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INFANT FEEDING PRACTICES AND GROWTH

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INTRODUCTION

In this review we focus on the relationship between infant feeding practices and the growth of children around the world. Children's growth is often used as an index of the overall health of a population. Because growth is affected by a variety of adverse environmental conditions, it is a sensitive indicator of children's health, and a population with healthy children is generally considered to be well adapted to its environment. However, this very sensitivity to the environment makes it difficult for researchers to disentangle the many factors that affect growth, including genetic differences in growth potential

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between populations (now thought to be relatively small), nutrition, disease, altitude, temperature, and psychological factors, to name only the most important. Here we are concerned primarily with nutritional factors that have an immediate and direct impact on growth.

One major research focus has been on worldwide patterns of breastfeeding, determinants of breastfeeding, the effects of using breast milk versus various artificial formulas, and the effects of the timing of the introduction of nonmilk fluids and foods on the morbidity, mortality, and growth patterns of children in Third World (and, to a lesser degree, in Western) contexts. Another, more limited, literature focuses on the cultural beliefs surrounding infant feeding, different infant feeding styles, and maternal "competence" (education, experience, attitudes, etc), and their effects on child growth.

Problems with the Literature

The two main problems with the literature on infant feeding and growth, which limit its usefulness and render comparisons between studies difficult, are a lack of consistency in the use of terminology and a lack of methodological rigor in defining clear-cut feeding groups for growth comparisons (see below). In addition, bioanthropologists question the accuracy of anthropometric measurements taken by personnel with little or no training, and/or using homemade or jury-rigged equipment. At the same time, cultural anthropologists may dismiss data on infant feeding practices collected by bioanthropologists, especially if they are based on maternal recall, which may be inaccurate (156), or report only cultural norms without also documenting behavior.

Much of the non-anthropological literature suffers from either ethnocentrism or a curiously acultural perspective. The implicit (and sometimes explicit) ethnocentrism that underlies much of the pediatric, nutritional, and psychological literature on infant feeding results in findings that apply only to middle-class Anglo-Americans and yet are written as though they refer to "human development" or "human behavior." They make bizarre reading for anthropologists used to contextualizing their findings within specific cultural milieus. In addition, much of this literature focuses on maternal behaviors as though they were not influenced by cultural belief systems. For example, one study reports that mothers in the United States are prompted to introduce solid foods to their infants based primarily on cues from the infants themselves. Another claims that "supplemental feedings are given when the infant is ready to take them," as though cultural and individual beliefs, and medical advice, play no role in structuring maternal behavior. Many clinical researchers studying infant feeding and growth among US children seem unaware of the vast Third World literature on this topic, and fail to appreciate that the effects of bottle/formula use in the United States cannot be extrapolated to Third World contexts.

Finally, although the literature seems overwhelming, it is standard practice in many disciplines (much less so within anthropology) to publish the results

of one study in multiple outlets. This broadcasts the research results to a wider audience but erroneously suggests that each publication presents new data or insights.

Issues of Terminology and Methodology

As several others have lamented (15, 46, 171), inconsistencies in terminology make it nearly impossible to derive conclusions from most studies relating infant-feeding choices to morbidity, mortality, and growth.

In 1988, the Interagency Group for Action on Breastfeeding (IGAB), composed of the United States Agency for International Development (A.I.D.), the Swedish International Development Agency, the World Health Organization (WHO), and UNICEF, proposed standardized terminology for the collection and description of data on breastfeeding behavior (14, 113). Categories of "exclusive," "almost exclusive" (which together constituted "full"), "partial," and "token" breastfeeding were adopted (113). However, in 1991, the WHO proposed modifications to these definitions, and it is widely assumed that the new terminology (190) will supersede the IGAB categories. In the WHO modifications, "predominant" has replaced "almost exclusive"; infants who receive medicinal "drops or syrups" may still be classified as "exclusively" breastfed, and limited amounts of certain fluids (notably nonnutritive) are allowed in the "predominantly breastfed" category. The WHO categories and criteria are summarized in Table 1 (190:3). Another problem arises from the fact that breast milk and formula come in very different packages. Van Esterik (179) was the first to distinguish clearly between breast milk as a product and breastfeeding as a process; much of the literature (especially the biomedical literature) reads as though the only difference between breast milk and formula is in its nutrient composition, when in fact, the "packaging" and the "process

Table 1 Summary of WHO breastfeeding terminology (after 190:3)

Category of infant feeding	Requires that the infant receive	Allows the infant to receive	Does not allow the infant to receive
Exclusive breastfeeding	Breast milk (including milk expressed or from wet nurse)	Drops, syrups, (vitamins, minerals, medicines)	Anything else
Predominant breast-feeding	Breast milk (including milk expressed or from wet nurse) as the predominant source of nourishment	Liquids (water, and water-based drinks, fruit, juice, ORS), ritual fluids, and drops or syrups (vitamins, minerals, medicines)	Anything else (in particular non-human milk, food-based fluids)
Complementary feeding	Breast milk and solid or semi-solid foods	Any food or liquid including nonhuman milk	
Breastfeeding	Breast milk	Any food or liquid including nonhuman milk	
Bottle-feeding	Any liquid or semi-solid food from a bottle with nipple/teat	Any food or liquid including nonhuman milk; also allows breast milk by bottle	

of delivery" are also critical. Few studies can separate the effects on infant health of the different products from the effects of the different modes of delivery.

The terminology applied to nonbreast-milk fluids causes further confusion. In Anglo-American culture, infant feeding bottles usually contain formulas manufactured by one of the leading infant formula companies which are based on cow's milk or soy beans. However, they may contain fruit juice, flavored sugar water, colas, or tea. In many Third World contexts, bottles may contain infant formula, but often they contain whole-fat cow's milk (reconstituted from powdered form) or heavily diluted cereal porridges. Most studies do not specify what the bottle-fed infants are actually consuming. Additionally, many researchers object to the use of the term "breast milk substitute." There really is no substitute for human breast milk. It has been suggested that "artificial feeding" or even "rice water substitute" might be more appropriate when referring to the use of infant formula.

Another problematic phrase is "prolonged" or "extended" breastfeeding. "Prolonged" and "extended" are relative terms. In pediatric parlance they are often used to refer to breastfeeding beyond 6 months. In other contexts (La Leche League, Third World) prolonged breastfeeding might be interpreted as anything beyond 3 or 4 years. Discussions of whether or not prolonged breastfeeding contributes to malnutrition, as some authors have suggested, are meaningless if "prolonged" is not defined.

Uses of the terms supplementary and complementary are not consistent in the literature. Some authors use them interchangeably. Others use complementary to refer to foods given in addition to breast milk and supplementary to refer to foods that replace breast milk (172). The WHO recommends the latter distinction (113), with complementary foods being those introduced to the diet relatively late that do not affect breast milk consumption. In contrast, supplements would refer to water, cow's milk, formula, semi-solid or solid foods, or any other substances introduced to the diet relatively early that are thought to replace breast milk.

The term *beikost* was originally introduced (73) to refer to any nonmilk food (neither breast milk, formula, nor any other milk-based product) given to the infant for nutritive purposes. The term eliminates such cumbersome phrasing as "the first introduction of food/semi-solid food/solid food" while acknowledging that in many cultures infants receive token amounts of nonnutritive liquids (glucose water, plain water, teas, animal milks, medicinal drops) in the first few days of life. The term beikost was introduced to the anthropological literature by Quandt (153) and is used by a number of researchers.

No studies have adequately addressed the problems introduced by variation in what, how much, and how often beikost is given to the child. Thus, for many Anglo-American mothers, beikost is introduced according to a doctor's recommendations, and once begun, the infant receives the same (or gradually

increasing) amounts every day, or even several times a day. In other cultures, the introduction of solids is a much more haphazard affair. A child may "start solids" one week, then not receive any more for several months; the quantity or quality of beikost may vary widely from day to day. Few studies differentiate feeding groups on the basis of what, how much, or how often infants are receiving beikost; rather, infants receiving "any" or "significant" amounts of solids may be lumped together in one category. Rarely are feeding-group categories adequately specified (see 94 for an exception).

The term "weaning" has two distinct uses. Many researchers use it to denote the gradual process of introducing beikost to accustom the infant to eating foods other than breast milk or formula. However, the final cessation of breastfeeding is sometimes also called "weaning." These two distinct usages are usually, but not always, apparent from the context. Problems arise when informants use the term to denote cessation of breastfeeding, while researchers assume they mean the switch from breastfeeding to an adult diet. Because of these linguistic misunderstandings, one finds reports that in some societies children are exclusively breastfed until the age of 1 or 2 years, then "abruptly weaned" onto an adult diet.

Differences in terminology and lack of a world-wide perspective also lead to erroneous interpretations of the cross-cultural literature. For example, Barness searches in vain for an "original" pattern of weaning. He completely dismisses the cross-cultural literature as confusing and contradictory because anthropologists have reported that in some cultures food or liquid other than breast milk is introduced in the first few days of life, while in others "exclusive" breastfeeding prevails for many months (19:84). Barness does not realize that both statements can be correct, even for the same culture. In addition to a lack of rigor in defining infant feeding, different measurement and analysis techniques complicate data comparison and interpretation (89, 90, 97).

BREASTFEEDING ISSUES

Forces Shaping the Biocultural Literature on Breastfeeding

The breastfeeding literature contains thousands of articles published in the past five years alone dealing with the macro- and microscopic forces affecting and affected by infant feeding choices. Anthropologists will find much relevant literature in the fields of lactation management and counseling (15, 16, 44, 138, 161) and in those of general nursing, pediatrics, nutrition, and public health. In addition, breastfeeding advocacy (103, 145), women's studies (116, 131, 136, 181), environmental issues (158, 181), economic and structural adjustment (118), and teaching and parents' manuals (63, 115, 132) constitute vast bodies of literature ripe for anthropological scrutiny.

The anthropological literature on breastfeeding per se is fairly applied, as it has been ever since Margaret Mead (126) instructed her students to "find a

way that we can go from the peasant and working class breastfeeder to the elite, well-educated breastfeeder without a generation of bottles in between" (see 159:146). Van Esterik (179) notes that "ethnographic fieldwork and attention to cultural factors can enrich our understanding of infant feeding and potentially improve the health and nutritional status of infants ... ." There are several additional important collections in the cultural/descriptive genre (99, 146, 159, 187).

The multi-disciplinary breastfeeding literature of relevance to this review chiefly answers questions asked by the international aid community (e.g. UNICEF, WHO, US A.I.D., and other bi- or multilateral agencies) in its effort to define "optimal" infant feeding and develop international policy in support of it. The epidemiological concept of "relative risk" is central to the definition of "optimal," based as it is on international demographic and health surveys reporting that some 2 million children under 1 year of age die every year from diarrhea and acute respiratory infection (41). Reviewing the relative risk of death associated with various forms of infant feeding (27, 42, 43, 67, 182, 183), and speaking with one voice, many researchers suggest that these deaths could be averted if children were exclusively breastfed through 4–6 months of age, thereby reducing their exposure to contamination while also conferring the nutritional and immunological protection of breast milk through this period (12, 58, 98). Thereafter, children should continue to be breastfed, while receiving appropriate and adequate uncontaminated complementary foods, till 2 years of age or beyond. This combination of early exclusive breastfeeding with timely introduction of complementary foods, which together create "optimal infant feeding," will also benefit the mother, primarily by prolonging her period of lactational amenorrhea (81), allowing her a longer interval to rebuild some of her nutritional stores depleted though pregnancy and lactation (127).

One difficulty with implementation of the concept of "optimal infant feeding" cross-culturally is that in some cultures, solid foods are not normally introduced to the diet until well beyond 4–6 months. Very different strategies and messages will need to be developed to convince people to introduce solids at an earlier age than traditional cultural practices dictate (50, 53, 55). In some cultures, "optimal infant feeding" will mean both a discontinuation of the practice of giving newborns ritual or medicinal drops and an earlier introduction of solid foods on a regular basis.

From an Interagency Group for Action on Breastfeeding (IGAB) meeting in 1990 came the Innocenti Declaration on the Protection, Promotion and Support of Breastfeeding. The declaration recommends global optimal infant feeding policy and action steps intended to reduce the population-level risk factors described above. Some researchers concerned with maternal health are not comfortable with the Innocenti Declaration. As described by Koniz-Booher et al (111), many women in developing countries experience marginal nutritional status as a result of inadequate dietary intake, high energy expenditures in physical activity, and still higher energy and nutrient demands of

pregnancy and lactation for 35–48% of their reproductive years. It is widely believed that poorly nourished women produce an insufficient quantity of breast milk or breast milk lacking in energy or other critical nutrients, although evidence suggests that women must experience severe nutritional stress before the quantity and overall quality of breast milk output are affected (28). Although water-soluble vitamins may be limited, other nutrients in human milk may be maintained at a satisfactory level at the expense of maternal stores (137).

The mother may well benefit from increased dietary intake during pregnancy and lactation. However, concerns about the infant's well-being, and recommendations to begin complementary foods before 4 months to prevent growth faltering, are not well founded. Foods available in most developing countries will not be nutritionally superior to the breast milk they replace in the infant's diet, and are likely to carry a pathogenic load that contributes to infant morbidity and death (see below.) As Rowland et al note, "It is very dubious whether we are entitled to make the value judgement that a period of malnutrition due to delayed weaning (supplementation) is preferable to the infective and immunological dangers of early supplementation. We should, however, keep growth standards in the first year of life under constant critical review, with the aim of acquiring a much more accurate notion of what is normal, or, more difficult, optimal growth in breastfed infants in different environments and of different ethnic groups. Without this quite basic knowledge the subject of weaning will be bedeviled by disagreement and polemic" (162:82).

The international aid community hopes to promote an environment in which women can feed their children optimally, which should include ways to increase women's dietary intake and/or reduce their workload. In the short run, aid workers are attempting to gain the support of developing-country health planners with studies proving that "optimal infant feeding" is probably best for most infants and mothers under all but the most extreme conditions. The extent of the change proposed is on the order of 85%, as on a worldwide basis only 8–15% of women interviewed in recent surveys practice exclusive breastfeeding for 4–6 months (170). Top-down programming is more or less guaranteed when "Global Policy" is applied to country-specific situations; however, alternatives to top-down programming have been suggested (30, 37, 71).

Getting into the Breastfeeding Literature Quickly

With the interagency support described above, it is logistically simple to access much of the breastfeeding literature. The A.I.D. Center for Development Information and Evaluation,[2] the American Public Health Association

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2 Written requests for information may be addressed to PPC/CDIE/DI, Rm. 209, SA-18, Washington DC 20523-1801.

Clearinghouse on Infant Feeding and Maternal Nutrition (Washington, DC), La Leche League International (Chicago), and the Wellstart Program (San Diego and Washington) all have extensive collections, which are accessible through "Medline" and "Popline" searches.

BIOMEDICAL RESEARCH Akre (7) synthesizes the literature on the physiological basis of infant feeding, emphasizing international research. This work should be complemented by the National Academy of Sciences's Subcommittee on Nutrition During Lactation's (137) more comprehensive volume, which focuses on maternal factors and breastfeeding in the United States. Cunningham (46) provides an update of his annotated bibliography (prepared in 1981) on breast- and bottle-feeding, current through 1986. Feachem & Koblinsky (67) lay the groundwork for the relationship between choice of infant feeding method and diarrheal disease. Cunningham et al (47) review the protective effects of breastfeeding against nongastrointestinal pediatric illnesses, stressing that breastfeeding provides significant health benefits even in Western, industrialized societies.

APPLIED BIOCULTURAL RESEARCH In the applied/biocultural area Popkin et al's (149) seminal review emphasizes the biomedical well-being of the mother and infant, how the household supports or hinders breastfeeding, and the impact on the household of the choice of infant feeding method (although the literature is thin in this last area). A number of edited volumes offer a range of regional and research foci (117, 122, 159, 187). Beasley (20) critiqued some of this literature, which she faulted for over-emphasizing biological processes, under-emphasizing cultural interpretation, and providing few new insights. Many of the articles Beasley reviewed are considered classic applied studies, which strive to bring cultural factors to the attention of biomedically oriented decision makers. The insights are critical to their specific policy or program context, and their potential contribution to anthropological theory has not yet been tested. A recent and indispensable entry in this field is that of Brownlee (30), who reviewed for A.I.D. the behavioral issues affecting breastfeeding, weaning, and nutrition.

HISTORICAL AND SOCIAL TRENDS Major works with particular historical or social emphases include that of Jelliffe et al (104), which presents an evolutionary and cross-cultural perspective on human milk, updated from their first edition. Detailed histories of infant feeding in Europe (69) and the United States (13) complement shorter reviews of trends in the United States during the last few decades (74). Dobbing (60) dissects the infant formula industry "controversy" (1973–1984), and Van Esterik (181) uses this period as a springboard to discuss poverty and shifts of control both towards and away from women, the medical community, and international corporations. Van Esterik (181) and Leslie & Paolisso (117) contribute anthropological voices to the breastfeeding advocacy literature.

PREVALENCE AND DURATION STATISTICS WORLDWIDE What we can say, in general, is that nearly all women in the Third World initiate breastfeeding, and for most cultures the average duration of breastfeeding is over 1 year. Most women begin adding to the infant's diet within a few weeks or months: first liquids, then mashed foods, then semi-solids, then cooked solids.

Program efforts to promote breastfeeding clearly have an impact on breastfeeding rates. The American Public Health Association report (11) summarizes government legislation and policies to support breastfeeding, improve maternal and infant nutrition, and implement a code of marketing of breast milk substitutes. A number of good programmatic reviews are available (30, 86, 103, 114, 157), although the rapidly changing development picture limits their shelf life. The US Agency for International Development's report to Congress on A.I.D.-funded programs (4) and its *Breastfeeding for Child Survival Strategy* (5) are available from the Agency.

In the late 1960s and during the 1970s, public debate focused on the marketing practices of companies like Nestlé, which were seen as discouraging breastfeeding in Third World countries. Such promotional activity amplifies the trend among educated and urban populations to choose to limit breastfeeding practices, given the perception that bottle-feeding is more elite, white, and modern (148). Ironically, the reverse trend was occurring simultaneously in the developed world. The principal sources of information in the United States are the National Center for Health Statistics (NCHS) Surveys of Family Growth, and the Ross Laboratories Mothers Surveys. Despite methodological differences, both surveys document similar trends between 1955 and 1987. Averaging the data, breastfeeding initiation rates climbed from approximately 30% in 1955 to 55% in 1987, with 19.6% still breastfeeding at 5–6 months. As classified by the surveys, the increase in initiation is primarily accounted for by white (non-Hispanic) women over age 25 with some college education living in the western region of the United States or in cities, with normal-birth-weight infants. Black (non-Hispanic), younger women residing in rural and southern regions of the country, with less than a college education and an infant of low birth weight, were least likely to breastfeed (24% of "black" respondents reported breastfeeding at one week of age) (163). Since 1984, however, breastfeeding rates in the United States have been declining again (163a).

The World Health Organization maintains an accessible data base of international indicators on prevalence and duration of breastfeeding; the most recent publication appeared in the WHO *Weekly Epidemiological Record* (189) for over 1000 surveys carried out in 130 countries between 1980 and 1989. Demographic and Health Survey Data (170) most likely provide the raw numbers for 60 countries in this data set. Additional recent references include Millman (130) and Williamson (186). WHO's earlier collaborative study (188) is still widely quoted in the international literature, although most figures need to be updated.

FACTORS AFFECTING CHOICE OF INFANT FEEDING METHOD While Bostock (26) once described the young infant as an "external fetus," in the sense that the newborn still needs the mother's body for nourishment, immunological protection, and shelter, humans have evolved to offer the mother a choice. As Van Esterik framed the question (180), "can we distinguish between mothers who want to breastfeed and cannot, and mothers who do not want to breastfeed and do not?" While the former group is assumed to have the knowledge and attitudes to support breastfeeding, they may be constrained by a lack of social or economic support, inadequate medical care or advice, or excessive urging (by family, physicians, or advertising) not to breastfeed. As Van Esterik notes, "the difference between these two categories of women lies not only in their demographic characteristics, but also in their heads—the ideas, beliefs, and assumptions about infant feeding that make up the cognitive and affective dimensions of human behavior" (180:189). Since values and choice are involved, social scientists have contributed abundantly in this domain, often finding culturally relevant reasons for women to choose not to breastfeed (see e.g. 23, 72). Forman (76) and Brownlee (30) review much of this literature. Two theoretical orientations stand out as particularly important.

Biocultural: the insufficient milk syndrome While primarily determined by the infant's sucking intensity, frequency, and duration, the woman's ability to perform the act of breastfeeding can be influenced by "how she feels about things"; both the breast milk letdown reflex and maintenance of breast milk production are susceptible to cultural modeling and interpretation. Since Gussler & Briesemeister (88) published their initial paper on the "Insufficient Milk Syndrome," many researchers have used a biocultural explanatory model to interpret the decision to begin, continue, supplement, or terminate breastfeeding. The perception of insufficient breast milk has been associated with many social and cultural factors, as well as with physiological variables. Several recent examinations of this "syndrome" summarize and extend the earlier studies (94, 155, 177, 181). A mother's perception of insufficient milk may come from her lack of understanding of "normal" infant breastfeeding patterns (the expectation that the infant will only want to nurse every 3–4 hours, based on the advice of doctors or the experience of formula-feeding friends). Millard (129a) provides a thorough review of how pediatric advice can lead to decreased milk production.

Additional reports of "insufficient milk" may be attributable to women using it as a culturally acceptable explanation for using formula, beginning solids, or even weaning the child from the breast for personal reasons (the woman doesn't enjoy breastfeeding, finds it too tiring or constraining, or her husband objects, etc). Moving away from the "syndrome," but retaining the research question, several authors (8, 154, 181) have noted that disentangling the mother-infant bio-behavioral feedback aspects of this phenomenon from such socioeconomic markers as education, income, and returning to work

might enable us to examine the mother's concept of how specific feeding events are regulated, including her own participation in governing the feeding. Maternal confidence and competence have also been discussed by Scrimshaw et al (169), who emphasized the role of health-care providers and hospital policies in affecting subsequent infant-feeding choices. The ability of unsupportive or untrained medical staff to undermine breastfeeding efforts has been observed many times over (see 30 for multiple international references) and can be seen as the rationale for educating medical personnel in lactation management and counseling (129a, 138).

Cultural constructions of breastfeeding Characterizations of mothering as "appropriate," "optimal," or "poor" are obviously culturally constructed, and both the perceived ability of a mother to feed her child and her choice of infant-feeding method contribute to this characterization. In some cases, women believe their breast milk is of poor quality, owing to humoral imbalance caused by diet, maternal mood, or subsequent pregnancies (51, 72, 184). In these cases, by local norms, a "good" mother finds another source of food for her infant. More often, however, choice of feeding method is determined by rules and behaviors that demonstrate participation in a particular social group rather than by perceptions about the feeding method's nutritional value (52, 107, 135).

The literature on women's employment indicates that the social construction of women's roles has placed many obstacles in the paths of women who wish to breastfeed and work away from home (17, 118, 141, 146, 181, 193). Most studies find that in urban settings, few employed women breastfeed exclusively for 4–6 months, but breastfeeding duration is at least as long as for unemployed women. In developing countries, virtually all women in rural settings work and breastfeed their children simultaneously, seemingly oblivious to breastfeeding as an activity that requires time or attention. Urban Third World women are constrained by obstacles similar to those in the United States: lack of childcare, work environments that do not facilitate pumping or storing breast milk, restrictive employer policies for maternity leave, and social attitudes of employers and coworkers toward breastfeeding that result in disapproval and harassment (137).

THE TWO-WAY RELATIONSHIP BETWEEN BREASTFEEDING AND MATERNAL NUTRITION AND HEALTH The biomedical literature turns on several intricately linked questions: What does a human infant really need to "thrive" (survive, keep warm, fight off illness, grow, play)? Which of the 200 known constituents in human milk produces these effects (energy, specific nutrients, other factors)? What is the impact of breastfeeding on the mother? And what do these thresholds of need suggest about supplementing mothers' diets or complementing breastfeeding?

What does the infant need? What does it get? Exclusively or predominantly breastfed infants have been found to consume between approximately 525

grams (38, 45, 139) and 1200 grams (160) of breast milk per day, or, in volume terms, roughly 600–1000 ml/day (191). The most common measurement methods are test-weighing (which disrupts feeding) and the doubly labeled water dose to the mother, which is less invasive (35).

Breastmilk is a nutritionally complete food for human infants, the result of millions of years of evolution. Estimates of the nutrient requirements of the full-term infant during the first 6 months of life are largely based on the composition of human milk (119).

Some researchers worry about the relatively low levels of vitamin D in human breast milk in societies where mothers and infants are kept from exposure to sunlight (because of purdah, pollution, high latitude, etc). Vitamin K stores in the infant are low at birth, and, except for colostrum, low in breast milk. A deficiency of vitamin B_{12} may be a problem among infants who are exclusively breastfed by vegetarian mothers for more than 6 months (120).

Iron deficiency anemia is prevalent among women worldwide and is a particular risk factor for low-birth-weight infants. Though the concentration of iron in breast milk is low, its bioavailability is much higher than in complementary food sources. Additional foods consumed by breastfed infants can interact with breast milk in the infants' digestive tract, dramatically reducing iron bioavailability (142, 164). However, new perspectives on iron metabolism argue convincingly that the low iron content of breast milk is an adaptive/protective response to infectious disease stress (108).

What does the mother need to produce breast milk? This literature has been synthesized recently (1, 137); Butte et al's recent work contributes substantially to our understanding of energy needs during lactation (32–34). As Parker et al (146) concluded, there are many gaps in knowledge about maternal nutrition, even on basic issues that involve measuring nutritional status of adult women during times of rapid tissue change, such as pregnancy and lactation; assessing prevalence of undernutrition in women; and measuring the functional outcomes of chronic undernutrition. One attempt to fill the gap is A.I.D.'s report (6) on maternal anthropometric indicators. Merchant & Martorell (127) have modeled the factors influencing maternal nutritional status; high energy expenditure, frequent reproductive cycling, and lactation seriously compromise dietary intake in many cases, which may lead to a state of nutritional depletion (128, 129). On average, maternal dietary needs increase to approximately 700 kcal of extra energy per day while lactating to produce 700 grams of breast milk (150). Although mothers' resting metabolic rates start to decrease postpartum, their overall energy intake needs continue to increase during lactation. Women's bodies respond to this demand by reducing the basal metabolic rate to a small degree, catabolizing fat reserves, and metabolizing food more efficiently. In addition, where possible, women may reduce work expenditure and increase consumption. The weight gain of pregnancy provides food stores that are drawn on during late pregnancy and lactation. Because representative energy expendi-

tures are hard to measure accurately for normal time use (not just per activity) in natural situations, we know little about this element of homeostasis. Most women seem able to produce enough breast milk to nourish their infants.

A number of studies have shown that women continue to produce breast milk of adequate quantity and high quality even when their own diets are marginal (104). The fatty acid composition of breast milk is affected by maternal diet, including the type of dietary fat and dietary carbohydrates (70), but overall fat concentrations appear similar in women on varying diets. Prentice et al (151, 152) found that among Gambian women, total dietary energy intake did not affect total fat levels in breast milk. Kneebone et al (110) found that among women of three different ethnic groups in Malaysia (Malay, Chinese, and Indian), dietary differences corresponded to different proportions of saturated and unsaturated fats, and different levels of linoleic acid in breast milk. In general, fatty acid levels were comparable to those reported for well-nourished Western women. A study of vegetarians (70) found that breast milk of vegetarian mothers had the same overall levels of fat as that from nonvegetarians, but "contained a lower proportion of fatty acids derived from animal fat and a higher proportion of polyunsaturated fatty acids derived from dietary vegetable fat" (70:787). The question of the effects of the differences in specific fatty acids in breast milk composition on the growth and health of infants has not been answered.

It has been argued that humankind's ability to survive droughts and ice ages, and to take advantage of different ecosystems, is related to our ability to consume opportunistically yet produce breast milk of relatively unvarying quantity and quality (104). According to Prentice & Prentice (150), adipose tissue (fat) stores of mothers are not usually catabolized for breast milk production but serve primarily as a buffer for lean times.

From a maternal-health perspective, perhaps the most striking consideration is the fact that exclusive breastfeeding, especially during the early months postpartum, causes a hormonal suppression of ovulation and menstruation. This suppression contributes to improved iron status by delaying the blood loss of menstruation. It can also effectively extend the recuperative period between pregnancies and thus enhance the opportunity for adequate repletion of maternal nutrient stores (127). Although our present understanding of the long-term nutritional impact of frequent reproductive cycling is limited, the available scientific evidence supports the conclusion that women should be encouraged to breastfeed exclusively for the first 6 months and to continue breastfeeding thereafter, since the best strategy for replenishing fat and nutrient stores is to delay the next pregnancy (111).

CONTAMINATION FROM THE EARLY INTRODUCTION OF OTHER SUBSTANCES Exclusive breastfeeding for the first 4–6 months of a child's life is what transforms the "womanly art of breastfeeding" into "one of the most cost-effective means of insuring child survival" (4). Postponing the introduction of nonbreast-milk foods and liquids until at least 4–6 months of age dramatically

reduces infants' risk of exposure to environmental contamination while assuring the nutritional and immunological benefits of breast milk through this period (12, 58, 98, 148). The evidence overwhelmingly indicates that on a population level, breastfeeding is positively correlated with lower morbidity and mortality rates, and with shorter and milder illness (47, 61, 83); exclusive breastfeeding is associated with the lowest mortality rates (82, 125, 144, 192). The protective effects of breastfeeding are largest for disadvantaged, rural, and illiterate populations. Most studies have not addressed how risk changes with increments of supplementation (see 182 for an exception). It is unclear how much of the protective effect of breastfeeding is due to the nutrients in human milk, how much to immunoprotection, and how much to the absence of the contaminants often present in supplementary foods. For whatever combination of reasons, breastfed infants have fewer and less severe infections and lower morality rates. Even water can compromise the health of the infant. The common practice of giving infants water may expose them to the environmental pathogens that breastfeeding precludes. In addition, extra water displaces infant demand for human milk, which may cause the mother to produce less breast milk. Thus giving water may indirectly lower the infant's long-term total fluid intake. Breast milk contains adequate levels of necessary electrolytes. As a result, infants do not require extra sources of electrolytes, nor do they require any extra water for hydration or excretion (165)—findings confirmed by recent studies of infant health in hot (9), dry (84), and humid (29) climates.

Offering high-calorie liquids such as juices, cereal-based beverages, and artificial formulas generally reduces the infant's intake of breast milk, with negative impacts on the infant's nutritional status and growth. High-calorie liquids may satisfy the infant's caloric needs and hunger without providing protein, fat, and other nutrients required for proper mental and physical growth and development. In addition, a decrease in demand for breast milk by the infant results in a decrease in maternal supply and a shortening of the period of lactational amenorrhea (81). Thus, giving the infant anything other than breast milk for the first 4–6 months of life is generally contraindicated.

GROWTH ISSUES

Effects of Breastfeeding Frequency on Breast milk Composition

Cross-cultural studies have documented many different styles and patterns of breastfeeding. Breastfeeding frequency, for example, is determined partly by the mother (through cultural beliefs, organization of maternal workload, etc, and individual decisions) and partly by the infant's temperament (56).
stricted," or "continuous feeding"): The infant is nursed whenever the mother

thinks s/he wants to nurse. Researchers assume this results in very frequent feeding. The second is scheduled feeding (also called "regimented," or "restricted"), with long intervals between feedings, coupled with a concerted effort to get the infant to sleep through the night at an early age. The restricted pattern, common in the United States (155), is based on recommendations developed for formula-fed infants, with feeding restricted to every 3–4 hours during the day, with one longer interval of 6–7 hours at night. Although some cultures can be categorized as showing either demand feeding or scheduled feeding, breastfeeding frequency actually varies from culture to culture, from child to child, from mother to mother, with the age and health of the child, and with the season.

Breastfeeding frequency data from a number of cultures exhibit great variation, ranging from the four nursing bouts per daytime hour reported for the San !Kung (112), to the 5–6 feeds in 24 hours for breastfed babies in Northern Europe (14). Other studies have found intermediate values, with average frequencies declining from 15 to 10 per 24 hours as lactation proceeds in Gambia (151, 152), and from 21 to 10 per 24 hours as lactation proceeds in Thailand (100). A study of US La Leche League mothers found an average of 15 feedings per day (36). A study of non-League US mothers (155) found relatively low breastfeeding frequencies, with an average of 7.2 per 24 hours at four weeks and 7.1 at eight weeks. An unknown amount of the variation reported in the literature is due to the way separate feeds are defined, but there is nevertheless great variation in how often infants are breastfed, whether mothers perceive themselves as feeding "on demand" or according to a schedule (129a, 155).

The literature suggests that frequency of breastfeeding may have profound effects on the composition of breast milk, which, in turn, could greatly affect growth rates (92, 153a, 155). One of the continuing methodological problems in studies of energy intake in breastfed infants is that fat is both the major source of energy in human breast milk and the most variable constituent of breast milk. The fat content of human milk rises from the beginning to the end of a feeding, varies according to time of day or night, from day to day, from season to season, and from woman to woman. As a result of millions of years of natural selection, the composition of breast milk changes as the infant gets older, providing an adaptive mix of protein, energy, vitamins, and minerals at each age. Studies of short- and long-term variation in breast milk composition among rural Gambian women (151, 152) associated shorter intervals between feeds both with higher fat concentration of the next feed and with smaller fat decrease between the end of one feed and the beginning of the next. Fat concentrations were lower during the rainy season (a time of decreased intake and increased workload), which coincided with falling breast milk volumes, "magnifying the nutritional problem faced by the breastfed child" (152:501). Fat concentration declined as the infant got older. Differences between mothers were greater than those within mothers. Average fat concentrations de-

creased with each succeeding pregnancy until leveling off at parities greater than four. Fat concentrations were found to be related to mother's triceps skinfolds but to neither her energy intake nor the volume of milk produced.

Studies of breast milk composition among rural Thai women (100, 101) confirmed these findings: the shorter the interval between feeds, the higher the fat concentration of the next feed. They also found that the greater the milk intake (volume) at a feed, the greater the increase in fat content during the feed. Fat concentration decreased with infant age. Older infants consumed more breast milk at night than younger ones, owing to separation of mother and baby during the day by maternal workload (daytime feedings as few as 0–2). Since nighttime milk had lower fat concentrations, older infants were taking in much less fat than younger infants (100).

Several studies have reported on circadian rhythms of fat concentration. For Gambian women, fat concentrations are highest in the early morning and lowest in the late afternoon (151). Exactly the opposite obtains for Thai women: Concentrations are lowest in the early morning and highest in the late afternoon and early evening (101). Various patterns have been reported for women in Western countries.

The mechanism for how breastfeeding frequency affects fat composition of milk has been clearly explained by Quandt (153a). At the beginning of each breastfeeding episode, in response to the infant's suckling, the mother's pituitary releases a surge of the hormone prolactin. High levels of prolactin suppress lipoprotein lipase action in adipose tissue, preventing the uptake of dietary lipids into maternal fat stores. At the same time, high levels of prolactin enhance lipoprotein lipase action in breast tissue, so that serum lipids (from maternal fat stores as well as dietary fat) are diverted into breast milk production. Thus, frequent nursing leads to frequent prolactin release and elevated serum prolactin concentrations, resulting in higher levels of fat in the breast milk (153a).

Differences in patterns of breastfeeding frequency between populations and between women will result in variation in breast milk fat concentration at both the population and individual levels. Likewise, differences in circadian rhythms of fat concentration are probably related to differences in circadian rhythms of nursing frequency (153a).

Another effect of frequent nursing is a reduction in serum bilirubin levels during the perinatal period, which results in less serious cases of neonatal jaundice, perhaps through the mechanism of more frequent stooling, which moves meconium out of the gut more quickly (49). Other effects of nursing frequency on the infant are unknown.

Infants consume different quantities of breast milk, depending on their age, temperament, activity level, and maternal production. If nursing frequency affects the energy content of milk, then even infants who consume the same overall quantity of breast milk may have very different energy intakes depending on their nursing frequency. Different breastfed infants may consume dif-

ferent quantities and qualities of breast milk, and the same is true among bottle-fed infants. These differences mean that most comparisons of the growth patterns of "breastfed" and "bottle-fed" infants are suspect, because they obscure the variation within each of these groups.

Comparing the Growth of Breastfed and Bottle-fed Infants

The literature that compares the growth of breastfed infants with that of bottle-fed infants can be divided into two groups. First, a number of studies have been conducted in Third World settings, where traditional practices of breast-feeding have been increasingly replaced by the use of infant formula or other artificial products. These studies have consistently found that exclusively breastfed infants grow better than supplemented or bottle-fed infants (77, 106, 121, 124, 178). However, it has been difficult to determine whether the better growth of breastfed infants under these conditions is due to the nutritional superiority of breast milk; the anti-infective and immunological constituents of breast milk, which protect the infant against infections; the fact that breast milk cannot be over- or under-diluted, or contaminated by environmental pathogens, the way formula and bottles can be; some unidentified effects associated with the process of breastfeeding itself; or some combination of these factors. Despite claims to the contrary (149, 159), most researchers agree that infant growth is negatively affected by the use of formula and bottles in Third World contexts. One potentially confounding factor in all of the comparative growth studies is that infants who are not thriving on breast milk may be switched to formula, while infants who do not thrive on formula usually cannot be switched to breast milk. Thus, the bottle-fed group may include infants who were not growing well for reasons unrelated to the mode of feeding.

Second, a number of studies conducted in Western, industrialized settings compare the growth of breastfed infants to that of formula-fed infants (or to the NCHS standards; see 91) in the relative absence of the problems with water quality, environmental sanitation, and over-dilution that confound studies in Third World settings. Some of these studies report comparable growth in breastfed infants (3, 32, 94, 153, 185). Other studies report just the opposite, finding that breastfed infants have slower growth rates than formula-fed infants (or NCHS standards) during the first year of life (33, 38, 39, 48, 57, 62, 78, 79, 140, 143). Some report better growth in breastfed infants during the first few months of life, followed by poorer growth during the rest of the first year (3, 39, 80, 109, 162, 185). Some have characterized breastfed infants as "faltering" relative to the NCHS standards (93), even when weight-for-age and length-for-age z-scores remain positive throughout the first year of life.

The literature comparing exclusively breastfed infants to breastfed infants also receiving solids likewise reveals conflicting results. Some studies report better growth in exclusively breastfed infants (2, 153), while others report

poorer growth in this group (22, 77, 95, 96, 166). Detailed comparisons among these studies are made difficult by definitional and methodological differences. Many studies do not control for the type and/or quantity of formula consumed, or for the type and/or quantity of beikost received by infants in their "supplemented" groups. "Solid foods" are not uniform; it makes a difference if the first foods introduced are sterilized, fortified cereals, fruits, vegetables, meats, etc (manufactured by baby food companies) or if they are high-bulk, low-calorie/low-protein cereal-based porridges, made with contaminated water and left to sit around in the heat, uncovered, for hours before consumption. It also makes a difference whether solids are given several times a day, once a day, once or twice a week as the mood strikes the mother, or in some other pattern.

Additionally, human breast milk affects the infant's gastrointestinal environment, resulting in differences in digestion and absorption, with potential effects on growth. Auerbach et al (16) conclude: "partial breastfeeding that derives from mixed feedings involving human milk should be distinguished from mixed feedings involving artificial formulas or nonhuman species–derived substances. Again, the mode of feeding needs to be specified to account for their different possible effects. Thus, although a breastfed baby is receiving solid foods, it should be assumed *until proven otherwise* that such an infant is receiving a different kind of nutrition with a potentially different outcome than an infant receiving artificial formula and the same solid foods" (16:66, emphasis in the original).

On the basis of the studies claiming that breastfed infants do not grow as well as formula-fed infants, some authors have concluded that breast milk is inadequate to support the growth of infants beyond the first few months of life, and recommend the early introduction of solids or supplementary formula to augment nutrient intake.

A more typical conclusion, however, has been that the NCHS standards are too high for infants who are breastfed (34, 39, 79, 143). NCHS standards for the period from birth to 2 years are based in large part upon the Fels Research Institute data, which came from children who were mostly formula-fed and introduced to solid foods at a very early age (often as young as 2–3 weeks) in accord with prevailing medical and cultural beliefs in the United States at the time. Based on these findings, some researchers have called for the development of alternative, presumably lower, standards for breastfed infants. However, a close examination of the literature reveals that the trend toward slower growth in breastfed infants is neither as uniform nor as pervasive as has been reported; in addition, differences in maternal health, birth weights, and breastfeeding styles might account for the slower growth in those cases where breastfed infants do grow more slowly than formula-fed infants in First World contexts.

An Alternative Explanation for "Poor Growth" in Breastfed Infants

In Western, industrialized nations, the recent resurgence in breastfeeding has occurred mainly among middle- and upper-class, well-educated women. Well-educated, middle- and upper-class women are more likely than the average woman to take good care of themselves during pregnancy by not smoking, drinking, or using drugs, by seeking good prenatal health care, by taking prenatal vitamins, and by maintaining better nutrition. Anglo-American women who breastfeed are thus not a random sample of all mothers. These factors contribute to higher birth weights and lengths and may explain the relatively high birth weights and lengths of breastfed infants found in most of the growth studies comparing breastfed infants to either bottle-fed infants or the NCHS standards (3, 31, 32, 57, 79, 80, 94, 153, 155). If this is the case, why don't these large babies maintain their positions relative to the NCHS standards after birth?

At least two factors can be identified that might contribute to slower growth in these infants: (*a*) the phenomenon of "catching-down" (174), in which greater than average intra-uterine growth is offset by slower than average growth during infancy, and (*b*) breastfeeding frequency.

Tanner (174) explains the concept of catch-down growth: "[Thus] during infancy a reassortment of relative sizes among children comes about: those who are larger at birth grow less, and those who are smaller grow more .... In the series studied by Smith et al (1976 [171a]), not only did many small babies catch up to higher centiles, but many large babies sank back to lower ones. These were the large babies born to medium-size parents ... [and] the sinking down, or dawdling, on average lasted ... some 13–14 months. *Catch-down,* originally suggested as a linguistic joke, seems to have caught on. *Catch-down is as normal a phenomenon in infancy as catch-up"* (174:173-74, emphasis added). If breastfed infants from First World populations tend, as a group, to have above-average birth weights and lengths, their slower growth rates during the first year of life would reflect, in part, the normal phenomenon of catch-down growth.

The phenomena of "catch-up" and "catch-down" growth are clearly observable in the data of Butte et al (32). At 1 month of age, breastfed infants have weight-for-age *z*-scores (WAZ) of 0.54, compared to bottle-fed infants with 0.26. By 4 months, the breastfed infants have "caught-down" to 0.42, while the bottle-fed infants have "caught-up" to 0.46. At 1 month, breastfed infants have length-for-age *z*-scores (LAZ) of 0.47, compared to bottle-fed infants with 0.12. By 4 months, the breastfed infants have "caught-down" to 0.23, while the bottle-fed infants have "caught-up" to 0.25. All of the *z*-scores for both groups of infants are positive (i.e. above the NCHS standards).

The second factor that might explain "poor growth" in breastfed infants is related to breastfeeding frequency (see the discussion above of the effects of

breastfeeding frequency on breast milk content). With the exception of the La Leche League mothers, it is probable that most of the mothers in the studies reviewed above breastfed their infants relatively infrequently, according to a typical "Western" schedule of every 4 hours during the day, and encouraged them to sleep apart from the mother, and to sleep through the night at an early age (in Quandt's 1986 study some of the infants were sleeping through the night as early as eight weeks after birth). Nursing frequency is not reported in the La Leche League study (3), but official League advice is for mothers to expect young infants to want to nurse only every 2–3 hours, including during the night. Although this is more frequent than a 4-hour schedule, it is still not as often as the frequencies reported for Gambia (151, 152) or Thailand (100, 101). Quandt (155) provides a thorough and well-written discussion of breastfeeding variation in US mothers; Millard analyzes the impact of American pediatric advice on maternal styles of breastfeeding according to a schedule (129a).

None of the studies to date has been based on samples of mothers in First World contexts feeding their infants using a true "on demand" or "continuous feeding" style. Relatively long daytime intervals, coupled with a cultural value placed on sleeping apart from the mother and sleeping through the night, result in relatively long inter-feed intervals and therefore lower fat content in the breast milk in Anglo-American mothers. If these mothers nursed using a true "on demand" pattern of very frequent feedings, including at night, facilitated by co-sleeping of mother and child, the energy content of the breast milk would presumably be much higher, and the infants might well grow faster.

Thus, we have three types of data: 1. growth patterns of infants breastfed "on demand" under conditions of chronic infections, 2. growth patterns of infants fed formula and early solids under conditions of good health, and 3. growth patterns of infants breastfed according to a schedule. As of this writing, we do not have the fourth type: growth patterns of infants breastfed "on demand" under conditions of good health. Such a study would have to be based on a sample of well-nourished, healthy mothers, with safe water supplies, good sanitation, and good maternal-child health care, who breastfeed their children using a true "on demand" or "continuous" breastfeeding style. Until these studies have been carried out, we won't know how breastfed children grow under good environmental conditions. The NCHS standards may be set too high for most Third World children, but standards based on US samples of high-birth-weight breastfed children, fed according to a schedule, would probably be set too low.

These two factors—the normal biological pattern of catch-down growth observed in large babies, and the cultural practice of breastfeeding according to a schedule—may account for most, if not all, of the apparent "growth faltering" of breastfed infants in Western populations. The existence of a single set of weight and length standards (NCHS) facilitates the kinds of detailed and precise comparisons of growth attainment that we see throughout

the literature. Calls for the development of revised standards based on breast-fed infants are therefore premature, and should await further research.

Effects of the Timing of the Introduction of Solid Foods

A critical question concerns the timing of the introduction of solid foods to the diet of the child who has previously been exclusively breast- or formula-fed. Like all other aspects of infant feeding, the introduction of solid foods (beikost) to the infant's diet is heavily influenced by cultural beliefs: about children, about food, and about health and growth. It is also influenced by the environment and the culture's cuisine. A number of studies describe typical infant feeding practices in cultures around the world (50, 51, 99, 149, 159, 172, 176, 187), including beliefs and practices related to the introduction of solids. Reasons for introducing solids at a particular age range from purely symbolic cultural guidelines, to decisions based on chronological or developmental criteria or the infant's own interest in or demand for food, to conflicts with the mother's other responsibilities (work, school, etc). Cultural beliefs, the opinions of friends and relatives, medical advice, and idiosyncratic beliefs all influence the decision to begin feeding solid foods.

In the United States, many factors influence this decision, ranging from misinformation (e.g. the claim that introducing solids will help the baby sleep through the night, a notion shown repeatedly to be incorrect; 65) to recommendations from doctors to introduce iron-fortified cereal because of the low iron content of breast milk. During the period from the 1950s (when proprietary infant foods were first sold) until the mid-to-late 1980s in the United States, many mothers introduced solid foods very early, even as early as two weeks post-partum, often at the urging of their pediatricians. Medical recommendations are constantly being revised but they currently suggest that human milk or infant formula should be the primary source of nutrients during the first year of life and that the introduction of solid food should be delayed until about 4–6 months of age (10, 65, 75).

Recent guidelines recommending the introduction of solid foods at 4–6 months of age are based on several considerations. First, most infants grow satisfactorily for the first 4–6 months of life, whether breastfed or bottle-fed. Second, the early introduction of solids tends to substitute less nutritious foods for breast milk or formula. Third, the young infant's gut absorbs whole proteins; delaying the introduction of solid foods until the infant's intestinal tract matures lowers the risk of developing food allergies. Fourth, much of the solid food fed to young infants passes through the body undigested and unabsorbed.

In addition to cultural beliefs and medical advice, the introduction of solid foods also depends on maternal perceptions of infant needs. We are not aware of any studies that address the effects of infant size (and maternal perception of infant size) on the timing of the breastfeeding mother's decision to begin solids. However, the distribution may be bimodal, with both small- and large-for-chronological-age infants being supplemented earlier than "average" chil-

dren. The mother of a small child may become concerned that she doesn't have enough breast milk and decide to begin solids at an early age in the hope that eating solid food will increase the child's overall intake, leading to better weight gain.

Several US studies have found that earlier supplementation either has no effect on intake or growth (79) or leads to poorer growth (2, 65, 153). Others have suggested that early supplementation results in greater growth and may even lead to obesity (140), and many mothers seem to subscribe to this view. On the other hand, the mother of a large infant may also fear that she can't support adequate growth of a big baby on breast milk alone, or she may begin solids at an early age simply to reduce the infant's demands to nurse. Quandt's study (153) showed that the early introduction of beikost did, in fact, reduce nursing frequency.

Such a relationship between infant size and introduction of solid foods would confound the interpretation of studies on the effects of beikost on growth, as both smaller- and larger-than-average children might start solid foods earlier than average children because of their prior growth patterns.

INFANT FEEDING STYLES, MATERNAL COMPETENCE, AND GROWTH

Much of the research on nutritional factors affecting children's growth has focused on the question of the availability of food, and on what happens when food quantity or quality is low. In much of this research, the population or the household was the unit of study, and it was generally assumed that as long as food was available to the population/household, children would receive adequate amounts to support normal growth.

In recent years, the focus has shifted to more proximate causes of child malnutrition, including, for example, the intra-household distribution of food (147), age and sex-linked inequalities, the contribution of fathers' and mothers' incomes to food-purchasing power (64), and maternal factors such as education, competence, and attitude. A number of ethnographic studies start from an "infant feeding beliefs and practices" perspective and argue on logical grounds that certain patterns of infant feeding contribute either to malnutrition or to good nutrition (24, 25, 51, 55, 99, 176). These studies often use anthropometric measurements of growth status as a confirming variable. Other studies start from an "infant growth patterns" perspective and look for differences in infant feeding practices that would explain these patterns (50, 105, 173, 194). Researchers using either or both of these approaches have found it difficult to determine how much infant feeding practices contribute to the observed growth patterns; but as evidence accumulates, it is becoming clear that providing adequate food to the community or adequate income for the household does not necessarily enhance the nutritional status and growth of children.

A number of early studies provided ethnographic descriptions of beliefs surrounding infant feeding cross-culturally (122, 149, 159, 187)—beliefs about whether to breastfeed or use artificial formula, when to begin solid foods, which foods from the local cuisine are appropriate vs taboo for young children, and when children should cease breastfeeding. In a review of the literature in the late 1980s, Dettwyler observed that few such studies treated specifically how food is given to the infant, or who decides what foods the infant should eat, how often, and, perhaps most importantly, how much (53, 54).

A number of recent studies have focused on maternal behaviors surrounding infant feeding interactions. Researchers have attributed differences in infant feeding styles to both inter- and intra-cultural variation in maternal "attitude" (50), maternal "experience" (173), or maternal "competence" (194). Despite terminological differences, all of these researchers are attempting to capture the essence, and the underlying causes, of maternal-infant feeding interaction styles. For example, Swenson found better growth among higher-birth-order children and among children whose mothers had experienced more than two previous fetal/infant deaths in Bangladesh. She concludes: "The results suggest that child care practices, particularly with regard to nutrition, may actually improve among women who have experienced previous fetal or child losses ... (who) may exercise greater caution and effort to provide adequate nutrition for their children ... . The lower proportions of malnourished children in pregnancy orders equal to or greater than 5 compared to first and second order births suggest that the experience a mother gains in child care may tend to diminish any potential adverse biological effects that have been attributed to higher pregnancy orders in infancy" (173:192). Dettwyler (50) also found better growth among higher-birth-order children in Mali and attributed it to maternal experience and attitude. McKenna reports the same findings in studies of parenting among nonhuman primates as well (118a).

A few researchers have pointed out that not all cultures share the Western emphasis on "child survival" and child health. This point has been made most eloquently by Cassidy (37), in her comparison of "adaptor" and "activist" positions. Scheper-Hughes coined the phrase "selective neglect" to refer to mothers who choose, for culturally sanctioned reasons, to allow some of their children to die, most often through nutritional deprivation (167, 168). Culturally sanctioned reasons include sex of the child, illegitimacy, physical and mental defects, too many children, children spaced too close together, and children who do not possess sufficient strength or "spirit" to survive in adverse circumstances (167, 168). What appear to Western researchers to be "maladaptive" infant feeding practices may result from ignorance of the relationship between food and health, but they may also be deliberate, though seldom articulated, choices of mothers to invest less time and fewer resources in certain children.

A number of other approaches can be found in the literature. Bledsoe and colleagues, working among the Mende of Sierra Leone, find that foster children have less access to the food resources in the family, and poorer growth, than "born" children in the same family (24, 25). In Peru, Bentley and colleagues have described "active" feeding behaviors of mothers during episodes of diarrheal illness in their infants. Although these mothers are usually relatively passive, they actively encourage their children to eat when illness has reduced the child's appetite (21). The roles of anorexia and maternal response to anorexia in affecting dietary intake and growth (21, 54) remain a rich area for further research. Gray (85) reports that Turkana children are buffered from seasonal food shortages because adults give children's nutritional needs higher priority at these times, a practice also reported for the Nuer (66). Dettwyler (55), on the other hand, finds that in rural southern Mali, adults, especially men, claim the best food for themselves, arguing that young children don't need, don't deserve, and can't appreciate good food. Engle provides a recent review of the literature on child care, including infant feeding, and its potential impact on child health (64a). Much work remains to be done on these and related topics.

The final body of literature to be reviewed here is that of Zeitlin and colleagues. Zeitlin's early work drew attention to the role of place and method of early infant feeding in the potential bacterial contamination of food (87, 195). More recently, Zeitlin and colleagues have been influential in focusing on the mothers of "positive deviants" (also known as "invulnerable" or "invincible" children)—children who are growing well in conditions that often lead to malnutrition and disease. This literature has been thoroughly reviewed in Zeitlin et al's survey (194).

The positive deviance approach has identified a wide range of social and psychological variables that affect maternal ability and motivation to provide the high quality of child care that leads to positive deviance in growth. This research aims to develop culture-specific intervention strategies that build on "positive deviance" behaviors already present rather than simply import Western beliefs and practices.

A potential criticism of the positive deviance approach is that it relies on several theoretical perspectives that most anthropologists reject and that may detract from an appreciation of the valuable insights offered by this approach. Zeitlin and colleagues interpet the mothers of "positive deviants" as unusual members of their culture. They assume that traditional infant feeding practices, which most mothers follow, must have adaptive value, in the evolutionary sense, even if they result in high rates of childhood mortality and large numbers of malnourished children who fail to grow properly. They argue that infant feeding practices that lead to malnutrition in early childhood represent adaptation at three levels.

First, Zeitlin et al claim that traditional infant feeding practices act as agents of natural selection, allowing only the hardiest to survive to become adults.

Here Zeitlin et al are employing a group selection argument. Most evolutionary biologists and human behavioral ecologists reject the group selection argument (see 45a for a review of this literature).

Second, they claim that traditional infant feeding practices produce adults with small body size who require less food. This position is known as the "small but healthy" hypothesis, and most anthropologists reject it as well. Small adult body size due to malnutrition in childhood results in functional impairments that outweigh any advantage accruing to lower nutrient requirements (123).

Third, they argue that rural societies "socialize young children not to expect favoured foods or special treatment because of their low position in the family" (194:6). "[P]arental goals," they claim, "are to produce an undemanding, compliant worker, starting work from 3–5 years of age. Once past the dangers of early infancy, the child must accept its lowly rank as the least productive and youngest member of the production team. As a symbol of his entry-level status, he may receive the poorest quality and the smallest portions of food, and must not question this" (194:7). Zeitlin et al (194) cite the work of Chavez & Martinez (40), who have argued that only people malnourished as children, who grow up with less than optimal cognitive capacities, would be able to endure the monotony of rural village life.

This third theoretical orientation, is flawed in two major ways. First, there is no evidence that traditional infant feeding practices that lead to child malnutrition (and its consequent long-term functional impairments) are "adaptive" in any way. Indeed anthropologists sometimes refer to such practices as "maladaptive," in the sense that a system in which women must go through multiple pregnancies and suffer high infant losses to produce an average of two surviving children is inefficient (in the biological sense) and painful (in the emotional sense). This is not to claim that such systems are either "maladaptive" or "adaptive" in an evolutionary sense (indeed, cultural evolution and biological evolution may not be governed by the same laws); but any cultural system that, on average, enables two or more children to survive for each adult couple qualifies as sufficiently "adaptive" in an evolutionary sense.

It may be difficult for researchers who work primarily in the United States, accustomed to the pervasive acceptance in US culture of the relationship between food and health, to appreciate that this biomedical knowledge is relatively new even to US culture, and is not part of the basic knowledge of many of the world's peoples. In cultures where this knowledge is not available, traditional infant feeding practices are based on other beliefs about food, about children, and about religion, for example, as the ethnographic literature on infant feeding amply demonstrates. The fact that these beliefs result in malnutrition does not make the beliefs themselves "maladaptive" in the evolutionary sense as long as the population is able to replace itself each generation; nor must we find ways in which they might be "adaptive" in order to explain their existence.

Second, the "rural village monotony" is ethnocentric and rather condescending. Like a New Yorker ruling out the possibility of happiness in Dime Box, Texas, Zeitlin and colleagues (194), along with Chavez & Martinez (40), don't understand a willingness to live in a rural village where, they imply, life must be stultifying. Such arguments are both insulting to the villagers and incorrect. Rural village life may appear monotonous to the outsider, but village residents have an emphatically different perspective. "From a European's point of view," wrote Evans-Pritchard, "Nuerland has no favourable qualities, unless its severity be counted as such, for its endless marshes and wide savannah plains have an austere, monotonous charm ... . But Nuer think that they live in the finest country on earth ..." (66:51).

Despite these problems, anthropological readers should resist the urge to dismiss the positive deviance literature, as it offers many interesting insights.

NON-ANTHROPOMETRIC OUTCOMES

As the quest continues for a breast milk equivalent, more and more constituents of human breast milk are identified that affect growth in subtle ways but cannot (so far) be duplicated in formula. At the same time, additional effects of breast milk and breastfeeding on the infant are being recognized. For example, recent studies have shown that formulas and "weaning foods" cannot duplicate breast milk as sources of long-chain polyunsaturated fatty acids, which are necessary for proper growth and development of the brain and of retinal and erythrocytic membranes (102). Use of formula can adversely affect the growth and development of many tissues in the body, not just those measurable through standard anthropometric techniques, and not just in Third World contexts (47).

Differences in feeding practices also affect the basic physiology of the infant. Several long-term studies by Dewey, Garza and colleagues have found that breastfed infants have significantly lower nutrient intakes than bottle-fed infants, both before and after solid foods are introduced (57, 79). Over the first 8 months of life, formula-fed infants take in about twice as much formula as breastfed infants do breast milk (1200 ml/day compared to 600 ml/day), which results in a "deficit" of 30,000 kcal in breastfed infants (79), or an excess in the formula-fed infants, depending on one's perspective. Breastfed infants have lower minimal rates of energy expenditure, lower rectal temperatures, lower heart rates, lower sleeping metabolic rates, and lower daily energy expenditures than formula-fed infants, all of which suggest significant differences in body composition (79).

Breastfed infants spend much less time fussing and crying than formula-fed infants, and, since they are more often in contact with the mother's body, they may spend less energy maintaining body temperature. These factors may account for the lower energy expenditures observed. A difference between breastfed and formula-fed infants that has not been studied in detail is that of

fecal volume (for a mention of the topic in passing see 32). Among the lay breastfeeding population in the United States, it is believed that breastfed infants have a much lower volume of feces than formula-fed infants owing to the increased digestibility and absorption of breast milk. Thus, some of the increased nutrient intake documented for formula-fed babies probably passes through the infant's gastrointestinal tract undigested and unabsorbed, and will be reflected in greater fecal volume. As far as we know, this area of research has not been explored.

Infant feeding patterns also affect infant cognitive and motor development. Follow-up studies of both breastfed and formula-fed children have been conducted at 2 years (134), at 5 years (175), and at 7 years (68, 133). In each case, after adjustment for social and behavioral variables, the breastfed infants demonstrated greater cognitive development, to statistically significant levels. As a final example, Martorell & O'Gara (124) report faster motor development among breastfed than among bottle-fed infants.

CONCLUSIONS

The study of infant- and child-feeding practices and their effects on infant growth is an active interdisciplinary field, with a voluminous literature. Anthropologists have drawn attention to the fact that cultural values and beliefs affect infant feeding practices (although the medical and nutritional research community has been slow to realize this), and to the effects of such beliefs on growth.

It is well established that breastfed infants have lower mortality and morbidity, and better growth, than bottle-fed infants in Third World populations. The evidence continues to mount that breastfeeding also provides better health and growth for infants in Western populations. It has been difficult to determine whether the better growth and health of breastfed infants are due to the nutritional superiority of breast milk; the anti-infective and immunological constituents of breast milk, which protect the infant against infections; the fact that breast milk cannot be over- or under-diluted, or contaminated by environmental pathogens or toxins the way formula and bottles can be; some unidentified effects associated with the process of breastfeeding itself; the subtle effects of the underlying maternal attitudes and patterns of mother-infant interaction that accompany the decision to breastfeed; or (most likely) some combination of these factors.

Defining "normal" growth in infants is problematic, as even physiological processes such as breastfeeding can be altered by cultural practices. Future comparative studies must be precise in defining distinctive feeding groups, so that different growth patterns can be interpreted accurately. The reporting of growth data using z-scores based on the NCHS standards (91), already widely used in the growth and development literature, would facilitate comparisons among studies.

Mother-child interactions during infant feeding provide an important topic for future research. The concepts of maternal "attitude" and "competence" are critical but poorly understood; further study of maternal/caretaker behaviors will contribute to an understanding of the proximate determinants of child nutritional status and growth. Cultural beliefs about infant feeding have only been explored thoroughly in a few cultures. The relationships among infant feeding beliefs and practices and other aspects of culture also remain fruitful areas for further research.

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