similar to the cohort as a whole in their socio-demographic characteristics (Table 1). Mean diary length was 49.6 (s.d. 12.7) h. 45% of the diaries commenced on the first or second day of life.

First-week feeding characteristics

During the period covered by the diary, 172 (34%) infants were exclusively breast-fed, 278 (56%) were bottle-fed, and 52 (10%) were mixed-fed (Table 2). The MIXED group

Table 1 Characteristics of sample in this study (diary returners) compared to cohort as whole

Characteristic	Sample returning usable diaries (N = 502)		Participants not returning usable diaries (N = 421)		Cohort as a whole (N = 923)		P (χ^2)
	N	%	N	%	N	%	
<i>Mother</i>							
Lacking one or more amenity ^a	204	42	217	54	421	47	<0.001
No education past age 16 ^b	335	68	300	73	635	70	0.145
Less than 30 y old	326	65	261	62	587	64	0.372
<i>Infant</i>							
First child	250	50	198	47	448	49	0.428
Boy	264	53	201	48	465	50	0.146
Breast-fed at birth ^c	250	50	174	42	424	46	0.011

^aData missing for 7 cases. Amenities include car or house ownership and employed parent.

^bData missing for 10 cases.

^cAs reported on recruitment questionnaire, not for period recorded in diary; data missing for 5 cases.

Table 2 Descriptive statistics for feed-to-feed interval and duration in diary (first week of life), by feeding group, *N* = 502

Feeding group ^a	N	Feed-to-feed interval (h)		Feed duration (min)			
		Mean (s.d.)	Range	25th	Median	75th	Range
BREAST	172	2.71 (0.66)	1.46–5.07	16.3	21.7	28.0	7–60
BOTTLE	278	3.25 (0.55)	1.53–5.23	15.3	21.4	28.8	4–58
MIXED	52	3.14 (0.55)	1.98–4.25	16.3	24.4	29.4	2–50
P		<0.001 (ANOVA) *		0.292 (Kruskal-Wallis)			

^aBREAST = exclusively breast-fed, BOTTLE = exclusively bottle-fed, MIXED = both breast and bottle fed, as recorded in diary.*Significant differences ($P < 0.001$) in mean feed interval for BREAST vs BOTTLE and also for BREAST vs MIXED, LSD post hoc tests.**Table 3** Number of mothers sustaining breast-feeding at 6 weeks, in relation to numbers in first-week breast-feeding groups

Feeding group in first week	Feeding group at 6 weeks				P (χ^2)
	BREAST	MIXED	BOTTLE	Missing	
BREAST (<i>N</i> = 172)	79 (48%)	32 (19%)	53 (32%)	8	0.001
MIXED (<i>N</i> = 52)	8 (15%)	8 (15%)	32 (70%)	4	

showed wide variation with respect to the proportion of feeds represented by breast-feeds (median = 50%, interquartile range 22.9–78.8%). BREAST infants were fed more frequently than the BOTTLE and MIXED groups ($P < 0.001$), but there was no significant difference between the BOTTLE and MIXED groups in feed-to-feed interval. Feed duration did not differ significantly between the three groups or by infant age.

Bottle- or mixed-feeding (ie, not BREAST) was associated in logistic regression with deprivation (odds ratio (OR) = 3.380, $P < 0.001$, 95% CI = 2.174–5.252) and negatively associated with maternal education (OR = 0.576, $P = 0.01$, 95% CI = 0.378–0.878, >16 y vs less). None of the analysed variables were associated with feed-to-feed interval for BOTTLE or MIXED feeders, but for the BREAST group, the age in days of the first recorded feed (β (standardized) = -0.276, $P < 0.001$) and mother's parity ($\beta = 0.150$, $P = 0.046$) were significant factors in multiple regression. However, these factors had no effect when diaries which began on the day of birth were excluded ($N = 98$).

Age was positively correlated with both volume consumed per feed (for BOTTLE) and feeding rate (ml/min) for the first five recorded feeds (logged values, $\beta = 0.548$, $P < 0.001$; $\beta = 0.252$, $P < 0.001$). Feed duration was negatively correlated with rate ($\beta = -1.055$, $P < 0.001$) and positively correlated with amount per feed ($\beta = 0.603$, $P < 0.001$).

Breast-feeding status at 6 weeks

In all, 48% of the BREAST infants were still exclusively breast-fed at 6 weeks, and 68% were still breast-fed at least in part (Table 3). Only 30% of MIXED infants were still breast-fed at all at 6 weeks (χ^2 $P < 0.001$), half of whom were now fully breast-feeding, and half still mixing breast and bottle feeding. In this MIXED group, those who continued to

breastfeed had significantly longer first-week feed duration than those who had stopped breast-feeding at 6 weeks (Table 4). Neither feed duration nor feed-to-feed interval differed significantly among the 6-week feeding groups for the initially BREAST group.

Maternal education past age 16 (OR = 2.380, $P = 0.004$, 95% CI = 1.313–4.315) and exclusively BREAST-feeding for the diary recording period (OR = 4.672, $P < 0.001$, 95% CI = 2.024–10.786) were associated with exclusive breast-feeding at 6 weeks. Feed-to-feed interval was not significantly associated with breast-feeding continuation.

Weight gain over the first 6 weeks

Weight gain (TI) was significantly lower for BREAST than for BOTTLE-fed infants at 12 days and 6 weeks (Table 5). Among the BREAST group, mother–infant pairs with lower first-week feed-to-feed interval, lower parity, and boys had significantly higher weight gain over the first 6 weeks (Table 6). No variables were significantly associated with weight gain for the BOTTLE or MIXED groups.

Discussion

This study generated three main results. First, the interval between feeds of the MIXED feeding group was closer to the BOTTLE feeding than to the BREAST feeding group in the first week of life. Second, we showed that only exclusive breast-feeding in the first week and maternal education were related to continued breast-feeding at 6 weeks. Finally, we found that higher infant weight gain was associated with more frequent feeding (lower feed-to-feed interval) among BREAST fed infants only.

The diaries demonstrated that, as expected, breast-fed infants were fed more frequently (ie, every 2.71 h) relative to

Table 4 Feed duration in first week and breast-feeding group at 6 weeks (median and quartile values, min)

Feeding group in first week		Feeding group at 6 weeks			P-value (Kruskal-Wallis) ^a
		BREAST	MIXED	BOTTLE	
BREAST	25th	17.0	17.0	14.7	0.526
	Median	23.1	20.9	20.8	
	75th	29.3	27.9	27.5	
MIXED	25th	25.5	23.4	13.3	0.005
	Median	30.8	29.0	18.9	
	75th	49.1	37.7	27.8	

^aThe data show that MIXED mothers feeding for longer durations in the first week were the ones still exclusively or partially breast-feeding at 6 weeks, but the first-week feed duration did not predict breast-feeding continuation for exclusively BREAST mothers.

Table 5 Mean TI at 12 days and 6 weeks, relative to first-week feeding group

Feeding group	12-day TI		6-week TI	
	N	Mean (s.d.)	N	Mean (s.d.)
BREAST	159	-0.081 (0.428)	170	+0.021 (0.700)
MIXED	47	-0.047 (0.436)	46	+0.203 (0.665)
BOTTLE	256	+0.084 (0.337)	249	+0.169 (0.671)
P-value (ANOVA)		0.003*		0.048**

*Significant differences in 12-day TI between BREAST and BOTTLE groups ($P < 0.001$) and MIXED and BOTTLE groups ($P = 0.032$), LSD *post hoc* tests.

**Significant differences in 6-week-TI between BREAST and BOTTLE groups ($P = 0.022$), LSD *post hoc* tests.

Table 6 Factors associated with TI at 12 days and 6 weeks in multiple regression analyses

Sample	12 days					6 weeks				
	N	R ²	Factor	β	P	N	R ²	Factor	β	P
All	462	0.02	Gestation	+0.140	0.025	465	0.03	Sex	-0.140	0.026
								Feed-to-feed interval	-0.128	0.043
BREAST	159	0.03	Gestation	+0.169	0.034	170	0.14	Feed-to-feed interval	-0.254	0.001
								Sex	-0.203	0.006
								Parity	-0.171	0.022

Note: No factors were associated for either BOTTLE or mixed groups.

bottle-fed infants (every 3.25 h). Interestingly, mixed-fed infants adopted a feeding schedule (every 3.14 h) that was more similar to the bottle-fed than the breast-fed pattern. For this reason, it may not always be appropriate, as other reports have done, to report exclusive breast-feeding and mixed-feeding as a single category (Foster *et al*, 1995). In contrast to feed frequency (measured in this study by feed-to-feed interval, h), the duration of feeds did not differ by type of feed, and was highly variable. One interpretation is that infants (and mothers) are still learning about feeding technique at this stage, and so the amount of time required to complete a feed will vary, whereas the feed-to-feed interval would reflect the rate at which the infant digests a previous feed and the type of milk being fed.

The World Health Organization recommends that infants be breast-fed exclusively until 6 months of age (World Health Organization, 2001). However, sustaining breast-feeding for this length of time is more the exception than the rule in the UK (and, indeed, in many countries). A 1995 Health Department survey reported that while 68% of mothers in England and Wales initiated breast-feeding, only 65% of these breast-fed for 6 weeks or longer, while only 32% breast-fed for at least 6 months (Foster *et al*, 1995).

The relationship between the spontaneous feeding patterns reported in this study and breast-feeding continuation is complex, making interpretation more difficult than in experimental-design studies (Salariya *et al*, 1978). Only exclusive breast-feeding at the time of the diary and

maternal education were found to be associated with continuation of breast-feeding for 6 weeks, while feeding schedule *per se* (ie, feed-to-feed interval, duration) did not.

Although the relationship of infant weight gain to health is complex, optimum early weight gain does appear to be an important protective factor against adult disease (Eriksson *et al*, 2001). Whereas the DARLING study (Dewey *et al*, 1992) found that breast-fed infants showed the same rate of weight gain in the first 3 months in breast and bottle-fed infants, another study found slower weight gain over the same period in breast-fed infants (Nelson *et al*, 1989), and a more recent trial of a breast-feeding promotion intervention found that in the intervention arm (where more babies were breast-fed for longer) the overall weight gain was better throughout than in the control arm (Kramer *et al*, 2002). Our study found lower weight gain for breast-feeders, particularly at 12 days, with an attenuated but persisting effect at 6 weeks. This may in part reflect difficulty in establishing feeding in a population where breast-feeding is comparatively rare and support from family and friends may be lacking. Feed-to-feed interval was related to weight gain at 6 weeks for breast-feeders, but not for bottle or mixed feeders. This finding contrasts with one earlier study (Agras, 1987), which found that fewer, but larger, feeds in the first month of life were associated with greater adiposity at age 1–2 y. However, it is difficult to compare this with our study as the time scale covered is so different.

The present study used a large data set of 502 feeding diaries, representing over 25 000 h of recording. Previous studies have also used diaries, but sample sizes tended to be small or the subjects not representative of the general population (Wright *et al*, 1980; Quandt, 1986; Hörnell *et al*, 1999). Only one other study (Hörnell *et al*, 1999) has examined infant feeding in such detail for such a large number of infants, and it found frequency of feeding (recorded at age 2 weeks) to be a significant predictor of breast-feeding continuation. That study's Swedish sample consisted of well-educated mothers who had previously breast-fed a child for at least 4 months; thus, those data may not be transferable in a population where most mothers have little or no breast-feeding experience.

These data do have some limitations; only half of the cohort completed diaries that were both long and detailed enough to be usable and it was not possible to validate the completeness of diary entries. Although there were varying rates of return from different sectors of the study population, the longitudinal design and socio-demographic data collected at recruitment allowed this to be quantified and explored by including socio-demographic variables in the regressions. There is also the possibility of self-selection bias with respect to feeding patterns: mothers feeding very frequently or having difficulty establishing feeding, for instance, may not have completed and returned diaries.

Although infant weights were collected under routine clinical, rather than research, conditions, careful crosscheck-

ing against other data available for each infant ensured that erroneous values would be a rarity. Routinely collected weights have been a powerful resource for previous studies (Wright *et al*, 1994, 2001) and make it possible to assemble much larger data sets than studies that rely on measurement by research staff.

Our results suggest that in clinical settings, the advice given to parents of breast-fed and bottle-fed infants should reflect both the differences in their feeding patterns and the different factors associated with weight gain for these groups. In particular, breast-feeding mothers should be encouraged to feed their children frequently to promote healthy weight gain, and not to supplement with bottle feeds, if sustaining breast-feeding for at least 6 weeks is a priority.

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