Solids and Formula: Association With Pattern and Duration of Breastfeeding

Agneta Hörnell, PhD; Yngve Hofvander, MD, PhD; and Elisabeth Kylberg, PhD

ABSTRACT. Objectives. To study changes in pattern and duration of breastfeeding associated with the introduction of solids and formula.

Study Design. Descriptive longitudinal, prospective study.

Setting. The participants were recruited from the maternity ward in the University Hospital in Uppsala, Sweden, between May 1989 and December 1992. A total of 15189 infants were born during the period, 1775 mother-infant pairs were found eligible for participation; 57% declined because of the perceived high workload.

Study Population. Five hundred six mother-infant pairs.

Methods. Daily recordings by the mothers on infant feeding, from the first week after delivery to the second menstruation postpartum or a new pregnancy; fortnightly home visits with structured interviews by a research assistant.

Results. Introduction of solids was associated with no or minor changes in breastfeeding frequency and suckling duration. Breastfeeding frequency remained constant the first month after the introduction and then declined slowly, while daily suckling duration started to decline slowly when solids were introduced. Breastfeeding was not associated with infants' age at introduction of solids. In infants given formula, as soon as regular formula feeds started, the breastfeeding frequency and suckling duration declined swiftly. The younger an infant was at the start of regular formula feeds, the shorter the breastfeeding duration.

Conclusions. Health care personnel and parents need to be aware that introduction of solids and introduction of formula can have very different consequences for breastfeeding. If the aim is to introduce other foods to breastfed infants under the protection of breast milk, it is important to realize that formula is also another food and needs to be treated as such. Pediatrics 2001;107(3). URL: http://www.pediatrics.org/cgi/content/full/107/3/e38; breastfeeding pattern, breastfeeding frequency, breastfeeding duration, weaning, solids, formula, follow-on formula.

Breastfeeding is a demand/supply system (ie, provided that the infant is well-attached to the breast and is allowed to decide on the frequency and duration of feeds); breast milk production will vary according to the infant’s needs.1,2 A common belief among many mothers and health professionals in the industrialized 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 in early lactation, because this would decrease the infant’s demand for breast milk. 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 the introduction of solid foods on the breastfeeding pattern,3–6 although none of them have specifically addressed the question of whether 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.7–10 However, these studies have either concerned only the introduction of formula8–10 or not differentiated between solids and formula.7 In contrast, in a study in Thailand, Jackson et al11 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 formula use was rare. But they noted that mothers who gave formula as the first additional food stopped breastfeeding slightly earlier than those who started with solids. In a Swedish study, Hillervik-Lindquist et al12 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 importance. 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, to avoid inadvertent shortening of the breastfeeding duration. When a breastfed infant is introduced to solids, he has to learn to cope with both 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.

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Aim
The aim of this study was to study changes in pattern and duration of breastfeeding associated with the introduction of solids and formula (for definitions see Table 1).

METHODS
The present study was one of several studies based on the Swedish part of a comprehensive collaborative World Health Organization project entitled “A multicentre, longitudinal study of the duration of lactational amenorrhoea in relation to breastfeeding practices,7,13,14 undertaken between 1989 and 1994. The Swedish part of the project was organized by the former International Child Health Unit, Department of Pediatrics, Uppsala University. Results from other studies within the Swedish part of the project have been published elsewhere.15,16

The present descriptive study had a longitudinal prospective design. The mother–infant pairs were followed up from the first week after delivery until the mother’s second menstruation post-partum or a new pregnancy. The mean duration (±1 standard deviation) of participation in the study was 8.7 ± 3.4 months.

The mother–infant pairs included in the study fulfilled several selection criteria that have been described in detail previously.19 In brief, all mothers had given birth to 1 to 3 children before 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 at 37 weeks of gestation or beyond by vaginal delivery.

The mean age of the mothers in the study was 30.7 ± 3.7 years. The mean number of years of formal education of the mothers was 14.2 ± 2.9 years; 65.2% had university education and all mothers had at least 9 years of formal education. The study comprised 270 male and 236 female infants.

Data were obtained from daily recordings by the mothers and from fortnightly structured interviews by a research assistant. The mothers completed 2 charts during every 14-day follow-up period. On one chart, on 13 of the 14 days, the mothers made daily recordings of the number of sucking episodes, the number and category of foods/fluids other than suckled breast milk (including expressed breast milk and water), and any vitamins/minerals or medicines given. When foods/fluids other than suckled breast milk were given, these were described as a taste (ie, ≤10 mL) or a meal (ie, >10 mL, Table 1). The second chart, which the mother completed every 14th day, consisted of a 24-hour record of the detailed timing of every sucking episode and the point in time when other foods/fluids were given.

The breastfeeding duration is known for 393 mothers; 257 had at least 9 years of formal education. A P value of <.05 was adopted as a criterion of significance.

RESULTS
The 2 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 2). There were no differences in parity and birth weight of the index children between the groups.

The infants in the solids group were introduced to solids slightly later than those in the formula group (median: 4.5 vs 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. Five of the mothers in the formula group gave their intention to stop breastfeeding as the reason for starting with 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 after the introduction of solids, before a slow decline began (Fig 1). Infants who were 6 months old or older at the introduction of solids started to decrease their breast-

<table>
<thead>
<tr>
<th>TABLE 1.</th>
<th>Definitions Used in the Study</th>
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</thead>
<tbody>
<tr>
<td>One breastfeed</td>
<td>Duration of suckling 2 min or longer and separated from previous breastfeed by at least 30 min. Suckling for &lt;2 min was not recorded</td>
</tr>
<tr>
<td>Taste</td>
<td>≤10 mL of any liquid or food</td>
</tr>
<tr>
<td>Meal</td>
<td>&gt;10 mL of any liquid or food</td>
</tr>
<tr>
<td>Solids</td>
<td>Semi-solids and/or solids</td>
</tr>
<tr>
<td>Formula</td>
<td>Formula, follow-on formula and/or gruel</td>
</tr>
<tr>
<td>Regular formula feeds</td>
<td>≥1 formula feed/d</td>
</tr>
<tr>
<td>Solids group</td>
<td>Infants starting with solids at 2 mo of age or later, and who never or only sporadically received formula</td>
</tr>
<tr>
<td>Formula group</td>
<td>Infants starting with regular formula feeds at 2 mo of age or later, and whose introduction to solids occurred ≤2 wk before the start of regular formula feeds</td>
</tr>
<tr>
<td>Age</td>
<td>Given as completed months, eg, at 3 mo = infant is 3 mo old but not yet 4 mo</td>
</tr>
</tbody>
</table>

Data Analysis
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 Table 1.

The breastfeeding pattern was 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 ≥2 weeks before regular formula feeds were started. To allow comparison between the 2 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 also analyzed 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.

Data were analyzed using the computer program SPSS, Version 9.0 (SPSS, Chicago, IL). To analyze differences between the solids and formula groups, and differences within these 2 groups according to age at introduction to solids or formula, the Mann-Whitney U test and the Kolmogorov-Smirnov Z test were used. To analyze 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 analyze the breastfeeding duration in relation to feeding regime (the 113 infants with unknown breastfeeding duration are censored and their ages at discontinuation from the project are used in the analysis), and the Pearson χ² test was used to analyze differences in relation to mothers’ education. A P value of <.05 was adopted as a criterion of significance.

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 after the introduction of solids, before a slow decline began (Fig 1). Infants who were 6 months old or older at the introduction of solids started to decrease their breast-
feeding frequency earlier than younger infants (Fig 2). The decline started after only 2 weeks, and from 6 weeks after the introduction of solids, the difference between those starting at $\geq 6$ months and those starting earlier was significant ($P < .05$). The median suckling duration per 24 hours started to decline earlier than the breastfeeding frequency, and its decrease already begun in the 14-day period after 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.

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 ($P = .013$) 4 weeks before the start (Fig 1). 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 2). The curve of the decline was equally sharp even when the 5 mothers intending to stop breastfeeding were excluded from the analysis (not shown). (Because only 3 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 analyzed for start of regular formula feeds at <4 months or $\geq 6$ months.)

The suckling duration 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 among individual infants, although the variation was smaller in the solids group than in the formula group (Fig 3). For instance, 2

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**TABLE 2.** 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>Age at start of solids (mo)</td>
<td>Median [25th–75th percentiles]</td>
<td>4.5 [3.9–5.0]</td>
<td>4.3 [3.8–4.9]</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>2.7–8.0</td>
<td>2.8–6.0</td>
</tr>
<tr>
<td></td>
<td>&lt;4, n (%)</td>
<td>18 (27.3)</td>
<td>20 (32.3)</td>
</tr>
<tr>
<td></td>
<td>4–6, n (%)</td>
<td>38 (57.6)</td>
<td>41 (66.1)</td>
</tr>
<tr>
<td></td>
<td>$\geq 6$, n (%)</td>
<td>10 (15.1)</td>
<td>1 (1.6)</td>
</tr>
<tr>
<td>Age at start of regular formula feeds (mo)</td>
<td>Median [25th–75th percentiles]</td>
<td>Not applicable</td>
<td>3.9 [3.1–4.7]</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>2.0–6.2</td>
<td>33 (52.3)</td>
</tr>
<tr>
<td></td>
<td>&lt;4, n (%)</td>
<td>Not applicable</td>
<td>27 (42.9)</td>
</tr>
<tr>
<td></td>
<td>4–6, n (%)</td>
<td></td>
<td>3 (4.8)</td>
</tr>
<tr>
<td>Mother’s age</td>
<td>Mean ± 1 standard deviation</td>
<td>31.7 ± 3.8</td>
<td>30.4 ± 3.7</td>
</tr>
<tr>
<td>Mother’s education</td>
<td>No university (%)</td>
<td>25.8</td>
<td>39.7</td>
</tr>
<tr>
<td>Breastfeeding duration (mo)</td>
<td>Previous child (recall data, complete mo)</td>
<td>9.0 [7.0–11.0]</td>
<td>7.0 [6.0–9.0]</td>
</tr>
<tr>
<td>Infant’s gender</td>
<td>Boys (%)</td>
<td>36.4</td>
<td>57.1</td>
</tr>
</tbody>
</table>

* One infant in the formula group discontinued from the study before he was introduced to solids.
Breastfeeding Duration and Related Factors: All Infants

Breastfeeding duration was studied in all infants who ever received solids and/or formula during the study. The breastfeeding duration increased during the course of the study and the proportion of infants receiving regular formula feeds showed a steady decline between 1989 and 1992 (Table 3). In addition, the infants who were given formula received their first formula feed at an increasingly higher age.

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: 9.1 [7.1–12.0] months vs 8.3 [6.0–10.1] months; \( P < .001 \)), 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% vs 24% of mothers without such education; \( P = .014 \)), and mothers with university education introduced solids and formula later (31% vs 41% gave solids at <4 months; \( P = .037 \) and 38% vs 55% gave formula at <4 months; \( P = .001 \)).

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 infant’s birth year and maternal education (Fig 4). Occasional formula feeds were usually given because the mother was temporarily absent, 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 to 6 months (–21% vs –10% and –9%, respectively), although the difference was not statistically significant (\( P = .058 \)). 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.

TABLE 3.  Age at Introduction of Solids and Formula, Proportion of Infants Never or Regularly Given Formula, and Breastfeeding Duration by Year of Birth of Infants

<table>
<thead>
<tr>
<th>Birth Year</th>
<th>1989 ( n = 92 )</th>
<th>1990 ( n = 158 )</th>
<th>1991 ( n = 135 )</th>
<th>1992 ( n = 121 )</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids—age at introduction</td>
<td>&lt;4 mo (%)</td>
<td>35</td>
<td>39</td>
<td>35</td>
<td>28</td>
</tr>
<tr>
<td>Formula—age at introduction</td>
<td>&lt;1 mo (%)</td>
<td>22</td>
<td>17</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>&lt;4 mo (%)</td>
<td>54</td>
<td>51</td>
<td>39</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>≥6 mo (%)</td>
<td>20</td>
<td>19</td>
<td>29</td>
<td>36</td>
</tr>
<tr>
<td>Formula—given</td>
<td>Never (%)</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Regularly (%)</td>
<td>38</td>
<td>39</td>
<td>36</td>
<td>31</td>
</tr>
</tbody>
</table>

NS indicates not significant.
stopped breastfeeding. Formula feeds, the younger they were when they started regular formula feeds, which meant that the decline showed no relation to the infants’ age at the start of regular formula feeds. The curve of frequency and suckling duration declined quickly after the start of regular formula feeds were essentially unaffected by the infants’ age at the introduction. In contrast, the breastfeeding frequency could be seen in this group of motivated mothers, and both the pattern and duration of breastfeeding experience of at least 4 months and intended to breastfeed the index child for 6 months or longer. The selection criteria undoubtedly had a bearing on the total breastfeeding duration as well as on the duration of exclusive breastfeeding. However, it is unlikely that the selection criteria had any effect on the way that solids and formula were given in the form of solid food.

Based on the research finding that introduction of gluten to infants while they are still breastfeeding might protect them against celiac disease, it has been recommended in Sweden since 1996 that gluten-containing foods be introduced in small amounts from 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.

The present study concerned a selected group of mother–infant pairs in a population known to have a high rate of breastfeeding. All mothers had had previous breastfeeding experience of at least 4 months and intended to breastfeed the index child for 6 months or longer. The selection criteria undoubtedly had a bearing on the total breastfeeding duration as well as on the duration of exclusive breastfeeding. However, it is unlikely that the selection criteria had any effect on the way that solids and formula were accepted by the infant, once they were introduced.

The mean duration of participation in the present study was >8 months. This gave a unique opportunity to investigate in-depth the association between introduction of solids and formula, and the pattern and duration of breastfeeding in a sizeable sample of mother–infant pairs, in a prospective day-to-day manner over a long period. During the course of the study, which included many contacts with each individual mother, the mothers were found to be very trustworthy and cooperative, and the recordings were in agreement with the interview results. The reliability of the records and of the data on supplementation was considered good.

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. However, the decline over a longer period was comparable in the 2 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 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 of age 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. However, in the present study 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 the study by Quandt, the average energy content of the initial solid feed was nearly 60 kcal in infants whose breastfeeding frequency declined. The caloric intake was not measured in the present study, but because 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 the study by Quandt probably consumed larger amounts earlier than did those in the present study. The reason for this difference is not known, but it might be associated with the setting of the studies, ie, differences in place (United States vs Sweden) and/or time (infants born 1978–1980 vs 1989–1992).

Our finding that age at introduction of solids had no association with breastfeeding duration seems to be in accordance with the results of a study in Thailand, 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 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.

In the present study, the age at introduction of regular formula feeds was correlated with the dura-
tion of breastfeeding. The lack of association between occasional formula use and breastfeeding duration might be partly explained by the reasons the mothers gave for introducing formula. Most mothers who only gave formula occasionally gave it when they themselves were temporarily absent, i.e., they had no intention of making it a permanent habit. Furthermore, the selection criteria for the World Health Organization project, which ensured that all mothers had had previous breastfeeding experience and were planning to breastfeed the index child for at least 6 months, might have made it less likely that occasional formula feeds would have acted as a gateway to regular formula feeds and decreased breastfeeding.

It is not surprising that introduction of regular formula feeds was associated with a larger decrease in the number of breastfeeds and the total breastfeeding duration than introduction of solids. The mothers stated different reasons for giving solids and formula. Regular formula feeds were commonly started because the mother believed that the infant needed more food than she could readily provide, whereas 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), usually in very small amounts for quite a long time. In addition, formula was mostly given with a bottle, which made it easier for the infant to consume large amounts. With solids, in contrast, the infant had to cope with both 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, because the mothers in the present study were all highly motivated and experienced breastfeeding mothers, the finding that introduction of solids was not associated with the duration of breastfeeding needs to be confirmed. Moreover, the present study cannot answer the question whether regular formula feeds, started when breastfeeding is well-established, leads 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. This trend is probably partly attributable 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, which was launched in Sweden in that year. The attitudes of others toward the breastfeeding mother and the support she receives are among the most important determinants of the duration of breastfeeding. 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.

**CONCLUSION**

For most infants, the introduction to solids is a slow process, mainly because the infant has to learn to handle the food properly before the volumes can be increased much, whereas large volumes of formula can be given immediately. For these reasons, giving an infant formula regularly is more likely to result in a fast decline in breastfeeding than giving him solids. This is important to keep in mind if a mother wants to continue to breastfeed while giving formula regularly. In addition, if the aim is to introduce other foods to breastfed infants under the protection of breast milk, it is important to realize that formula is also one of the other foods and needs to be treated as such.

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