BREASTFEEDING PERFORMANCE AND CHILD SURVIVAL:

METHODOLOGIC ISSUES

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Abstract

Breastfeeding performance affects child survival by providing a major nutrient source for the child, through its anti-infective properties, and by enhancing birth spacing. Intervening variables that modify the effect of breastfeeding on child survival include patterns of suckling, type and manner of supplemental feeding, the infection load of the environment, and the availability of health services.

Several methodologic issues need to be considered when assessing the effect of breastfeeding on child survival. The duration of breastfeeding and whether it is full or partial has a major effect on child survival, and how these terms are defined needs to be clearly specified.

The role of breastmilk in providing nutrients to be child is assessed by measuring the quantity and quality of breastmilk. Direct measures of breastmilk output include mechanical expression of milk, and use of the Doppler Ultrasound Transducer. Indirect measures include the use of test weighing, deuterium oxide, and child growth. Results produced by these measures need to be considered in light of their effects on normal suckling patterns, whether 12 or 24 hour collections are taken, the child's health status, and maternal characteristics.

The anti-infective properties of breastmilk are measured through the assessment of humoral and cellular components in breastmilk and by studying morbidity patterns of breastfed children. Quantity of breastmilk, duration of breastfeeding, maternal and child nutritional status, and the child's gestational
age appear to affect immunologic components. Studies relating breastfeeding and morbidity are confounded by social, economic and environmental conditions. Variables of recall error, access to medical care, and recognition of disease may affect results of retrospective studies. Self-selection to breastfeed is a significant factor as well.

Measurement of the contraceptive effect of breastfeeding is based on the length of anovulation and the length of postpartum abstinence. Anovulation is generally assessed directly by the duration of postpartum amenorrhea, and indirectly by the pattern of suckling or the duration of breastfeeding. Suckling patterns are difficult to measure because of the need for intensive observation. Methodologic problems in the measurement of durations of amenorrhea, abstinence, and breastfeeding include age heaping, recall errors, lack of accurate dates of birth, and whether closed or open birth intervals are used.

In order to examine the influence of breastfeeding on child survival, it is necessary to take into consideration these measurement problems involved in assessing breastfeeding performance and to examine the confounding effects that intervening variables can have on breastfeeding performance and child survival.
I. Introduction

Child survival is dependent upon adequate nutrient intake and the ability of a child to resist or recover from infections. Breastmilk can provide the major nutrient source in a child's diet. It can also be an important contributor to the child's immunologic defense system, enabling enhanced resistance to disease. By the consumption of breastmilk in place of other food sources that may be contaminated, the ingestion of certain infectious agents is reduced. The practice of breastfeeding can also contribute to enhanced child survival by lengthening intervals between births, through extending the period of postpartum anovulation and through postpartum abstinence. Enhanced birth intervals have been associated with improvements in child survival' (Gray, 1981).

Breastfeeding can therefore affect child survival by its role in nutrient intake, anti-infective properties and birth spacing. Although these factors appear straightforward, the association of breastfeeding and child survival is dependent upon external conditions facing the child. Breastmilk's role in nutrient intake is important when other products of similar nutrient quality and quantity are unavailable because of low level of production, inadequate distribution mechanisms, storage incapacities, cost, etc. The anti-infectious properties of breastmilk become less important when the load of infection is low, or when health care services are available for early treatment of illness. Its effect on birthspacing is less important as other contraceptive methods become available, or as the mother's nutritional status is not negatively affected by pregnancy.
In modernized societies, these conditions are common, therefore a direct link between breastfeeding and child survival is more difficult to discern than in developing countries. This is not to minimize the role breastfeeding has either as a nutrient source or for its anti-infective properties. Numerous nutrients available in breastmilk may be important for the child's health status, but their significance is as yet unknown to researchers. For example, selenium and manganese levels vary substantially between infant formula and breastmilk (Picciano, 1983). The anti-infective properties in breastmilk in developed countries may also be extremely important for reducing morbidity, as seen in the evidence for a lower rate of otitis media, gastro-intestinal illnesses, and allergies among breastfed infants (Cunningham, 1981). This overall impact of breastfeeding on child survival, however, is less dramatic than that seen in developing countries, where other non-contaminated foods to replace breastmilk are not available, and where the load of infection is high, and health care services inadequate.

Figure 1 diagrams the possible mechanisms by which breastfeeding can influence child survival. Although it is often assumed that breastfeeding affects only infant survival, these pathways may influence the child's health beyond the first year of life. We therefore will discuss the impact of breastfeeding on child, rather than infant survival. In addition to the three issues discussed above, the benefit of enhanced maternal-infant bonding associated with breastfeeding is also included in the figure since it may also have an indirect effect on child survival. Mata (1983) observed that there was a decrease in abandonment of infants in the hospital following delivery associated with increases in the proportion of breastfeeding women. There have also been reports of decreased levels of child abuse and failure to thrive among infants of mothers who breastfeed (Klaus and Kennel, 1976).
BREASTFEEDING EFFECTS ON CHILD SURVIVAL

NUTRIENTS IN BREASTMILK
- QUANTITY
- QUALITY

CHILD GROWTH

BIRTH SPACING EFFECT OF BREASTFEEDING

FREQUENCY AND SEVERITY OF INFECTIONS

ANTI-INFECTION PROPERTIES OF BREASTMILK
- IMMUNOLOGIC ASPECTS
- REDUCED CONTAMINATION

MATERNAL-INFANT BONDING

CHILD SURVIVAL
Duration of Breastfeeding

The impact of any of these pathways on child survival is dependent upon the duration that breastfeeding is practiced. Although often treated as a dichotomous variable (a woman is either breastfeeding or not up to a particular point in time), breastfeeding should be thought of more as a continuum, which will vary depending upon the child's age. Influences on this continuum will be discussed in detail below, but it is helpful to first illustrate some of the definitional problems in assessing duration of breastfeeding.

Full or exclusive breastfeeding has been defined differently depending on the researcher, and often the purpose of the study. The most commonly used definition is the consumption of breastmilk as the only nutrient source except for water, which may also be given to the child, either by bottle, cup or spoon. Some include the addition of juice to be considered full breastfeeding if no other foods are given (Perez et al, 1972). The least rigorous definition of full breastfeeding is one that assumes "exclusive" breastfeeding as long as the child is not receiving a bottle, even if consuming cereals or other supplemental foods (Steckle et al, 1983). Figure 2 illustrates these various definitions.

Partial breastfeeding can be seen as the inverse of any of these definitions. The total duration of breastfeeding will be the combination of the duration of full and partial breastfeeding, although it is obvious that in some cases, the duration of exclusive breastfeeding may equal the duration of total breastfeeding. In cases where milk or formula are used from birth onwards, the duration of partial breastfeeding may equal the duration of total breastfeeding. In many populations, mixed feeding (both breast and bottle) is the norm, but women are reported to be breastfeeding, not bottle feeding. It is therefore evident that in discussing the effect of breastfeeding on child survival, it is important to keep in mind which type of breastfeeding and for what duration.
**FIGURE 2**
**CONTINUUM OF BREASTFEEDING**

<table>
<thead>
<tr>
<th>EXCLUSIVE (FULL) BREASTFEEDING</th>
<th>BREASTMILK</th>
<th>WATER</th>
<th>JUICE</th>
<th>SEMI-SOLIDS</th>
<th>MILK IN CUP</th>
<th>MILK IN BOTTLE</th>
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As Winikoff (1981) discusses, the mixed-partial-feeding group is the most difficult to define since it can contain very different breastfeeding patterns. Such a group could include "both a predominantly breastfed child given one supplementary bottle during the day when the mother is away, and a child who is 'put to breast' just once a day."

The determination as to when breastfeeding stops may also differ. In studies of the effect of contraceptives on milk output, Guiloff et al (1974) used "complete lack of secretion," while others have used the term when less than two feeds per day are given (Zanartu et al, 1976).

An important distinction to be made also refers to the use of frequency and duration of breastfeeding meaning the proportion of women breastfeeding, and the number of months breastfed. This term needs to be differentiated from the frequency (times per day suckled) and duration (number of minutes per feed), which are also used to describe suckling patterns (McCann, 1981).

There is a differential effect of breastfeeding on child survival depending on the child's age. Breastfeeding's impact on child survival through its role in nutrient intake and anti-infective properties is strongest in the early months of life, and although significant in later months, its effect is at a much lesser level. Butz et al (1982) illustrated that an additional week of full breastfeeding in the first month of life was related to a decrease in mortality of 16 deaths per 1000 compared to 1.8 deaths per 1000 for ages 6-12 months.

This effect of breastfeeding on child survival appears in some cases to be primarily dependent on the duration of unsupplemented breastfeeding. For example, it was observed in this study of Malaysian children, that fully breastfed infants had reduced mortality risk in the first month, and in the next five months of life. Even infants who survived their first six months had lower
mortality if they were fully breastfed in the first six months. Plank and Milanesi (1973) found similar results of a protective effect of full breastfeeding at age 1 month on infant mortality.

II. Intervening Variables

Aside from the overall duration of breastfeeding and timing of introduction of supplements, the pattern of suckling, the type and manner in which supplements are given, and the infection load within the environment all influence breastfeeding performance.

Suckling Pattern

The physiologic process of breastmilk production and output is dependent on the suckling process, including its frequency, intensity and duration. We have a greater understanding of the importance of frequency than of the other two factors, both in terms of milk production and in maintenance of anovulation.

As the infant sucks at the breast, prolactin and oxytocin are released. Prolactin is the hormone necessary for milk production and secretion and is also associated with the maintenance of the anovular state. The mechanism is as yet not well understood (Delvoye and Robyn, 1980; McNeilly et al, 1980). Oxytocin is the hormone necessary for milk ejection from the breast (let down reflex). Its release can be inhibited or facilitated by psychological and emotional factors (Jelliffe and Jelliffe, 1982). Stress can block the release of oxytocin and prevent the let down reflex, causing a physiologic but not anatomic inability to breastfeed.

Figure 3 illustrates factors associated with suckling frequency, including access of the child to the mother, occurrence of night feeds, the use of
FIGURE 3

FACTORS ASSOCIATED WITH FREQUENCY OF SUCKLING

- SCHEDULED /DEMAND FEEDINGS
- ACCESS TO MOTHER
- NIGHT FEEDS
- USE OF PACIFIERS
- SUPPLEMENTAL FEEDING
  - USE OF BOTTLES
  - HANDFED SUPPLEMENTS
- MATERNAL NUTRITION
pacifiers, the practice of demand or scheduled feedings, maternal nutritional status, and supplemental feeding practices.

**Access of Child to the Mother**

Access of the child to the mother will influence frequency of suckling. This can be clearly seen in relation to working patterns of mothers. Women who work outside the home are limited in their access to the child, and thus in the number of opportunities the child has to breastfeed. This causes obvious reduction in suckling, depending on the amount of time the mother is separated from the child.

Lozoff and Brittenhorn (1979) compared the bodily contact of infants and their mothers among hunter gatherers, the !Kung San, and U.S. women. They noted that the !Kung spent about 75 percent of the time with their infants compared to about 25 percent among U.S. women at 8 weeks postpartum. These values decreased to about 60 percent and 10 percent respectively at 30 weeks.

Seasonal activity patterns, especially in agricultural societies, can play an important role in determining frequency of suckling. In Bangladesh, the frequency of suckling was reduced during the peak harvest season when women were busy with rice processing activities, even though not working outside their baris (Chen et al, 1979). In the Gambia, women reduced breastfeeding frequency with increased demands for women in the fields (Lunn et al, 1981). Similar seasonal patterns have been observed in Zaire and Kenya (Vis et al, 1975; Hennart and Vis, 1980; Van Steenbergen et al, 1978).

**Night-feeds**

Although less evident, but as important in terms of assessing breastfeeding performance, are periodic absences between mother and child.
Night feedings are an excellent example. Mothers who sleep with their infants at night have a greater opportunity for suckling. Therefore, sleeping patterns may affect breastfeeding performance. Although night feeding may be common among many breastfeeding women, whether the child is isolated from the mother sleeping in a separate crib, or whether the child sleeps with the mother will affect breastfeeding patterns.

**Use of Pacifiers**

Breastfeeding fulfills an instinctive need of the child as well for suckling, both nutritive and non-nutritive. Wolff (1967) has shown that in the early months of life, infants spend a substantial amount of time involved in non-nutritive sucking. The use of pacifiers causes much of the non-nutritive sucking needs to be met, thus reducing the overall frequency of suckling at the breast. As discussed later, this can affect breastfeeding's effect on fertility.

**Scheduled - Demand Feedings**

In developed countries, pediatricians often provide instructions on when (time of day) and how long (number of minutes) mothers should breastfeed. Such scheduling of feeds is generally associated with less frequent suckling. In traditional societies, suckling is more likely to be on demand and initiated by the child. For example, in Bangladesh 96 percent of the time suckling was initiated by the child (Huffman et al, 1980).

**Maternal Nutritional Status**

Some authors have suggested that maternal nutritional status indirectly affects suckling by enabling a well-nourished woman to produce more breastmilk with less suckling than those who are poorly nourished (Whitehead, 1981). This was not supported by data in Bangladesh when the total amount of time spent suckling by infants ages 18-36 months did not differ by mother's
weight for height (Huffman et al, 1980). However, in a Mexican study, supplementation of mothers did seem to result in higher milk outputs and was associated with less total suckling time by infants (Chavez et al, 1975), though the major factor affecting suckling time was supplemental feeding of the infant rather than maternal supplementation. In the Gambia, it is reported that suckling frequency was reduced when maternal caloric intakes increased (Whitehead, 1981), but this may have been related to changes in maternal activity patterns.

Bowen-Jones et al (1982) report that when milk flow is reduced, suckling rate (sucks per second) increases, even when the baby's hunger is controlled. These data support an effect of milk availability on suckling rate. However, it may be that with frequent suckling as practiced by many infants in developing countries, the amount of milk secreted in each bout is less, not because of maternal malnutrition, but instead because of short intervals since the previous suckling episode. This is supported by data collected by Pao et al (1980) in a study of U.S. infants in which milk consumption was measured on three consecutive days through test weighing conducted by the mothers at home. They noted that the volume of milk consumed per feeding was positively correlated with the interval between feeds. With an increase in the interval since the previous feeding of one hour, the mean breastmilk consumption increased by 11-12 ml. When previous intervals were controlled, the mean intakes had a tendency to decrease during the day. In this study, completely breastfed infants had shorter intervals between feeds compared to partially breastfed infants.

Lucas et al (1979) observed higher intakes in the first compared to the second breast suckled. They also observed that about half of the total milk was
consumed within two minutes of feeding, and by four minutes 80-90 percent was consumed. The intake after seven or ten minutes did not differ significantly from that consumed by four minutes. This again does not support the theory that some infants (those whose mothers are malnourished) will need to suckle longer to obtain the same amount of milk. They state that the sucks towards the end of the feed are more non-nutritive in nature.

**Supplementation of the Child’s Diet**

The type and manner of supplements (weaning foods) given to the child will affect the frequency of suckling, the duration of breastfeeding, and the effect breastfeeding has on child survival. Whether or not bottles are used plays an important role in each of these variables.

Several studies have indicated that the use of bottles is associated with decreases in suckling at the breast. Howie et al (1981) have shown that as bottles were introduced by Scottish women for feeding infants, the total number of breastfeeds per day declined. The use of bottles was also associated with lower frequencies of suckling in studies in Iran, the U.S., and Kenya (Simpson-Hebert, 1977; Kippley and Kippley, 1972; Huntington-Hoestelte, 1966; Van Steenbergen et al, 1981). In studies in Chile, Steckle et al (1983) observed that when women fed their infants milk in bottles, the duration of breastfeeding declined. Studies in the West Indies also support this effect (Gueri et al, 1978). Greiner et al (1981) stated that "the earlier supplementation is introduced, the larger its quantity, and the more it is fed by bottle, the greater its impact on breast milk supply." Van Esterlick (1977) reported that in Thailand, when considering breastmilk supply to be inadequate, rural mothers would increase it by more frequent feedings, while professional women would supplement infants with infant formula instead.
Use of bottles has also been suggested to impart greater levels of bacterial contamination to the infant due to a greater difficulty in sterilization in comparison to more easily cleaned cups or spoons (Jelliffe and Jelliffe, 1978).

Aside from how the supplement is fed, the type given (caloric-density), amount, and frequency, all influence breastfeeding performance. Frequent feedings with calorically dense foods will make the child less dependent on breastmilk for his/her nutrient needs. This is the type of feeding seen in developed countries, where the most common supplement to breastmilk is cows milk or formula, both as nutrient dense products easily consumed by infants. In developing countries, when milk is given, it is often diluted (Surjono et al., 1980). Paps or gruels fed to the child are also inadequate in calories to meet the child’s nutrient needs. Breastmilk therefore often continues to be the principal source of nutrients for the first few years of life. For example, in Bangladesh, Brown et al (1982b) have shown that breastmilk provides 50 percent of calories at two years of age.

When supplemental foods are inadequate because of low frequency of feeding and caloric density, they are less likely to interfere with suckling. In the Gambia, Zaire and among the !Kung, where supplementation is begun early but only provides a small part of daily nutrient requirements, suckling frequency is high. In Zaire, the frequency of breastfeeding and the amount of milk consumed did not differ between infants aged less than six months receiving supplements and those fully breastfeeding (Hennart and Vis, 1980). The lack of adequate supplementation of breastmilk after four to six months postpartum is associated, however, with poor child nutritional status.

The hygienic properties of the supplement are important aspects contributing to the effect of breastfeeding on child survival. If supplements
can be made without contamination and stored properly (refrigerated) until fed to the child, as is the common practice in developed countries, the risk of contamination is small.

In developing countries, the pattern is quite different. Studies on the bacterial content of food and water have illustrated the high level of weaning food contamination in developing countries. Barrell and Rowland (1979) have paid attention to the preparation and storage of weaning foods as the source of contamination. In their study in the Gambia, they compared two commercial baby milks and a traditional weaning food, millet gruel. The significant factor was not what type of food was prepared, but the hygienic conditions under which it was prepared. The unboiled water used to prepare all three foods, and to wash bowls and utensils, was heavily contaminated with fecal coliforms. Metal bowls and utensils were found to have infective levels of bacteria after being scrubbed with well water and palm leaves and left to dry. Freshly cooked gruel or reconstituted milk had as an average $10^2-10^3$ organisms/ml, reflecting mainly the contamination of the containers. Milks prepared with unboiled water were contaminated by $10^4-10^7$ organisms/ml. The bacterial content of the foods determined 8 hours after preparation and storage at ambient temperatures was observed to be at highly infective levels for both Staphylococcus and E. coli. A seasonal variation in the level of contamination was also noted (Barrell and Rowland, 1979).

It was concluded that a large percentage of foods eaten by infants were contaminated with bacteria to an unacceptable level, even after thorough cooking. The longer the period after preparation, the more evident was the bacterial growth. The levels of contamination in the rainy season were higher, coinciding with the seasonal increase of diarrheal disease among children. This
is because of greater contamination of food and water at that time of year as well as mothers' increased farming activities in terms of the farm work at that time of year. The mother does not have time to prepare meals for every infant feeding and is therefore more likely to use foods which have been prepared earlier and stored improperly.

Studies in Bangladesh and Indonesia have illustrated similar findings. In Indonesia, examination of bottles of mothers attending a clinic showed high level of bacterial pathogens (Sujorno et al, 1980). In studies in Bangladesh, Black et al (1982) noted high levels of contamination in both weaning foods and water, from either ground sources or tube wells. Contamination was also highly correlated to ambient temperatures.

Aside from contamination of water or food, spread of pathogens through contact with the mother is also probable. Studies in Bangladesh have illustrated relatively high levels of Rotavirus and Shigella on the hands of some mothers (Samadi et al, 1983; Khan, 1982). Such contamination may cause infection of food sources or direct infection of the child through bodily contact.

Few studies have compared contamination of bottles to cup and spoons, although it is commonly stated that bottles are more difficult to keep free from contamination. Contamination of the mother's nipples is also seldom studied. One study of poor women in Chile noted that 26 percent of the samples from nipples of lactating mothers were positive for fecal coliforms or *Staphylococcus aureus*. Fecal coliforms were evident on 46 percent of hand imprints and 60 percent of formula bottles (Brunser, 1983).

**Infection Load**

Aside from the direct contamination of supplemental foods, the general level of environmental contamination and prevalence of infectious diseases will
determine the level to which breastfeeding performance can influence child survival. When the infection load is high, the immunologic protection provided by breastmilk will be more important than when few infectious agents are evident. Availability of water plays an important role in reducing infection load, by diluting and washing away the infectious agents. Adequate sanitation facilities helps to ensure the removal from the environment of infectious agents. Recent studies also have shown the high general level of environmental contamination and its effect on levels of contaminants on the hands and breasts of women in poor households (Brunser, 1983). Studies on use of soap for hand washing have illustrated reduced spread of disease in families exposed to Shigellae (Khan, 1982). The availability of water and sanitation facilities may also differentially affect child survival depending upon the breastfeeding practices.

The interaction between the practice of breastfeeding and water/sanitation availability is shown by Butz et al (1982) in Malaysia. For children not fully breastfed in the first month of life, the mortality rate in the next 5 months was 94.7 deaths per thousand if no toilet or piped water was available. This rate was reduced to 81.6 deaths per thousand if piped water was present, 17.3 if there was a toilet, and 4.2 when both were present in the household. The presence of piped water and toilet sanitation is most important for affects on child survival among women who breastfeed little or not at all. These results suggest that the lack of breastfeeding is most dangerous in areas without piped water or toilet sanitation, but less so when these facilities are available. Socio-environmental conditions, the length of breastfeeding and whether full or supplemented, therefore, are important variables to consider when examining the effect of breastfeeding on child survival.
Health care services can mediate the effects of high infectious loads. Immunization can protect children from certain infections that antibodies in breastmilk also protect against. Treatment of illnesses can reduce the detrimental impact, both on nutritional status and severity of morbidity (McCord and Kielmann, 1978), and thus may reduce any noticeable effect breastfeeding could have.

Figure 4 summarizes the pathway by which each of these three intervening variables affects breastfeeding performance as it influences child survival. Suckling patterns can affect the quantity of breastmilk produced and the duration of breastfeeding. Suckling patterns exert a major influence on the birthspacing effect through the association of frequent suckling with anovulation. Whether the quantity of anti-infective properties in breastmilk is influenced by the frequency of emptying the breast is unknown.

Supplementation of the child's diet affects the quantity of breastmilk consumed, the child's total nutrient intake and the level at which pathogens are introduced to the child's gastro-intestinal tract. The general infection load in the environment and availability of health care services will affect the frequency and severity of illnesses, and therefore the impact that breastmilk can have on preventing or reducing the severity of such illnesses.

IV. Measurement Issues

With this background in mind, the measurement issues involved in assessing breastfeeding performance can be discussed. We will examine the direct and indirect measurements of 1) nutrient intake in relation to both quantity and quality of breastmilk, 2) the anti-infective properties of breastmilk, and 3) the contraceptive effect of breastfeeding through postpartum anovulation and abstinence.
FIGURE 4
EFFECT OF BREASTFEEDING AND INTERVENING VARIABLES ON CHILD SURVIVAL
Nutrient Intake

Quantity of Breastmilk

The question of whether or not an infant's nutritional needs are being met by breastfeeding, and for how long these needs are met by breastmilk, brings to light the importance of determining how much breastmilk an infant receives. Several methods of measuring infant milk intake and lactation performance have been used to varying degrees of success. Expression of milk from the breast and the use of the Doppler Ultrasound flowmeter are direct measures of breastmilk output. Testing weighing of the infant pre and post feed and measurement of total body water by deuterium oxide breakdown in the saliva are more indirect methods of measuring breastmilk intake. Actual child growth while on a diet of only breastmilk in itself can be a measure of the adequacy of breastmilk intake, although many other factors come into play. Self-reports of breastmilk production have also been used. These methods will be considered here in terms of their relative accuracy and practicality for use in determining lactation performance.

Expression of Milk

The most direct method of determining how much breast milk can be produced by a woman is the mechanical expression of milk from the breast and its measurement. It has been determined, however, that this may not be a true indicator of the quantity of milk received by the child during suckling (Gibbs et al, 1977 as discussed by Hibberd et al, 1982). The absence of the natural contact between the mother and her child and the resulting lack of stimulus of a baby's suckling, may result in inaccurate measurements. In a study of Burmese mothers, a combination of manual expression of milk after test weighing of babies who nursed from the breast yielded what the
investigators called the mother's "potential output" (Oo and Naing, 1982). This combination of test weighing and expression produced a milk output greater than that indicated by test weighing alone or manual expression alone. This study brings attention to the difference between the actual intake of the child as compared to what breastmilk the mother can produce. In another study it was found that manual expression produced 7 percent more milk than that measured during test weighing of infants of the same women over one week testing periods (Brown et al, 1982a).

**Doppler Ultrasound**

The Doppler Ultrasound flow transducer is a fairly recent development for the measurement of lactation performance. Developed by the John Radcliffe Hospital, Headington, Oxford (How et al, 1979), an electronic transducer is located in the tip of a latex nipple which is attached to the mother's own nipple before breastfeeding. The signal processor works in a manner similar to a Doppler blood velocimeter and measures the rate of flow of breastmilk using piezoelectric crystals in the lumen of the nipple. The intensity and pattern of suckling can be observed as feeding takes place (the pattern recorded in line graph form on a hardcopy printout). A small catheter may be placed behind the nipple to allow for small amounts of breastmilk to be withdrawn for composition analysis. The composition of breastmilk can then be correlated with the time and intensity of suckling.

In initial trials of the method only half of the 32 mothers were able to use the transducer nipple successfully in both breasts. The other 16 were able to use it on one breast but did not attempt the second breast for various reasons (Woolridge et al, 1982). Similar results were seen in a second study. When successfully attached to the mother's nipple, breastfeeding with the Doppler transducer proceeded normally.
Although this is a fairly recent development and still under trial, this method offers the opportunity to measure milk output without critically disturbing the natural nursing environment. This is true only if the child can accept the nipple as if it were its own mother's. Further studies are anticipated to indicate the feasibility of applying this method in the field and in comparing the amount of milk measured by this method to other methods.

**Test-weighing**

Probably the most commonly known method of estimating breastmilk is that of weighing the baby before a session of breastfeeding and immediately thereafter, the weight difference representing the amount of milk ingested. The development of electronic scales and the relative ease of training both field workers and mothers to carry out the weighing has increased the accuracy and practicality of this method (Woolridge et al, 1982). However, there are several considerations about the method that must be taken into account.

The procedure requires that the maternal/infant nursing environment be interrupted before every feed to weigh the baby. Post feeding weights are then taken. This must continue for every session of breastfeeding over a specified period of time, usually 12 or 24 hours, in order to estimate a daily breastmilk intake. This interruption, however, may have an effect on the mother's ability to perform and the child's desire to feed. This becomes especially significant where breastfeeding is not a scheduled event but on demand. The continual observation of the field worker, the frequent interruption for weighing, and the mother's compliance record all may act to alter the results of the weighings.

Observations and weighing of night time breastfeeding become even more difficult as the field worker must be present in the home or the mother
more conscious of feedings that usually occur uninterrupted and often unnoticed during sleep. Because of these difficulties, investigators have often relied on the more easily attained daytime - 12 hour measurements, estimating daily intake by doubling the 12 hour average. However, it has been found that the 12 hour average is not an accurate estimate of half the daily intake of a child on an individual basis (Brown et al, 1982a). In this study in Bangladesh, comparing 12 and 24 hour measurements, the intake of breastmilk over a 12 hour period varied between 37 and 72 percent of the daily total. Intakes in 12 hour measurements of individuals varied day to day and were affected by a variety of factors, including month of lactation, season, maternal diet and the baby's weight for age. Because individual feedings usually produce small amounts of milk, the margin of potential measurement error is relatively large. Measurement error may also result from loss of weight by way of urine, vomiting, regurgitation or stool.

Breastfeeding patterns as well are often culturally defined. In Bangladesh it was found that 52 percent of breastmilk intake on average occurred during the day. A doubling of the 12 hour intake in this case may be more accurate than in another area where the majority of breastfeeding may occur at night, or in varied 12 hour periods. In terms of an overall population estimate, 12 hour weighings may be adequate as long as the results are interpreted with a recognition of the potential effects of interrupting the natural nursing environment and an analysis of the cultural breastfeeding pattern. However, to get a fairly accurate individual intake measurement, a 24 hour average measurement taken from samples of daily feeding over time is still a better measure, although some of the same problems still apply (Brown et al, 1982a).
Deuterium Oxide

Heavy water or deuterium oxide enrichment in saliva has been described by Coward et al (1979) as a means of measuring the percent and turnover of an infant's total body water as an indicator of breastmilk intake. A 20 percent dilute solution of $^2\text{H}_2\text{O}$ in sterile water is given to infant with a syringe after a predose sample of saliva is taken. The child is allowed to breastfeed regularly afterwards and saliva samples are taken at intervals up to 14 days after ingestion of deuterium oxide. Breastfeeding must be halted at least 2 hours before the initial dose is given. Total body water is estimated by the dilution of $^2\text{H}_2\text{O}$ in the saliva through hydrogen exchange, and the turnover is estimated from the decay of the deuterium concentration. When compared by Coward to the test weighing procedure, measurement of breastmilk intake was comparable. The investigators indicate that $^2\text{H}_2\text{O}$ technique had slightly higher values although not significantly higher, given that test weighing may underestimate intake (Coward et al, 1979). However, in studies of the technique by Butte et al (1983), it was found that deuterium oxide dilution results were significantly higher than the test weighing results. They indicate that this may be due to the basic assumption of the $^2\text{H}_2\text{O}$ technique that deuterium labels body water only and that the infant's total body water is represented by breastmilk intake. In both cases the assumption leads to problems. There may be some exchange of deuterium with nonaqueous sources of hydrogen as well as enrichment of background levels of urine, plasma, serum and saliva with deuterium. Breastmilk may also not be the only source of body water in the infant as water input via skin and lungs should be considered. Supplementation with other foods may increase total body water and complicate the results as well. Correction of these potential errors can be
calculated to some extent. The investigators state that although the
determination of intake in individuals may not be acceptable, the technique
may have some use in terms of population measurements (Butte et al, 1983).

Concern has also been voiced over the possible biological effects that may
result in the use of the deuterium isotope (Baum and Dobbing, 1979). The
recent availability of the stable isotope oxygen$^{18}$ may offer safer alternatives
(Graham, 1983, personal communication).

The deuterium dilution technique however offers a noninvasive approach
to measuring breastmilk intake. After the initial dose of deuterium only two
further samples are needed to accurately estimate intake. It does not interfere
with feeding habits or maternal lifestyle nor does it depend on the mother's
expertise. This is especially true when compared with the test weighing
procedure. Test weighing, however, gives an indication of the quantity of milk
consumed at an individual feed where the deuterium oxide technique is a full
day measure of intake. There must be some balance of accuracy and
practicality of measurement procedures.

Child Growth

Adequate child growth while on a diet of breastmilk is only an
indirect measurement of the quantity and quality of breastmilk intake. Delgado
et al (1982), in a study of four rural villages in Guatemala suggested effects on
milk output since supplementing the diets of lactating women had a positive
effect on the growth of the infants during the first two trimesters of life. The
Murrays (1983) stated that breastmilk output was adequate in his study of
undernourished Nigerian mothers since they were able to provide breastmilk for
normal growth comparable to U.S. growth standards. In studies of the effect of
contraceptive methods on milk output, several researchers have used weight

Adequate child growth as a measure of breastfeeding performance may be confounded by many factors that influence growth, such as supplemental feeding, infection, health status and environmental factors. Therefore, measurement by child growth should be used when other factors can be controlled.

Subjective Measures

Subjective impressions have also been used in some studies to assess changes in milk production (Guiloff et al, 1974; Kamal et al, 1969; Koetsawang et al, 1972; Parveen et al, 1977), alone or in conjunction with other measures. Some report decreases or increases in perceptions of milk output, and other have used introduction of supplemental foods to indicate decreases in milk output.

Quality of Breastmilk

Expression and analysis of milk from the breast is the most common method of determining breastmilk quality. However there are several problems with this method that must be kept in mind. Breastmilk composition may vary over the duration of the feeding session, by time of day, by month of lactation, the timing within the mother's menstrual cycle, smoking habits of the mother, gestational age of the infant, contraceptive use (current and previous) of the mother, maternal diet and whether the milk is expressed from the right and left breasts (Allen, 1983; Anderson et al, 1981; Chandra, 1983). The quality and quantity of expressed breastmilk may differ significantly from that of naturally suckled milk (Gibbs et al, 1977 as discussed by Hibberd et al, 1982). Therefore, the timing and amount of the sample of breastmilk may make a critical
difference in its composition. In a study of ten mothers by Hibbert et al, a milk sample was expressed at every feed for a 24 hour period. A high degree of variation was found between samples from the same mother on the same day of lactation; the variation in the maximum and minimum lipid analysis was at a magnitude of 8 times. There was also a significant difference between mothers in milk composition although the duration of lactation was similar.

The Doppler Ultrasound transducer may offer an alternative method of extracting milk for analysis during the natural breastfeeding session. As mentioned earlier, a small catheter may be able to be placed behind the nipple enabling small samples to be taken during the natural flow of breastfeeding. For analysis, this method may bring to light the possible differences in composition between expressed milk and the milk the child ingest:. This procedure is under development and the results of preliminary trials are anticipated.

**Anti-infective Properties of Breastmilk**

Discussion of the measurement of the anti-infective properties of breastmilk needs to take into account both the direct benefit of the immunologic and other properties in breastmilk, and the indirect effect of the near sterile breastmilk contrasted to the possibility of contaminated breastmilk substitutes. The anti-infective properties can be measured directly through the assessment of hormonal or cellular components of breastmilk, or indirectly through the study of morbidity of infants with various feeding patterns.

**Anti-infective Components**

Breastmilk has a high concentration of immunoglobulins, with IgA the predominant immunoglobulin. Numerous antigen specific anti-bodies have been found in breastmilk including those protecting against pathogens affecting
the intestinal or respiratory system including \textit{E. coli}, cholera, rotavirus, polio, etc. (Glass et al, 1983; Yolken et al, 1978; Chandra, 1982). Breastmilk also contains growth factors for protective bacteria \textit{Bifidobacillus bifidium}, the enzyme lysozyme which destroys the cell wall of certain bacteria, and lactoferrin which has bacterial-static properties due to its ability to chelate ferrous iron from micro-organisms, such as enteric bacterial pathogens (Goldman et al, 1983). Leucocytes, including neutrophils, macrophages, and lymphocytes, also evident especially in colostrum, have phagocytic activity (Hanson and Winberg, 1972).

Studies that attempt to measure these components must be able to control for several factors. The quantity of breastmilk produced will obviously affect the amount of anti-infective components that the child receives. This can cause problems in interpretation of studies if not clearly defined. For example, a recent study at INCAP noted that the concentration of IgA was reduced in rural mothers, compared to urban mothers, but the total intake was the same because rural mothers had higher outputs of breastmilk. The urban infants received supplemental food earlier and thus were less reliant on breastmilk for nutrient intake (Cruz et al, 1982).

The duration postpartum has the largest effect on the concentration of anti-infective properties. Decreases in the concentration of leucocytes, lactoferrin, IgA have been seen in the early postpartum period (Goldman et al, 1982). Lysozyme concentrations were seen to decrease initially up to the first month postpartum and then increase. Lysozyme concentrations have also been noted to increase as weaning foods are added to the diet (Nichols, personal communication 1983).
Maternal malnutrition has been observed by some to affect the concentration of antibodies in breastmilk (Miranda, 1983; Cruz et al 1982), but not by others (Carlson et al, 1976; Reddy et al, 1977). The child's gestational age may also be associated with immunologic properties. Chandra (1982) has shown that the milk produced by mothers of preterm infants was higher in IgA up to 56 days postpartum (the period studied). The child's diet may affect the capability of the anti-infective properties to function. For example, it has been suggested that increased levels of iron in diet as in iron-fortified formulas may combine with lactoferrin to reduce its effectiveness.

**Breastfeeding and Morbidity**

Numerous studies have observed decreased morbidity rates (both frequency and severity) among breastfed infants compared to those partially breastfed or not breastfed at all. These effects have been seen both in the perinatal and neonatal periods, and up to 2 years of life (Cunninham, 1981; Mata, 1978).


Several investigators have noted a decreased prevalence of respiratory illness with the practice of breastfeeding, but when maternal education and family living standards were controlled, this association was no longer
significant (Fergusson et al, 1981; Fergusson et al, 1978). Frank et al (1982) noted that when virus infection was documented by culture and serologic tests in U.S. bottlefed and breastfed children, rates of respiratory virus infection were similar, but it appeared that breastfeeding may have lessened the severity of illness. The advantage to the latter investigation is that in contrast to mothers reports, or data on admissions to hospitals - that may be biased dependent upon maternal care variables, the testing of viral infection was independent.

The problems with using morbidity or mortality as the end point to assessing the impact of breastfeeding on health are well discussed by Winikoff (1981). Mortality is affected by social, economic, and medical factors, the historical period, geographic location, and other environmental factors. It is difficult to obtain reliable data on mortality differences if sample sizes are small, since death is a relatively rare event. However, morbidity data are more difficult to gather accurately due to recall problems, subjective judgements needed to assess severity of illness and the relationship between recorded illnesses and access to medical care (Winikoff, 1981).

Numerous other methodological issues arise when attempts are made to assess the effect of breastfeeding on morbidity. Sauls (1979) summarizes these issues as:

1) Self-selection bias: women who breastfeed may be different from those who bottlefeed on factors (such as socio-economic status, education) that affect morbidity.

2) Initially breastfed infants can become bottlefed due to factors associated with health, but the opposite is not true.

3) Maternal recognition of disease may be different for breastfeeding compared to bottle feeders (Berksonian Bias).
The major factor affecting breastfeeding performance and child survival is the first listed above: that women who breastfeed may have characteristics that differ from those not breastfeeding. There may be important socio-cultural, environmental, and economic factors that increase the chance of morbidity among nonbreastfeeders in developing countries. Women who choose not to breastfeed may also be different infant care practitioners (treatment of illness, hygiene habits, etc.). However, in research that were studied women of the same socio-economic class, consistent advantages in the morbidity or mortality associated with breastfeeding have been shown.

Winikoff (1981) suggests that these last two factors listed above could affect the results in the opposite direction, reducing bottlefeeding's rather than enhancing breastfeeding impact on morbidity.

A major methodologic issue relates to when breastfeeding stops due to child death. Since the cause of not breastfeeding is child death and not the opposite, not considering this effect can result in overestimates of the effect of breastfeeding on survival. Based on results from studies in Malaysia, Butz et al (1982) states that spurious correlations between infant mortality and the duration of breastfeeding can produce large overestimates of the mortality-inhibiting effects of breastfeeding.

An important variable that is often not defined in studies assessing the association of breastfeeding and morbidity or mortality is the definition of breastfeeding, whether other foods are given and whether bottles are used. As discussed previously (see Figure 2) there are numerous definitions used to define breastfeeding, exclusive or partial. This will influence the likelihood of introduction of pathogens to the child through the source of supplementation. The environmental context will also play a major role, depending on the
quantity and quality of water available, access to refrigeration, and cooking facilities and time available for fresh preparation of weaning foods. The season during which the study is conducted may therefore affect the results, given differences in environmental conditions due to combined temperature or rainfall (Brown et al, 1982c).

Contraceptive Effect of Breastfeeding

Breastfeeding prevents conception through primarily two mechanisms. By its associated hormonal mechanisms, breastfeeding causes a delay in the resumption of ovulation in the postpartum period. Though to a much lesser extent, it is also associated with delays in conception once ovulation occurs, perhaps due to shortened luteal phases of the menstrual cycle, or problems with implantation of the fertilized ovum (Howie and McNeilly, 1982). In populations where postpartum abstinence is practiced, the duration of breastfeeding may determine the period for which abstinence is practiced.

Anovulation

The frequency of suckling appears to be the major factor affecting the period of anovulation. Measurements of the period are usually estimated by the duration of postpartum amenorrhea, though this is not an exact predictor, since ovulation often precedes resumption of menses, and menstrual cycles can resume that are in fact anovulatory. However, because of the difficulties in measuring ovulation under field conditions, the measurement of resumption of menses is used. Studies are currently being conducted by Gray and colleagues to develop field techniques to determine when postpartum ovulation occurs.

The length of amenorrhea is directly measured by retrospective data on length of amenorrhea during the last closed birth interval, or current status
data on menstrual status in the current open birth interval or the combination of the two. The last closed birth interval includes women having experienced at least two births, since it is defined as the birth occurring prior to the last birth. The open birth interval includes women with at least one birth, since it relates to the status associated with the last birth. Some of the World Fertility Surveys (WFS) and contraceptive prevalence surveys in developing countries contain information on length of amenorrhea. Studies in the WFS countries that included the special module "Factors Other Than Contraception Affecting Fertility" provided this information directly.

Problems involved with using retrospective data on the last closed birth interval include age heaping, and the inclusion of only those women with at least two births. This causes a strong downward bias in the estimate, since women with shorter than average intervals are more likely to be included in the sample. The use of the current open interval has the opposite bias, since women with long intervals are more likely to have them currently open (Lesthaeghe, 1982). Figure 5 illustrates these differences for the duration of breastfeeding. Page et al (1982) suggest the use of data for all births in a fixed period preceding the survey, a period that exceeds the duration studied for most women. The problems involved in using this method include recall errors in remembering the duration of amenorrhea, whether only surviving children are included, and lack of accurate birth dates. It is also important that postpartum bleeding be differentiated from resumption of menses. However, these problems are evident in the use of the open or closed interval analyses described previously as well.

Estimates based on suckling patterns

High frequencies of suckling are related to extended periods of amenorrhea, as observed in field studies in Bangladesh, Zaire, Kenya, the
Figure 5

Comparison of Measurement of Duration of Breastfeeding for 28 Countries

Ref: Ferry and Smith (1983).

It is not a clear-cut effect, however, since the distribution in resumption of menses of women within a population illustrates that some women with frequent suckling patterns resume menses early in the postpartum period, while others with less frequent suckling have more extended amenorrhea.

The use of suckling frequency to determine when resumption of menses is likely to occur within that population probably is the most accurate indirect measure. Few studies have been able to directly observe and record suckling, because of its time-consuming and difficult nature. Of those that have, several factors affecting suckling estimates need to be considered. First is the definition of suckling frequency, whether it includes total time spent suckling, or the number of suckling bouts. When breastfeeding is on demand, frequent bouts of small durations are common. Whether each bout is defined as a separate event, or whether bouts are combined into one event will change substantially the number of times a woman is considered to breastfeed. Most studies do not explain how a breastfeeding event is defined, thus leaving the area to misinterpretation. In our studies in Bangladesh, we initially defined our breastfeeding event as the feeds occurring within a 30 minute period (Huffman et al, 1980). Following Konner and Worthman's study on the importance of interbout intervals, rather than total suckling time in determining when ovulation will resume, the need to classify bouts separately is evident. Most published studies leave this area open to interpretation, but it appears that in each some local standard of what constitutes a feeding event is used. These definitions need to be clearly stated, but generally are not.

An equally important factor to consider in measuring frequency of suckling is whether 24 hour or lesser periods of observation are employed (8, 12
hours). It is often assumed that the frequency of daytime feeds are similar to night feeds, but the validity of this assumption is open to question. Even when daytime feeds vary, night feeds may not be affected. An important finding from studies in Kenya suggests that as the child receives supplements (generally through the use of bottles), daytime breastmilk output and daytime suckling decrease (Van Steenbergen et al 1981). In contrast, night suckling time and number of feeds remain fairly constant for a year and a half.

The filming of suckling bouts has been used by researchers in Britain (Bowen-Jones et al, 1982; Drewitt and Woolridge, 1979) to study suckling patterns. This technique also provides quantification of suckling frequency and intervals between sucks. This method has not been used as yet in the field.

Aside from observations of suckling, self reports (either based on prospective recording or recall of the previous day’s pattern or usual pattern) by women on their frequency of suckling has also been used. These can be seen to be most appropriate when discreet breastfeedings are the common practice. This is most common in developed countries, and may be relevant under this context. However, self-reports when used among women in developing countries can be misleading because of lack of discreet events or when night-feedings are included, as mothers may not be awake when the child feeds. The IFRP, in collaborative studies on breastfeeding, uses a constant of 3 feedings per night per woman added to the daytime frequency which is recorded prospectively by the woman. The problems with this are obvious.

Another indirect measure to assess the period of anovulation is the incidence and duration of breastfeedings or the duration of unsupplemented breastfeeding. In most countries the incidence and duration of breastfeeding are highly correlated; where there is a long duration the incidence is high.
However, there are a few countries which are exceptions to this rule, including Jamaica and Brazil which have relatively high incidences but short durations of breastfeeding (Lesthaeghe, 1982; Marin, 1982). We will discuss influences on these two factors together, since seldom are low incidences associated with extended durations, and the factors affecting the duration of breastfeeding are similar to those affecting the incidence of breastfeeding.

The incidence and duration of breastfeeding are assumed to be highly correlated to the frequency of suckling, since populations exhibiting high suckling frequencies have extended periods of breastfeeding. Given the variations in suckling patterns and types of supplements given, it is evident that duration of total breastfeeding is not necessarily indicative of suckling frequency. However, although a short duration of breastfeeding can occur with high suckling frequencies, extended durations of breastfeeding are unlikely unless the child has suckled frequently, because with infrequent suckling, an older child is less likely to continue breastfeeding (since milk supply will be low).

Another reason that total duration is often used is that total duration is highly correlated with the duration of full breastfeeding - where suckling frequency is likely to be high, since it provides the child's only source of nutrients. Prema and Ravindrath (1982) have illustrated in a study in Hyderabad, India, that a high proportion of the association of duration of breastfeeding with length of amenorrhea is mediated through the length of time the infant is fully breastfed.

Policy makers would like to be able to use this association to predict when resumption of menses will occur in breastfeeding women. The major problem with this was described in the section on supplemental feeding, in that
supplements vary substantially in their types, frequency of feeding and manner fed - all with direct effects on suckling. The introduction of adequate supplements through the use of bottles, as seen in Scotland, will probably lead to resumption of menses. Use of adequate supplements without use of bottles and with maintenance of high suckling frequencies may not be correlated with resumption of menses.

In a U.S. study in which supplementation of infants was delayed until at least five months and no bottles were used, the observed duration of amenorrhea was 14 months. This suggests that if infants are fed without the use of bottles and the mother maintains her other "natural" breastfeeding patterns (including night feeds, no use of pacifiers, unscheduled feeds), extended amenorrhea may still result, although it would be of a shorter duration than under circumstances of poor or no supplementation (Kippley and Kippley, 1972). Recent studies in rural Mexico confirm these results. Ovulation did not return among women who gave their infants supplemental foods, but continued to suckle them more than ten times per day (Rivera, 1981).

**Estimates based on duration of breastfeeding**

Through the use of data on breastfeeding patterns, demographers have estimated the duration of amenorrhea based on mathematical formulas. Bongaarts (1982) equation converts the mean duration of breastfeeding (BF) into the mean duration of amenorrhea (Amen):

\[ \text{Amen} = 1.753 \times e^{0.1396 \times BF - 0.001872 \times BF^2} \]

Lesthaeghe and Page (1981) used logit analyses to linearize the pattern of breastfeeding and estimate the median duration of amenorrhea and the curve of
its distribution. These equations illustrated on average that the effect of increases in breastfeeding duration are greatest in extending amenorrhea from about 10-24 months postpartum. Before or after this, increases in durations have lesser impacts (Bongaarts, 1982). Table 1 gives data on the proportion of children breastfed, and estimates of the mean durations of breastfeeding and of postpartum amenorrhea using WFS data.

The measurement problems involved with these estimates are the same as those described above in relation to direct estimation of amenorrhea: age heaping, biases of which interval (open or closed) is used, inclusion or exclusion of child deaths, and recall. An additional problem is that the equations use the same distribution in resumption of menses for each population with the underlying assumption that suckling patterns are the same. As discussed previously, this is in fact not true, and thus the estimates may be off by a few months. Table 2 gives the calculated estimates of amenorrhea based on Bongaarts equation compared to the observed durations. As illustrated, the highest difference between the two estimates is 3 months, suggesting a fairly close association of amenorrhea with the duration of breastfeeding on a population basis.

Postpartum Abstinence

Aside from the direct hormonal effect of breastfeeding on fecundity, it may also have an indirect effect because of its association with postpartum abstinence. In some populations, abstinence exceeds the duration of breastfeeding and in others it is shorter (Nag, 1982). Extended postpartum abstinence is seen primarily in parts of Africa, especially sub-sahara Africa.

Schoenmaeckers et al (1981) discuss some of the problems involved in measuring postpartum abstinence. Often the duration can be given in terms of
TABLE 1
Mean Duration of Breastfeeding and Amenorrhea from World Fertility Surveys

<table>
<thead>
<tr>
<th>Country</th>
<th>Proportion of Children Breastfed (a)</th>
<th>Breastfeeding (mo) (a)</th>
<th>Amenorrhea (mo) (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>.99</td>
<td>31</td>
<td>22</td>
</tr>
<tr>
<td>Nepal</td>
<td>1.00</td>
<td>29</td>
<td>21</td>
</tr>
<tr>
<td>Indonesia</td>
<td>.98</td>
<td>25</td>
<td>18</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>.98</td>
<td>22</td>
<td>16</td>
</tr>
<tr>
<td>Pakistan</td>
<td>.99</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>Kenya</td>
<td>.99</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Jordan</td>
<td>.93</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Thailand</td>
<td>.93</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Malaysia</td>
<td>.74</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Peru</td>
<td>.95</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Mexico</td>
<td>.83</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Colombia</td>
<td>.92</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Panama</td>
<td>.80</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Jamaica</td>
<td>.95</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>.75</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

(a) Calculated based on current status data for surviving children born in last 36-48 months

(b) Calculated from breastfeeding mean duration using Bongaart's equation

\[ \text{Amen} = 1.753 e^{(0.1396 \text{BF} - 0.001872 \text{BF}^2)} \]

Ref: Lesaegthe, 1982
### TABLE 2

**Observed and Calculated Durations of Amenorrhea**

<table>
<thead>
<tr>
<th>Location</th>
<th>Observed</th>
<th>Calculated&lt;sup&gt;(a)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bahia</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Rio Grande de Norte</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Paraiba</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Pernambuco</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dakar</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Guatemala</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Java, Indonesia</td>
<td>21</td>
<td>19</td>
</tr>
<tr>
<td>Calabar, Nigeria</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Punjab, India</td>
<td>11</td>
<td>14</td>
</tr>
</tbody>
</table>

<sup>(a)</sup> Using Bongaarts (1982) formula

Ref: Lesaegthe, 1982.
events such as "until the child can walk" or "until the child is weaned." This taboo often is related to its effect on "poisoning breastfeed," so that some may practice coitus interruptus and be considered to have abstained. Because of the strong cultural prohibitions to intercourse, reporting errors may also be common.

In addition to these measurement problems, similar issues as discussed previously in relation to measuring breastfeeding are involved, including recall error, and age heaping.

**Birth Spacing and *J Survival**

The evident association between amenorrhea and duration of breastfeeding has led to the examination of the effect of increased birth spacing caused by breastfeeding on child survival. A major concern with such analyses is that the birthspacing effect of breastfeeding is curtailed by child death, so that there will be an automatic direct link between short birth intervals and preceding child death (the child dying before short birth interval). A problem in studying the effect of birth spacing on the subsequent child (the child born following a short interval) is that a subsequently pregnancy is often the reason for stopping breastfeeding. Winikoff (1982) discusses these problems in extensive detail.

Gray (1981) summarizes the methodologic problems involved in assessing the impact of birth spacing on child survival. There is a need to control for other variables affecting birth intervals and child survival.

1) The association of age, and parity, with birth intervals: young, high-parity women by definition will have short intervals, and they also are at risk to poor outcomes.
2) Birth interval durations may be associated with socio-economic status, which is also associated with high child mortality.

To assess the effect of breastfeeding on child survival through its birth spacing effect, it will be necessary to compare populations who stop breastfeeding early to those who stop later within the same socio-cultural group, in order to control for factors other than breastfeeding that will affect death (such as morbidity experience).

V. Conclusion

In attempting to make comparisons of populations undergoing changes in the duration of breastfeeding, the interplay of various factors affecting child nutrition and health need to be considered.

As modernization occurs, the duration of breastfeeding is often reduced, which could have detrimental effects on child health as discussed in this paper, through the pathways of decreasing nutrient intake, decreased immunologic protection, increased contamination of nutrient sources, and decreased birth spacing. However, these negative effects can be moderated by associated changes occurring with modernization: increased availability of other food sources for the child, improved environmental and sanitary conditions which reduce the infection load in the environment, enhanced health services to prevent and treat illnesses among children, and increased use of contraception as an alternative to breastfeeding for child spacing. However, when isolated changes in breastfeeding patterns occur, without the additional improvements described above, effects on child survival are likely to be substantial. For example, if working patterns of women cause them to abandon breastfeeding,
unless income increases enough to counter the additional cost of breastmilk substitutes, and enables preparation and storage of the food in a manner preventing contamination, it is likely that this change in breastfeeding will reduce the probability of child survival, especially in the early months of life. Among urban slum dwellers, where some modernizing influence affect them (such as the advertising of infant formula) that may reduce prevalence of breastfeeding, other factors such as health care utilization or use of birth control may be enhanced, countering negative effects or child health of declines in breastfeeding. If such corresponding influences are not available, then child health will be negatively affected.

Examples of the lack of countering forces to declines in breastfeeding are available. In a study in rural Chile, where the average age of weaning was about 6 months, rural families with higher incomes, increased availability of running water and some sewage system had higher infant mortality rates than poorer families without these amenities. The high degree of correlation between enhanced socio-economic status and reductions in the duration of breastfeeding suggests that the improvements in socio-economic status were unable to counter-act the negative effect of early weaning. In this study, partial breastfeeding did not provide a protective effect, while full breastfeeding did (Plank and Milanesi, 1973).

The average length of breastfeeding in Malaysia is greater than that seen in Chile, and the interaction between breastfeeding and socio-economic status different. In Malaysia, families with access to toilets and piped water had lower mortality rates in spite of reduced levels of breastfeeding (Butz et al, 1982). These differences suggest that the influence of breastfeeding on survival is very much dependent on the local ecological context, and how it influences the intervening variables described in this paper.
Declines in breastfeeding although generally associated with increases in contraceptive use, may in fact lead to increases in fertility and subsequently lowered birth spacing. Evidence for increases in fertility associated with declines in the incidence and/or duration of breastfeeding have been suggested by studies conducted in Kenya, Zaire, Algeria, and among natives in Canada and Alaska (Lesthaeghe, 1982; Romaniuk, 1980; Romaniuk, 1981; Blackwood, 1981).

Countries that have illustrated recent declines in breastfeeding, Malaysia, and Thailand, for example, have also experienced improvements in the standard of living and associated reductions in infant mortality (Butz and DaVanzo, 1978; Knodel and Debavalya, 1980). This has led some to suggest that breastfeeding is not an important factor in child survival under modernizing conditions. This paper has attempted to illustrate that in order to assess the influence of breastfeeding on survival, it is important to go beyond ecological correlations between declines in breastfeeding and changes in mortality. It is necessary to examine the many conditions affecting breastfeeding's influence on child survival, because populations and subgroups within populations are likely to be influenced differently. Rather than implying a null effect of the importance of breastfeeding for child survival, such aggregate results should encourage us to examine which factors are most important in balancing the consequences of declines in breastfeeding, and to understand how to maintain the benefits of breastfeeding in the midst of modernization influences.
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