Breast is Best? A Review of the Role of Breastfeeding in the Prevention of Infectious Disease

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Abstract: The hypotheses about how breastfeeding protects infants from infectious diseases are reviewed. While there is strong evidence in favour of breastfeeding as prevention against infectious diseases, the exact mechanisms and duration of its effects still remain unclear. It is argued that basing the promotion of breastfeeding on so-called scientific facts is a dangerous endeavour, as medical information has been and will continue to be formed by societal values, market forces and public interest groups. It is concluded that rather than conducting breastfeeding research as if it is value-neutral, it should be considered to be a behaviour which is shaped by its socio-cultural context in which mothers play an active role in decision-making.

Introduction

While sound arguments for the promotion of breastfeeding can be and are based on the fact that breast milk is a healthy, sustainable resource which fosters intimate emotional bonding between mothers and infants, policy makers, health care workers and breastfeeding advocates often discuss breastfeeding in the context of infant morbidity and mortality rates. Breastfeeding is extolled as a form of protection against infectious disease for infants. Often this claim is made without reference to the precise means by which breastfeeding is protective or to the duration of its effects. For example, Van Esterik, who advocates for breastfeeding on the platform of consumer rights and not biomedical evidence, refers to breast milk as containing "irreplaceable immunological protection" (Van Esterik 1985: 65).

Much of the evidence about the protective aspects of breastfeeding derives from retrospective mortality studies which reveal an association between artificial feeding and high infant mortality rates. Historical data from nineteenth century Germany show that in regions where breastfeeding was commonly practised, infants had better survival rates compared to those where artificial feeding was the norm (Knodel and Van De Walle 1967; Knodel and Kintner 1977). Similarily, a contemporary study of 1,712 rural Chilean mothers and infants surveyed from 1969-70 concluded that there were three times as many deaths for infants introduced to the bottle before three months of age compared to those who were exclusively breastfed (Plank and Milanesi 1973).

The precise means of protection, however, is still not understood. The three major hypotheses proposed as the most likely mechanisms are: i) breast milk is clean and not contaminated as are some water sources, unpasteurized and/or unrefrigerated milk and foods; ii) human milk contains immunological properties which directly combat infectious pathogens; iii) breastfeeding ensures that the infant is well nourished and therefore the body is better able to marshal immunological defenses against pathogens.

This paper will review the role that breastfeeding plays in infant health, specifically in regard to infectious diseases. The hypotheses stated above will be critically reviewed in order to illustrate that scientific evidence and biological arguments about breastfeeding are on shifting ground. In doing this exercise, I do not argue that breastfeeding should not be encouraged, but rather that to base its promotion solely on scientific research is precarious, since the data can be manipulated to suit multiple perspectives. While policy makers and the general public should be informed about scientific research, they should not rely solely on the "scientific experts"; ultimately, their choices are better guided by a broad understanding of the biological, economic and socio-cultural perspectives of breastfeeding both at the local and international levels.

A Review of the Evidence

1. Avoidance of Contamination

Infectious diarrheal diseases are a leading cause of morbidity and mortality in the developing world today, as they were historically in developed countries (Snyder and Merson 1982; Gordon *et al.* 1963). The most common etiological agents of diarrhea are bacteria (e.g. *Shigellae, Salmonellae,* diarrheagenic *E. coli*, *Vibrio cholerae*), rotaviruses and parasites (e.g. *Giardia lambilia*) (Gorbach 1986). They are all transmitted through the fecal-oral route via water, food and person-to-person contact. Although each pathogen has a variety of symptoms, they all commonly produce diarrhea, which may lead to constitutional imbalance, dehydration, malnutrition and ultimately death (Mata 1986).

Rowland and Barrell (1980), in their study of infant diarrheal morbidity in Gambia, West Africa, demonstrated how diarrhea prevalence increases dramatically during the rainy season when well-water is contaminated by human feces. The growth of pathogenic bacteria on food is common, especially during the humid season when it is cooked in the morning and left to stand throughout the day. Compared to contaminated water and food, breast milk is clean. Although there may be some contamination of the breast nipple by staphylococci, the bacterial count is low and there is no opportunity for growth and multiplication of micro-organisms as with stored milk and water (Jelliffe and Jelliffe 1978:84).

Diarrheal mortality is difficult to study prospectively because the presence of medical researchers doing surveillance will lead to prevention of deaths through medical aid (Snyder and Merson 1982). A study of retrospective mortality employing hospital and coroner records from an urban centre in Brazil indicated that breastfed infants had a significantly lower diarrhea death risk ratio compared to artificially fed infants (Victora *et al.* 1987). As well, a study of diarrheal morbidity in Peru demonstrated lower prevalence and incidence rates of diarrhea among breastfed infants (Brown *et al.* 1989).

It is difficult to discern whether prevention of diarrhea is due to avoidance of contamination or to providing the infant with immunocompetence. Plank and Milanesi (1973) found that "mixed feeders", i.e., infants fed alternately from the breast and the bottle, had mortality rates that were not significantly lower than artificially fed infants. They believe that the lack of an intermediate mortality risk supports avoidance of contamination as the most important factor, since both artificially fed and mixed feeders are exposed to contamination. But the fact that mixed feeders may not have received enough breast milk to boost immunocompetence is an equally valid explanation.

Victora and colleagues (1987) did reveal what they called a "dosage" effect for diarrheal morbidity depending on whether an infant was exclusively breast, mixed or artificially fed. However, there may have been some difference in the definition of a mixed feeder, since neither study stipulated a precise definition of it. It is necessary to consider how much and what kind of food, besides breast milk, an infant is ingesting. Since most studies do not collect these details, it is difficult to draw conclusions. As Popkin and colleagues point out "...the rapid and often subtle shifts in feeding regimens occurring throughout infancy make simplistic definitions of bottle and supplemental feeding misleading" (1990: 874).

2. Immunologic Properties of Breast Milk

One of the more important findings in the last thirty years regarding breastfeeding was the discovery that breast milk contains immunologic properties (Mata and Wyatt 1971; Jelliffe and Jelliffe 1978). This finding suggests that breastfeeding is not just a way of avoiding contaminated food and water sources, but may directly aid the infant's immune system in fighting infectious disease pathogens.

There are several components of the immunological properties in human milk. Unspecific factors such as macrophages produce lysozyme and complement C3 and C4 in addition to destroying and ingesting micro-organisms (Meeuwisse 1985). A protein named lactoferrin binds iron in the milk, making the milk unavailable to pathogenic bacteria in the intestine, which requires iron to survive and flourish (Forsyth 1992). It has also been proposed that the composition of human milk inhibits the growth of pathogens as cow's milk' moreso than human milk' promotes the growth of flora in the infant's gastro-intestinal tract (Braun 1981). As well, *lactobacilli*, a commensal bacteria which grows in the breastfed infant's gut, may inhibit the colonization of pathogenic bacteria (Howie 1985).

Unlike many mammals, primate fetuses receive maternal antibodies transplacentally, a process called "passive immunity". Cows, sheep, pigs and horses, however, are born without humoral immunity and depend on antibodies derived from the maternal colostrum several days after birth. Without colostrum these animals frequently die from *E. coli* diarrhea and septicaemia during the first week of life (Jelliffe and Jelliffe 1978: 85). Although the mucosal immune system is not mature until approximately 10 to 12 days after birth (Ogra *et al.* 1981), the human infant can survive without ingesting colostrum due to the prenatal acquisition of maternal antibodies.

Despite passive immunity, specific immunological factors are present in human milk. These are B and T lymphocytes and immunoglobulins, the main variety being called secretory immunoglobulin A (SIgA). SIgA was characterized and isolated in human milk by Hansen in 1961 (Forsyth 1992: 20). SIgA is so named because it is secreted from the exocrine glands, including the mammaries. The process by which

SIgA reaches the infant has been recently elucidated. It is thought that the mother ingests pathogens which activate the B cells found in the Peyer's patches of her large intestine. The B cells produce plasma IgA, which then "home" to the mammary glands and the IgA is secreted into the lactating mother's milk (Howie 1985). In other words, SIgA is context dependent in that the mother must be exposed to the pathogen before the infant can acquire the antibodies. Although this process is thought to provide passive immunity, research involving infant polio vaccination indicates that antibodies transmitted through the milk may also actively prime the infant's immune system (Hanson *et al.* 1990). SIgA is effective on mucosal surfaces such as the intestine. It is thought to provide a barrier for the lining of the intestine, thus inhibiting pathogens from binding to the mucosal surface. A similar process may occur on the mucosal surfaces of the respiratory system when the infant suckles and "gurgles" the milk through the nose and mouth (Welsh and May 1979: 2).

A range of antimicrobial activity against certain pathogens has been found to exist in human milk (Table 1).

Bacteria	Viruses	Fungi
Enterobacteriaceae	Enteroviruses	*Candida*
E. coli enterotoxin	Polio 1,2,3	
Clostridium tetani	Coxsackie A,B	
Diptheria	Rotavirus	
Streptococcus pneumoniae	Herpes Simplex	
Salmonella	Influenza	
Staphylococcus aureus	Arboviruses	
Vibrio cholerae	Similiki Forest	
	Ross River	
	Japanese B	
	Dengue	
	Rubella	
	Respiratory syncytial	

Table 1: Spectrum of Antimicrobial Activity in Human Colostrum and Milk ***(Source: Gershwin, Beach and Hurley 1985, p. 297).***

The strongest evidence for the activity of antimicrobials in breast milk comes from *in vitro* studies, although several studies have also been devoted to finding clinical proof (Glass *et al.* 1983; Ahmed 1992). In a review of the evidence from developing countries, Jason *et al.* (1984) consider studies that have the fewest methodological problems and conclude that the weight of the evidence is in favour of a protective factor from breastfeeding. In terms of protection against a specific disease, the strongest testimony comes from studies done in Bangladesh employing cholera patients (Jason *et al.* 1984). Glass *et al.* (1983) attempted to demonstrate the *in vivo* effects of SIgA on *Vibrio cholerae* by measuring cholera antibodies in breast milk and comparing them to infant stool samples and the disease outcomes. They demonstrated that infants whose mothers' milk contained high levels of antibodies were less likely to manifest diarrheal symptoms when they were colonized by the bacteria. Interestingly, some mothers had sufficient antibodies in their breast milk where as others did not. As Hanson *et al.* (1990)

point out, there are wide individual variations in SIgA antibody titres in breast milk, which may affect the protective capacity of breastfeeding. There is also some evidence that breast milk's anti-microbial properties provide immunocompetence against respiratory infections, but it is less convincing than that found for gastro-intestinal infections (Victora *et al.* 1987; Howie *et al.* 1990).

One way to try and differentiate the active effects of breast milk from avoidance of contamination is to set studies in developed countries. Since most women in developed countries have access to clean water and sterilization techniques, it is reasoned that a demonstrated protective effect could only be explained by the inherent immunological properties of breast milk.

Such research has offered conflicting results because of the difficulty in designing a study which is able to prove causality between breastfeeding and inhibition of infectious disease (Bauchner *et al.* 1986) . The ideal study would involve randomized controlled trials in which infants are assigned to be fed either by breast or by bottle. Realistically, this is impossible and unethical; therefore, researchers employ cohort (either retrospective or prospective) or case control studies. In the cohort studies, infants are divided into breastfed or artificially fed groups and the morbidity rates of each group are compared. In the case-control studies, children who have been identified as falling ill with an infectious disease are then compared according to their mode of feeding. Below is a summary of the methodologic limitations that Kovar *et al.* (1984) found in the studies they reviewed.

1. There was no control for confounding factors such as socio-economic status, birthweight, parity and parental smoking, among other factors which could be associated with the mode of feeding and affect morbidity outcome.

2. The methodology lacked detailed definitions of what constituted the clinical diagnosis of either the gastro-enteritis or the respiratory infection. Since stools are softer and more frequent for breastfed infants, it may be more difficult to detect diarrhea among breastfed infants.

3. There was minimal specificity of type of feeding category. If "mixed feeding" was used as a category, the amount and quality of bottle milk was not specified.

4. Mothers were not asked why they chose a particular method or why they switched from breastfeeding to artificial feeding. Mothers may have ceased to breastfeed and adopted artificial feeding if their infant became ill.

5. Researchers did not control for the age of the infant. Since breastfeeding may be more or less effective at a certain age, grouping all infants under one year of age may lose some of the effects seen for very young infants.

Because of these limitations, Kovar and colleagues (1984) and Bauchner and colleagues (1986) concluded that there is minimal evidence to prove that breastfeeding protects infants against infectious disease in developed countries.

One recent study, however, done in Scotland heeded the critiques of previous studies and avoided all the biases stated above in their research design (Howie *et al.* 1990).

The authors found that infants who were breastfed from 14 to 52 weeks had a significantly lower incidence of gastro-intestinal illness than bottlefed infants. There was a reduction in illness whether supplements were added to breastfeeding or not, and hence they concluded that the immunological properties in breast milk protect infants. More such studies must be performed in order to draw definitive conclusions.

Despite increasing evidence of the clinically effective anti-microbial properties of breast milk, there is little consensus on the duration of the effects. This is an important point since many advocates of breastfeeding, including the WHO/UNICEF (1991), encourage mothers to breastfeed with supplementation for two to three years after birth. The concentration of SIgA in milk is highest within the first week postpartum. The concentration thereafter decreases from 0.2 g/dl to 0.08 g/dl at three months and reaches a nadir at nine months of lactation (Forsyth 1992: 20). These quantities, however, are meaningless without knowing the threshold at which SIgA is effective against pathogens. Howie *et al.* (1990) demonstrated that protection was significant at a $p < 0.01$ level up to 26 weeks or 6.5 months of age. Kovar *et al.* (1984) state that none of the studies they reviewed confirmed that breastfeeding is protective beyond its duration, whereas Howie *et al.* (1990) claim that infants who were breastfed until 13 weeks maintained protection beyond the period of breastfeeding itself.

3. Nutrition

The final hypothesized means by which breastfeeding protects infants from infectious disease is through the nutritive value of human milk. Clear links between malnutrition and vulnerability to parasitic organisms through a compromised immune system have been established (Martorell and Ho 1984). Several studies of diarrhea and breastfeeding in Matlab, Bangladesh have found that the protective effects of breastfeeding were greatest for malnourished children, even if the breast milk was supplemented by other food and liquid and continued beyond 18 months of age (Briend *et al.* 1988; Ahmed *et al.* 1992). But again this kind of result does not confirm whether it was the nutritive value of the breastfeeding or the immunological properties of the breast milk which afforded protection.

One might presume that an infant who is breastfed is well nourished and thus would have good immunocompetence and would rarely be ill. That is, of course, if one assumes that exclusively breastfed infants are well nourished.

The whole concept of evaluating the nutritive content of breast milk arose with the development of humanized infant formula products in the 1930s by Drs. Tisdall and Drake at the Hospital for Sick Children in Toronto, Ontario (Van Esterik 1989: 118). For that research, the contents of cow and human breast milk were scrutinized and compared. The assumption that human milk was the "perfect" food was beginning to be questioned; with technology, the content of infant formula could be designed to improve on "nature's work". This point of view, of course, reflected an industrial society where technology and products were created in the name of "progress".

Comparative analyses of human and cow milk show that there are differences in the content of specific nutrients. For example, there is three times less protein and twice as much vitamin A in human milk compared to cow milk (Caliendo 1979). Although most of the comparisons have been between human and cow, one study analyzed the proteins in the milk of the Rhesus monkey (*Macaca mulatta*) and human milk (Kunz and Lonnerdal 1993). Human milk proteins, which are not present in cow milk, are found in Rhesus monkey milk, although Rhesus milk has a higher concentration of protein than human milk. This is not surprising considering that different species have varying energy requirements and growth trajectories.

Not only is there interspecies difference in milk content, there is also intraspecies and even intraindividual variation. Throughout any one day, breast milk may vary in both quality and quantity (Howie 1985). Research on the variable content of breast milk indicates that suckling frequency may influence the fat content in milk. A second feed shortly after a first will have a higher concentration of fat than the previous feed (Dettwyler and Fishman 1992:185).

The contents of human and cow milks are often represented in tables which break down the components of milk by quantity. This is an artificial portrayal of breast milk due to the wide variability in content both between individual women, within a woman's reproductive life cycle, and even, as explained above, within the course of a single day. Of course, cows also display variation in milk content, but as cow's milk is pooled and "humanized" to produce infant formula, it is easier to quantify it and refer to it as a product. In essence, then, breast milk is reified by scientific analyses, thereby promoting it as a commodity much like infant formula.

Another difficulty in analyzing the nutritive value of breastmilk is the measurement of the amount that an infant eats. Formula can be measured in a bottle, whereas it is more difficult to know how much an infant ingests when suckling at the breast. The traditional means was to employ manual or mechanical expression of the breast milk to obtain a sample, along with "test weighing", i.e., weighing the baby before and after a feed. The problem with this method is that because of the variation in nutrients in milk throughout the feed, it is difficult to obtain a representative sample. In recent years more refined methods have been developed and it is now thought that, in the past, the energy density of human milk may have been overestimated (Lucas *et al.* 1988). More precise data will alter ideas about energy demands on lactating mothers and the nutritional requirements of infants (Prentice and Prentice 1990).

In evaluating whether breast milk provides optimal nutrition, it becomes readily apparent that the definition of "optimal" depends on the limitations of the mother's and the infant's environment. Most would agree that in a developing country, where many people live in poverty and cannot afford to buy sufficient amounts of infant formula, breastfeeding exclusively for the first four to six months is advisable. Research is also beginning to reveal that extending breastfeeding into the second or third year of a child's life is beneficial if there is a lack of energy-dense weaning food (Mahalanabis 1991; Prentice 1994). Studies of marginally malnourished lactating mothers have demonstrated that the amount and quality of their breast milk does not significantly depreciate, although there is some decrease in the fat content. Conditions must be quite severe before mothers' breast milk will dramatically decline in value (Gershwin *et al.* 1985). There is more controversy over the optimal nutrition for mothers and infants living in more affluent conditions in developed countries (Miller and Chopra 1984). One of the most contentious points is the issue of prolonged breastfeeding beyond the third month of an infant's life. After about three months of lactation, the concentration of nutrients, with the exception of lactose, decreases by approximately 10 to 30%, reaching a low plateau by the end of the year. This is thought to be programmed, although it may also occur because an infant begins to suckle less after the introduction of weaning foods. There is some concern that an infant who continues to breastfeed after four months will ingest smaller amounts of nutrient rich solid foods and will be disadvantaged compared to a weaned infant (Prentice and Paul 1990).

There is also some debate about the benefits of exclusive breastfeeding for the first four months of life. The quantities of milk produced by well-nourished mothers are less than the recommended dietary standards and some growth studies show that formula-fed infants grow faster and larger than breastfed infants (Butte *et al.* 1990). Dettwyler and Fishman (1992) offer some explanations for the discrepancy. First, feeding schedules prescribed in the West, compared to feeding on demand observed in many non-Western settings, may not provide infants with enough breast milk. Second, breastfed infants of well-nourished healthy mothers may experience "catch-down" growth in which greater than average intrauterine growth is off-set with slower infantile growth.

Is maximal growth optimal nutrition or is it overnutrition? Is there a problem with the dietary standards that are employed to evaluate infant growth? This is an issue which is difficult to resolve empirically; in part it depends on the cultural values held by society. For example, during the post-war climate in the 1950s, a high-protein, low-carbohydrate diet was favoured by nutritionists. Currently, in part because of an ageing population and new findings about cholesterol and cardiovascular disease, a low-fat, low-protein, high-carbohydrate diet is recommended. In much the same way, the medical profession has had changing ideas about infant nutrition. Seventy years ago the appropriate age to introduce solid food was just before the first birthday; in the 1950s and 1960s it was considered to be one month of age (Raphael 1973). Current thinking says that an infant cannot digest solid food until about six months of life (South-Paul 1987).

Much of the anxiety about the introduction of solid food revolves around nutrient deficiencies in breastfed infants. There are cases in the medical literature of iron (Siimes *et al.* 1984 cited in South-Paul 1987:174) and vitamin B12 deficiency (McPhee *et al.* 1988) among exclusively breastfed infants. Some nutritionists today recommend that an infant be given Vitamin D and C supplements immediately after birth, and iron supplements at about four months (Gershwin *et al.* 1985); others believe that under "ideal" breastfeeding conditions nutrient supplementation is unnecessary (Howie 1985).

As research questions are framed in new ways, ideas about feeding change. For example, Kent and colleagues (1990) question the healthfulness of fortifying baby pablum and processed food with iron. They argue that one of the ways the body combats infectious disease is through inducing a state of iron deficiency anaemia by depriving pathogens of iron which they need to thrive. As stated earlier, breast milk contains lactoferrin which binds iron. If lactoferrin is saturated by iron it can no longer effectively bind. Overnutrition, in terms of iron, may be inimical to the body's defenses against infectious disease.

Evolutionary and Biological Ideas about Breastfeeding

Some of the advocates of breastfeeding reason that breast milk is the nutritionally complete food for human infants because it has been fine-tuned by millions of years of evolution (Dettwyler and Fishman 1992). The fairly low iron content in human milk, compared to dietary standards, may be a response to a high disease load and may provide the perfect nutritional balance between states of anaemia and infectious disease (Kent *et al.* 1990) . Can we, however, assume that there is an absolute level of nutrition when ecological conditions vary both geographically and through time? If the high disease load of our evolutionary past did shape the content of breast milk, is that evolutionary product ideal for infants living under a relatively low disease load in the twentieth century's so-called "developed world"?

The idea that breast milk is an evolutionary product, moreover, perpetuates what was discussed above: the reification of breast milk as a uniform commodity much like "2% milk" found in a supermarket. Current research on breast milk reveals that perhaps one of the unique elements of mammalian milk, at least in terms of its immunological properties, is its ability to deliver specific antibodies to the infant depending on the infectious diseases present in the mother's and infant's environment. New understanding of suckling frequency and nutrient content of breast milk suggests that lactation may be more dynamic and responsive to maternal and infant needs than previously thought.

If one views breast milk as a "finished product" of sorts, then the debate about breastfeeding is opened up to pro-infant formula arguments which also employ evolutionary logic. For example, Dugdale (1986), whose research was funded by a pharmaceutical company, contends that if one thinks about maximizing the reproductive fitness of an individual, one has to consider the mother as well as the infant in terms of survival. According to his logic, a woman who survives and reproduces eight offspring, five of whom survive to reproductive age, is more reproductively successful than a woman who reproduces two surviving offspring after which she herself dies because of nutritional deficiencies. Thus, Dugdale (1986) reasons that the breast milk product of evolution will be a trade-off between optimal nutrition for children and a mother's nutritional resources. Of course, there are some problems with this argument, one being that Dugdale (1986) assumes that *Homo sapiens* of the evolutionary past lived in nutritionally marginal conditions as do many people in the Third World today. Nevertheless, the argument is as convincing as other evolutionary ideas about breast milk.

The other problem with understanding breastfeeding in an evolutionary context is that it becomes bound up with ideas about social evolution and modernization. For example, Huffman and Lamphere (1984) point out that because of recent simultaneous declines in breastfeeding and infant mortality rates in more developed countries (e.g. Malyasia and Thailand), some people suggest that breastfeeding is not an important factor in child survival under modernizing conditions. Thus, breastfeeding can be equated with "primitive" conditions, a behaviour which inhibits or at least is not suitable for "modern" behaviour. As Van Esterik and Greiner (1981) point out, many policy makers assume that a decline in the initiation of breastfeeding in the developing world has occurred because women have entered the paid labour force, but there has been no convincing evidence to support this assertion (see also Winikoff and Laukaran 1989).

Connected with evolutionary ideas about breastfeeding is the conception that it is "natural" and therefore the best form of infant feeding. This is the position adopted by groups such as the La Leche League and New Conservative Feminists, who advocate a return to celebrating the nurturing qualities of women as mothers (Stacey 1983, cited in Van Esterik 1989: 93).

In response to the claim that breastfeeding is "natural", one could argue that although lactation is a biological function, the act of breastfeeding is a learned primate behaviour, which in human societies is shaped by culture. This is evident from research on cross-cultural infant feeding styles.

> Patterns of infant feeding in any community have an underlying basis in cultural beliefs concerning, among other things, the nature of children, the nature of food, and how, when and what kinds of food children should eat (*Dettwyler 1987: 633*).

Dettwyler's (1986, 1987) research in Mali, West Africa documents that breastfeeding occurs on demand throughout the night until the second year or so of the child's life. This contrasts with scheduled feedings which are now the norm in most contemporary Western settings. As pointed out earlier, unlike other mammals, humans will not die as infants if they do not receive their mothers' milk. Humans, therefore, do have the flexibility to choose alternative feeding methods. Fildes (1986) has documented evidence of the use of artificial feeding methods as far back as 3000 BC among artifacts and texts from ancient Egypt and the Near East. Although *Homo sapiens* probably did not have adequate milk substitutes before the domestication of animals during the Neolithic, they may have supplemented breastfeeding with water and food.

One of the dangers of conceptualizing breastfeeding solely in biomedical terms is the medicalization of women who do not have enough breast milk to feed their infants, a condition labeled Insufficient Milk Syndrome (IMS). Many doctors treat IMS as a biological dysfunction. It may be, however, that mothers who supplement breastfeeding with bottle feeding experience a reduction in breast milk because the infant is suckling less. Or alternatively, the mother may not produce breast milk during lactation because she is worried about the process and does not have a supportive mother or friend who can teach her how to breastfeed (Van Esterik 1988).

Breastfeeding and Policy

Several medical doctors, Drs. Jelliffe and Jelliffe (1978) from the United States and Dr. Howie (1985, 1990) from England openly advocate breastfeeding. They actively research the positive benefits of breastfeeding, including the idea that breastfeeding is protective against infectious disease. Dr. Dugdale (1986), on the other hand, employs similar research methods, data and biological theories to argue that breastfeeding is not necessarily the best and only way to feed infants. Other researchers (*cf.* George and Lebenthal 1981; Gershwin *et al.* 1985) take a very neutral position, comparing the compositions of breast milk and infant formula as if they were simply products of equal value with no further cultural or political attachments. The WHO Innocenti Declaration states that after an exclusive breastfeeding period of 4-6 months, children should continue to be breastfed while receiving appropriate and adequate complementary foods for up to two years of age or beyond (WHO/UNICEF 1991). While this policy is supposedly based on scientific fact concerning, among other things, breast milk's prevention of disease, the review of the evidence in this paper illustrates that there is no clear understanding of the exact mechanism and duration of this protection as yet.

It seems clear that it is best to avoid giving an infant contaminated water and food; research shows that exclusively breastfed infants do not need supplemental water, even in tropical climates (Sachdev *et al.* 1991). However, many mothers do, in fact, feed their babies supplemental liquids, in many cases soon after birth. This has been documented in Latin America (Schmidt 1990), West Africa (Rowland and Barrel 1980), the Philippines (Popkin *et al.* 1990) and Thailand (Jackson *et al.* 1990). Mothers in Thailand may wish to begin socialization of infants early by feeding them significant foods such as rice (Jackson *et al.* 1990). Feeding infants small amounts of liquids may promote the acquisition of natural immunity to infectious diseases like cholera or rotaviruses which cause diarrhea. As there is no longitudinal research on infants who survive infancy in harsh climates and go on to survive early childhood, this latter hypothesis remains untested.

I am not arguing that the WHO policy on breastfeeding is unsound; there is more evidence that shows that breastfeeding, especially in developing countries, is more helpful than harmful. It is important to realize, though, that this policy was probably more influenced by consumer advocacy groups and environmental movements established during the 1970s, than empirical scientific fact (Van Esterik 1989). From the turn of the century in North America, many physicians encouraged mothers to bottlefeed rather than breastfeed (Raphael 1973: 48), and they too were giving advice based on medical evidence. In retrospect, one can see that the direction was more likely influenced by infant feeding companies, societal expectations about the advantages of technology and progress, and conflicting notions of women as sexual objects and mothers.

Breastfeeding is not a panacea. Infants and children who breastfeed do die from infectious diseases; breastfeeding alone cannot save lives. In terms of child survival, there are many equally and maybe more important factors such as social poverty, environmental degradation, lack of access to clean water and nutritious food. Breastfeeding must be examined within a particular ecological and socio-cultural environment, not as a purely scientific phenomenon. As Van Esterik (1989) suggests in her book *Beyond the Breast-Bottle Controversy*, breastfeeding must be viewed as a process, influenced by world markets, cultural milieux and the socio-economic conditions of women.

Ironically, health care researchers never ask mothers themselves about breastfeeding. The medical literature treats mothers as if they are vessels, equivalents of feeding bottles. As Van Esterik (1989) rightly points out, the biomedical view of breastfeeding is product- rather than process-oriented. Mothers are viewed as being pivotal to child survival only in reference to the antibodies and the nutrients that they will extend to their children. Clearly, cultural forces such as medical practice, commodification of infant formula and societal attitudes towards women's breasts must be taken into account when examining why women do not breastfeed. Researchers should also recognize that mothers do play a role in making choices about reproduction and lactation and that they must be consulted about their beliefs and aspirations. See Wright *et al.* (1993) for a good example of research that does do this.

Conclusion

The issue of breastfeeding sparks strong feelings because there are vested interests: those who believe in technology and marketing infant formula and those who believe in nature and motherhood. Although their research questions and answers can be both subtly and not so subtly biased by these interests, both sides look to medical science to support their position. Interestingly, unlike studies of human reproduction and reproductive technology where medical researchers admit there are issues of ethics and human values beyond the "facts", research on breastfeeding has adopted a neutral and distanced perspective, treating women like feeding vessels full of nutrients and antibodies.

One of the most promising avenues of this scientific research over the last thirty years has been the inquiry into the protection that breastfeeding offers infants against infectious disease. Researchers, however, have erroneously equated breast milk with infant formula, treating it as a product which can be measured and quantified. Unfortunately for medical science, human beings do not lend themselves well to experimentation. There are many social and biological confounding factors that are linked to whether or not a mother breastfeeds. Moreover, mothers do not always follow WHO guidelines and they do supplement their infants' diets with food and drinks according to what they believe to be appropriate. Perhaps the more exasperating and fascinating part of researching the properties of breast milk is the fact that it is a product which is dynamic: Its content changes from one minute, one year, one woman and one environmental context to the next.

This is not an anti-science diatribe. Rather, it is a plea for health policy makers to admit that science does not and never will have all the answers. To propose that, based on scientific truth, there is one way to feed an infant is ludicrous. Research in human biology must be done in its appropriate socio-cultural context.

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