Breastfeeding and Introduction of Other Foods

A Prospective Longitudinal Study in Sweden

BY

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ACTA UNIVERSITATIS UPSALIENSIS
UPPSALA 2000
This study, based on daily recordings of infant feeding, comprised 506 infants from Uppsala, Sweden. All mothers had had previous breastfeeding experience of at least 4 months, and were planning to breastfeed the index child for \( \geq 6 \) months.

Among exclusively breastfed infants there were wide variations in breastfeeding frequency and suckling duration per 24 hours both between infants and in the individual infant over time in the first 6 months. Most infants had an average of 1.0-2.9 feeds per night. Infants using a pacifier had fewer feeds and a shorter total suckling duration per 24 hours, and stopped breastfeeding earlier than infants not using a pacifier. These associations were not found for thumb sucking.

Accustoming the infants to solids was a lengthy process, the longer the younger the infant at introduction, and was associated with small changes in the pattern and duration of breastfeeding. In contrast, formula was usually given in large amounts from the beginning, and when formula was given regularly the daily breastfeeding frequency and suckling duration declined swiftly. The younger an infant at the start of regular formula feeds, the shorter the breastfeeding duration. Occasional formula feeds did not affect the breastfeeding duration.

It is important for health personnel and parents to keep in mind that exclusively breastfed infants are not a homogeneous group, but rather members of distinct 'breastfeeding entities'. Moreover, if the aim is to introduce other foods 'under the protection of breast milk' it is important to realise that formula is also 'another food' and needs to be treated as such.

**Keywords**: Accustoming, breastfeeding duration, chewing, coeliac disease, exclusive breastfeeding, feeding frequency, formula, night feeding, pacifier use, sleep, solids, suckling duration, thumb sucking, weaning.

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ISSN 0282-7476

ISBN 91-554-4818-6

Printed in Sweden by University Printers, Ekonomikum, 2000
To Mats, Tove and Björn
Titles of papers included

This thesis for the Degree of Doctor of Philosophy (Faculty of Medicine) in Pediatrics is based on the papers listed below, which will be referred to in the text by the numerals I to IV.


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Errata list

In I. Hörnell A., Aarts C., Kylberg E., Hofvander Y., Gebre-Medhin M. (1999) Breastfeeding patterns in exclusively breastfed infants. *Acta Paediatrica* **88**:203-211. page 204, right-hand column, second paragraph: "Most of the infants (94.5%) were put to the breast within 1 h after delivery". Should read "Most of the infants (76%) were put to the breast within 1 h after delivery (an additional 18% within 2 h)".
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Background

_Becoming a parent_

Becoming a parent entails major adjustments in a person's life. This event is made more difficult if the anticipations do not match reality, i.e. if the infant's behaviour does not match the parents' expectations.

Mankind belongs to the class of mammalia and breastfeeding is therefore the biological norm for the feeding of young infants. However, being biological and natural does not mean that breastfeeding 'comes naturally' to all women (or infants for that matter). In the Western industrialised world, where the nuclear family is the norm, many parents have never taken care of a child before their own infant is born, let alone seen one being breastfed. Most parents turn to books to learn about the behaviour and needs of infants, but there is often a large difference between reality and what books on parenting teach parents to expect, particularly when it comes to breastfeeding and sleeping behaviours.

**Health aspects of breastfeeding**

During the breastfeeding period, breast milk provides passive immunity, protecting the infant against gastrointestinal illness, otitis media and lower respiratory tract infections. Not being breastfed has been referred to as “the most common immunodeficiency” (1). In areas with poverty and poor sanitation, the question whether an infant is breastfed or not often decides whether he will live or die. But breastfeeding is also important where conditions are more favourable. Only with respect to the three illnesses mentioned above, it has been calculated that, compared with exclusive breastfeeding for $\geq 3$ months, non-breastfeeding burdens the American health care services with an increase in medical costs of $331-475$ per never-breastfed infant during the first year of life (2). This calculation only takes account of direct medical costs and does not include factors such as transport to and from the doctor, and parental absence from work.

In addition, through active stimulation of the infant’s own immune system, breastfeeding may also lead to an improvement in the immune response even after cessation of breastfeeding (3). This could explain why breastfeeding might protect against immunological diseases such as coeliac disease (4-7) and (possibly) allergies (8, 9). It has also been shown that breast milk contains factors that improve the neurological development (10, 11).

**Recommendations**

The positive effects of breastfeeding increase with increased exclusiveness of breastfeeding during the first half-year of life and with an increased total breastfeeding
duration. The optimal duration of exclusive breastfeeding and the appropriate age for introducing solid foods are subjects of debate. Between 1990 and 1994, the World Health Assembly (WHA) changed their recommended age for introduction of solids from "4-6 months" to "around 6 months" (WHA resolutions 43.3 and 47.5). In 1995, the World Health Organization (WHO) once again recommended 4-6 months as the suitable age for introducing solids (12). In 1998, a review of current scientific knowledge was published by the WHO Programme of Nutrition (13). The reviewing authors concluded that it would seem safer to recommend exclusive breastfeeding up to the age of about 6 months. Continuation of breastfeeding with addition of suitable foods in sufficient amounts for 2 years or beyond has been recommended by WHO throughout this debate.

Since 1997, the American Academy of Pediatrics (AAP) has recommended about 6 months of exclusive breastfeeding, with gradual introduction of solids in the second half of the first year and continued breastfeeding for up to at least 12 months or for as long thereafter as is mutually desired (14). In the latest UNICEF document (15), it is stated that infants should be exclusively breastfed for about the first 6 months, and that breastfeeding should continue well into the second year and for longer if possible.

In Sweden there is no explicit recommendation as to the length of the period of exclusive breastfeeding, although it is recommended that solids be introduced from the age of about 4 to 6 months. For some time after 1982, parents were told to avoid giving their infants foods or fluids containing gluten up to the age of 6 months in order to reduce the risk of the child developing coeliac disease. In the period 1985-1995, however, an increase in symptomatic coeliac disease among small children was noted in Sweden (7), and after it had been shown that introduction of gluten while the infant is still breastfeeding might protect against this disease (16) the recommendation concerning gluten was changed in 1996. It is now recommended that gluten-containing foods should be introduced in small amounts from around 4-6 months of age, when most Swedish infants are still being breastfed, to allow this introduction to be made under the protection of breastfeeding.

Definitions of breastfeeding terms
In 1991, a consensus was reached on new, more stringent breastfeeding definitions, so as to be able to categorise feeding patterns and simplify comparisons between studies (17). The breastfeeding categories used in the present studies conform with the definitions agreed upon in 1991, except for the use of an extra category (Paper I) of infants receiving formula but no solids, since these infants did not fit into any of the agreed definitions.

The category 'exclusive breastfeeding' comprises infants who receive breast milk only, but allows drops of vitamins, minerals, and/or medicines in addition. In studies
prior to 1991, as well as in several subsequent studies, less stringent criteria for exclusive breastfeeding were used. For instance, infants considered to be 'exclusively breastfed' could have received ritual foods, water, formula feeds and semi-solids (18-21). Furthermore, there have been very few studies with daily recordings, undertaken to follow the day-to-day variation in exclusively breastfed infants over a relatively long period (22). Thus few data are available on the daily variations in breastfeeding patterns. Such information is not only essential for individualised counselling in breastfeeding, but also provides an insight into the mechanisms of breastfeeding.

**Prevalence of exclusive breastfeeding**

Despite recommendations, only a small proportion of the world's infants are exclusively breastfed beyond the first few weeks, even in societies where breastfeeding is the norm (23-27).

In Sweden, as in the other Scandinavian countries, the breastfeeding rates are very high compared with those in most other Western societies, although there are large differences within some areas, e.g. the Stockholm region (28). It has been reported that among Swedish infants born in 1991 (29), virtually all of them (98%) started to breastfeed, and 55% were still being breastfed at 6 months (the latter increased to 73% among infants born in 1996). There are no national statistics, however, on the rate of exclusive breastfeeding in Sweden. In Swedish data derived from Child Health Centre records, 'full breastfeeding' is often denoted as 'exclusive breastfeeding' even though it includes not only exclusively breastfed infants, but also breastfed infants who have received occasional bottles of formula and/or regular tastes of semi-solids. One-third of Swedish infants born in 1991 had started with regular complementary feeds or had ceased to breastfeed altogether at 4 months (29).

**Factors influencing breastfeeding**

Breastfeeding patterns and breastfeeding behaviour depend on a complex interplay between the mother and the infant, and on a number of influencing factors. The frequency of feeds and the completeness of milk removal influence the milk output (30, 31) and the milk fat (31). The frequency of feeds is, in turn, influenced by the infant’s demand and the mother’s ability to store milk (32, 33). The frequency and duration of feeds also has an important impact on the duration of lactational amenorrhoea (34).

The total duration of breastfeeding is correlated with many factors, such as breastfeeding support (35-37), early supplementation (38-41), the mother's age (38, 39, 42), education (23, 38), employment status (23, 38, 43), social class, economic status (42) and smoking habits (39, 42, 44), co-sleeping (42) and the infant's use of a pacifier.
Whether education and social class have a positive or negative association with breastfeeding duration depends on the setting and the time period. The most common reason given for introduction of formula or cessation of breastfeeding during the first 6 months is that the mother believes that she is not producing sufficient milk (23, 50-52). However, Hillervik et al. (53) found no difference between breast milk consumption on days with perceived breast milk insufficiency and that one week later. They concluded that perceived insufficiency was mostly not real and that with prompt encouragement and support there would be no need for supplementation or cessation of breastfeeding.

Infant sleep
Solitary infant sleeping and infants sleeping through the night are seen as the norm in most Western countries. During recent years, pamphlets on how to teach infants to sleep through the night from an early age have been distributed to parents through the Child Health Centre system in some parts of Sweden. In some infants who sleep through the night, it might not be possible to breastfeed successfully, since the breast milk production can be adversely affected if the interval between feeds is too long (54, 55).

Thumb sucking and pacifier use
Infants' sucking habits are described in the literature as nutritive and non-nutritive sucking (56). The prevalence of non-nutritive sucking (i.e. pacifier use and thumb/finger sucking) varies greatly between different cultures (57, 58). The sucking reflex is present from an early age, and thumb sucking has even been shown in the foetus from a gestational age of as early as 18 weeks of (59).

If the infant's inborn urge to suck is not completely satisfied by nutritive sucking i.e. breastfeeding or bottle feeding, he will probably start sucking either his thumb/finger or a pacifier if it is offered (57). There are at least three occasions when the sucking needs of a breastfed infant might not be satisfied by breastfeeding alone: 1) when he is breastfed on schedule, i.e. when the mother decides when and for how long a breastfeed will take place, 2) when he is exclusively breastfed on demand but satisfies his nutritional needs before his sucking needs, and 3) when in addition to being breastfed he is given other foods/fluids by spoon or cup, which might fulfil his nutritional needs but not his need for sucking.

Non-nutritive sucking habits have been studied extensively in both social and medical sciences. Possible positive effects of pacifier use in the prevention of sudden infant death have been discussed (60, 61), but such an effect has also been questioned (62). Thumb sucking and pacifier use have been claimed by orthodontists to be related to dental malocclusion (63). Further, an increased prevalence of oral candida has been
observed in infants using a pacifier (64). Among 845 children in Finland, pacifiers were found to be associated with an increased risk of recurrent acute otitis media (65). It has been shown that the use of a pacifier in the early post-partum period, when the infant is learning to suck from the breast, may interfere with proper sucking and can contribute to so called ‘nipple confusion’ (41, 47, 66, 67). Most studies (42, 45-49) have shown a negative correlation between pacifier use and breastfeeding duration. However, in a study among 650 mothers and infants in Brazil, Victora et al. (41) found no association between use of pacifier and shorter breastfeeding duration among mothers who were comfortable with breastfeeding. This observation has not been verified in other studies or in other cultural settings.

WHO/UNICEF recommends avoidance of pacifiers, step 9 of the “Ten steps to successful breastfeeding“, as part of the Baby Friendly Hospitals Initiative (68).

Definition of ‘weaning’

The breastfeeding definitions agreed upon in 1991 did not include the term ‘weaning’, and its meaning is ambiguous. According to the Concise Oxford Dictionary (69) the word 'wean' means "to accustom an infant or other young mammal to food other than milk", and it has also been defined as the process of accustoming an infant to a full adult diet (while maintaining breastfeeding) (70, 71). But there are also other commonly used interpretations of the term 'to wean', for example gradual discontinuation or even complete cessation of breastfeeding. Often, authors do not clearly state which interpretation they are using. To avoid confusion, it might be best to refrain from using the term 'weaning' altogether (72).

Accustoming to foods other than breast milk

A better understanding of the process of accustoming an infant to foods other than breast milk, especially regarding the introduction of solids and formula, is needed. On the basis of some studies it is claimed that late introduction to solids increases the likelihood of later feeding problems. These studies concern two different aspects of food acceptance, namely 1) the acceptance of new tastes (73), and 2) the acceptance of 'lumpy food' (74, 75). Other studies have shown no detrimental effect of delaying the introduction of solids to 6 months on the appetite or food acceptance (76), growth (77, 78) or iron status (79).

Introduction of other food – effect on pattern and duration of breastfeeding

Breastfeeding is a demand/supply system. That is, provided that the infant is well attached to the breast and is allowed to decide on the frequency and duration of feeds, the breast milk production will vary according to the infant’s needs (33, 55). A common belief among many mothers and health professionals in the industrialised
world is that even small amounts of foods other than breast milk given to a breastfed infant inevitably lead to a decline in breast milk production, especially if they are given during early lactation. This belief is strengthened by many pamphlets on infant feeding in which the introduction of solids is described as a process in which solids replace breast milk and a 'breastfeed' is referred to as a 'breast meal'.

Several groups have studied the effect of introduction of solid foods on the breastfeeding pattern (77, 80-82), although none of them have specifically addressed the question of whether the age at introduction of these foods has any effect on the breastfeeding duration. Many studies have shown an association between early introduction of additional foods and shortened breastfeeding duration (22, 38-40). However, these studies have either concerned only the introduction of formula (38-40) or not differentiated between solids and formula (22). In contrast, in a study in Thailand, Jackson et. al. (83) found no association between early introduction of additional foods and shortened breastfeeding duration in a population where sustained breastfeeding was the norm (median duration 12 months) and use of formula was rare. But they noted that mothers who gave formula as the first additional food stopped breastfeeding earlier than those who started with solids. In a Swedish study, Hillervik-Lindquist et al. (84) also found that small amounts of solid food caused no decrease in breast milk consumption, whereas formula did.

A better understanding of the possible effects of introduction of solids compared with introduction of formula on the pattern and duration of breastfeeding would be of great value. Parents need to know about the likelihood of such effects, so that they can make informed decisions on how they want to feed their infants, in order to avoid inadvertent shortening of the breastfeeding duration. When a breastfed infant is introduced to solids he has to learn to cope both with a new texture and a new way of eating. In contrast, formula is usually given with a bottle, which makes it easy to consume large volumes at once; thus it may be assumed that introduction of formula is associated with greater changes in the pattern and duration of breastfeeding than introduction of solids.

Definitions used in the present studies
The following definitions have been used in the studies:
One breastfeeding episode. Duration of suckling 2 minutes or longer and separated from previous breastfeed by at least 30 minutes. Suckling for less than 2 minutes was not recorded.
Feeding on demand. The mother fed her baby whenever he cried or indicated by some other means that he was hungry.
Daytime. 06.00 - 21.59.
Night-time. 22.00 - 05.59.
Co-sleeping. The infant slept in the same bed as his mother at night with unrestricted access to the breast.

Occasional use of a pacifier or sucking of thumb (or finger/toe). <3 times/24 hours

Frequent use of a pacifier or sucking of thumb (or finger/toe). ≥3 times/24 hours

Age. Given as completed months; e.g. "at 3 months" = infant is 3 months old but not yet 4 months.

Exclusive breastfeeding. The infant received breast milk (including expressed milk) and was allowed to receive vitamins, minerals and medicines (in the form of drops and syrups), but did not receive anything else.

Expressed breast milk. Mother's own breast milk given to the infant by other means than suckling (i.e. with a spoon, bottle or cup).

Taste. ≤10 mL of any liquid or food

Meal. >10 mL of any liquid or food

Solids. Semi-solids and/or solids

Formula. Formula, follow-on formula and/or gruel

Regular formula feeds. ≥1 formula feed/day

Accustoming period. The time from when solids were first given (irrespective of volume) until they were given as daily meals (i.e. >10mL/occasion every day).

Pause. A period during the accustoming period when no solids were given for more than 7 consecutive days.

Solids group. Infants starting with solids at 2 months of age or later, and who never or only sporadically received formula.

Formula group. Infants starting with regular formula feeds at 2 months of age or later, and whose introduction to solids occurred ≤2 weeks before the start of regular formula feeds.

Aims

The specific aims of the four studies were:

- to investigate the breastfeeding patterns of healthy, exclusively breastfed infants (I);
- to study any associations between these breastfeeding patterns and the total duration of breastfeeding (I);
- to study the association between thumb sucking/pacifier use and breastfeeding pattern in exclusively breastfed infants (II);
- to determine whether thumb sucking and pacifier use are associated with breastfeeding duration in infants of mothers with breastfeeding experience and an intention to breastfeed for at least 6 months (II);
- to investigate the introduction of solids and formula to breastfed infants (III), and
- to study changes in the pattern and duration of breastfeeding associated with the introduction of solids and formula (IV).

Material

The present work had a longitudinal prospective design and was based on the Swedish part of a comprehensive collaborative WHO project entitled 'A multicentre, longitudinal study of the duration of lactational amenorrhoea in relation to breastfeeding practices' (34, 85), undertaken between 1989 and 1994. The Swedish part of the project was organised by the former International Child Health Unit, Department of Pediatrics, Uppsala University. All the infants included in the study were born at the University Hospital, Uppsala, where all the deliveries in the county of Uppsala take place. During the recruitment period, May 1989 to December 1992, 15,189 infants were born in the county, 1,177 mother-infant pairs were eligible for participation and 506 agreed to take part. The main reason for non-participation was the anticipated high workload that it was considered the study might entail.

The mother-infant pairs were admitted to the project 3-7 days post-partum, and were followed up until the mother's second menstruation post-partum or a new pregnancy occurred (7.7% of the Swedish mother-infant pairs dropped out of the project for other reasons). The mean duration of participation in the project was 8.6 ± 3.4 months, with a 95% confidence interval (CI) of 6.4-10.7 months.

The mother-infant pairs included in the project fulfilled several selection criteria described in detail in paper I. In brief, all mothers had given birth to one to three children prior to the index child and had had previous breastfeeding experience of 4 months or longer with at least one of them. All were planning to breastfeed the index child for at least 6 months. The infants were singletons, healthy, weighed ≥3.0 kg at birth and were born by vaginal delivery at 37 weeks of gestation or beyond.

The mean age of the mothers was 30.7 ± 3.7 years. Of the 506 mothers, 344 had had one child prior to the index child, 140 had two previous children, and 22 had three previous children. Almost two-thirds (65.2%) of the mothers had university education, and all mothers had at least 9 years of formal education. Seventy-one per cent were married, and 29% lived in a common-law marriage; none was single. Most of the infants (76%) were put to the breast within one hour after delivery (an additional 18% within 2 hours). The study comprised 270 male and 236 female infants.

A convenience sub-sample of 98 mothers was formed to study the introduction of food other than breast milk in more detail. There were no differences between the 98 mothers in the sub-sample and the remaining 408 regarding mother's age and education, number of children, previous breastfeeding experience, duration of labour, length of time before first breastfeed, infant's birth weight, pacifier use and
supplementation before admission to the study, and mother’s smoking habits during pregnancy. However, there were more girls in the sub-sample than among the remaining 408 infants, 57% versus 44%, CI 1.8-23.8 for the difference between the sub-sample and the rest, p=0.030.

Data collection
Data were obtained from daily recordings made by the mothers throughout the duration of the study and from fortnightly structured interviews conducted by a research assistant. The mothers completed two charts during each of these 14-day follow-up periods.

On one chart, on 13 of the 14 days, the mothers made daily records of the number of suckling episodes and of the number and category of other foods/fluids (including expressed breast milk and water), vitamins, minerals or medicines given. When foods/fluids other than suckled breast milk were given, these were described as a 'taste' (i.e. ≤ 10 ml) or a 'meal' (i.e. >10 ml).

The second chart, which the mother completed every 14th day, consisted of a 24-hour detailed record of the timing of every suckling episode and the point in time when other foods/fluids were given.

Thus, in each 14-day follow-up period, the individual infant's breastfeeding frequency was calculated as an average based on one 13-day record, and data on the suckling duration was based on one 24-hour record.

During the fortnightly home visits, the research assistant checked the record charts and recorded data for the previous two weeks, including information about thumb sucking and/or pacifier use. If any foods/fluids other than suckled breast milk had been given, the mothers were asked about the reason for this if a) it was given as a meal (i.e. >10 ml) for the first time, b) the food/fluid had been discontinued but started anew, or c) the reason for giving the food/fluid had changed. The reason for giving tastes was not requested.

The sub-sample of 98 mothers recorded in more detail the volumes of solids and formula taken by their infants (III). The mothers used household measuring cups and estimated the volumes consumed. They were not asked to weigh the food as this was deemed too cumbersome in view of all the other recordings the mothers were already making.

Missing data
Occasionally some mothers did not make records every day in a 14-day period. The missing days in the daily recordings of the exclusively breastfed infants (papers I and II) amounted to 0.7% of the possible days, and 4.0% of their 24-hour detailed recordings were not made.
In each 14-day period, between 8% and 14% of the exclusively breastfed infants co-slept frequently or nightly with their mothers. For these infants, the proportion of missing data concerning the duration of night feeds varied from 7% to 37% between different 14-day periods. Their mothers were usually able, however, to give a good estimate of the number of night feeds. For infants sleeping in their own bed, missing data on the duration of night feeds varied from 0% to 1.2% between different 14-day periods.

Data analysis

The computer programs Quest (86) (I, II) and SPSS (II-IV) were used for data analysis. A p value of less than 0.05 was adopted as a criterion of significance and 95% confidence intervals were used. The breastfeeding duration was known for 393 mothers; 257 mothers stopped breastfeeding while still in the study and an additional 136 sent a letter stating when their infants/children had stopped breastfeeding. The breastfeeding duration in the remaining 113 infants was unknown, and they were therefore censored and their ages at discontinuation from the project were used in the analysis on breastfeeding duration.

Papers I and II

In the studies reported in papers I and II, only infants exclusively breastfed since admission to the study (at 3-7 days post-partum) were included in the analyses of the breastfeeding pattern. Any supplements given to the infants before inclusion in the study were disregarded in the classification.

Table 1. Number of infants in the study at different ages and number of infants exclusively breastfed at each age.

<table>
<thead>
<tr>
<th>Age (weeks)</th>
<th>Infants taking part in the study</th>
<th>Exclusively breastfed infants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total n</td>
<td>Only suckled breast milk n</td>
</tr>
<tr>
<td>2</td>
<td>506</td>
<td>430</td>
</tr>
<tr>
<td>4</td>
<td>499</td>
<td>395</td>
</tr>
<tr>
<td>8</td>
<td>493</td>
<td>337</td>
</tr>
<tr>
<td>12</td>
<td>486</td>
<td>290</td>
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<tr>
<td>16</td>
<td>472</td>
<td>189</td>
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<tr>
<td>20</td>
<td>454</td>
<td>79</td>
</tr>
<tr>
<td>24</td>
<td>423</td>
<td>20</td>
</tr>
<tr>
<td>26</td>
<td>400</td>
<td>7</td>
</tr>
</tbody>
</table>
After admission to the study, as soon as an infant was given anything extra (besides expressed breast milk, vitamins, minerals and medicines), he was excluded from further analysis. The number of infants included in these analyses at different ages can be seen in Table 1. Thirty-five per cent of the 430 infants who were exclusively breastfed during the first 14-day period were given supplements (6% other mothers’ milk, 24% water and 5% formula) before inclusion in the study.

In each 14-day period, the 10-15% of the exclusively breastfed infants who were given expressed breast milk were excluded from the analyses of the breastfeeding pattern during that particular 14-day period, since the patterns could be affected when anything other than suckled breast milk was given.

To analyse differences between groups, the two-sample t-test, the Chi-square test and Fisher’s exact test were used. The Kaplan-Meier life-table was used to assess the duration of breastfeeding. The survival curves were compared using the log-rank test, estimates of relative risk (RR) and median values. Linear regression analysis and/or Cox regression analyses were used to assess associations between breastfeeding patterns, thumb sucking, pacifier use and duration of breastfeeding.

**Paper III**

To analyse differences between groups, the unpaired t-test, Chi-square test or Mann-Whitney U test was used. The Kaplan-Meier life-table and Cox regression analysis was used to analyse the duration of the accustoming period (see Definitions). The Kaplan-Meier life-table was also used to analyse the duration of continued breastfeeding after the decision to stop, and the length of time needed to reach ≥100 mL of solids and/or formula consumed in one day. For comparing the survival curves, the log-rank test was used.

**Paper IV**

The breastfeeding pattern before and after the start of solids (*Solids* group) or regular formula feeds (*Formula* group) was studied both on a group level and on an individual level within the group. For group descriptions see Definitions.

The median breastfeeding frequency and suckling duration in each 14-day period were studied on a group level from 8 weeks before the start of solids or regular formula feeds to up to 14 weeks after this start. To reduce the influence of the introduction of solids on the breastfeeding pattern in the *Formula* group, infants who were given solids in addition to the regular formula feeds were excluded from the group if they were introduced to solids more than 2 weeks before regular formula feeds were started. To allow comparison between the two groups, the 14-day period in which solids were introduced in the *Solids* group and the 14-day period in which
regular formula feeds were started in the Formula group were set to zero in each individual infant.

The change in breastfeeding pattern was analysed for the individual infants within the groups. The breastfeeding frequency and suckling duration 2 weeks before the start of solids or regular formula feeds, respectively, were compared with the corresponding values at 2, 4 and 8 weeks after the start. The difference is expressed as a percentage of the frequency and duration at 2 weeks before the start.

To analyse differences between the Solids and Formula groups, and differences within these two groups according to age at introduction to solids or formula, the Mann-Whitney U test and the Kolmogorov-Smirnov Z test were used. To analyse individual differences within the groups in relation to age at the start of solids or formula, the Jonckheere-Terpstra test was applied. Cox regression analysis was used to analyse the breastfeeding duration in relation to the feeding regime and the Chi-square test was used to analyse differences in relation to the mothers' education.

Summary of results
Most of the exclusively breastfeeding mothers (95%), including those whose infants used a pacifier, considered that they breastfed on demand. A longitudinal analysis showed that 85% of the infants (including those given expressed breast milk) were exclusively breastfed for 2 weeks, 68% for 2 months, 40% for 4 months and 2% for 6 months (Table 1).

Prevalence of thumb sucking and pacifier use (II)
Both thumb sucking and use of a pacifier started early. Mothers were not asked about the infant's thumb sucking during the first week of life, but at 2 weeks of age 61% of all infants sucked their thumb. Pacifiers were given to 60% of the infants during their first week of life. The proportion of infants given pacifiers during their first week of life decreased over time from 67% of the infants born in 1989 to 51% of those born in 1992 (p=0.03) (Table 2). The decrease was greatest between the first and second half of 1992, when 57% and 36%, respectively, used a pacifier during the first week of life.

Changes in non-nutritive sucking between the first and the fourth month were studied longitudinally in all infants who were still in the study at 4 months (n=472). It was found that an increase in thumb sucking was common during the first four months among infants who were non-thumb suckers or occasional suckers at 1 month of age. Most of the infants who sucked their thumb frequently at 1 month continued to do so. In contrast, changes in pacifier use over time were not common among infants who were non-users at 1 month, and those who used a pacifier occasionally at 1 month were almost as likely to become non-users by 4 months as they were to become
frequent users (44% and 37%, respectively). Most of the infants who used a pacifier frequently at 1 month continued to do so.

Table 2 Pacifier use and water consumption during the first week of life, introduction of solids and formula, and breastfeeding duration, by year of birth of infants.

<table>
<thead>
<tr>
<th>Birth year</th>
<th>Pacifier used (%)</th>
<th>Water given (%)</th>
<th>Solids - age at introduction</th>
<th>Formula - frequency</th>
<th>Breastfeeding duration (months) median [25th-75th percentiles]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989 (n=92)</td>
<td>67</td>
<td>35</td>
<td>&lt;4 months (%) 22</td>
<td>Never (%) 2</td>
<td>8.3 [6.4-10.0]</td>
</tr>
<tr>
<td>1990 (n=158)</td>
<td>67</td>
<td>39</td>
<td>&lt;4 months (%) 54</td>
<td>Regularly (%) 38</td>
<td>8.0 [6.3-10.5]</td>
</tr>
<tr>
<td>1991 (n=135)</td>
<td>58</td>
<td>35</td>
<td>≥6 months (%) 20</td>
<td>&lt;1 month (%) 22</td>
<td>8.8 [6.7-11.9]</td>
</tr>
<tr>
<td>1992 (n=121)</td>
<td>51</td>
<td>7</td>
<td>≥6 months (%) 20</td>
<td>&lt;4 months (%) 54</td>
<td>10.3 [8.2-14.6]</td>
</tr>
</tbody>
</table>

P value: 0.03 (1989 versus 1992) <0.001 (1989 versus 1992) n.s. <0.01

Breastfeeding patterns (I and II)

Study I showed that, excluding the infants given expressed breast milk, the median breastfeeding frequency per 24 hours declined slightly during the first 3 months, after which it started to increase again. This was entirely due to changes in the number of night feeds, since the median number of daytime feeds remained relatively constant at slightly below six feeds throughout the first 6 months (Fig. 1a-b).

Wide variations in the breastfeeding frequency and suckling duration were found both between different infants and in the individual infant over time. For instance, the frequency of daytime feeds ranged from 2.9 to 10.8 at 2 weeks of age and from 3.2 to 8.5 at 20 weeks (Fig. 1a).

The frequency of night-time feeds ranged from 1.0 to 5.1 at 2 weeks and from 0 to 4.0 at 20 weeks (Fig. 1b). At any given age during the first 6 months, a maximum of only 2% of the infants were not breastfed during the night. At 2 weeks of age, 75% of
the infants had $\geq 1.0$ breastfeed/night. At 10-14 weeks of age, when the prevalence of nightfeeds was at its lowest, 75% of the infants had $>0.9$ breastfeed/night. At 20 weeks, 75% of them had $>1.1$ breastfeeds/night.

The median total suckling duration per 24 hours declined slowly over the first 6 months (Fig. 2), mostly due to a decrease in suckling duration per feed over time. The suckling duration per 24 hours varied between 25 minutes and 5 hours 35 minutes at 2 weeks and between 44 minutes and 3 hours 52 minutes at 20 weeks.

In study II it was shown that infants who used a pacifier frequently at 1 month of age were less likely to be exclusively breastfed at 4 months than infants who did not use a
pacifier at that age (51% versus 65%, p=0.009, CI 3.9-23.8). In addition, in each 14-day period during the first 4 months, infants who were exclusively breastfed and used a pacifier frequently had approximately one breastfeed less and a 15-30-minute shorter total suckling duration per 24 hours than exclusively breastfed infants who did not use a pacifier (p≤0.01). Infants using a pacifier occasionally had 0.5 breastfeed less per 24 hours during the first 2 months. No differences were seen for thumb sucking.

Breastfeeding frequencies (I), thumb sucking and pacifier use (II) were studied longitudinally in two special groups of infants who were exclusively breastfed at 2 weeks of age. There were 12 infants in each group, corresponding to the 3rd and 97th percentiles regarding frequency of breastfeeds at 2 weeks of age. The infants in the first group ('low frequency') were breastfed ≤5.5 times per 24 hours, whereas those in the second group ('high frequency') were breastfed >11 times per 24 hours at this age. The total suckling durations were 1 hour 50 minutes and 2 hours 47 minutes, respectively, at 2 weeks.

In the first group, eight infants continued on the same low feeding frequency level for 4½-6 months. The remaining four fluctuated between five and eight feeds per 24 hours. In the second group, three infants continued with >11 breastfeeds per 24-hour for 5-6 months. In the remaining nine infants, the number of feeds gradually decreased, but at least eight breastfeeds were usually given per 24 hours. All 24 infants received only small amounts of or no supplements during the first 4 months. The supplements they did get were occasional and consisted mostly of water or formula. The infants in the low frequency group were exclusively breastfed for a mean of 1.8 months, compared with 4.0 months in the high frequency group. The mean breastfeeding durations were 8.2 months and 12.9 months respectively (RR 3.19, p=0.01).

In each 14-day period during the first 3 months, between eight and ten of the 12 infants in the 'low frequency' group used a pacifier frequently, compared with a maximum of two of the 12 infants in the 'high frequency' group (the p values varied between 0.001 and 0.01 in the different 14-day periods). There were no significant differences in the frequency of thumb sucking between the two groups at any age.

The infant with the consistently highest frequency of feeds (Fig 3a) was exclusively breastfed on demand for 22 weeks and was thereafter given semi-solids in addition. He usually co-slept with his mother, sucked his thumb occasionally from 2 weeks of age and frequently from 8 weeks, and started to use a pacifier occasionally at 5½ months of age. The infant with the consistently lowest feeding frequency (Fig 3b) was exclusively breastfed for 16 weeks, mostly not on demand. She was then given tastes of semi-solids (i.e. <10 mL per occasion) in addition up to 26 weeks. This infant never used a pacifier, but sucked her thumb occasionally from 4 weeks and frequently from 8 weeks of age.
Figure 3. Day-to-day variation in the number of feeds per night and per 24 hours in (a) the exclusively breastfed infant with the highest frequency of feeds for the longest period and (b) the exclusively breastfed infant with the lowest frequency of feeds for the longest period.

Thus, there were large variations in the breastfeeding pattern between different infants as well as in the individual infant (I), and pacifier use (but not thumb sucking) was associated with a lower breastfeeding frequency (II).

*Introduction of solids and formula (III)*

**Introduction of solids**

Of the 506 infants, 462 had been given solids before they left the project (Table 3). Four months was the most prevalent age for introduction of solids, with 43% starting at this age. The proportion of infants introduced to solids before the age of 3 months was almost the same as that of infants who started at 6 months or later (3.9% and 5.4% respectively). Most of the infants given solids consumed ≤10 mL at the introduction (n=350; 75.8%) (Table 3).

<table>
<thead>
<tr>
<th>Age at introduction</th>
<th>Solids, n (%)</th>
<th>Formula, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4 months</td>
<td>158 (34.2%)</td>
<td>191 (44.2%)</td>
</tr>
<tr>
<td>4-6 months</td>
<td>279 (60.4%)</td>
<td>132 (30.5%)</td>
</tr>
<tr>
<td>≥6 months</td>
<td>25 (5.4%)</td>
<td>109 (25.3%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>≤10 mL at introduction</th>
<th>Solids, n (%)</th>
<th>Formula, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>350 (75.8%)</td>
<td>22 (5.1%)</td>
</tr>
</tbody>
</table>
The increase in volume was studied in more detail in the sub-sample of 98 infants. Life-table analysis showed that the median duration from the first introduction of solids until the infants consumed 100 mL of solids in a single day was 46 days. The duration was longer the younger the infant at introduction (Table 4). Half of the infants introduced to solids at <4 months reached 100 mL within 65 days of introduction, and 75% within 70 days compared with 39 and 57 days respectively for infants introduced to solids at ≥4 months (p=0.027).

Table 4. Association between age at introduction of solids and time taken to reach 100 mL consumed in a single day. (CI = 95% confidence interval). Median, [25th-75th percentile], (range), CI

<table>
<thead>
<tr>
<th>Age at introduction</th>
<th>Duration to reach 100 mL (days) p value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (n=98)</td>
<td>46, [31-70], (3-155), 38-54</td>
<td></td>
</tr>
<tr>
<td>&lt;4 months (n=30)</td>
<td>65, [46-88], (12-100), 59-71</td>
<td>0.027</td>
</tr>
<tr>
<td>≥4 months (n=68)</td>
<td>39, [27-57], (3-155), 34-44</td>
<td></td>
</tr>
</tbody>
</table>

Accustoming the infants to solids was a slow process, not only in regard to the increase in volume but also in regard to how often the infant was offered solids. Only 16% of the infants were given solids (regardless of volume) on a daily basis immediately after the introduction. During the 'accustoming period' (see Definitions), 110 infants (24%) had at least one period of more than seven consecutive days when no solids were consumed (i.e. a 'pause').

The younger the infant at introduction, the more likely it was that at least one pause would occur. Thirty-six per cent of the infants who were introduced to solids before the age of 4 months had one or more pauses, compared to 20% of those who started with solids at 4 or 5 months of age, and to 4% of the infants starting at 6 months or later (p<0.01). The prevalence of pauses did not differ between infants who first ate solids as a taste and those who ate meals immediately.

The duration of the accustoming period was associated with age at introduction, the occurrence of pauses, the volume consumed at introduction, and the infant's gender (Table 5).
Table 5. Duration of accustoming period (days) by age and volume at introduction of solids, occurrence of pauses, and gender. (95% CI = 95% confidence interval)

<table>
<thead>
<tr>
<th>Age at introduction</th>
<th>Volume at introduction</th>
<th>Pauses¹</th>
<th>Infant gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4 months (n=158)</td>
<td>≤10 mL (n=350)</td>
<td>No (n=340)</td>
<td>Boys (n=243)</td>
</tr>
<tr>
<td>4-6 months (n=279)</td>
<td>&gt;10 mL (n=112)</td>
<td>Yes (n=110)</td>
<td>Girls (n=219)</td>
</tr>
<tr>
<td>≥6 months (n=25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>28</td>
<td>32</td>
<td>21</td>
</tr>
<tr>
<td>95% CI</td>
<td>25-31</td>
<td>28-36</td>
<td>18-23</td>
</tr>
<tr>
<td>25th-75th percentile</td>
<td>13-52</td>
<td>17-56</td>
<td>8-40</td>
</tr>
<tr>
<td>range</td>
<td>0-226</td>
<td>1-226</td>
<td>0-160</td>
</tr>
</tbody>
</table>

¹. Twelve infants have missing data on occurrence of pauses due to discontinuation from study shortly after the introduction of solids.

Kaplan-Meier life-table analysis showed that the median duration of the accustoming period in the whole group was 28 days. The younger the infant at introduction, the longer the accustoming period, with median durations of 42, 25 and 12 days in infants introduced to solids at <4 months, 4-6 months, and ≥6 months, respectively (p<0.001). The median accustoming period was more than twice as long in infants who ate ≤10 mL on the first occasion as in those who ate >10 mL (32 versus 15 days, p<0.001), and almost three times longer in infants who had one or more pauses compared with those who had none (55 versus 21 days, p<0.001). Boys had a slightly shorter accustoming period than girls (27 versus 30 days; p=0.0048), although the age and volume at introduction and the occurrence of pauses; did not differ between boys and girls.

In a Cox regression analysis the duration of the accustoming period in relation to the infant's age at introduction of solids was adjusted for occurrence of pauses (yes/no), volume at introduction (taste/meal), and infant's gender. After adjustment, younger infants still took a longer time to reach daily meals (p<0.001) (Fig. 5).
Figure 5. Duration of accustoming period in relation to age at first introduction of solids. Cox regression analysis adjusted for occurrence of pauses (yes/no), volume at introduction (taste/meal), and infant's gender.

The breastfeeding duration was known for 38 of 71 infants who received solids, but who never (n=47) or only sporadically (n=24) were given formula. The whole breastfeeding period in these 38 infants, including details of the introduction of solids, is shown in Figure 6. Ten, 21 and 7 of these infants started with solids at <4 months, 4-6 months and ≥6 months, respectively. The proportion of infants who had an accustoming period of >30 days decreased with increasing age of the infant at introduction, from eight of the 10 infants who started with solids at <4 months to 8/21 and 2/7, respectively, for infants who were older at introduction.

Reasons for giving solids
Irrespective of the infant's actual age, "infant old enough" was the most common reason (60%) given by the mothers the first time they gave >10 mL of solids. In the individual infant, the reason for giving solids did not change over time.
Figure 6. The whole breastfeeding period, divided into four different periods according to how solids were given, in infants who never or only sporadically were given formula, and whose total breastfeeding duration was known: 1) no solids given (possibly other fluids sporadically), 2) first taste of solids to first meal, 3) first meal of solids to daily meals, and 4) daily meals of solids to last breastfeed. Each bar represents one infant (n=38).

Breastfeeding duration for infants breastfed ≥12 months is given as completed months.

Introduction of formula

Of the 506 infants, 432 had been given formula before they left the project (Table 3). The infants’ age at the first formula feed was more evenly distributed than the age at the introduction of solids, with 6-16% of the infants getting their first formula feed in
each of the first 8 months of life. The use of formula varied considerably both between infants and in the individual infant over time. Twenty-four infants were only given formula sporadically and 279 infants were given formula in each 14-day follow-up period from a median age of 5.1 months. When different 14-day periods were compared regarding the average frequency of formula feeds per 14-day period in the individual infant over time, it was found that this frequency fluctuated between zero and several times daily. However, in those cases where formula began to be given consistently in each consecutive 14-day period, the frequency varied less.

Few of the infants given formula (5.1%) consumed ≤10 mL on the first occasion it was given (Table 3). Of the sub-sample of 98 infants, 32% were given ≥100 mL of formula on the first occasion and a further 34% received this within one week. No association was found between the age at introduction of formula and the volume consumed at introduction. When the formula volume was below 100 ml, it was usually only given occasionally. Rather than giving small amounts of formula to let the infant get used to the formula, expressed breast milk was often given to let the infant get accustomed to the bottle. Most of the time when an infant did consume smaller amounts of formula, it was not because he had not been offered more, but because he refused to take any more.

Reasons for giving formula (>10 ml).

Thirty-one infants (6%) were given formula before admission to the study (at 3-7 days post-partum). The reason for this was not asked for. Before the age of 4 months (excluding the first 3-7 days) the main reason stated for giving formula for the first time was "infant not satisfied/too little milk" (38.2%). The second most common reason was "mother temporarily absent" (21.9%). At 4 and 5 months, "infant not satisfied/too little milk" was still the main reason for introducing formula (28.0%), but now the second most common reason (22.0%) was "infant/mother sleep at night" (i.e. the mother wanted the infant to sleep better during the night or she herself needed more sleep). When the stated reason was that the parents wanted the infant to sleep better, either the mother or the father usually gave formula in the evening. When the reason given was that the mother needed more sleep, the father usually gave formula during the night.

"Infant old enough" was first mentioned at 4 months as a reason for introducing formula (7%). This was the main reason between the ages of 6 and 10 months (22.9%), closely followed by "infant should get used to bottle and/or formula" (18.3%) and "mother is planning to stop breastfeeding" (14.7%).

Infants who only received formula occasionally usually received it because the mother was temporarily absent, while the main reason for starting regular formula
feeds was that the mother thought that she did not produce enough milk for her infant's needs.

Fifty-seven of the 432 mothers who ever gave their infant formula gave their intention to stop breastfeeding as the reason for giving formula. Kaplan-Meier life-table analysis showed that after the decision to stop breastfeeding, they continued to breastfeed for a median of 57 [32-94] days. One mother continued for another 258 days.

Effect on breastfeeding pattern (IV)

The two groups whose breastfeeding patterns were studied, the Solids and Formula groups, differed in several respects. The mothers in the Solids group were older, were more likely to have university education, had breastfed their previous child longer, and breastfed the index child more than twice as long as the mothers in the Formula group (Table 6). There were no differences between the groups regarding parity and birth weight of the index children.

The infants in the Solids group were introduced to solids slightly later than those in the Formula group (median 4.5 versus 4.3 months), but the difference was not significant (Table 2). In both groups, regardless of the infant's actual age at the time of introduction of solids, the main reason for this introduction was that the infant was old enough (56.1% and 54.8%, respectively). The main reason (38.1%) for the start of regular formula feeds was that the mother thought that she did not have enough milk for her infant's needs. Only two of the mothers in the Formula group gave their intention to stop breastfeeding as the reason for starting regular formula feeds.

Group analysis of breastfeeding pattern

The median breastfeeding frequency per 24 hours was stable in the Solids group during the 8 weeks before solids were started, and remained so (even increased slightly) during the first 6 weeks following the introduction of solids, before a slow decline began (Fig. 7). Infants who were 6 months old or older at the introduction of solids started to decrease their breastfeeding frequency earlier than younger infants (Fig 8). The decline started after only 2 weeks, and from 6 weeks after the introduction of solids the difference between those starting at ≥6 months and those starting earlier was significant (p<0.05).

The median suckling duration per 24 hours started to decline earlier than the breastfeeding frequency, and its decrease already began in the 14-day period following that in which solids were introduced. The curve of the decline was similar irrespective of the infants' age at the introduction of solids, although older infants had a shorter suckling duration per 24 hours before the introduction of solids.
Table 6. Comparison of the Solids and Formula groups; age at introduction of solids and regular formula feeds, some background factors, and breastfeeding duration of index child.

<table>
<thead>
<tr>
<th></th>
<th>Solids Group (n=66)</th>
<th>Formula Group (n=63)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age at start of solids (months)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>4.5</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>25&lt;sup&gt;th&lt;/sup&gt; - 75&lt;sup&gt;th&lt;/sup&gt; percentiles</td>
<td>3.9-5.0</td>
<td>3.8-4.9</td>
<td>0.067</td>
</tr>
<tr>
<td>Range</td>
<td>2.7-8.0</td>
<td>2.8-6.0</td>
<td></td>
</tr>
<tr>
<td>&lt;4 months, n (%)</td>
<td>18 (27.3)</td>
<td>20 (32.3)</td>
<td></td>
</tr>
<tr>
<td>4-6 months, n (%)</td>
<td>38 (57.6)</td>
<td>41 (66.1)</td>
<td></td>
</tr>
<tr>
<td>≥6 months, n (%)</td>
<td>10 (15.1)</td>
<td>1 (1.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Age at start of regular formula feeds (months)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>3.9</td>
<td>Not applicable</td>
<td>n.s.</td>
</tr>
<tr>
<td>25&lt;sup&gt;th&lt;/sup&gt; - 75&lt;sup&gt;th&lt;/sup&gt; percentiles</td>
<td>Not applicable</td>
<td>3.1-4.7</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>2.0-6.2</td>
<td>3.2-7.2</td>
<td></td>
</tr>
<tr>
<td>&lt;4 months, n (%)</td>
<td>33 (52.3)</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>4-6 months, n (%)</td>
<td>Not applicable</td>
<td>27 (42.9)</td>
<td></td>
</tr>
<tr>
<td>≥6 months, n (%)</td>
<td>3 (4.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mother's age</strong></td>
<td>Mean ± 1 SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31.7±3.8</td>
<td>30.4±3.7</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Mother's education</strong></td>
<td>No university (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.8</td>
<td>39.7</td>
<td>0.067</td>
</tr>
<tr>
<td><strong>Breastfeeding duration (months)</strong></td>
<td>Previous child (recall data, complete months)</td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Median</td>
<td>9.0 [7.0-11.0]</td>
<td>7.0 [6.0-9.0]</td>
<td></td>
</tr>
<tr>
<td>25&lt;sup&gt;th&lt;/sup&gt; - 75&lt;sup&gt;th&lt;/sup&gt; percentiles</td>
<td>13.9 [10.4-19.8]</td>
<td>6.2 [5.3-7.7]</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Infant's gender</strong></td>
<td>Boys (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36.4</td>
<td>57.1</td>
<td>0.018</td>
</tr>
</tbody>
</table>

1. One infant in the Formula group discontinued from the study before he was introduced to solids.

In the Formula group, the breastfeeding frequency started to decrease already before regular formula feeds were begun, and the difference from the Solids group was significant (p=0.013) 4 weeks before the start (Fig. 7). As soon as regular formula feeds were initiated, a sharp decrease in the frequency of breastfeeding and the suckling duration was seen. These decreases showed no relationship to the infants’ age at the start of regular formula feeds (Fig. 8). (Since only three infants in the Formula group started to have regular formula feeds at 6 months, differences in relation to age
Figure 7. The median breastfeeding frequency in the Solids and Formula groups before and after the start of solids or regular formula feeds. The 14-day period when solids and regular formula feeds were started is set to zero. ● = Solids group, ○ = Formula group.

Figure 8. The median breastfeeding frequency by age at introduction of solids in the Solids group and of formula in the Formula group, before and after the start of solids or regular formula feeds. The 14-day period when solids or formula was started is set to zero. Solids: ■ = <4 months, ▲ = 4-6 months, × = ≥6 months. Formula: □ = <4 months, △ = ≥4 months (includes three infants starting with regular formula at 6 months).

The duration of suckling per 24 hours also decreased quickly in the Formula group. The difference in suckling duration was significant from the 14-day period when solids and formula were started.

Individual analyses of changes in breastfeeding pattern

The individual analyses showed that the changes in breastfeeding frequency and suckling duration varied considerably between individual infants, although the variation was smaller in the Solids group than in the Formula group (Fig 9). For instance, 2 weeks after the start of solids in the Solids group, the individual changes in breastfeeding frequency varied between a 23% increase and an 18% decrease. In the Formula group, the individual change 2 weeks after the start of regular formula feeds varied between an increase of 25% and a decrease of 94%.

In the Solids group, the group median for individual change in breastfeeding frequency did not deviate much from zero until 8 weeks after the introduction of solids, when the median change in the group was -11%.
Figure 9. Individual changes (%) in breastfeeding frequency. The breastfeeding frequency 2 weeks before the start of solids or regular formula feeds is compared with the frequencies 2, 4 and 8 weeks after the start in the individual infant. The box-plots show the median values, 25th and 75th percentiles, outliers (O) in the Solids and Formula groups.

In contrast, the group median change in breastfeeding frequency in the Formula group was -18% as early as 2 weeks after the start of regular formula feeds. Eight weeks after the start, the median change was -72%.

A decline in suckling duration was seen in both groups as early as 2 weeks after the start of solids or regular formula feeds. This decline was considerably less pronounced, however, in the Solids group (median changes -12%, -12% and -32% at +2, +4 and +8 weeks, respectively) than in the Formula group (median changes -37%, -55% and -90%).

Again in the individual analysis, infants starting with solids at 6 months or later showed a larger decrease in the breastfeeding frequency 8 weeks after the introduction of solids than infants introduced to solids at <4 months and at 4-6 months (-21% versus -10% and -9% respectively), although the difference was not statistically significant (p=0.058). There were no significant age-related differences in suckling duration in the Solids group, and no age-related differences in either frequency or duration in the Formula group.

Thus, both on a group and on an individual level, introduction of solids was associated with a much smaller change in the breastfeeding pattern than the start of regular formula feeds, and the infant's age at the start made little difference.
duration in the *Solids* group, and no age-related differences in either frequency or duration in the *Formula* group.

Thus, both on a group and on an individual level, introduction of solids was associated with a much smaller change in the breastfeeding pattern than the start of regular formula feeds, and the infant's age at the start made little difference.

**Breastfeeding duration and related factors; all infants**

The duration of breastfeeding increased during the course of the study, both within the project (Table 2 and Fig. 10) and in the county of Uppsala as a whole (Fig. 10), and several factors known to be associated with the breastfeeding duration also changed (Table 2).

![Breastfeeding frequencies at 4, 6 and 12 months by birth year. Comparison between the WHO project and the county of Uppsala (Note: no data available for breastfeeding at 12 months in the county of Uppala).](image)

The routines at the maternity wards changed in 1992, and as a result fewer infants were given water and/or offered a pacifier during the first week of life. The use of formula showed a steady decline between 1989 and 1992, and in addition the infants that were given formula received their first formula feed at an increasingly higher age.

No significant difference in total breastfeeding duration was found between infants who used a pacifier during the first week of life and those who did not. Nor was there any difference in total breastfeeding duration between infants who never used a pacifier (n=75) and those who stopped using a pacifier within 2 months (n=84; RR=0.91, p=0.63). The combined group of children who never used a pacifier or stopped within 2 months (n=159) was used as a reference group in a Cox Regression analysis. In this analysis, an increasing frequency of pacifier use during the first 6 months was found to be related to a decline in the total breastfeeding duration. The
median breastfeeding durations in infants who did not use a pacifier/stop early, and in those who used a pacifier occasionally, often or frequently were 10, 9.0, 8.3 and 7.5 months, respectively (p<0.001).

Among the infants never given formula, age at introduction of solids showed no association with total breastfeeding duration. Age at start of regular (but not occasional) formula feeds was significantly associated with breastfeeding duration even after adjustment for mother's education and infant's year of birth (Crude model in Table 7, p<0.001). When the use of pacifiers was entered in the model these associations remained (Table 7 and Fig. 11).

Table 7. Median (Md) breastfeeding duration in months in relation to pacifier use during the first 6 months and the use of formula during participation in the study, calculated from a Crude regression model and after adjustment for mother's education and infant's year of birth.

<table>
<thead>
<tr>
<th>Formula use</th>
<th>Crude model</th>
<th>Never/occasional pacifier</th>
<th>Often/frequent pacifier</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Md</td>
<td>Md</td>
<td>Md</td>
</tr>
<tr>
<td>Never</td>
<td>14.7</td>
<td>15.9</td>
<td>11.9</td>
</tr>
<tr>
<td>Occasionally</td>
<td>12.0</td>
<td>12.8</td>
<td>10.2</td>
</tr>
<tr>
<td>&gt;1/day from &lt;4 months</td>
<td>9.0</td>
<td>9.8</td>
<td>8.5</td>
</tr>
<tr>
<td>&gt;1/day from 4-6 months</td>
<td>7.0</td>
<td>7.8</td>
<td>6.4</td>
</tr>
<tr>
<td>&gt;1/day from ≥ 6 months</td>
<td>5.9</td>
<td>6.4</td>
<td>5.8</td>
</tr>
</tbody>
</table>

The proportion of mothers with university education did not change over time, but mothers with university education breastfed longer than mothers without such education (median [25th-75th percentiles] 9.1 [7.1-12.0] months versus 8.3 [6.0-10.1] months; p<0.001), and they also differed in how they fed their infants. For instance, a higher proportion of mothers with university education never/only occasionally gave their infants formula (39% versus 24% of mothers without such education; p=0.014), and mothers with university education introduced solids and formula later (31% versus 41% gave solids at <4 months, p=0.037; and 38% versus 55% gave formula at <4 months, p=0.001).
Discussion

The most important findings

The most important findings in the present work were as follows: a) There were wide variations in breastfeeding patterns among exclusively breastfed infants, both between individuals and in the same individual over time (I). b) Pacifier use, but not thumb sucking, showed an association with the breastfeeding pattern and the duration of both exclusive breastfeeding and total breastfeeding, even among these infants with motivated and experienced mothers (II). c) Accustoming infants to solids was a lengthy process in most cases (III), and it took several weeks before introduction of solids affected the breastfeeding pattern (IV). On the other hand, formula was usually given in large amounts immediately (III); and the breastfeeding frequency and suckling duration declined quickly when regular formula feeds were started (IV).

On the basis of the research finding that introduction of gluten to infants while they still are breastfeeding might protect them against coeliac disease (16) it has been recommended in Sweden since 1996 that gluten-containing foods be introduced in small amounts from around 4 to 6 months of age (an age when most Swedish infants are still being breastfed). One clinical implication of the findings in the present study is that this would easily be achieved if gluten were given in the form of solid food.
Validity and reliability

These studies have provided unique opportunities to study infant feeding in a prospective, detailed, day-to-day manner over a long period of time in a sizeable sample of mother-infant pairs. It is clear that the studies concern a highly selected group of mother-infant pairs from a population known to have a high rate of breastfeeding, but nevertheless the studies have provided information of value for the understanding of breastfeeding patterns of exclusively breastfed infants, of the accustoming of breastfed infants to solids and formula, and on the way in which breastfeeding is affected by this introduction and by pacifier use and thumb sucking. However, it is important to remember that the work is observational and does not address the issue of optimal timing of introduction of solids or formula.

All mothers had had previous breastfeeding experience of at least 4 months and intended to breastfeed the index child for 6 months or longer. Undoubtedly these selection criteria have had a bearing on the total breastfeeding duration as well as on the duration of exclusive breastfeeding. However, in view of the fact that most mothers (95%), including those giving their infants pacifiers, considered that they breastfed on demand and that it seemed as if the feeding of solids and formula also was basically child-led, it is unlikely that the selection criteria will have had any influence on the individual infant's breastfeeding pattern while exclusively breastfeeding, or on the way solids and formula were accepted by the infant once they were introduced. However, the mothers might have been more likely to notice (and act upon) signs of dislike from their infants.

At every home visit, the research assistant judged whether the information given in the detailed 24-hour record was likely to be accurate. Between 5.3% and 9.2% of the 24-hour recordings were deemed to be not accurately made. The most common reason for 'inaccuracy' was that the mother was not entirely certain about the number of feeds (especially during the night), or that she had given an estimate instead of the exact timing of a feed during the 24 hours. An estimation of the number of feeds was more likely to be made when infants fed frequently, but it is not known whether the reported frequency was an under- or overestimation of the true frequency. The definitions of thumb sucking and pacifier use employed in study II sometimes made it difficult to classify the sucking as 'occasional' (<3 times/24 hours) or 'frequent' (≥3 times/24-hours). At least during the first 3-4 months, when the infant is unable to take the pacifier by himself, the frequency of thumb sucking is more likely to be underestimated than the frequency of pacifier use, since thumb sucking is controlled by the infant and parents do not observe their infants continuously during the 24 hours of the day. However, during the study period, which lasted many months and included numerous contacts with each individual mother, the mothers were found to be very
trustworthy and co-operative, and the recordings were in agreement with the interview results. Gaps in data due to missed recordings were few. The reliability of the data was thus considered good.

Variation in breastfeeding pattern

The most important finding in study I was the wide variation in the breastfeeding pattern, both between infants and within the same individual infant over time. Quandt (87) found corresponding variations in the breastfeeding pattern at 4 (n=68) and 8 (n=48) weeks of age among exclusively breastfed infants in the USA. The intra-individual variations in breastfeeding frequencies over time in study I were quite consistent in some infants, while others showed wider day-to-day variations. It is important for health personnel and parents to keep this variation in mind and not focus on the median or mean values, when dealing with individual infants.

Thumb sucking and pacifier use

The prevalence of thumb sucking and pacifier use was already high by the age of 2 weeks, even though at that age most infants only sucked their thumb and/or pacifier occasionally. Frequent sucking of the thumb and/or pacifier by the age of 1 month was usually a sign of an established habit.

The 24 infants who constituted the 3rd and 97th percentiles in breastfeeding frequency at 2 weeks illustrate how the inborn urge to suck can be channelled in different ways. During the first 6 months, most of the infants in the 'low frequency' group used a pacifier frequently, whereas virtually all of the infants in the 'high frequency' group never used a pacifier. We did not ask the mothers the reason why they gave their infants a pacifier, so we do not know whether it was given in a conscious effort to keep the number of breastfeeds down, or whether the breastfeeding frequency declined as a consequence of the pacifier use. The question whether the use of pacifiers leads to inadvertent shortening of the breastfeeding duration probably depends both on the mother and on the infant. It is clear that it is the parents who decide whether a pacifier should be introduced or not, although it is up to the infant to accept or reject it.

Feeding on-demand

Most of the mothers in the present studies considered that they breastfed on demand, even those who provided their infants with a pacifier. It was the mother's own perception of 'on-demand feeding' that decided whether she was classified as feeding on demand or not. This resulted in a wide range of 'feeding styles' within the 'on-demand feeding group', from a more rigid (but not scheduled) style, to a true on-demand style. In her American study, Quandt (87) found an association between the
size of the home and the frequency of feeds. Mothers living in compact dwellings were physically closer to their infants and therefore more able to detect early feeding cues, which reduced the between-feed intervals and increased the feeding frequency. Most of the mothers in Quandt's study also reported that they fed on demand, but Quandt concluded that their feeding pattern might be more accurately described as 'on perceived demand'. 'On-demand feeding' is difficult to define objectively, as it concerns an interaction between the mother and infant. Differences in the mothers' perception of feeding on demand might explain the wide range in breastfeeding frequencies seen in study I. They might also explain why pacifier use was associated with a decrease in breastfeeding while thumb sucking was not - it is possible that mothers who did not give their infants a pacifier were more likely to have fed their infants in a 'true' on-demand style.

Sleep

In the Western industrialised world, sleeping through the night is seen as a developmental milestone and the 'normal' thing to do. During recent years it has become popular to try to make infants sleep through the night from an early age (88-90). Although it would be more convenient if infants did sleep through the night, this might not be biologically compatible with keeping up the breast milk supply. The level of prolactin, the hormone that stimulates milk synthesis (54), increases after a breastfeed, thus ensuring continued breast milk production. Owing to the circadian rhythm of prolactin, night feeds have a stronger effect on the prolactin level than feeds during the day. It has also been discovered that milk secretion is under autocrine control by an inhibitory milk protein, named FIL factor (Feedback Inhibitor of Lactation) (91). This protein acts by locally controlling the rate of milk secretion within each mammary gland. The concentration of FIL-factor in the mammary gland is dependent both on the length of time since the last breastfeed and the degree of breast-emptying at that feed, a longer duration and less milk removed resulting in a higher FIL factor concentration. Milk production can be adversely affected if the interval between feeds is too long. In some women, having an infant who sleeps through the night may thus lead to insufficient breast milk.

McKenna et al. (92, 93) have conducted extensive research on infant sleep, and McKenna states that "we need to determine if unrealistic parental expectations, rather than infant pathology, play a role in creating parent-infant sleep struggles..." (94). Breastfed infants usually wake more often than those that are formula-fed. Elias et al. (95) followed up 32 mother-infant pairs prospectively for two years. They found that breastfed infants slept for a median of 4-7 hours at a time regardless of age, whereas weaned infants slept 9-10 hours at a stretch. When they added co-sleeping as a factor, they found that breastfed infants who co-slept with their mothers had the shortest sleep
bouts. Breastfed infants who did not co-sleep slept longer, and those infants who had stopped breastfeeding and did not co-sleep had the longest sleep bouts. Wolke et al. (96), in a study on sleep problems in Finland and Germany, classified co-sleeping per se as a sleeping problem. Yet in a world-wide perspective, solitary sleeping by infants is a rare phenomenon, and it did not occur in the Western World until about 100-200 years ago (92). With this in mind, co-sleeping should not be classified as a problem unless the parents see it as such. Early termination of breastfeeding might be prevented if parents are told that breastfed infants usually need some feeds during the night. A breastfeeding mother who compares her infant's sleep with the sleep pattern shown by formula-fed infants might otherwise be inclined to believe that her own infant sleeps less because she has an insufficient milk supply. If parents are told that their infant will probably feed several times during the night and that this is normal and healthy, they will be more likely to take the night feed(s) in their stride. If they assume that most infants (except their own) sleep through the night from an early age, they will be more inclined to see the night waking as a problem.

Introduction of solids and formula

Parents all over the Western world are usually advised to introduce solids by giving them daily, slowly increasing the amounts, until a whole 'breast meal' can be replaced. This would enable the infant to become slowly accustomed to the new taste and texture. There is generally no such recommendation regarding formula. The reason for this might be partly that health professionals (and parents) conceive formula as being equal to breast milk and partly that it is seen as a replacement for breast milk.

Getting accustomed to other foods

In the present study, solids were usually given regularly straight from the introduction, although in most of the infants it took quite a long while before they were given on a daily basis (and the amounts could be very small for a considerable time). However, almost one-fourth of the infants (24%) had at least one period of seven days or longer, after the first introduction, when solids were not given at all. These pauses were usually not related to any adverse reactions to the food given. In a report from Thailand in 1992 (83), Jackson et. al. noted that 18% of the mothers did not immediately continue feeding supplements after introducing them for the first time. They give no further details about the length of the interruption or the reasons for them.

There are several possible explanations (not mutually exclusive) for why younger infants needed more time before receiving daily meals and larger volumes of solids, and also why they had more pauses during which solids were not given. Younger infants are more physically immature and probably therefore need more time to master
the art of eating solids. For instance, the extrusion reflex only starts to disappear at around 4-6 months (97) and when this reflex is still present, the infant is more likely to 'spit out' the food. Parents might take this as a sign either that the infant does not like the food or that he is still too immature to receive it. Both these interpretations could result in periods of varying lengths when solids are not given. In addition, mothers of the younger infants possibly felt that they could accustom their infants to solids at a more leisurely pace because the infants were younger. As some mothers stated, "My infant is old enough to receive solids now and if I introduce them this early, there is no rush and it doesn't matter if it takes a long time for him to learn".

The use of formula could fluctuate considerably over time in the individual infant. About one-fifth (18%) of the infants changed back and forth between several times daily, several times during a 14-day period, only occasionally and/or no formula at all.

**Age at introduction and later food acceptance**

Swedish recommendations state that solids should be introduced from 4-6 months of age. Thus it was surprising to find that as many as 34% of the infants in this study received their first solids before they were 4 months old.

There has been some concern that a longer duration of exclusive breastfeeding (or even prolonged/sustained breastfeeding per se) might lead to problems with acceptance of solid food, i.e. of the new tastes and textures (73, 75). According to Harris et al. (98) and Harris (73) there is a period of optimal acceptance of new tastes at, or possibly before, 4 months and solids should therefore be introduced at about this time. They state that "After this age, new tastes, other than those predominant in the milk feed, are less likely to be accepted" (73). However, as the only tastant they used was salt (sodium chloride), this 'preference for foods resembling breast milk' is only equivalent to a preference for foods low in sodium and does not really give any indication as to how well the infant will accept foods other than breast milk.

Furthermore, in view of the association between a high salt intake in infancy and increased blood pressure (99, 100), and of the association between a high salt intake in adults and a later risk of hypertension, stroke and several other illnesses (101), many Western countries recommend a reduction in salt intake (102, 103). If delaying the introduction of solids to breastfed infants until about 6 months of age results in an established preference for foods low in sodium from an early age it might be advantageous.

Mennella and Bauchamp (104-106) tested a range of flavours other than salt by altering the breastfeeding mother's diet, and found that breastfed infants are subjected to a wide range of flavours through the breast milk. They concluded that breast milk accustoms the infant to the flavours characteristic of his family's diet. In contrast, formula-fed infants experience a very constant set of flavours. It has been shown in
animal studies that animals experiencing a wide range of flavours during suckling are more likely to accept unfamiliar foods later on (107).

The question whether the difference in sensory experience between breastfed and formula-fed infants influences the human infant's willingness to accept new foods was studied by Sullivan and Birch (108). They compared 19 breastfed infants (10 were given some formula) with 17 exclusively formula-fed infants and found that although the infants' intake of a new food did not differ initially, breastfed infants increased their intake of the new food after exposure to it, much more quickly than the formula-fed infants.

The belief that a longer duration of exclusive breastfeeding might cause later problems with food acceptance has also been contradicted by Cohen et al. (76). They found no difference in food acceptance at 9 and 12 months between two groups of infants exclusively breastfed for 4 and 6 months, respectively, and subsequently given solids. Heinig et al. (82) compared infants introduced to solids at ≥6 months of age with infants starting with solids before 6 months. They found that the former group had a lower energy intake from solids at 6 and 9 months, but not at 12 months.

If there is a period of optimal acceptance of new tastes at around 4 months, as claimed by Harris (73), this would probably be most important for exclusively formula-fed infants, who do not experience the same range of flavours in their milk feed as breastfed infants.

Most researchers seem to agree that foods that require chewing should be introduced at about the ages of 6 and 8 months in order to avoid later problems with acceptance of lumpy food (74, 75, 97). A late introduction to chewable foods is probably equally detrimental to later acceptance whether the infant is breastfed or bottle fed (with formula or breast milk). This requires further research.

It is important to keep in mind that sustained breastfeeding per se does not imply late introduction to other foods. Nor does early introduction to solids equate to a timely introduction to chewable foods.

Effect on breastfeeding pattern
The decrease in breastfeeding frequency after the introduction of solids started later in the present study than the decrease of 0.6±0.5 breastfeeds per month reported from an American study by Stuff and Nichols (81). However, the decline over a longer period of time was comparable in the two studies. The study by Stuff and Nichols comprised 45 breastfed infants who were followed up with monthly 24-hour records from the age of 16 weeks up to 10 weeks after the introduction of solid food.

Quandt (80) studied 45 breastfed infants longitudinally in their first 6 months of life, using 24-hour records every eighth day. She found that infants who were introduced to solids before the age of 4 months decreased their breastfeeding
frequency after solids had been introduced, whereas infants introduced to solids at 4 months or later maintained or increased their frequency. In the present study, no such differences between the effects of introducing solids before and after 4 months of age was seen (IV). However, it was found that infants who were introduced to solids at 6 months or later decreased their breastfeeding frequency more quickly than those who were younger at this introduction. In Quandt's study (80), the average energy content of the initial solid feed was almost 60 kcal in infants whose breastfeeding frequency declined. The caloric intake was not measured in the present study, but since the volume of the initial solid feed was ≤10 mL in most of the infants, it is reasonable to assume that the energy content was low. Thus, the infants in Quandt's study probably consumed larger amounts earlier than those in the present study. The reason for this difference is not known, but it might be associated with the setting of the studies, i.e. differences in place (USA versus Sweden) and/or time (infants born 1978-80 versus 1989-1992).

Our results are also in accord with those of another study on Uppsala infants in which Hillervik et al (84) found that small amounts of solids caused no decrease in breast milk consumption, while the introduction of formula had a greater effect. The infants in their study seemed to get accustomed to the solids more quickly than the infants in the present study, 50 per cent consuming >30 grams of solids/24 hours within 3 weeks. This might reflect a temporal change in the way solids have been introduced in Sweden, since the infants in the study by Hillervik et al. were born in 1983, while those in the present study were born in 1989-1992.

In a small longitudinal study (n=27), Howie et al. (22) found that the number of supplementary feeds had a profound effect on the breastfeeding pattern. However, they did not differentiate between solids and formula, so it is difficult to compare their data with the present results.

**Breastfeeding duration**

Many studies have shown an association between early introduction of formula and a shortened breastfeeding duration (19, 22, 40). In this study, the age at introduction of regular formula feeds was strongly associated with the duration of breastfeeding. In contrast, the breastfeeding duration showed no association with the age at which occasional formula feeds were first given or when solids were introduced. This might be partly explained by the selection criteria for the WHO project, which ensured that all mothers had had previous breastfeeding experience and were planning to breastfeed the index child for at least 6 months. This might have made it less likely that occasional formula feeds would have acted as a gateway to regular formula feeds and decreased breastfeeding.
Our finding that age at introduction of solids showed no association with breastfeeding duration seems to be in accordance with the results of a study in Thailand (83), where most of the infants were given rice as their first additional food and where the breastfeeding duration, by tradition, was long. Jackson et al. (83) did not find any association between early supplementation and breastfeeding duration, but they mention that mothers who gave infant formula as the first additional food (14%) stopped breastfeeding slightly earlier than the others.

It is not surprising that introduction of regular formula feeds was associated with a greater decrease in the number of breastfeeds and the breastfeeding duration than introduction of solids. Firstly, the mothers stated different reasons for giving solids and formula. Regular formula feeds were commonly started because the mother felt that the infant needed more food than she could readily provide, while solids were introduced when she thought that the infant had reached an appropriate age. As a result, formula was mainly given instead of a breastfeed (as a replacement), while solids more often were given together with a breastfeed (as a complement). Secondly, formula was mostly given with a bottle, which made it easier for the infant to consume large amounts. With solids, on the other hand, the infant had to cope both with a new texture and a new way of eating, which would contribute to a slower increase in volume and thus a greater need for breast milk.

However, since the mothers in the present study were all highly motivated and experienced breastfeeders, the finding that introduction of solids was not associated with the duration of breastfeeding needs to be confirmed in other groups. Moreover, the present study cannot answer the question as to whether regular formula feeds, started when breastfeeding is well established, lead to inadvertent shortening of the breastfeeding duration.

Lengthening of the breastfeeding duration has been observed for several decades in Sweden, with a marked increase since 1992 (29). This trend is probably due partly to an increasing awareness in Sweden of the benefits of breastfeeding. The most important factor contributing to the marked increase since 1992 is presumably the Baby Friendly Hospital Initiative (BFHI), which was launched in Sweden in that year (109). This was reflected in the proportion of infants taking part in the present project who were given pacifiers and water during the first week of life. The attitudes of others towards the breastfeeding mother and the support she gets are among the most important determinants of the duration of breastfeeding (36). They are probably the most important reason when solids are given alone with no or only occasional bottles of formula. When regular formula feeds are given, there is also the added risk of interference with the breast milk production and the infant's feeding technique, especially if formula is started early.
**Introduction of gluten and coeliac disease**

Coeliac disease has a multifactorial aetiology and there are two prerequisites for its development - a genetic disposition and exposure to gluten. Between 1985 and 1995, Sweden experienced an unparalleled increase in symptomatic coeliac disease in children, with a four-fold increase in the incidence in the mid-80s followed by an equally swift decline in the mid-90s (7). The increase in incidence was preceded by doubling of the amounts of gluten-containing flours in follow-on formulas and a recommendation to postpone the introduction of gluten from 4 to 6 months. About 50 per cent of Swedish infants were breastfed for 6 months or longer in the mid-1980s.

In the early 90s it was discussed whether the change in infant feeding practices in Sweden in the mid-80s unnecessarily provoked a disease which otherwise might never have occurred (or only many years later) (110), or whether genetically susceptible individuals would have developed coeliac disease sooner or later anyway, in which case an early manifestation of the disease would be beneficial, since patients with untreated coeliac disease run an increased risk of ill-health and the symptoms of the disease become less distinct with age (111).

In 1992, the Swedish Paediatric Association's working group on coeliac disease initiated a multicentre study on the incidence of and possible risk factors for the disease. Preliminary results from the study indicated that continuation of breastfeeding while gluten-containing foods were introduced reduced the risk of developing coeliac disease (16). This resulted in a recommendation to introduce gluten at 4-6 months, preferably while still breastfeeding. Later it was found that the infant's age at introduction of gluten probably is less important than was previously thought, while it has become clear that large amounts of gluten-containing foods increase the risk for coeliac disease and that continued breastfeeding during the period when gluten is introduced protects against this disease in young children (112). Whether breastfeeding merely delays the development of the disease or actually gives lifelong protection is still unclear. This question can only be answered through screening studies on cohorts with both a low and a high incidence of symptomatic disease.

Unfortunately, the recommendation to introduce gluten at 4-6 months is often interpreted as a need to introduce gluten no later than at 4 months. This would perhaps be appropriate if the mother were planning to stop breastfeeding by 6 months, but might be unnecessarily early if she were planning to breastfeed longer. In view of our results on the differences between the ways in which solids and formula are introduced and the effects of these introductions on breastfeeding, it is also of great concern that the recommendation on how gluten should be introduced to infants only seems to take solids into account. Gluten-containing follow-on formula plays a very important part in infant feeding traditions in Sweden and is usually given from the age of about 6 months. If the aim is to introduce other foods to breastfed infants under the protection
of breast milk, it is important to realise that follow-on formula/gruel is also one of the 'other foods' and needs to be treated as such.

It is important not to forget the mother's intended breastfeeding duration in the calculation on when other foods should be introduced. The potential benefits of early introduction of solids and/or formula (e.g. a potentially decreased risk of problems with later food acceptance and possibly a decreased risk of coeliac disease) must be carefully weighed against the potential risks of increased morbidity (113-119) and/or of a shortened breastfeeding duration (40, 120). As WHO so aptly puts it (121), "… the mere fact that the physiologically immature organism can adapt to a feeding mode that is nutritionally unnecessary hardly justifies its use".

Summary
The breastfeeding pattern in exclusively breastfed infants varied considerably, both between infants and within the individual infant over time, and most infants were found to have at least one feed during the night throughout the first 6 months. Pacifier use, but not thumb sucking, was associated with fewer feeds, a shorter duration of suckling and a shorter total breastfeeding duration. The possible negative effects of pacifiers seemed to be related to the frequency of use, frequent pacifier use being associated with larger declines than occasional use.

In most infants, the introduction to solids was a slow process, mainly because the infant had to learn to handle the food properly before the volumes could be increased much, whereas large volumes of formula could be given immediately. For these reasons, giving an infant formula regularly was more likely to result in a fast decline in breastfeeding than giving him solids.

If the aim is to introduce other foods to breastfed infants under the protection of breast milk, it is important to realise that formula is also one of the 'other foods' and needs to be treated as such.
Acknowledgements

This work was carried out at the Department of Women's and Children's Health, Section for International Maternal and Child Health. I wish to express my sincere thanks to all those who have helped me in various ways to complete this work, especially:

Elisabeth Kylberg, my main supervisor and good friend, for continuous support and encouragement throughout all phases of this work and for valuable guidance, constructive criticism, and instructive discussions;

Yngve Hofvander, my co-supervisor in the last two studies, for getting me started in the field of breastfeeding research and for valuable guidance, positive criticism and instructive discussions;

Mehari Gebre-Medhin, my co-supervisor in the first two studies, for valuable guidance, constructive criticism and instructive discussions;

Clara Aarts for collaboration and friendship;

Tore Lundström, Gary Jansson, Lennart Gustavsson and Hans Stenlund, for answering my questions on statistics – any remaining faults are all my own;

Martha Garrett and Ted Greiner for valuable criticism;

Karin Wennqvist and Kristin Eklund for dealing with all practicalities while I was in England;

The entire staff of the Section for International Maternal and Child Health for enjoyable 'coffee' breaks, unfortunately too few and far between during most of my PhD studies;

Anneli Ivarsson, for letting me share your knowledge about coeliac disease;

Maud Marsden, for improving the English of my papers;

Diana, Angela and Sam, my very dear friends, for making our years in England so pleasurable. An extra-special thank you to Angela for enabling me to concentrate on work and never having to worry about the children, and for making Friday afternoons special;

Marianne, for remaining my dear friend through good and bad, and for always pointing out my strengths when I needed reminding;

My parents, Britt-Marie and Herje, and my parents-in-law, Dagny and Bengt, for your support and for always being happy about taking care of our children when I have needed to go to Uppsala to work and Mats has been busy;

My husband, Mats Wedin, for his unfailing support, valuable criticism and interest, and for putting up with me when I’ve been my most infuriating self;

Tove and Björn, our children, for giving me personal experience of breastfeeding, for proving that as long as there is a demand breast milk production continues, and for finally (!) agreeing to stop;

I am also indebted to all the mothers who made this study possible through their invaluable contributions with recordings and support, and to their infants. I also want to express my thanks to my other collaborators Lena Burström, Elisabeth Granberg and Kristina Tanninger – it was fun working with you!

The project was part of “The WHO Multinational Study of Breastfeeding and Lactational Amenorrhoea”, and received financial support from the UNDP/UNFPA/WHO/World Bank Special Programme of Research, Development and Research Training in Human Reproduction, World Health Organisation.

The writing of the papers was supported by grants from Barnets Lyckopenning, the Gillberg Foundation, the Faculty of Medicine at Uppsala University, the Göransson-Sandviken Stipendiefond at Gästrike-Hälsinge Nation in Uppsala, the University College of Health and Caring Sciences in Uppsala, Uppsala Sjuksköterskehem, and Vårdalsstiftelsen.
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88. Thunström M, Östberg M, Berg C. När barnet ska sova. Råd till föräldrar om barns sömn. Brochure to be given to Swedish parents at the Child Health Centre when infants are 3 months old.


p. 29. Two lines have disappeared. The last sentence of the page should read:
"(Since only three infants in the *Formula* group started to have regular formula feeds at 6 months, differences in relation to age within the *Formula* group were only analysed for start of regular formula feeds at <4 months or ≥4 months.)"