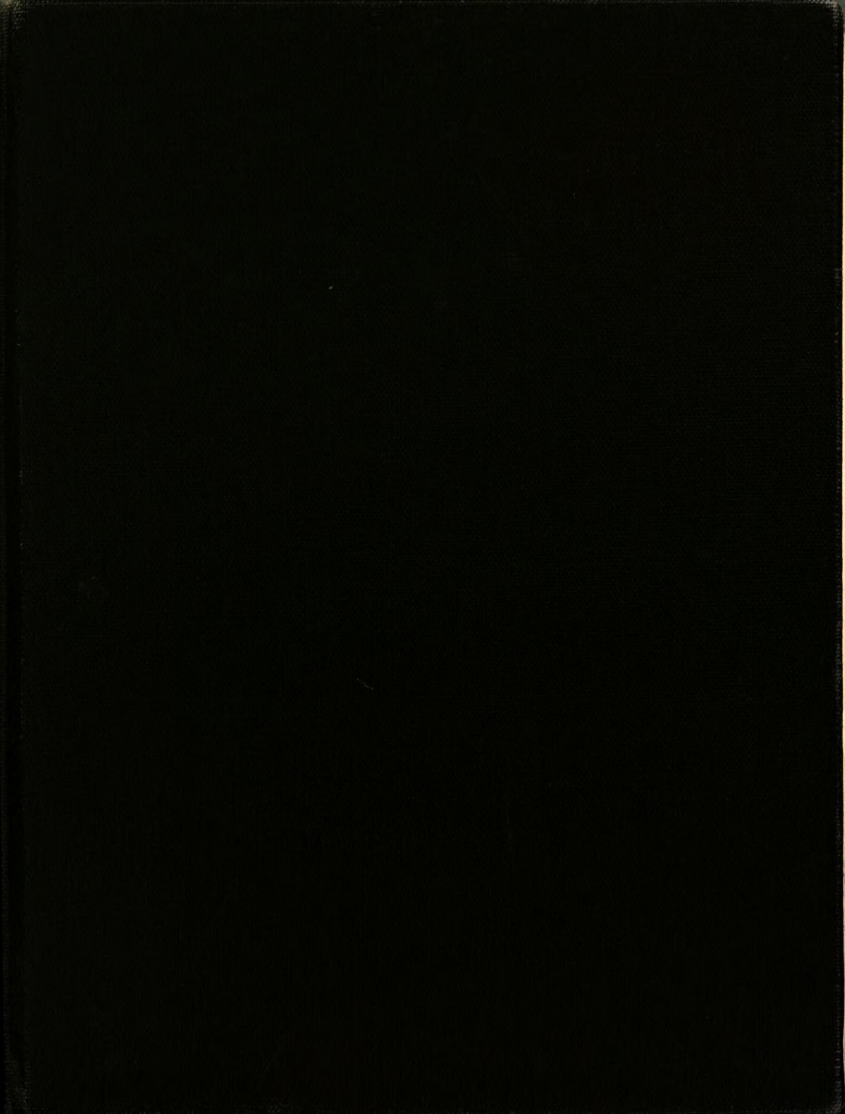




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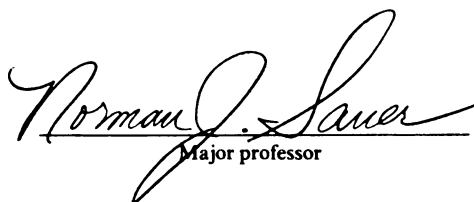
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THE BIOBEHAVIORAL DYNAMICS OF
THE INFANT FEEDING PROCESS

By

Sara Ann Quandt

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Anthropology

1981

ABSTRACT

THE BIOBEHAVIORAL DYNAMICS OF THE INFANT FEEDING PROCESS

By

Sara Ann Quandt

This research examines longitudinally the interaction of infant growth, maternal postpartum nutritional status, and infant feeding strategies involving breast-feeding. Subjects were 80 normal, first-born neonates and their mothers, drawn from a low-risk, Caucasian obstetrical population in Michigan. Infant weight, length, and fat-folds were measured monthly from birth to six months. Maternal weight, upper arm circumference, and triceps fat-fold were measured monthly during the postpartum. Infant dietary data were reported by mothers in diary form every eight days throughout their six months of participation. Additional social data were obtained through interviews and observations at monthly home visits.

The number of nursing bouts per day during the early weeks of infancy appears to be a key variable in predicting long term infant diets and to be part of a complex interaction with infant growth. Those infants nursing seven or more times per day were far more likely to be exclusively breast-fed for at least three months and to be weaned after six months than were infants initially fed less

frequently. Infants larger at birth and one month followed this pattern of frequent nursing more than did smaller infants. These findings are used to demonstrate that the seemingly contradictory results of previous growth and diet research can be explained by focusing on how infants become members of particular feeding groups.

Maternal postpartum weight loss was not associated with breast-feeding strategies. Two patterns of change in maternal midarm fat area were found among women exclusively breast-feeding at least three months and not weaned until after six months postpartum. Frequent nursing was strongly correlated with progressive reduction in fatness, while infrequent nursing was associated with increases in fatness. It is hypothesized that the differences observed in maternal fat change patterns result from variations in lipoprotein lipase and hormone activity, induced by variable levels of serum prolactin resulting from different breast-feeding styles.

ACKNOWLEDGMENTS

I gratefully acknowledge the financial support I have received for the research reported here. The Medical Anthropology Training Program at Michigan State University provided predoctoral training funds from National Institute of Mental Health grant 5SS T32 RM 243 MH15132. Substantial additional funding was contributed by Gerber Products Company, Fremont, Michigan. Both the College of Social Science and the College of Human Medicine, Michigan State University, provided computer funding.

My thanks go to the members of my doctoral guidance committee: Drs. Cheryl Ritenbaugh, Norman Sauer, Kathryn Kolasa and Ann Millard. I appreciate the help they have given me throughout my graduate training and their maintenance of high standards for my work in both anthropology and nutrition. I am especially grateful for their prompt and critical reading of the earlier drafts of this dissertation.

Special thanks go to Dr. Cheryl Ritenbaugh who urged me to undertake this research. Her interest in the study and faith in the significance of its results helped to maintain my enthusiasm during three rather long years of data collection.

Perhaps my greatest debt is owed to the mothers and infants who participated in this research. Their willingness to share their personal experiences with me and to cooperate in all phases of the study is sincerely appreciated.

I thank my friends in the Department of Anthropology at Michigan State for tolerating endless discussions of breast-feeding and baby fat and for providing the diversions necessary for the successful completion of graduate school.

And finally, I thank my parents who encouraged me to return to school. During the past six years they have supported me in many ways--and almost never lost hope that I would someday graduate!

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CHAPTER I

INTRODUCTION

In order to survive, an animal must eat; if it is a young and helpless mammal, it must be fed. All successful mammalian species have evolved ways of nourishing their young and, from an intra-specific perspective, these behaviors are remarkably uniform. However, one such species does not conform to this generalization. When one compares human populations, a high degree of variability emerges in what is fed to infants, when it is fed, and by what modality. Even within specific populations, infant feeding behaviors vary. It is a basic premise of this study that such behaviors are not random, but are patterned by the interactions of both cultural and biological characteristics of the group which the infant belongs. It is a second premise that the detailed examination of the feeding behaviors for individual children can help to map these biocultural interactions.

In Europe and the United States, infant feeding behaviors are increasingly cited as determinants of lifelong growth and health. As a result, the medical professions prescribe what they consider to be desirable patterns for feeding young children. Yet there is an enormous amount of variability in

the diets actually fed to infants--and the observable results are not easily classified as harmful. Obviously, factors other than medical advice are affecting infant diet. While research has been done on the factors influencing certain isolated choices which mothers make concerning infant diet, little study has been done of the manner in which these choices interact to result in observed, long term infant dietary patterns. Further, although the effect of specific foods on growth has been studied, little is known about the way in which feeding strategies as a whole affect both infant and--in the case of breast-feeding--maternal nutritional status.

This research follows a trend toward the increased use of interaction and feedback models to describe and analyze human diets. On a general, theoretical level Katz (1980) and Jerome et al. (1980) have published models of the adaptability of foodways for human populations. Also at the theoretical level, Bass et al. (1979) have presented a feedback model for understanding individual food habits. All of these models consider the interaction of a variety of aspects of the physical and social environments as well as aspects of human biology. Related more directly to infant feeding are two models which deal with the biosocial components of lactation. Jelliffe and Jelliffe (1979b) outline the basic reflexes necessary for successful breast-feeding in individual women. Gussler and Briesemeister (1980) have expanded on this to explore specific attributes

of social interactions which can lead to lactation failure both in individual cases and as a population-wide phenomenon. However, their model remains untested on a single body of data.

This dissertation presents a prospective study in which infant growth, maternal postpartum nutritional status, and infant feeding strategies involving breast-feeding were documented in a free-living population from central Michigan. The dissertation has three primary goals. The first is to identify the principle infant feeding strategies which exist in this population. A processual approach is taken in the analysis of these feeding strategies. This approach--in contrast to that of many previous studies--serves to emphasize that an infant feeding strategy is not a set of independent behaviors. Rather, it is the product of a series of decisions, each informed and limited by previous ones and, in turn, influencing those subsequent to it. In addition to examining the interaction of dietary components with each other, the study examines the influence on the decision points of factors external to the infant feeding process. These include socioeconomic variables and food beliefs as they are shaped by parental interaction with the medical community, family, and friends.

Having identified the major infant feeding strategies and associated influences, the second goal of the dissertation will be to examine the interaction of these strategies with infant growth. Specifically, it will determine whether

different patterns of growth as well as differences in attained size can be linked to feeding strategies. Weight, length and measures of body fat will be examined.

The final goal is to study the interaction of those feeding strategies involving breast-feeding with maternal nutritional status assessed anthropometrically. Variability in times of weaning and supplementation, as well as differences in lactation "styles" (e.g., length and frequency of nursing bouts) will be examined in attempts to explain postpartum changes in weight and body composition.

The results of this investigation may be valuable in a number of ways. First, they will provide a comparison of the explanatory power of processual descriptions of diet for infant growth with more traditional infant diet categories. The results should provide mother/infant "profiles" of the most common growth and diet patterns. Furthermore, the results will identify the decision points in the infant feeding process for particular subsets of the mother/infant population, a finding of potential significance for those interested in diet and growth intervention. And finally, this investigation will provide basic data on the impact of different kinds of breast-feeding practices on maternal nutritional status. Currently, such data are virtually nonexistent in both the medical and nutritional literature. They are potentially relevant to policy decisions regarding promotion of various infant feeding practices among women of varying levels of nutritional status, and are of interest

in the formulation of statements on the biologically adaptive value of breast-feeding as a human food habit.

The chapters of the dissertation are arranged in the following sequence: literature review, methods, results, discussion, and a final synthesis with conclusions. Chapter II reviews previous studies of infant diet, infant growth, and maternal nutritional status. It presents findings relevant to the present study and assesses the limitations of current knowledge in the area of infant feeding.

Chapter III describes and justifies the research design. It also discusses the sample and the data collection techniques. The rationale for choosing a particular infant dietary data collection strategy is presented and its effectiveness is assessed.

Chapter IV contains the results of the data analysis. In the first section, the most common infant dietary patterns are defined in terms of sample demographics, timing of major feeding events, and details of the breast-feeding process. A second section summarizes data obtained through interviews with mothers. These focus on the process by which infant feeding decisions are made. Analyses of infant growth are presented in the third section, and the fourth describes analyses designed to identify patterns of change in maternal nutritional status.

These somewhat discrete categories of results are each summarized and discussed in Chapter V. They are then merged

to form the basis for a synthetic biobehavioral model of the infant feeding process in Chapter VI. The potential application of this model to two current scientific controversies--the critical body composition hypothesis and the nutritional adequacy of breast milk--conclude the chapter.

CHAPTER II

REVIEW OF THE LITERATURE

This review of the literature will discuss infant feeding studies from the last several decades in terms of three general and not necessarily discrete categories. The first is infant diet, the behavioral study of what is fed to infants and the rationale for such behavior. The second is infant nutrition, the interaction of infant diet and physiology. Infant growth studies fall into this category. The third involves the relationship of lactation to the nutritional status of nursing mothers.

Investigations will be reviewed with respect to their findings and their assumptions in order to discover why the current picture of infant feeding is generally fragmentary and inconsistent. It will be shown that these inconsistencies can often be understood through considering the nature of the researcher and of the research design. Finally this chapter will attempt to demonstrate that by changing or at least making more explicit the assumptions about infant feeding inherent in these studies, it may be possible to design new and more productive research which can present a more complete and coherent picture of the infant feeding process.

Infant DietU.S. Breast-Feeding and Artificial Feeding Practices since 1900

An historical overview of infant feeding practices and recommendations provides two types of information: what has been fed to infants and the sources of influence on physicians and others which have caused the observable trends in feeding patterns.

Although a survey of medical texts throughout the 1900s shows a consistent recommendation of breast milk as the best source of nutrients for infants, physicians have apparently been less than consistent in their enthusiasm for or effectiveness in promoting the practice. Reported figures vary, but in general, the incidence of breast-feeding in the United States and Western Europe decreased from high levels at the beginning of the 20th century to a very low percentage in the 1950s and 1960s (Fomon 1974). Meyer collected data on infant feeding modality at hospital discharge at ten year intervals in a representative group of U.S. hospitals and found a steady decline from 38% to 21% to 18% in 1946, 1956, and 1966, respectively (1958, 1968). The decrease was not uniform across all social strata. Breast-feeding remained the most common form of infant feeding in the lower social classes until the 1960s, while the upper classes adopted the more "modern" practice of artificial feeding. Since the 1960s there has been a resurgence of interest and incidence of breast-feeding in

the U.S. and Europe. This has been particularly apparent in the upper social classes, with the lower classes lagging behind due to what one author has called the "osmotic trickling down" action of social attitudes and practices (Meyer 1968:713).

Medical recommendations of appropriate ages for the feeding of solid foods have shown marked changes through time. (Most U.S. authors include cereal, juice and all non-milk foods in the "solids" category.) In the early 1900s solids in general were forbidden until after one year of age, with vegetables, for example, considered inappropriate until three years of age (Fomon 1974). By 1937, pediatricians were suggesting such foods by four to six months of age (A.M.A. Council on Foods 1937). The extreme was reached by the 1950s when Sackett published his "new concept in baby feeding" (1953), which prescribed solids on the second day of life. Since that time, surveys of medical textbooks and practicing physicians show a return to the 1930s recommendation of four to six months as the appropriate age for solids (Jelliffe and Jelliffe 1979b). This is also the most recent recommendation of the American Academy of Pediatrics (1980).

In reviewing changing patterns of infant feeding, it is evident that trends in the relative proportions of infants consuming breast milk or formula and in ages for introduction of solids have tended to coincide (American Academy of Pediatrics 1978). This suggests that infant

feeding has been influenced by changes in medical wisdom through time. It also suggests that the entire process may be responsive to general changes in lifestyles external to the health professions.

The amount of information available to physicians relevant to infant feeding increased rapidly at the beginning of this century. New (although not always accurate) data on the composition of human milk led to what has been called the "chemical period" (Meyer 1952). Rotch, for example, advocated "percentage feeding," in which minute proportions of different nutrients in infant milks were calculated (1907). Milk prescriptions were in vogue, and the intricacies of these--some were over a page in length--were responsible for the term "formula" which is still in use today. Knowledge about rates of gastric emptying and curd tension of different kinds of milk contributed to the scientification of infant feeding. While the official medical policy on issues such as breast-feeding versus artificial milks remained unchanged, the increasing research emphasis on artificial feeding and its inclusion in medical texts probably helped make physicians more amenable to the use of such methods when advocated by the public.

Research on lactation or any aspect of infant feeding dealing with the mother was conspicuously absent in the first half of the century. When writers did start to mention mothers, it was usually in the context of easing their

workload through reducing the number of infant feedings per day, often by lowering the age at which solid foods were introduced (cf. Clein 1943, Sackett 1953). However, this one-sided view of infant feeding was replaced to some extent in the 1970s by an interest in the interactions inherent in the total infant feeding process (e.g., maternal-infant interactions, food interactions).

Paralleling the changes in infant feeding through the 1900s have been broader trends in life styles and popular conceptions about infants. The increased use of infant formulas, first mixed at home and later commercially prepared, was part of a general increased reliance on things scientific and technologically modern. Time and labor saving devices were sought in all areas of women's work in the home, and the use of formula and canned baby foods fed on a rigid schedule was consistent with this. At the same time, the conceptualization of the infant changed. Writers of the early 1900s (cf. Rotch 1907) referred to infants as totally helpless and vulnerable creatures. By the 1940s and 1950s this view had changed. Child rearing practices were seen as the time in which lifelong habits were taught. The emphasis was on conformity, on orderly patterns of behavior, and on molding the willful infant into his role as a member first of a family and later of society (Aldrich 1942; Clein 1943; Sackett 1953).

However, since the 1960s, reaction against this trend has become widespread, as an emphasis on naturalism has

become a pervasive force in certain segments of Western society. For diet in general, this has included advocating a reduced consumption of processed and fortified foods and for infants and mothers in particular, a return to breast-feeding. Role models for this naturalism in food consumption come from a variety of sources, including popular, romanticized notions about the ways in which technologically simple societies function. Part of these ideas focus on the child as a free, self-determining spirit. This has resulted in a widespread belief that breast-feeding should be carried out on demand from immediately after birth for as long as several years. Other foods should be restricted until at least the second six months of life, a time when the infant has enough muscular control to regulate its own intake. Infant diet research has tended to follow these popular influences. Articles on the long term adequacy of breast milk are now increasingly common (Ahn and MacLean 1980; Saarinen and Siimes 1979).

Yet despite the current medical recommendations for extended breast-feeding and delayed non-breast milk foods and despite the vocal nature of the support this receives from many mothers, data from a number of sources (Fomon et al. 1979; Kemberling 1979; American Academy of Pediatrics 1978) indicate that 40 to 50% of all newborns are formula-fed rather than breast-fed at hospital discharge and that most are fed some non-milk solid foods by two months of age. This contradiction has led to a new dimension of research--

the study of why infants are fed in different ways.

Current Research Directions

Recently there have begun to appear reports of research designed to discover the rationale for different patterns of infant feeding from the side of those directly responsible for implementing such action: parents, particularly mothers. These include studies of the following decisions: to breast- or bottle-feed from birth, when to cease breast-feeding, and when to introduce solid foods into the infant diet.

The first decision--to breast-feed or use formula--appears to be made well before delivery. Guthrie and Kan (1977) report that among unmarried and non-pregnant females up to 21 years of age in Pennsylvania, most had first thought about their future choice in infant feeding methods between the ages of 12 and 17. Furthermore, all of the oldest women could articulate reasons for their choice beyond simple previous exposure to the infant feeding method. This indication that the bottle/breast-feeding decision is made long prior to delivery is supported by Brimblecombe and Cullen (1977). They report that a concerted effort by midwives, public health visitors, and physicians to increase the rate of mothers choosing to breast-feed in 1975 was unsuccessful. Rates of breast-feeding were not significantly different in before and after surveys. The most significant factors in these mothers' feeding decisions were the methods by which they had fed previous infants and the way they

themselves had been fed as children.

Postpartum decisions on the length of breast-feeding have been investigated in New Zealand by Hood et al. (1978) and in Sweden by Sjolín et al. (1977, 1979). In a retrospective survey of 574 New Zealand mothers, Hood et al. (1978) found that 26% of the weanings (defined by the authors as the complete cessation of breast-feeding) were said by the mother to be voluntary. Either she had breast-fed as long as she wanted to, or the infant had "weaned itself." The latter usually occurred after six months of age. Thirty-seven percent reported weaning because of "concerns with the milk supply," and nine percent because of "maternal stress." The categories "maternal illness," "nipple problems," and "other breast problems" accounted for 10%, and several other miscellaneous reasons accounted for the remaining mothers. In another retrospective survey of 298 Swedish mothers, Sjolín et al. (1977) found that the following accounted for over 40% of the decisions to wean:

- 1) concern about the child's getting sufficient milk,
- 2) anxiety and insecurity, 3) lack of motivation, and
- 4) stress.

There is no indication whether these are actual reasons given by the mothers, categories presented to them from which to choose, or whether the authors grouped the mothers' responses as they saw fit.

A prospective study of individual breast-feeding experiences among 75 Swedish mothers was designed to explore in detail the factors leading to weaning (Sjolín et al. 1979).

These factors were categorized as emotional, rational, and medical reasons connected with the mother; environmental reasons; and the interplay of maternal and environmental reasons. However, the distinctions among these categories are not clear, nor are sufficient statistical computations done to show whether or not each of these categories is specific to any group of children or age of weaning.

There have been very few studies of the decision to add solids (and other non-milk foods) to the infant diet. Auerbach (1978), in a study of 102 American mothers, notes that infants on mixed breast milk and formula diets tend to be fed solids much earlier than those on a diet consisting exclusively of breast milk. The results of Wilkinson and Davies' (1978) study of British mothers support those findings and indicate that maternal perceived hunger is the most common reason for starting solids, regardless of composition of the milk portion of the diet.

While the emphasis on maternal decision making and behavior in infant feeding is recent and thus the studies cited above do much to open up this area of research, several important shortcomings must be mentioned. First, the research generally focuses on a single food or food category. For example, Brimblecombe and Cullen concentrate only on the effect of nutrition education on the breast/bottle decision. Yet, delayed feeding of solids is normally part of the breast-feeding education message and may in fact have been effectively transmitted. Similarly, Sjolín et al. (1979)

purport to examine causes of lactation crises and weaning, without ascertaining the composition of the infant diet beyond breast milk.

A second and related problem with many of the studies is that foods are viewed in presence/absence terms. Women in the Hood et al. (1978) study are listed as breast-feeding at up to three years postpartum. Obviously other foods are being consumed by the child, and having more information about them would make it possible to interpret reasons for weaning in the appropriate context, as would such details as daily frequency of breast-feeding sessions.

A final problem is that while factors such as "maternal stress," "insufficient milk supply," and "poor infant growth" constitute a major proportion of the reasons given for weaning or adding solids to the diet, these are rarely explored in any detail. Even though some studies did collect infant anthropometric data (Wilkinson and Davies 1978; Brimblecombe and Cullen 1977), no attempts were made to associate specific decision making factors with growth parameters. One reason for the failure to examine these categories in any depth may be the orientation of those conducting the research. The majority are either physicians or public health workers coming out of a medical training background. It may be that while such training sensitizes them to the subtle distinctions in some categories (e.g., Hood et al. [1978] have three separate categories related to maternal health), possibly meaningful distinctions in other categories are ignored.

Although the studies cited above fail to integrate the factors cited by mothers as reasons for modifying the course of breast-feeding, the interaction of these and their connection via the physiology of lactation have been discussed by others. Jelliffe and Jelliffe (1978) have called attention to the importance of alleviating maternal anxiety in order to insure an adequate oxytocin induced let-down reflex. This, in turn, promotes suckling, which stimulates the prolactin secretion necessary for continued milk production. Gussler and Briesemeister (1980) have developed this in greater detail, concentrating on the specific components of the social and physical environments which, when combined, result in either successful lactation or the "insufficient milk syndrome." This Gussler and Briesemeister see as a phenomenon specific to Western society or to those non-Western societies undergoing a transition from traditional to more modern lifestyles. The model they propose for this "syndrome" contains many of the factors cited by mothers in studies such as Hood et al. (1978) and Sjolín et al. (1977, 1979), but it remains to be verified with a single complete body of behavioral and biological data.

Infant Nutrition

Research interest in the interaction of infant diet and growth has centered on two main questions. First, are there growth differences between infants breast-fed and those fed artificial formulas? Second, does the age at which infants

start to consume solid foods influence their later growth? The way in which these questions have been phrased has dictated the design of the research based on them and has probably contributed to the confusion and controversy surrounding diet and growth of young infants.

Milk Consumption and Growth

A recent review of this research area is provided by Himes (1979), who notes the conflicting results obtained by investigators studying infants in industrialized countries. Some of the most recent or most frequently cited studies are discussed below.

The strongest support for the notion that growth differences exist between breast milk- and formula-fed infants comes from Fomon et al. (1970, 1971). They studied the growth from 8 to 112 days of 149 infants breast-fed and 154 formula-fed from birth. Breast-fed infants were permitted one supplementary formula feeding daily. After 28 days, both groups of infants were permitted strained cereal and fruit on a prescribed schedule of introduction. However, feeding these foods was left up to parental discretion. Although there were no significant differences between groups as a whole in terms of mean weight and length parameters, differences did appear between groups by 112 days in the distribution of body weight. While the distributions had been the same for breast- and bottle-fed infants at 8 days, at 112 days the 90th percentile for bottle-fed infants was "substantially" higher. The 10th percentiles remained equal

for the two groups. These results have been supported by results obtained in England by Taitz (1971). In this study, 21 breast-fed and 240 bottle-fed infants were compared, and significantly greater weight gain velocity was noted from birth to six weeks among those infants bottle-fed. In contrast to data in the Fomon et al. studies, Taitz's came entirely from clinic records. There were no exclusions for feeding solid foods in any form or amount or at any age.

A number of other studies, however, have found no growth differences between breast milk and formula-fed infants. Thomson (1955) found no significant differences in weight gain to 16 weeks between wholly bottle-fed and wholly breast-fed members of 40 pairs of female infants in Scotland matched for birthweight. Evans (1978) studied 94 normal British infants from birth to six months of age. Each infant consumed either breast milk or one of three commercial formulas. No significant differences in weight, length, and skinfold velocities were found. It was pointed out that the breast-fed infants made the most rapid gains during the first month. No data were given on sample attrition. In another frequently cited study, deSwiet et al. (1977) found no effect on body weight of the type of milk fed to 758 infants in Great Britain. Their comparisons were made at six weeks and six months, among groups identified at six weeks as breast-feeding, bottle-feeding, or mixed breast- and bottle-feeding. Some infants in each of

these three groups consumed solid food as well. No significant differences were found at six weeks or at six months. The same three feeding types were studied to nine weeks of age in another sample of 457 British infants (Holly and Cullen 1977). Again, no significant differences in weight could be found between feeding groups. Despite the lack of significant results, an examination of the data shows differences in the patterns of growth. The mixed feeding group is most notable. Although it has a lower growth rate than either of the other two feeding groups in the first month, these infants recover and by nine weeks are over-represented in the highest decile of weight for age.

Saarinen and Siimes (1979) followed the growth of 238 Finnish infants during the first 12 months of life. One group of these infants was breast-fed for at least six months, with no solids until three and a half months. These infants were compared with others who were weaned from breast milk to formula by one month of age. These infants also consumed solids after three and a half months. No significant differences in weight or length were found between these two groups at any point during the study. However, an examination of the data Saarinen and Siimes present shows differences in the average patterns of weight gain. The extended breast-feeding group gained weight more rapidly for the first two months. After that, its growth velocity slowed relative to the early weaning group, which was on the

average heavier from six to twelve months of age.

One recent study of 92 female infants has concentrated on the relationship of infant fatfold thickness to feeding modality (Ferris et al. 1979). Four fatfolds were measured monthly from one to six months. There were no significant differences among four groups of infants identified at two months as breast-fed or formula-fed, exclusively or with solids.

Thus, a review of the literature presents no definitive answers to questions concerning the differential impacts of breast milk and formula on growth. After examination of studies involving growth and solid food, reasons for the inconclusive nature of the breast milk/formula investigations will be discussed.

Growth and Consumption of Non-Milk Foods

Results of studies designed to answer the question of the impact of solids on growth are as conflicting as those described above from milk types. Weil (1977) provides a review and critique of some of the older research in this category. Other investigations will be reviewed below.

One study which is repeatedly cited as evidence for an impact of solid food on infant weight is that of Shukla et al. (1972). In it, weight, length, fatfolds, and types of foods consumed were monitored periodically from birth to one year of age in 300 British infants. The investigators found that at all ages, these infants consistently exceeded accepted weight, weight for length, and fatfold standards. Furthermore,

they found that 40% had been given solids by four weeks and 93% by 13 weeks. From this, a casual link between the consumption of solids and overweight was inferred. Almost all these infants also consumed formula, but the investigators failed to determine whether or not the solid food was replacing or truly supplementing this intake.

Of the more recent studies of growth and solids, only a few confirm the 1972 findings of Shukla et al. One of these is Hodgson (1978). In this, 301 British infants were weighed at birth, six weeks, six months, and one year of age. Dietary histories were collected at unspecified times. Hodgson divided the infants into the following groups by date of first solid food: earlier than six weeks, six weeks to three months, and later than three months. At six months, infant weight of the first group was found to be significantly greater than that of the last. Hodgson thus concluded that early introduction of solid food leads to increased weight gain in infancy.

Davies et al. (1977) studied 821 British infants and used the same age divisions for introduction of solids as those used by Hodgson (1978). In this study, however, no significant differences in weight or length were found. In a later study of only 50 infants, Wilkinson and Davies (1978) again found no statistically significant relationship of growth parameters to date of introduction of solids. Thus, studies exist to support either side of the question of the impact of solids on infant growth.

Underlying Assumptions

The confusing and conflicting results of the studies discussed above appear to be derived, at least in part, from the nature of the assumption on which the research questions are based. There are at least five such assumptions, not all of equal impact and significance, and each will be discussed in turn.

The first assumption implicit in this research is that infants in dietary studies can be treated as though they are randomly assigned to feeding groups. If this assumption were valid, then there should be no differences, for example, in demographic variables between infants breast- or bottle-fed. However, Sauls (1979), in a review of the infant feeding and morbidity literature, has shown that consistent differences do exist. At present in the U.S., compared with bottle-feeders, breast-feeding mothers are likely to be older, married mothers, who are healthy, non-smokers, not employed outside the home, and not receiving any type of governmental assistance. Furthermore, the educational level of breast-feeding mothers is generally higher than that of bottle-feeders (Cunningham 1977). Such differences make it likely that basic differences in prenatal influences, postnatal health care, and other environmental factors exist. These may, in turn, be confounding factors in studies which do not control for them.

A corollary of the first assumption of random assignment of infants to feeding groups is the assumption that

"breast-fed" and "bottle-fed" are the same sort of categories. Since, as Himes (1979) has stated, there is a one-way passage of infants from the breast-fed to the bottle-fed category, the former is a highly selected group. This is particularly obvious in Ahn and MacLean's (1980) study of growth in exclusively breast-fed infants. Their sample size decreases rapidly after five months of age; at eight months only 28 of 96 infants remain. There is no way of knowing whether or not actual or perceived growth crises were responsible for the attrition. Thirty percent of the breast-fed infants studied by Fomon et al. (1970) dropped out of the project by day 112, compared to an attrition rate of only 8% among formula-fed infants (1971). A comparison of those leaving the breast-feeding study with those continuing to participate showed the former to be on the average lower in weight in the early weeks of the study than the latter. Fomon et al. (1970) report that at least some attrition was due to failure to thrive on breast milk. Bottle-feeding, in contrast with breast-feeding, is more of a cumulative group than a selected one. In studies such as Saarinen and Siimes (1979), many of the infants in the bottle-fed category had originally been breast-fed, but for one month or less. The proportion of these weaned due to growth inadequacies is unstated. However, based on data of Hood et al. (1978) and Sjolín et al. (1979), it may have been quite high. This may, in turn, have confounded the results of growth data analyses.

The second implicit assumption in these studies is that a one-way, casual relationship exists between infant diet and growth. That is, dietary manipulations lead to growth differences. This orientation is contrary to what most clinicians would acknowledge to really be the case: that dietary changes are made when growth has deviated from an expected norm. While a growth correction following the diet change is expected, it was a growth, rather than a dietary, action which originally set the chain of events in motion. Only attending to the one-way effect of diet on growth may obscure the interrelationships of infant diet and growth.

The issue can be further confused by the way in which infant dietary intake data are collected. Twenty-four hour diet recalls and diaries such as those used by Shukla et al. (1972) and Evans (1978) provide information for only that short period of time. There is no way of knowing whether the diets reported represent long term patterns of feeding--and thus "causes" of the observed growth--or recent feeding changes which might be "effects" of previous growth. This problem can be overcome to some extent by increasing the frequency of the diet recalls or, as Ferris et al. (1979) have done, by taking a diet history at the same time. However, the investigator must still decide which information is to be given priority in assigning infants to feeding groups. And his or her assumptions about the interrelationships of infant diet and growth will help to inform that decision.

This can be a fairly serious confounding factor if feeding changes tend to coincide with times chosen for dietary data collection. This problem has been described by Ritenbaugh and Harrison (1980) for a study of Arizona infants in which dietary and growth data were obtained at six month intervals, often at approximately the same time as a regular medical examination at which a diet change was prescribed. In these cases several days difference in the researchers' appointment scheduling made little difference in anthropometric data, but resulted in major shifts in dietary intake. Thus, the fact that most of the British infant studies are conducted by physicians collecting data at regular well-baby checkups, while most of the American studies are not, may explain some of the conflicting results obtained. At least it indicates another set of problems to be considered in interpreting such results.

A third assumption about diet and growth made by several researchers is that excessive weight indicates fatness. Although it is widely recognized that the contribution of fat to body weight is less than that of the same volume of lean body tissue, the confusion of body size with body composition persists. Taitz (1971), for example, uses no measure of fat, yet talks about the prevalence of over-nutrition and obesity in the study population. It is, in fact, quite possible for individuals of the same body weight to have significantly different percentages of body fat (Brozek 1963).

A fourth assumption is that when solids are introduced into the diet, they are nutritional additions to the existing dietary base. It is this assumption which has been behind research designed to identify the suspected connection between early solids and obesity. However, Marlin et al. (1980) have shown that, at least until the age of 12 weeks, solids actually replace either breast milk or formula in caloric terms. They conducted a longitudinal study of 39 infants fed a diet selected by the mother. Mothers kept three-day diet diaries for their infants at two, four, eight and twelve weeks. Breast milk volume was obtained by pre- and post-feeding infant weighings, and its nutrient composition was estimated using values published by Fomon (1974). When caloric intake of the entire diet was calculated, there were no significant differences at any age between those consuming solids and those consuming only breast milk and/or formula. The research practice of attending only to single foods or food categories has led to this ignorance of the impact of dietary change on the existing diet. It is not known whether formula also acts as a nutritional addition or replacement in a breast milk diet and whether solids continue to be replacements at ages of greater than three months.

A final assumption inherent in much of the research on infant nutrition conditions the tone in which results are discussed and evaluated. It is the assumption that "normal growth" exists as a constant standard against which growth

or research subjects and samples can be evaluated. Shukla et al. (1972) and others discovering high rates of "over-nutrition" in Great Britain in the late 1960s and early 1970s assumed this, and never investigated what their subjects' idea of normal growth was or whether their own medical notion of normal growth had changed through time. Normal growth does, of course, follow certain curves at different ages or stages of maturation. However, both the magnitude and amplitude of the curves can vary. The boundaries between "normal" and "abnormal" variability are culturally defined. In the past in almost all cultures and continuing to the present in many, "bigness" in infants had been considered healthy and desirable. Bryant (1978) found Anglo, Puerto Rican, and Cuban mothers in Dade County, Florida still using evaporated milk formula because it "fattens" babies better. Weil (1977) describes a group of mothers he labels "more nutritionally sophisticated" who fed diets designed to produce fatter infants due to their concerns about the possibility of brain damage resulting from underfeeding. In contrast, among the medical community and other segments of the public, such healthy looking (by one standard) babies have recently come to be labeled obese and considered at risk for adult obesity, heart disease, and reduced lifespan (cf. Charney et al. 1976; Kannel and Dawber 1972). Adair (1980) found white, middle-class Philadelphia mothers manipulating their infants' growth patterns through sometimes extreme dietary means to

produce the thin infants now considered "normal" by some physicians. Thus the findings of Fomon et al. (1971), Hodgson (1978), and others cited above that different patterns of infant feeding produce statistically significant differences in infant growth should not necessarily lead to the conclusions that these differences: 1) are culturally meaningful, or 2) are indicative of abnormalities in the infants' growth.

These five assumptions, then, have shaped the research conducted on infant growth and diet interactions in recent years. Like any research base, they have in some ways limited and selected for the research results which have been derived, and they have contributed to the ambiguity of those results.

Maternal Nutritional Status

Several long term studies exist of lactation and maternal nutritional status of women living under conditions of nutritional stress. A British study in the Gambia, West Africa, for example, has identified annual patterns of maternal weight change, birthweight, and lactation performance and has correlated these with seasonal fluctuations in disease, rainfall, and food supply parameters (Rowland 1978; Rowland and Paul 1981; Whitehead et al. 1978). In an experimental study in Guatemala, the effects of different nutritional supplementation plans on reproductive performance have been studied (Lechtig et al. 1975; Newman et al. 1980). In addition to these, a large

body of knowledge exists specifically on the composition of human milk under conditions of nutritional stress. Jelliffe and Jelliffe (1978) have published a review of this literature.

Together, the studies cited above and others like them have provided a general picture of the average patterns of maternal nutritional status and milk production in populations existing under sub-optimal conditions. What are missing, however, are comparable baseline studies of lactation and the postpartum period in well-nourished women in which the dynamics of maternal nutritional status, including milk production, are documented. This section will review the few studies of well-nourished mothers which can be found in the literature. It will then consider evidence from a variety of other types of studies which point to possible patterns of change during the postpartum period among lactating women and the ways in which these may interact with milk production and, hence, infant growth.

Breast-Feeding and Postpartum Weight Loss

It is widely assumed that women store nutrients during pregnancy which are later used to meet the demands of lactation and that, as these stores are mobilized, weight loss occurs. Twenty years ago Hytten and Thomson commented that there was "very little evidence in the literature on this rather elementary point" (1961:27). The evidence that did exist at the time of their review was inconclusive, showing

that women both gained and lost weight during lactation. Hytten and Thomson also presented their own data on mean weight change of 37 primiparae who lactated more than 10 weeks and 35 who lactated less than three weeks (1966). Between the second and thirteenth weeks postpartum most women lost weight. Those breast-feeding longer tended to lose more weight than those breast-feeding for a limited time. However, the distribution of weight change is wide in both groups ranging from losses of over twelve pounds to gains of more than eight. Furthermore, no data on pregnancy weight gain or supplementation of breast milk are given to help interpret these results.

Research since 1961 to substantiate the alleged association of rapid weight loss and breast-feeding is equally meager. Dennis and Bytheway (1965) combined postpartum weight loss data gathered for other reasons in a number of different studies. They show that between ten days and ten weeks postpartum lactating women lose on the average $1\frac{1}{2}$ pounds more than non-lactating women. While this study is widely cited (e.g., Jelliffe and Jelliffe 1979), it is based on a highly selected sample of 17 subjects. All women with any pregnancy edema, heavy blood loss at parturition, or cesarean delivery were excluded. While such exclusions are reasonable in a research context, they may invalidate or greatly limit any promises of weight loss to individual women based on this research.

Naismith and Ritchie (1976) report postpartum weight changes in 22 lactating and 20 non-lactating women. Group weight losses from hospital discharge to three months postpartum average 2.6 kg and 2.9 kg, respectively. By six months, the non-lactating women had a mean cumulative weight loss of 4.4 kg, compared to only 2.7 kg for those lactating. These findings run counter to the assumed relationship of postpartum weight change and breast-feeding. However, the investigators note that dieting was reported more frequently among non-lactating than lactating women. This points to one of the major factors confounding such studies. In non-laboratory samples, dietary intake cannot be standardized. Blackburn and Calloway (1976) studied energy intake and expenditures in 12 mothers at various stages of lactation and five controls who were not lactating. They found that breast-feeding women consumed an average of 30 kcal/kg and expended the same amount on non-lactation activities. In contrast, the non-lactating women consumed an average of only 19 kcal/kg, while expending 34 kcal/kg. If these energy consumption patterns are typical of postpartum women in general, they may explain the failure of postpartum weight loss studies to provide conclusive support for the assumed relationship of breast-feeding to maternal body weight.

Breast-Feeding and Changes in Maternal Body Fat

The primary component of weight loss expected during lactation is fat. Taggart et al. (1967), in a longitudinal

study of primagravidae in Scotland, documented the regular growth of adipose tissue during pregnancy. It has been reasoned that this is an adaptive mechanism to support breast feeding, and the automatic assumption of fat loss during lactation follows. Popular publications (e.g., LaLeche International 1963) promise women that the fat will be "burned" during lactation and health professionals predict a "slimming effect" (Jelliffe and Jelliffe 1979b:113). However, studies of infant feeding and postpartum changes in maternal fatness are virtually non-existent. A review of the literature yielded a single research report. In the study by Naismith and Ritchie (1976) described above, biceps, triceps, subscapular, and superiliac fatfolds were measured and used to compute total body fat. No distinct patterns of change in total body fat were found which could be correlated with lactation status.

Despite the lack of supporting evidence, this assumed loss of fat during lactation has been used uncritically as the basis for other proposed interactions, most notably the critical body composition hypothesis of Frisch and colleagues (cf. Frisch et al. 1973; Frisch and McArthur 1974). According to this hypothesis, a certain minimum level of body fat is necessary for onset and maintenance of ovulatory cycles. This is alleged to be a determining factor in menarche as well as in the length of amenorrhea during lactation.

Although what is commonly believed about the relationship of infant feeding to maternal fatness is based more on logic than on solid evidence, there are a series of interactions documented in the literature which suggest relationships between maternal body fat and a number of components of the infant feeding process. The following paragraphs review this evidence.

One breast-feeding variable--the daily frequency of nursing--has been linked to levels of prolactin and gonadal hormones in mothers. These in turn have been correlated with maternal fatness and with the quality and quantity of milk produced.

In both animal and human studies, the frequency of nursing periods has been found to be directly related to the level of serum prolactin. Grosvenor et al. (1967) found that frequent suckling was necessary to maintain pituitary prolactin release in laboratory rats. The length of the suckling stimulus had no effect on prolactin level. Delvoe et al. (1977) studied a group of 97 nursing mothers in Zaire and obtained similar findings. Serum prolactin levels rose with frequency of daily nursing. Moreover, nursing frequency was also related to the length of time mean prolactin levels remained elevated after parturition. Women nursing seven or more times per day maintained high prolactin levels for a year. Those nursing four to six times per day returned to non-lactating levels by about ten months, and those nursing less than four times per

day, by six months.

The relationship of nursing bout frequency to serum concentrations of the gonadal hormones estrogen and progesterone has also been documented. Among lactating !Kung mothers, Konner and Worthman (1980) found that high nursing frequency was associated with low levels of estrogen and progesterone. Less frequent nursing correlated with higher hormone levels. They hypothesize that this is a result of the suppression by prolactin of gonadal hormone production. (Tyson [1977] reviews the details of this interaction.) Among the !Kung, total nursing time and length of feedings were uncorrelated with hormone levels. The time interval between the initiation of nursing bouts was the crucial variable.

Variations both in the gonadal hormone progesterone and in prolactin have been linked to body fat. An inverse relationship exists between serum prolactin and progesterone: the higher the prolactin, the lower the progesterone production. Studies in both humans (Hyttén and Leitch 1971) and rats (Galletti and Kloppe 1964) show that increasing the level of progesterone induces fat deposition. Thus, the variations in progesterone levels mediated during lactation by prolactin would be expected to have an impact on fat levels. Those women nursing frequently should be less disposed to increase fat stores than those women nursing infrequently.

Prolactin is associated with body fat through the activity of lipoprotein lipase, the enzyme responsible for the uptake of dietary lipids into adipocytes. In studies of laboratory animals, prolactin has been found to induce and maintain shifts in lipoprotein lipase activity level in different body sites (Zinder et al. 1974; Scow et al. 1973). When prolactin is at normal low levels, lipoprotein lipase activity is high in the peripheral layers of adipose tissue. However, when prolactin levels are elevated, there is a suppression of lipoprotein lipase activity in adipose tissue and a concomitant increase in activity in the mammary glands. Thus, when nursing frequency is high, serum prolactin concentration should be high also, causing dietary lipids to be diverted from body stores to the mammary glands. When nursing frequency is low, uptake of lipids by peripheral adipose tissue should be closer to normal levels.

It is well known that the frequency of nursing bouts has an impact on the quantity of milk produced. Egli et al. (1961) in a frequently cited study varied the feedings per day of a woman who was successfully lactating. They noted reduced milk output following a reduction in feedings and an increase to original levels of milk production three days after the number of feedings returned to normal. The cause of such variations in milk production is assumed to be the corresponding variation in prolactin, which causes milk secretion in the alveoli.

In addition to affecting breast milk quantity, the frequency of feedings affects milk quality. Tyson et al. (1972) found that artificially stimulated prolactin release in lactating women was followed by increased fat content of their breast milk. The mechanism for this may be the prolactin-induced increases in mammary lipoprotein lipase activity. Therefore, it appears that infant growth should also be affected by the ongoing interactions of feeding frequency and maternal physiological parameters during the postpartum period.

Thus, the literature suggests that the relationship between breast-feeding and maternal nutritional status is considerably more complex than the simple loss of weight and fat often assumed to occur during lactation. It appears that attention to specific behavioral aspects of breast-feeding may help to reveal patterns of maternal biological response. These responses, in turn, may affect the way in which infants grow.

Summary

This review of the literature has indicated that a complex interaction exists among the components of the infant feeding process: infant diet, infant nutrition, and maternal nutritional status. It has further shown that different aspects of this interaction are better understood than others. This chapter has attempted to indicate what those aspects are and why the remaining ones have either not been studied or, having been studied, have produced

contradictory results.

Studies of maternal decision making in infant diet indicate that perceptions of infant growth patterns are a major factor in mothers' choice of feeding strategies. However, infant growth data are generally analyzed as though only a one-way relationship between diet and growth exists. Because of this and other assumptions about the relationship of infant diet to growth, few conclusions can be drawn at present about this interaction.

The aspect of the relationship of infant diet to maternal nutritional status about which most is known is the average composition and volume of milk produced by malnourished mothers. However, the dynamics of milk production in individual women--particularly in well-nourished women--are relatively unknown. The effect of infant feeding on maternal nutritional status is widely assumed to be a gradual draining of body stores, but research on the hormones involved in lactation indicates that this may be overly simplistic. This research hints that different patterns of change in maternal nutritional status may accompany different styles of breast-feeding. To investigate these requires attention to behavioral as well as biological data, and to the ways in which these two types of phenomenon interact in individual women.

CHAPTER III

METHODS

This chapter describes the research undertaken to meet the objectives identified in Chapter I. After a discussion of the overall research plan, it details the sample and the methods by which it was obtained. Data collection procedures are described, and the rationales for their use discussed. The final section of the chapter presents the justification for combining various types of data.

Research Design

Because the objectives of this research are to examine the interaction of infant diet and growth and maternal postpartum nutritional status through time, a longitudinal design was selected. Such a research strategy has a distinct advantage over the less time-consuming cross-sectional design in that it enables one to document individual courses of growth or behavior, thus clarifying the nature of the relationship between events at one time and those at another.

The research reported here actually comes from longitudinal studies of two samples from a single population. The first, an exploratory study referred to hereafter as

Study I, was conducted in central Michigan from January 1978 through January 1979. Its purpose was to examine general relationships between infant diet and growth. The data collected in Study I were subjected to only minimal analysis (Quandt and Ritenbaugh 1979). Further analysis was postponed because, in the course of the study, it became apparent that a number of potentially interesting problems in the data could be explored only with the collection of additional behavioral data.

Thus, the second study (Study II) was conducted from August 1979 through February 1981. It continued the same data collection strategy used in Study I, but added other items to the research protocol which were designed to explore the problem areas which had emerged during Study I. It should be stressed that although it was hoped the two samples could be combined into one larger one, Study II was not in any way intended to increase sample size to improve levels of statistical significance of some already recognized associations.

It was planned that, if no differences were found between the two studies in basic data (e.g., pregnancy characteristics, parental size), it could be assumed that they were samples from the same population. Thus, while different frequencies of behaviors might exist at the times of the two studies--and indeed would be expected given the rapid changes which take place in infant feeding norms--this would not preclude their being combined into a single

sample. Biologically similar individuals should react in similar ways to the same diet or behavior at different times (Bass et al. 1979). On the other hand, it was assumed that for any analysis examining cultural factors and their changes through time, the two studies could legitimately be separated into two independent groups.

The Sample

Description of the Sample

The total sample consisted of 79 mothers and 80 neonates. All infants weighed at least 2,500 grams at birth and were products of at least 36 week pregnancies. Forty-five of these mothers and 46 infants (44 singleton infants and one set of fraternal twins) participated in Study I. The remaining 34 mothers and 34 infants were in Study II. Table III.1 shows the number of infants by sex, Study, and month of participation. The diminishing sample size is due to mothers moving from the area. This group of subjects was taken from a larger sample, drawn to study other pregnancy and postpartum issues, which included infants never breast-fed, infants born prematurely, and infants whose mothers left the study area before two months postpartum.

TABLE III.1--Number of Infants Measured at Birth and at each Month.

		Month					
Sample	Birth	1	2	3	4	5	6

TOTAL SAMPLE							
Total N	80	80	80	79	76	75	72
Females	43	43	43	42	41	40	40
Males	37	37	37	37	35	35	32
STUDY I							
Total N	46	46	46	45	44	43	41
Females	27	27	27	26	25	24	24
Males	19	19	19	19	19	19	17
STUDY II							
Total N	34	34	34	34	32	32	31
Females	16	16	16	16	16	16	16
Males	18	18	18	18	16	16	15

The sample used in this study represents a predominantly middle class population. The annual household incomes ranged from \$5,000 to over \$40,000; the median falls in the \$20,000 to \$24,999 category (Table III.2). The median income was slightly higher in Study II than in Study I. However, considering the inflation rate during the two years between studies, the effective income can be considered equal. Maternal education ranged from high school graduate to Ph.D. The modal category was composed of women who had completed a bachelor's degree program (Table III.3).

TABLE III.2--Gross Household Income by Study and for Total Sample.

Income Category	Study I N	Study II N	Total N
(1) \$5,000 - 9,999	3	2	5
(2) \$10,000 - 14,999	9	4	13
(3) \$15,000 - 19,999	11	7	18
(4) \$20,000 - 24,999	10	12	22
(5) \$25,000 - 29,999	7	5	12
(6) \$30,000 - 39,999	6	2	8
(7) \$40,000	0	2	2

TABLE III.3--Highest Level of Maternal Formal Education by Study and for Total Sample.

Education Category	Study I N	Study II N	Total N
(1) High School or Vocational School	10	9	19
(2) Some College (Less than Bachelor's Degree)	10	8	18
(3) Bachelor's Degree	16	11	27
(4) Any Graduate School	10	6	16

Sample Recruitment

Throughout the sample recruitment, care was taken not to influence potential participants' choices of feeding modality or to differentially attract women with different feeding plans. Women asked to participate in the study were told that the researcher had a number of interests that involved new mothers and their infants. They were told that she was aware that there were many different ways in which mothers fed their infants and that she was trying to find out what these feeding methods were. She was also interested in the way infants grew and how that might be related to the way they were fed. Finally, they were told that some mothers might be breast-feeding their infants and, in those cases, maternal postpartum anthropometric data might help to explain infant growth. Since comparisons between those breast-feeding and those not breast-feeding were useful, they were told, the researcher would like to monitor postpartum changes in all mothers.

Slightly different procedures for enrolling mothers were followed in Studies I and II. Women participating in Study II were identified during pregnancy with the assistance of obstetricians in private practice in the Lansing area. The physicians agreed to give letters explaining the study (Appendix A) to patients who met the criteria for the study. These criteria are discussed below. These women were then contacted by telephone by the investigator, who further explained the research and asked their participation. The

rate of refusal was approximately 20%.

In Study I, women already enrolled in a study of pregnancy weight gain were given a letter by the 36th week of pregnancy requesting their participation in a study of infant growth and dietary practices (Appendix A). These women had originally been recruited through most of the same physicians and in the same way as described for Study II. The rate of refusal to participate in the pregnancy weight gain study was approximately 10%; that for the follow-up infant study was 8%.

In order to be included in either study, women had to meet certain criteria. First, only Caucasian women were contacted in order to minimize possible genetic differences in growth patterns. Second, each woman had to be either a primipara or, if a multipara, expecting her first liveborn child. This requirement was an attempt to, minimally at least, standardize experience in child-rearing. Finally, the women were expected by their physicians to have no pregnancy complications which might adversely affect the health or development of the infant. There were no criteria related to mode of infant feeding, and the fact that breast-feeding was of primary interest was not mentioned during any of the study recruitment or during the course of the research.

Mothers read and signed statements of informed consent (Appendix A) at their first meeting with the investigator.

Data Collection

All data were collected in the subjects' homes at their convenience. S. Quandt collected all Study II data and about 80% of that in Study I. C. Ritenbaugh collected the remaining 20%.

Maternal Data Collection

The nutritional status of mothers was assessed anthropometrically eight times: once during the third trimester of pregnancy (a maximum of two weeks before delivery), early in the postpartum, and at monthly intervals from one to six months postpartum. The early postpartum data were collected at one week after delivery in Study I and at two weeks, in Study II. This change was made to facilitate the collection of infant data described below. Measurements on each of the occasions included weight, mid-arm circumference, and triceps fatfold. Weight was measured to the nearest tenth of a kilogram on an Accu-Weigh portable beam balance. Women were weighed without shoes; they were requested to wear approximately the same weight indoor clothing for each weighing. A steel tape and Lange skinfold calipers were used for the remaining anthropometrics. Standard methods for mid-arm circumferences and triceps fatfold described by Weiner and Lourie (1969) were used.

Stature was measured using a free-standing anthropometer once during the study. Prepregnant weight was obtained from the mother when the prenatal measurements were made. She

was asked to give her best recollection of her weight at the time of conception, rather than her "normal" weight, which might have been different.

Although it is possible to measure fatfolds at a variety of sites on the body, triceps was chosen for two reasons. First, unlike sites such as superiliac or midabdomen, triceps is unlikely to be distorted shortly before or after parturition by gross anatomical adjustments related to delivery. Second, triceps, along with mid-arm circumference enables one to compute upper arm fat area (Gurney and Jelliffe 1973). This is an expression of adiposity which can be used to assess changes in adiposity independent of changes in underlying lean body tissue. It may be particularly important in monitoring changes following pregnancy, which is--to a variable degree in all women--a super-hydrated physiological state.

No biochemical or dietary intake data were collected as additional assessments of maternal nutritional status. Although such information would possibly have been valuable, it was decided that the high degree of long term cooperation required for the study as a whole might be jeopardized with the inclusion of these types of data collection. The collection of dietary data is not usually considered invasive. However, it was observed that many of these women were extremely sensitive about their food consumption during the postpartum. Although most had expected to weigh more after pregnancy than before, many were quite unprepared for the

proportion of weight left to lose. Furthermore, they experienced conflicting pressures regarding diet. On the one hand, they were told to eat more than usual for breast-feeding. On the other, they were told to eat less than usual to return to their pre-pregnant size and shape. Thus, because of the feelings attached to food intake, it was decided that the collection of such data might endanger the rapport between mothers and researcher necessary for other portions of the study.

Mothers were asked their expected delivery dates at the prenatal measuring session, as well as the method by which the dates were calculated.

Parental ages at the child's birth as well as socio-economic information were solicited during an interview at the six month measuring session. Total gross household income for the previous year was obtained, as well as highest level of maternal education. The decision to use maternal education was based on research by Green that indicates that in American society, most health related decisions are made by mothers; and thus their education rather than that of fathers correlates most closely with health behaviors (1970). Observations were also made of the style of dwelling in which the mother and infant lived. Since it has been suggested by others that differences in physical environment affect maternal child interaction including breast-feeding in the neonatal period (Klaus and Kennell 1970), the possibility that gross differences in

environment might continue to be influential was considered.

Infant Data Collection--Anthropometric

Infant growth was assessed seven times during the study: in the hospital within 24 hours of birth and at home, monthly from ages one to six months. Weight, length, and eight fatfolds were measured on each occasion. Birth weight was obtained from the hospital chart. Subsequent weights were calculated to the nearest 0.1 kg by subtracting the weight of the mother from that of the mother holding the child on the beam balance. Infants were weighed naked except for a diaper. Length was measured to the nearest 0.1 cm as the distance on a flat surface from the crown of the head to the soles of the feet. The researcher positioned the child and applied pressure to the infant's knees while another person (usually the mother) held the head still and in the sagittal plane. The triceps fatfold was measured on the posterior of the arm midway between olecranon and acromion. Biceps fatfold was taken at the same level on the anterior surface of the arm over the biceps muscle. The midabdominal fatfold was measured in a vertical line at a point 2 cm lateral to the umbilicus, and the subscapular, below the angle of the scapula on the back. All of these fatfolds were taken bilaterally with the child in a relaxed, recumbant position. The calipers were applied to the fold and read as soon as the needle had stabilized, after the method of Brans et al. (1974). A total fatfolds variable was calculated by summing each set of fatfolds. This was

done to control for assymetry and trunk-extremity variability in fat distribution.

Infant Data Collection--Dietary

Data pertaining to infant dietary intake were obtained through written records kept by the mother and through information elicited during interviews at monthly measurement sessions. The emphasis on mothers was not meant to deny the role others--particularly fathers--play in infant feeding. Whenever other family members were present during a measuring session, their views were solicited as well as those of the mother. However, since among families such as those in the population represented by this sample, mothers have the major responsibility for care of newborn infants, most of the data collection strategy concentrated on mothers.

Mothers completed 24-hour diet diaries for the infants approximately every eight days from the second week postpartum to the end of the study. These forms were mailed to the mother at the appropriate interval with a stamped, addressed envelope in which to return the completed diary. Mothers were asked to complete the form as soon as possible, recording everything the child consumed during a 24-hour period, the times of consumption, and the amount consumed. For breast-feeding, they were asked to note the minutes of active suckling for each nursing bout. Time and length of sleep episodes were also noted to provide information on feeding frequency.

Of the numerous methods used by researchers to collect dietary intake data, the diet diary system was chosen because it seemed best able to provide the data on infant feeding behaviors desired for this investigation while minimizing problems inherent in many recall reporting techniques. Data were reported frequently enough to allow reasonable verification of dates of dietary changes such as first introduction of solids, breast milk to formula transitions, and elimination of night feedings. Had information on specific nutrient intake been desired, more or less frequent reporting might have been required. With the eight day interval, food behaviors specific to a particular day of the week were not overrepresented. Because the data were recorded by the mother or caretaker as the day progressed, the problems of accurately remembering numerous similar events were avoided.

The level of cooperation of mothers in completing and returning the diet diaries was generally high (Appendix B). The median number of diaries returned was 15. Mothers tended to be more conscientious about the forms during the first months of their participation. It became apparent within the first few weeks postpartum that certain mothers--often despite their professed good intentions--were never going to return many of the diet diaries. In these cases other means of obtaining the data were intensified. These methods are described below.

The second source of infant diet data is information obtained during both unstructured and formal interviews and through observations conducted whenever the investigator met with subjects. In Study I, observations and unstructured interviews took place at all postpartum measuring sessions. Questions were asked to verify changes in infant feeding which had appeared on the diet diaries since the previous meeting. In cases where no diet diaries had been completed, specific questions about the infant's usual diet were asked. At the sixth month measuring session a more formal interview took place during which mothers were asked to give as detailed a diet history from birth to six months for the infant as they could remember. They were also questioned about their own recovery from pregnancy and childbirth (e.g., when did they resume a normal schedule of activities; when did they feel like they were really "back on their feet?") Responses to questions at six months were written during the interview. On all occasions prior to that, notes were written after leaving the subject's home.

In Study II the content of the postpartum interviews was expanded. In addition to using measuring sessions to verify content of the diet diaries, information was elicited on the decision making process related to each dietary change. While the sequence and wording of questions varied, in general the investigator tried to establish why the change had been made, whether or not there had been input

from family members or others, and whether or not any behavioral or physical change observable in the child preceded or followed the dietary change. Much of this discussion took place while the child was being measured so, as in Study I, responses were recorded after leaving the home.

At six months a formal final interview was conducted with Study II mothers. They were asked to give a diet history for their infants and describe the decision making process involved at the various transition points. The same questions on maternal recovery were asked as had been asked in Study I. Each mother was also asked to describe her infant's body shape by choosing from a set of six infant outlines varying from thin to fat (Appendix C) the one she thought looked most like her own child.

In any case where a mother did not complete a diet diary for a particular time period for which data is analyzed in later chapters, one of two possible actions was taken during the analysis. If data were available from interviews during that time, such data were used and the mother or infant included in the analysis. If none were available, the subjects were excluded from that particular analysis. Data from interviews on types of foods consumed and dates of introducing new foods or weaning were considered of acceptable accuracy. Data on numbers of feedings per day and length of feedings were not. Hence, the numbers of cases varies somewhat in those data analyses

involving any of the infant feeding data.

Statistical Considerations and Reporting Reliability
Levels of Statistical Significance

The statistics used throughout this dissertation vary with data being analyzed. Anthropometric data meet the conditions of statistics which assume a normal distribution and an interval or ratio level of measurement. However, many of the other data--e.g., socioeconomic measures, numbers of breast-feedings--do not meet such assumptions. Therefore, nonparametric tests are used in their analysis. At various points throughout the description of the results (Chapter IV), specific statistical treatments will be done, based on subgroupings of data derived in the course of the data analysis. These statistical treatments will be described in the appropriate section of Chapter IV.

When the results of statistical tests are reported in this dissertation, the actual significance level associated with each test will be given. Any results at or below the 0.05 level of probability that the relationship is due to chance will be considered significant. This level was chosen because many of the tests used involve nonparametric statistics. The weakness of such tests is their relatively low power. That is, they fail to show statistical significance even when samples being compared are different. Hence, a 0.05 level of probability is normally used in such tests.

In some of the description of the data analysis, results significant at the level of up to 0.10 will be

discussed, though not described as statistically significant. This will be done where groups with small sample size are being compared because lower sample sizes, in general, reduce the power of a test. That is, they increase the likelihood of failing to show statistically significant associations where such associations do exist (Siegel 1956).

Indicators of Accuracy: Infant Diet Diaries

Because the 24-hour diet diary has not been widely reported as a means of collecting infant dietary data and because verification could only be made by further questioning of the same person who had filled out the diary, several factors were examined which were assumed to indicate accuracy in completing the forms.

One indicator was the presence or absence of night feedings. In all cases when a child was reported to be regularly sleeping through the night no night feedings were noted in the diary. More importantly, when many infants were reported to be awakening for night feedings again at about five months of age, the night feedings reappeared on the diet diary forms.

A second indicator of reporting accuracy was evidence that the diet diaries were completed as ongoing records rather than as a mother's recollections at the end of a day. In many cases, differences in writing implements and in hand writing styles indicated that feeding events were jotted down as they occurred throughout the day, instead of all at one time. Many mothers reported carrying the form around

in a pocket during the day they chose to record data, and the crumpled condition of the forms supported this. Also, in cases where a mother had returned to work, notes by the babysitter were evident because of differences in handwriting and because of the types of foods fed the child--e.g., "frozen mother's milk."

A third possible indicator was variation in reported length of breast-feeding bouts. It might be expected that feedings reported in five minute increments were estimates or evidence of rounding off the actual length of a feeding. While such times appeared fairly commonly, closer checking revealed that for many infants, this was accurate reporting. Mothers had read or been told that they should limit nursing to a certain number of minutes to avoid nipple irritation, and they tended to stay with such a pattern for a long time.

The final indicator was the correlation of infant growth extremes with diets reported. As will be described below, such correlations exist. Moreover, significant relationships exist between details of reported breast-feeding behavior and maternal body composition.

Thus, despite the lack of an independent means of verifying the accuracy of the diet diaries, the indicators discussed above suggest that the majority of mothers were honest and accurate in their reporting.

Combining Subjects from Study I and Study II

In order to combine data from Studies I and II for some of the analytical procedures which follow, it was necessary

to establish whether or not the two samples differed significantly. Several categories of variables were examined: parental biological characteristics, pregnancy, birth outcome, and socioeconomic status.

Analysis of variance showed no statistically significant differences between the studies in parental ages, heights, or weights ($p < .05$; Table III.4). There also were no differences in length of pregnancy, maternal weight gain during pregnancy, and infant birth weight. Chi square tests of independence were used to compare income and education categories for the two studies. Again, no statistically significant differences were found.

Thus, for all variables it was impossible to reject the null hypothesis that the two samples do not differ biologically and demographically. For this reason, the samples are combined for analysis where appropriate in Chapter IV.

TABLE III.4--Comparison of Biological Variables, Analysis of Variance: Study I
versus Study II.

Variable	Mean $\pm$ Std Dev		F	Sig
	STUDY I	STUDY II		
Prepregnant Weight (kg)	58.9 $\pm$ 8.4	57.5 $\pm$ 7.6	1.22	.56
Maternal Height (cm)	164.7 $\pm$ 7.3	166.0 $\pm$ 7.4	1.01	.96
Paternal Weight (kg)	80.4 $\pm$ 11.9	79.5 $\pm$ 9.6	1.53	.20
Paternal Height (cm)	179.3 $\pm$ 7.2	181.5 $\pm$ 6.9	1.07	.86
Maternal Age (years)	27.7 $\pm$ 3.2	24.8 $\pm$ 3.0	1.16	.66
Paternal Age (years)	29.5 $\pm$ 4.7	26.7 $\pm$ 3.4	1.92	.06
Pregnancy Weight Gain (kg)	14.4 $\pm$ 3.8	13.4 $\pm$ 3.8	1.01	.98
Pregnancy Length (days)	283.2 $\pm$ 10.2	279.3 $\pm$ 11.8	1.32	.39
Birthweight (kg)	3.5 $\pm$ 0.5	3.4 $\pm$ 0.4	1.19	.62

CHAPTER IV

RESULTS

The purpose of this chapter is to present the results of data analyses. First, the infant dietary data are discussed, both in terms of specific foods and feeding behaviors and in terms of general patterns of individual courses of feeding. The second section deals with infant growth. Data on factors related to maternal decision making regarding infant feeding are presented in the third section. The last describes analysis of postpartum changes in maternal nutritional status.

Infant Diet

General Description of Infant Diets

Figure IV.1 shows the number and percentage of infants who consumed breast milk and were weaned during the first through sixth months of life. Different authors use the term weaning for different changes in a breast milk diet. It is used throughout this study as the total cessation of breast feeding. "Breast-feeding" refers to consumption of any breast milk, whether in combination with other foods or alone. Breast-feeding decreased in frequency over time, with the greatest decrement during the fourth month, when

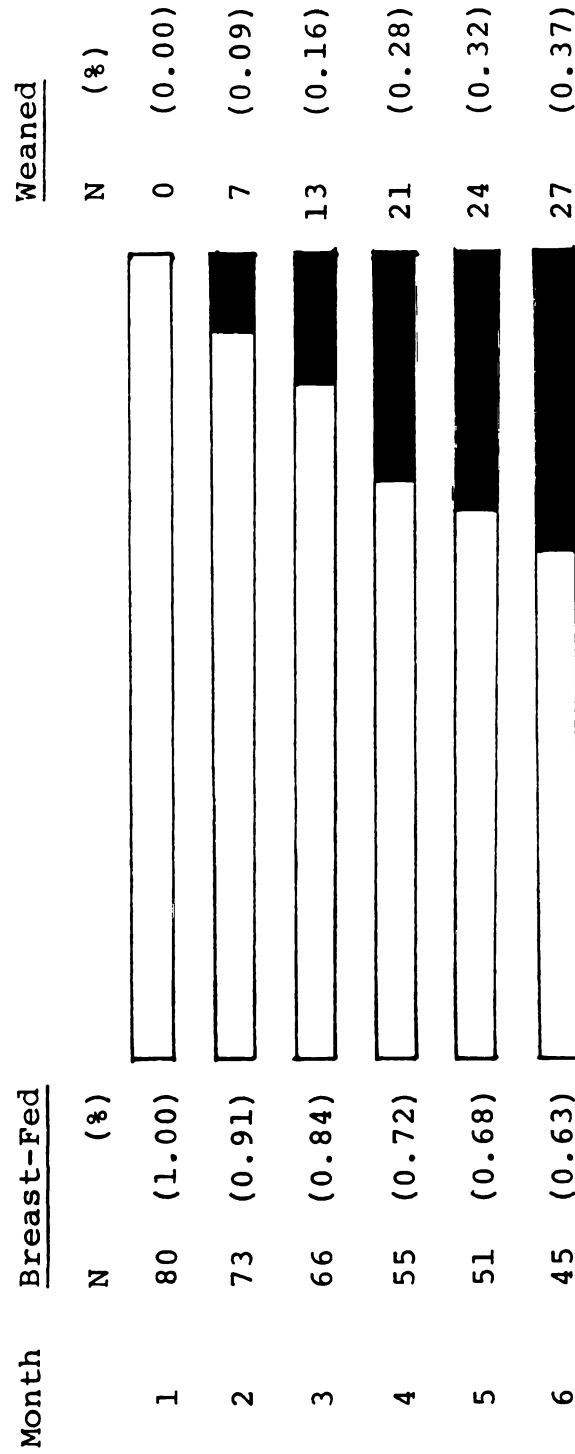


FIGURE IV.1--Number and Percent of Infants Breast-Fed (Consuming any Breast Milk) and Weaned (Consuming no Breast Milk) during First through Sixth Months of Life.

12% of the infants were weaned. Sixty-three percent of the infants were still being breast-fed at six months of age.

By the end of the first month, 20% of the infants received commercial formula of some kind (Table IV.1). This proportion increased to a peak of 41% in the fifth month. The largest incremental change after the first month was a change of 11% in the second month. Cows milk replaced or supplemented formula or breast milk in only a small percentage of cases; in no case was cows milk consumption reported until the fourth month. There were no reports of home prepared evaporated milk formula being consumed by any infant.

The term "solids" is used throughout this study to refer to all foods except breast milk, formula, or cows milk. It includes fruit juices. The addition of solids to the infant diet in general started later than that of formula, but the rate of increase over the six month period was greater, with the cumulative total rising smoothly from 9% in the first month to 93% in the sixth. An increase in 29% in the fifth month was the greatest monthly change.

Cereal was the first solid food given to most of these infants (Table IV.2), regardless of timing of introduction of solids. Seventy percent of those ever consuming non-milk foods were fed cereal first. An additional 14% consumed it as a first food in combination with fruit, vegetables, or meat.

TABLE IV.1--Number and Percentage of Infants Consuming
Major Non-Breast Milk Food Types during each
Month of the Study.

		Month					
Type of Food		1	2	3	4	5	6
Formula	N	16	25	28	28	31	26
	(%)	(.20)	(.31)	(.35)	(.37)	(.41)	(.36)
Solids	N	7	18	29	42	63	67
	(%)	(.09)	(.23)	(.37)	(.55)	(.84)	(.93)
Cows Milk	N	-	-	-	2	9	14
	(%)	-	-	-	(.03)	(.12)	(.19)

TABLE IV.2--First Solid Consumed; Number of Infants by
Month of Introduction.

Month							
Food	1	2	3	4	5	6	Total
Cereal	3	12	8	10	16	3	52
Fruit/Juice	2	1	1	2	4	1	11
Meat	-	-	-	-	-	1	1
Cereal + (other)	1	-	3	3	2	1	10
Totals	6	13	12	15	22	6	74 ¹

¹Six infants consumed no solids.

Table IV.3 shows the frequency of combined consumption of major dietary components. Concurrent consumption of breast milk and formula was most frequent during the first month and disappeared entirely by six months. In contrast, frequency of breast milk and solids combinations increased from lows of 3% and 4% during the first two months to a high of 74% by six months. This increase was greatest (26%) during the fifth month. Consumption of both solids and formula with breast milk ranged from 5% to 17% and followed no distinct pattern during the six month period.

TABLE IV.3--Percentage and Number of Infants Consuming Combined Dietary Components during each Month of the Study.

		Month					
Diets		1	2	3	4	5	6
Breast Milk & Formula	N (%)	12 (.15)	9 (.12)	4 (.06)	2 (.04)	1 (.02)	-
Breast Milk & Solids	N (%)	2 (.03)	5 (.04)	7 (.11)	17 (.31)	29 (.57)	34 (.74)
Breast Milk, Formula & Solids	N (%)	4 (.05)	10 (.14)	11 (.17)	7 (.13)	10 (.20)	8 (.17)

Association of Infant Diet with Maternal Education and Household Income

Highest level of maternal formal education and first introduction of non-breast milk food are not independent (Table IV.4). Mothers with less than a four year college education tended to supplement at or before the median month of supplementation (the fourth month), while those with more education supplemented later ($\chi^2 = 5.55$, $p < .02$). Maternal education is also related to weaning (Table IV.5). Women with fewer years of education weaned before six months more frequently and, within that time, earlier than women with more education. The relationship between the occurrence of weaning before or after six months and maternal education is significant ($\chi^2 = 10.90$; $p < .001$). However, total household income is not significantly related to infant diet. Timing of first supplementation and incidence and date of weaning are distributed evenly across the range of incomes found in the sample (Tables IV.6, IV.7).

A review of sex differences in consumption of single food items or dietary combinations reveals a weak association of longer breast-feeding with female infants (Figure IV.2). Although a higher percentage of females were weaned initially, by four months of age males had a higher rate of weaning. At the end of six months, the sex differences in numbers weaned and still breast-fed are not statistically significant. The lower incidence of breast-feeding among males is reflected in their higher rate of formula consumption (Table IV.8).

TABLE IV.4--Highest Level of Maternal Formal Education and Month of Introduction of First Non-Breast Milk Food.

Education	Month						Totals
	1	2	3	4	5	6	
Bachelor's Degree	11	6	4	6	5	3	35
Bachelor's Degree	7	5	3	7	14	7	43
Totals	18	11	7	13	19	10	78 ¹

Median Test²: Median = Month 4; $\chi^2 = 5.55$; $p < .02$

¹Two exclusively breast-fed infants left the study before 6 months of age.

²The median test is used here rather than the chi-square test for independence because cells exist for which the expected frequency is 5 or less. This test combines cells of values $\leq$ the median and compares them with the combined cells of values $>$ the median (Siegel 1956).

TABLE IV.5--Highest Level of Maternal Formal Education and Month of Weaning.

Education	Month						Totals
	1	2	3	4	5	6	
Bachelor's Degree	4	5	6	2	2	0	16
Bachelor's Degree	3	1	2	1	1	0	35
Totals	7	6	8	3	3	0	51

Chi-square test of independence of education and incidence of weaning before or after 6 months of age: $\chi^2 = 10.90$; $p < .001$

TABLE IV.6--Month of Introduction of First Non-Breast Milk Food by Household Income Category.

Income	Month						Totals
	1	2	3	4	5	6	
\$ 5,000 - 9,999	-	-	-	1	2	-	3
\$10,000 - 14,999	3	4	2	-	3	1	13
\$15,000 - 19,999	5	1	1	3	4	4	18
\$20,000 - 24,999	7	3	1	3	5	3	22
\$25,000 - 29,999	1	1	1	4	4	1	12
\$30,000 - 39,999	2	1	2	1	1	1	8
> \$40,000	-	1	-	1	-	-	2
Totals	18	11	7	13	19	10	78
Median Test ¹ : Median = Month 4; $\chi^2 = 1.74$; not significant							

¹The two lowest categories are combined, as are the two highest, to eliminate empty cells.

TABLE IV.7--Month of Weaning by Household Income Category.

Income	Month						Total
	1	2	3	4	5	6	
\$ 5,000 - 9,999	-	-	-	-	-	3	3
\$10,000 - 14,999	1	1	3	1	-	7	13
\$15,000 - 19,999	1	2	1	-	2	12	18
\$20,000 - 24,999	4	3	3	-	-	12	22
\$25,000 - 29,999	1	-	-	-	1	10	12
\$30,000 - 39,999	-	-	1	2	-	5	8
≥ \$40,000	-	-	-	-	-	2	2
Totals	7	6	8	3	3	51	78

Median¹ Test of Household Income and Incidence of Weaning before and after Six Months of Age

Median = (\$20,000-\$4,999); $\chi^2 = 1.89$; not significant

¹Income categories < \$24,999 combined and compared with combined categories > \$25,000.

TABLE IV.8--Percentage and Number of Infants Consuming Formula by Sex and Month.

		Month					
		1	2	3	4	5	6
Males	N	7	14	15	15	18	14
	%	(.19)	(.38)	(.41)	(.43)	(.42)	(.44)
Females	N	9	11	13	13	13	12
	%	(.21)	(.26)	(.31)	(.32)	(.33)	(.30)
Total	N	16	25	28	28	31	26
	%	(.20)	(.31)	(.35)	(.37)	(.41)	(.36)

A higher proportion of males were fed solids than females in any month (Table IV.9). By six months all males were consuming solid food. Sex differences in introduction of first solids are more apparent in Study I than in Study II (Table IV.10). The distribution of Study I males is bimodal, with the highest percentage of male infants receiving first solids at three months of age or less or at five months or more. Study I females were introduced to solids at a less variable rate, with a peak in the fourth month. In contrast, Study II males and females had almost identical distributions, with median age of introduction of solids at four months (Figure IV.3).

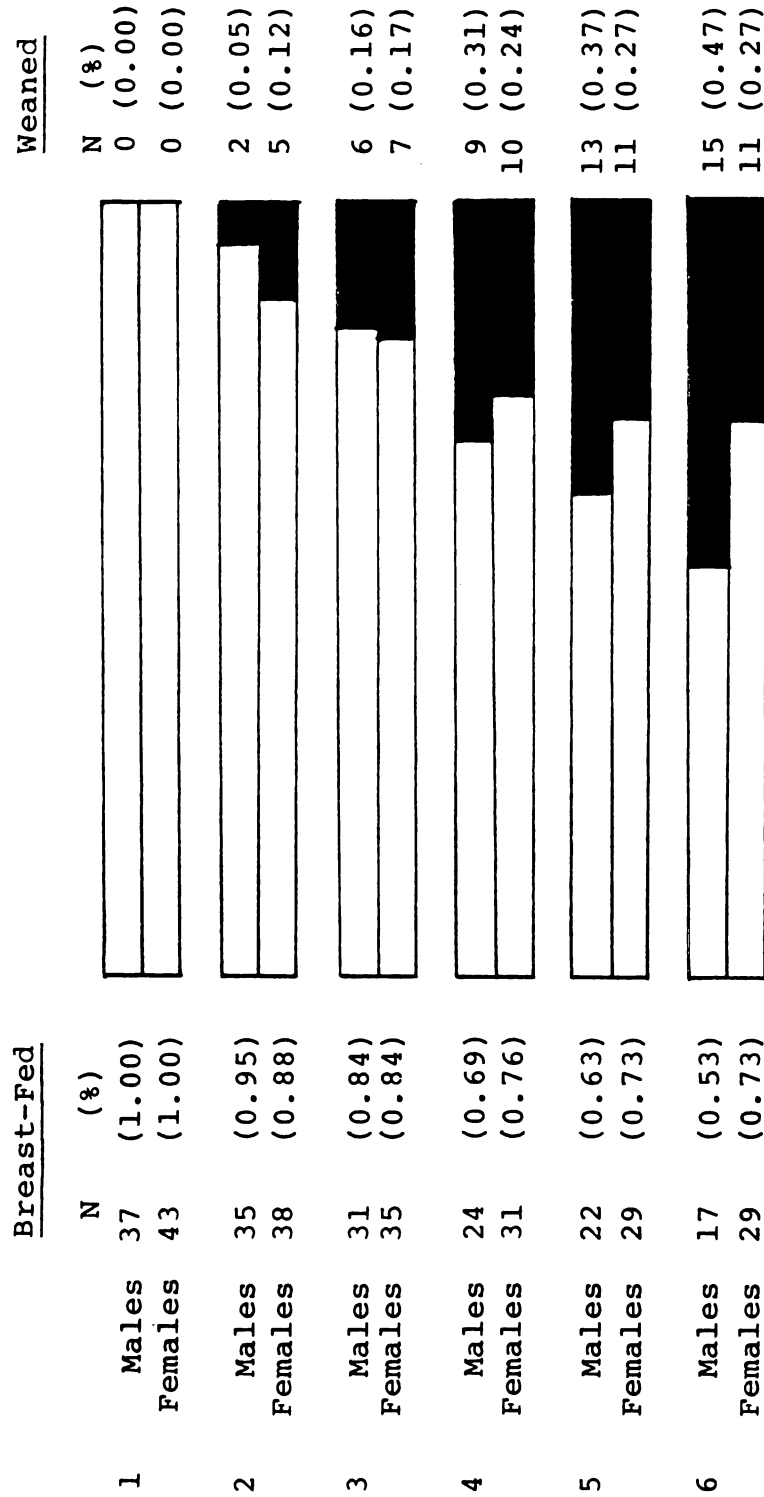


FIGURE IV.2--Sex Differences in Breast-Feeding Status by Month of Study.

TABLE IV.9--Percentage and Number of Infants Consuming Solid Food by Sex and Month.

		Month					
		1	2	3	4	5	6
Males	N	4	10	17	22	32	6
	%	(.11)	(.27)	(.46)	(.63)	(.91)	(.100)
Females	N	3	8	12	20	31	35
	%	(.07)	(.19)	(.29)	(.49)	(.78)	(.88)
Total	N	7	18	19	22	63	67
	%	(.09)	(.23)	(.24)	(.29)	(.84)	(.93)

TABLE IV.10--Number and Percentage of Infants Consuming First Solid Food by Month, Sex, and Study.

			Month						
			1	2	3	4	5	6	Total
STUDY I	Males	N	3	5	4	1	3	3	19
		%	(.16)	(.26)	(.21)	(.05)	(.16)	(.16)	(1.00)
	Females	N	2	5	3	6	5	2	23
		%	(.09)	(.22)	(.12)	(.26)	(.22)	(.09)	(0.88)
STUDY II	Males	N	0	2	3	5	6	1	17
		%	(.00)	(.12)	(.18)	(.29)	(.35)	(.06)	(0.90)
	Females	N	1	1	2	3	8	0	15
		%	(.07)	(.07)	(.13)	(.20)	(.53)	(.00)	(0.88)

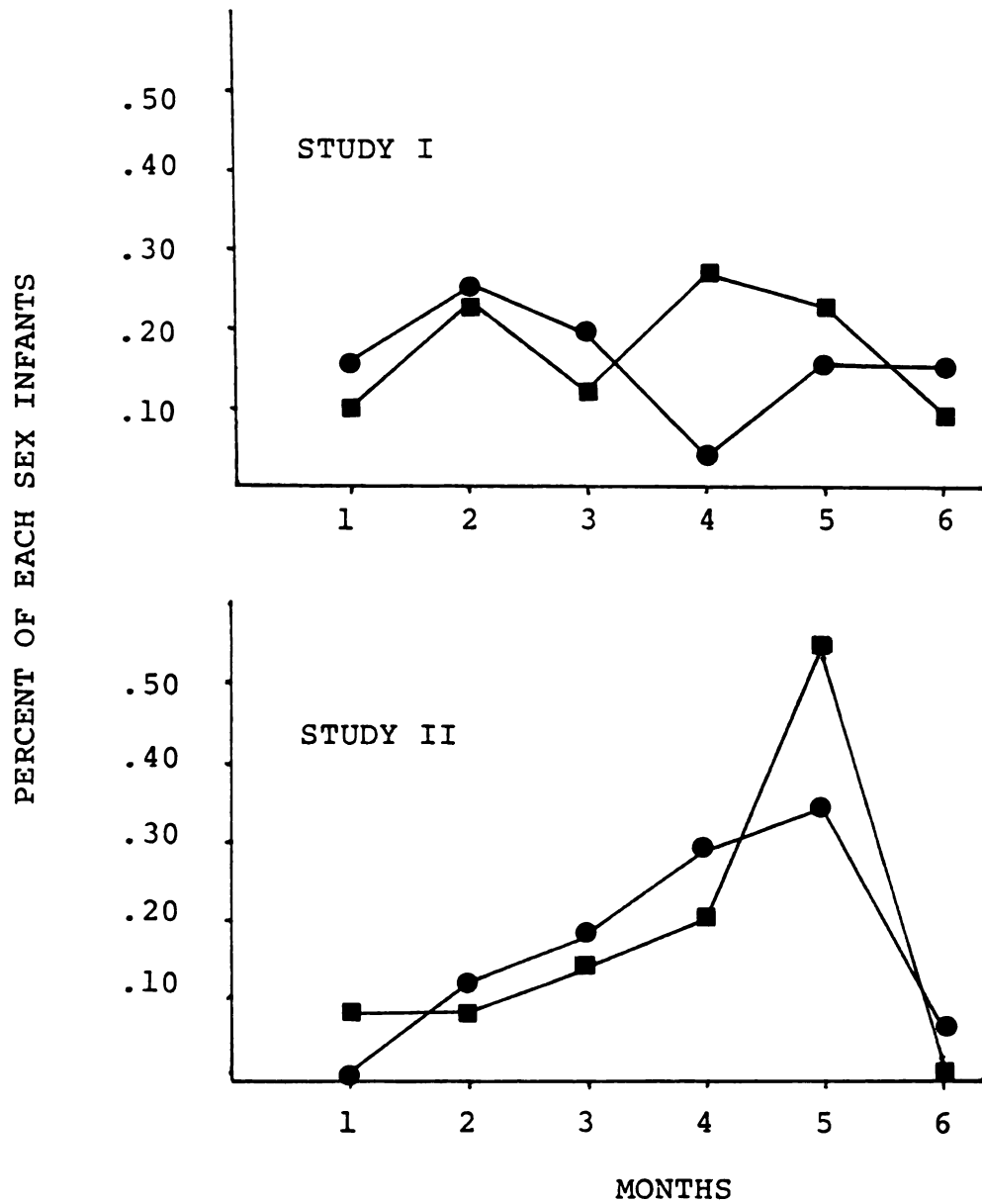


FIGURE IV.3--Percent of Infants First Consuming Solids for Male (●—●) and Female (■—■) Infants by Month of Age.

Length and Frequency of Nursing Bouts

The only infants included in analyses in this section are those for whom at least one initial diet diary of exclusive breast-feeding is available. This excludes those 18 infants whose diets were supplemented at or before 30 days. Also, as was discussed in Chapter III, infants whose diet diaries are incomplete or missing for a particular period are excluded from that section of the analysis.

Mean number of feedings per day in the first month ranged from 5 to 13, with a median of 7 feedings per day (Figure IV.4). In the second month, the median of mean feedings per day of those still exclusively breast-fed remains at 7, although the range shifts slightly lower.

Infants receiving first non-breast milk foods during Months 1 and 2 tended to have fewer feedings per day in the first month than did those infants exclusively breast-fed for longer periods of time (Figure IV.5). The median number of feedings per day ranged from six among infants supplemented between one and two months to eight among those supplemented during the third month or later. A median test produces a χ^2 of 13.64, showing a significant ($p < .01$) relationship between month of supplementation and proportion of infants less than and equal to ($\leq$) or exceeding ($>$) the overall sample median of seven feedings (Table IV.11). Similarly, infants exclusively breast-fed longer had more feedings per day in Month 2

(Figure IV.6). A median test demonstrates the statistical significance of the association between length of exclusive breast-feeding and the number of feedings per day in Month 2 (Table IV.12); $p < .05$).

The duration of exclusive breast feeding also varied with the change in the number of feedings per day for individual infants between the first and second months (Table IV.13). Although the overall tendency was for the number of feedings to decrease with time, infants who consumed their first non-breast milk foods later appeared to be more likely to have the same or greater number of feedings in the second as in the first month. Conversely, the fewer the months of exclusive breast-feeding, the more likely was the infant to have had a stable or decreasing number of feedings from one to two months of age.

Mean minutes per feeding ranged from 7 to 53 in the first month and from 7 to 42 in the second. Both had medians of 18 minutes. There was no correlation of minutes per feeding with length of exclusive breast-feeding similar to that observed in number of feedings per day (Table IV.14). In both months, the distribution of minutes per feeding of those feeding non-breast milk foods early is not significantly different from that of those doing so later (Figure IV.7 and IV.8).

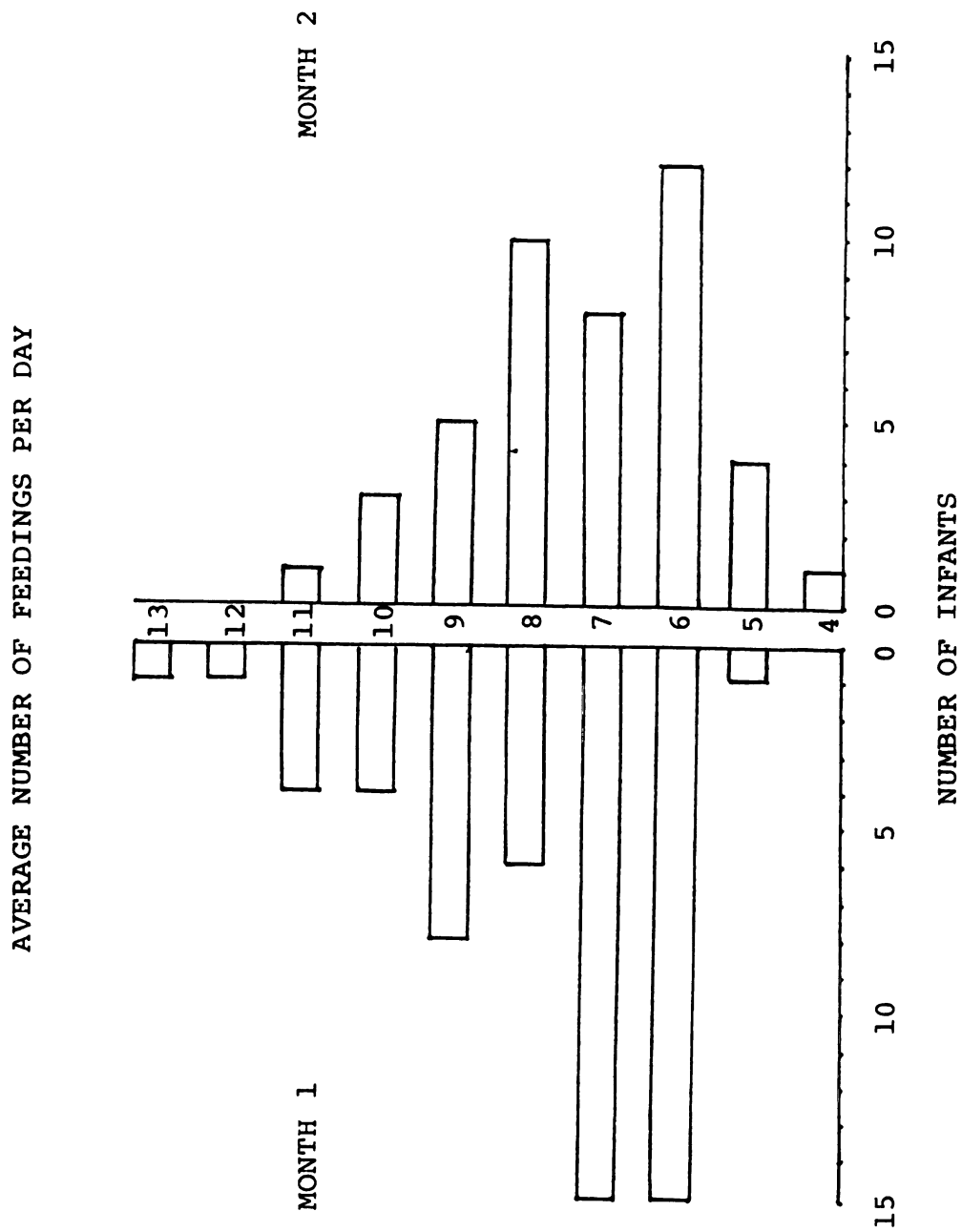


FIGURE IV.4--Average Number of Breast-Feedings per Day for
Infants Exclusively Breast-Fed during Months
1 and 2.

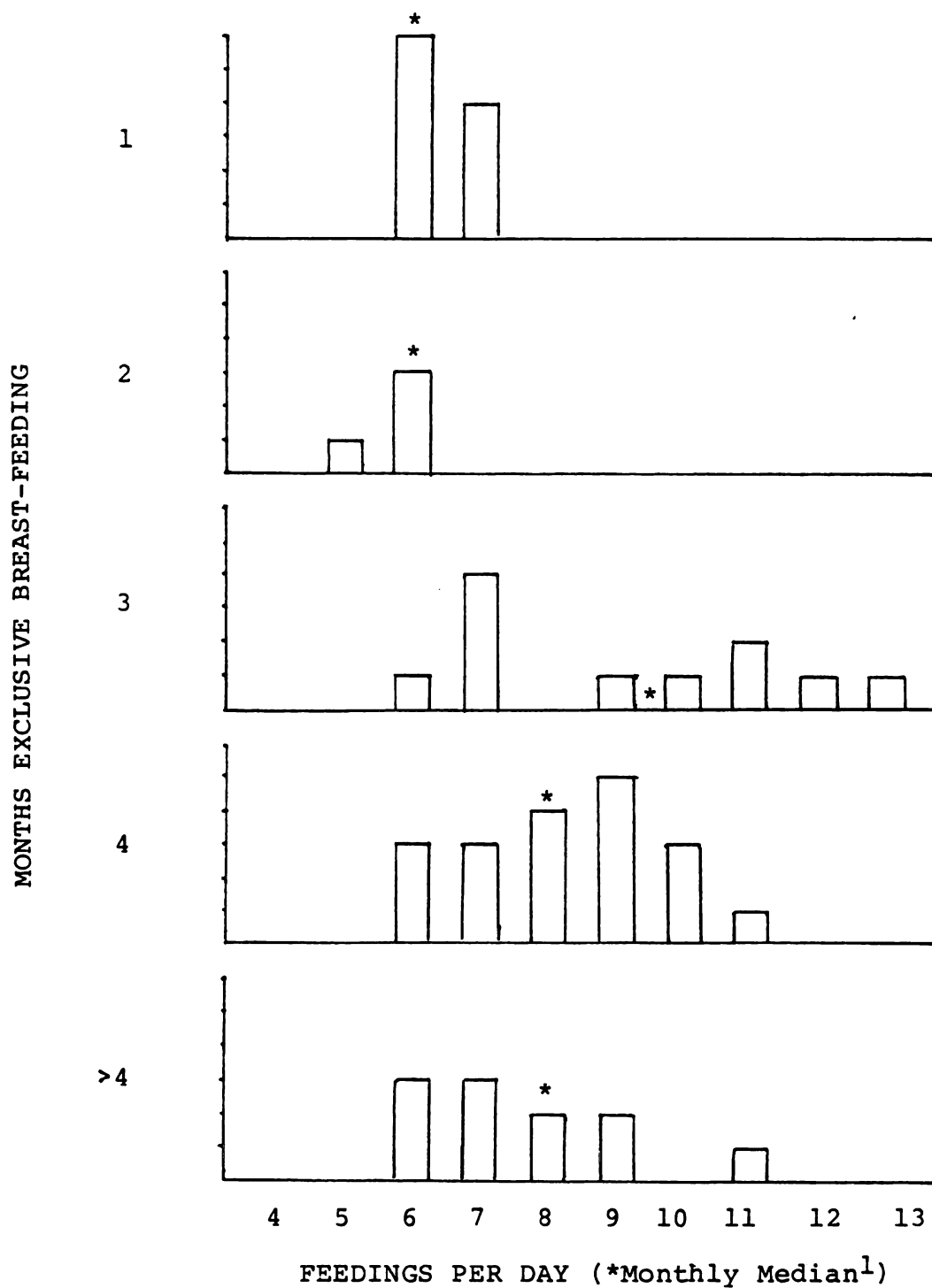


FIGURE IV.5--Number of Breast-Feedings per Day in Month 1 by Length of Exclusive Breast-Feeding.

¹Since there are an even number of observations, median for Month 3 is the mean of the two observations in the central position (Dixon and Massey 1969).

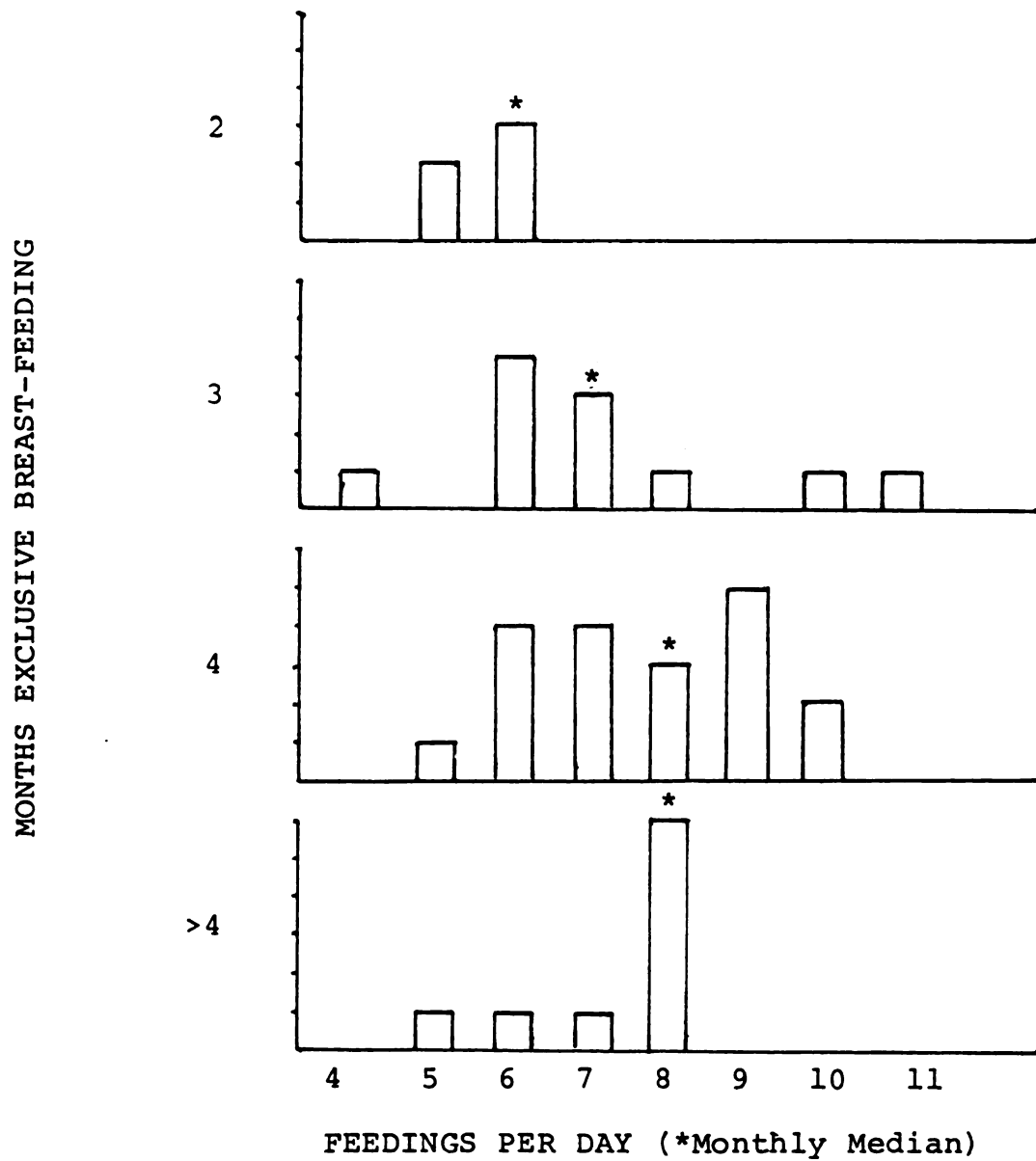


FIGURE IV.6--Number of Breast-Feedings per Day in Month 2 by Length of Exclusive Breast-Feeding.

TABLE IV.11--Number of Breast-Feedings per Day in Month 1 by Length of Exclusive Breast-Feeding.

Months Exclusive Breast-Feeding	Number of Infants 7 Feeds/Day	Number of Infants 7 Feeds/Day	Totals
< Two Months	14	1	15
Three Months	4	5	9
Four Months	6	13	19
> Four Months	4	5	9
Totals	28	24	52
Median Test: Median = 7 Feedings/Day, $\chi^2 = 13.64$, $p < .01$			

TABLE IV.12--Number of Breast-Feedings per Day in Month 2 by Length of Exclusive Breast-Feeding.

Months Exclusive Breast Feeding	Number of Infants 7 Feeds/Day	Number of Infants 7 Feeds/Day	Totals
< Three Months	13	3	16
Four Months	9	10	19
> Four Months	3	6	9
Totals	25	19	44
Median Test: Median = 7 Feedings/Day, $\chi^2 = 6.56$, $p < .05$			

TABLE IV.13--Change in Number of Breast-Feedings per Day between Month 1 and Month 2, by Months of Exclusive Breast-Feeding.

Months Exclusive Breast-Feeding	Increase	No Change	Decrease
Two Months	0	3	2
Three Months	1	1	8
Four Months	4	6	8
> Four Months	2	2	6
Totals	9	12	24

TABLE IV.14--Change in Minutes per Breast-Feeding between Month 1 and
Month 2, by Months of Exclusive Breast-Feeding.

Months Exclusive Breast-Feeding	Increase	No Change	Decrease
Two Months	0	2	3
Three Months	4	0	5
Four Months	6	3	10
> Four Months	3	1	3
Totals	13	6	22

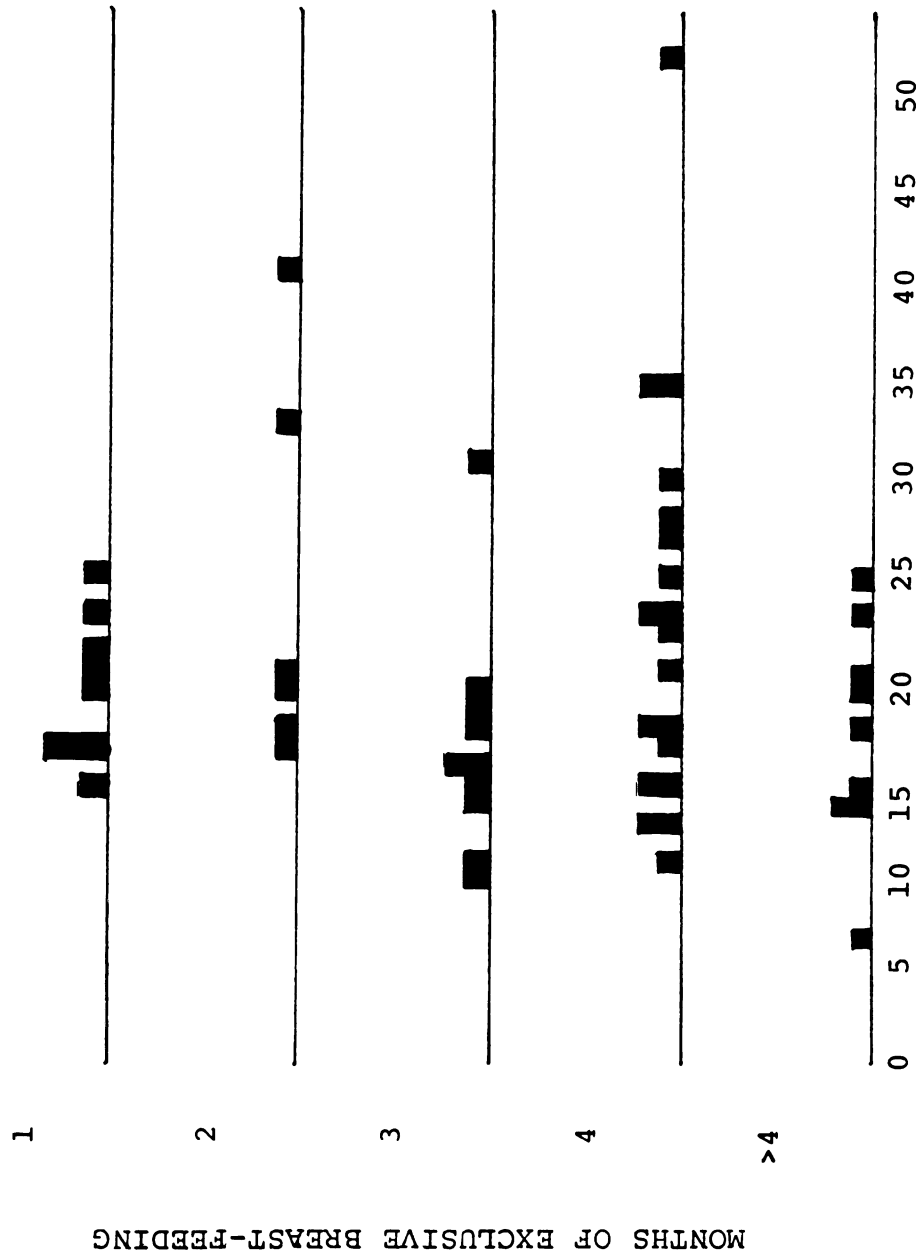


FIGURE IV.7--Mean Number of Minutes per Feeding during Month 1.

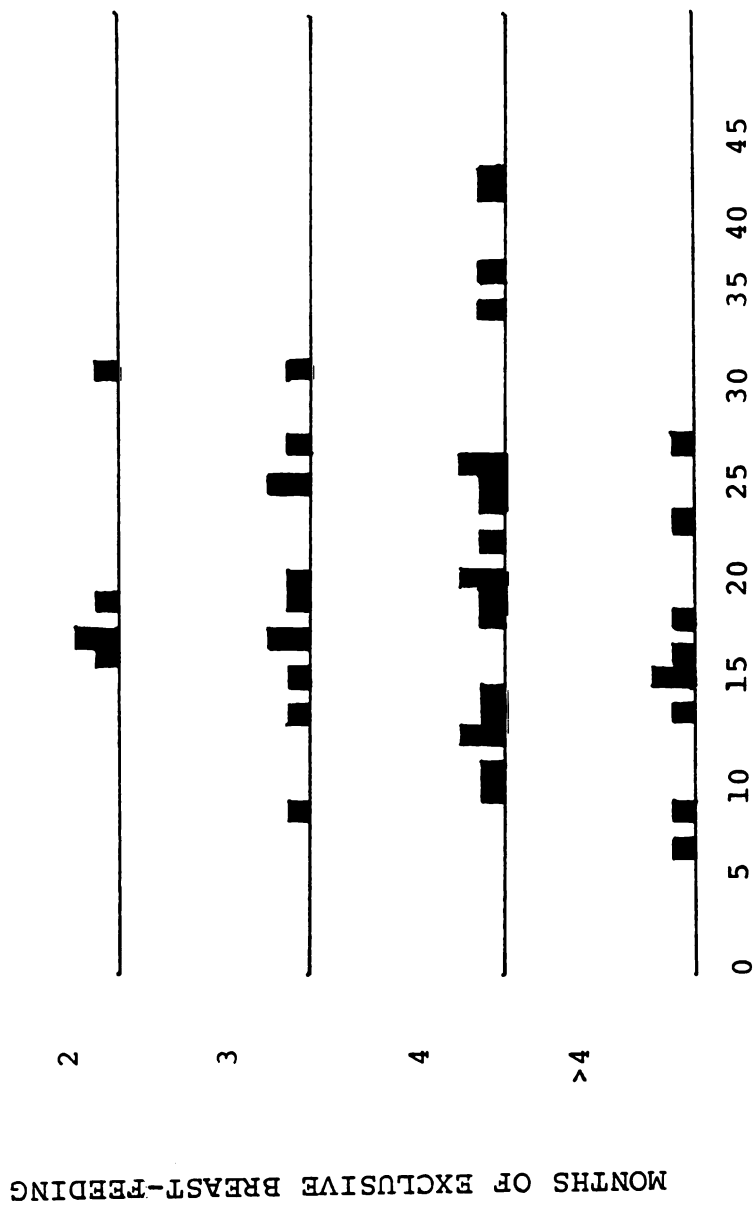


FIGURE IV.8--Mean Number of Minutes per Feeding during Month 2.

Transitions to a Mixed Diet

The feeding of formula, juice, or solid food in an infant diet previously consisting solely of breast milk is usually termed "supplementation" (e.g., Fomon 1970). The use of this term, however, can create confusion. Although it implies the addition of more food to an existing level of intake, this is not necessarily the case. While--in terms of absolute numbers of foods consumed--the supplement is always a dietary addition, it is not necessarily a nutritional addition. The new food can replace part or all of the previous diet; or it can, in fact, be a true addition, increasing overall nutrient intake.

To avoid confusion, the terms "addition" and "replacement" are used in the following analysis rather than "supplement." If the number of breast feedings stays the same or increases when a new food enters the diet, the food is considered an addition. If the number of breast-feedings decreases, that food is considered a replacement. Since prior feeding data do not exist for Month 1, criteria for differentiating additions from replacements have been modified slightly. The consumption of formula as one isolated feeding is labeled replacement. "Addition" is considered to be the use of small amounts of formula immediately after breast-feeding bouts.

Of the two breast-feeding attributes readily observable in a study such as this one--number of feedings per day and length of feedings--the former is used here as the criterion

for assessing the impact of dietary change. It is used with the recognition that it is hardly an exact estimate of breast milk intake. The other variable, length of feeding, varies with the enthusiasm of the infant. It has been shown that an infant can empty a breast in 10 minutes and that the length of feeding is more an indication of the vigor and attentiveness of the infant than the amount of milk consumed. Number of feedings per day, on the other hand, can indicate actual differences in amount consumed (Egli et al. 1961). Only that amount of milk which can be stored in the mammary gland ducts will be available, regardless of how long the infant sucks or whether or not more time is allowed to elapse between feedings. In fact, a reduction in milk production may occur with decreased sucking frequency. Thus, the "replacement" of a breast-feed should reflect lower total milk intake from both loss of one or more feedings per day and from lower milk output at the remaining feedings.

In this study, the effect of the introduction of the first non-breast milk food on the diet appears to depend on the infant's age at introduction. Although there is no real distinction between the frequency of addition and that of replacement in Month 1, replacement clearly predominates in Months 2 and 3. After that time, the majority of new foods are additions (Table IV.15).

TABLE IV.15--Role of Newly Introduced Foods in Diet
Formerly Consisting Exclusively of Breast
Milk.

=====							
Month							
Role of Food	1	2	3	4	5	6	Totals

Addition	7	1	2	8	15	5	38
Replacement	11	10	8	2	4	1	36

Totals	18	11	10	10	19	6	74

Median Test: Median = Month 3, $x^2 = 21.70$, $p < .001$							

A x^2 test of additions and replacements at or before the median of three months with those after is highly significant ($x^2 = 21.70$; $p < .001$).

The predominance of replacements in Months 2 and 3 is not simply a function of some overall decrease in feedings per day. If such a decrease were the rule, any new food item would automatically appear to be replacing the missing breast-feed(s). To test for the existence of a general decrease in feedings, the number of feedings per day in Months 1 and 2 were examined in infants who did not experience the first introduction of non-breast milk foods until after Month 3. Among those infants, 23 (51%) had a decrease in number of feeds per day. Thus, about half would have been classified as "replacing" breast milk if a dietary change had been made. Almost the same number--22 (49%)--either increased their rate of feedings (N=9) or

maintained the same level ($N=13$), either of which would have made the introduction of a new food appear to be an "addition." The difference between this distribution and that observed among those actually experiencing introduction of a new food in Months 2 or 3 is significant (Table IV.16, $p < .01$). Thus, the predominance of "replacement" in Months 2 and 3 is not simply an artifact of a general reduction in feedings per day during those months.

Whether the non-breast milk item consumed was formula or solid food appeared to be a function of the infant's age at introduction of the food rather than its action as an addition to or replacement of existing intake. Formula consumption predominated before four months and solids, after (Table IV.17, $p < .001$).

Sex of the infant was unrelated to whether a food was an addition or a replacement. Table IV.18 shows that the percent of male and female infants was almost equal for the two categories at every month.

As mentioned above, there was little difference in the frequencies of addition and replacement of non-breast milk food in Month 1. These categories, however, are predictive of future time of weaning for the 18 infants involved (Table IV.19). In those 11 cases where the new food was a replacement, 10 weaned by the end of the second month. In contrast, those 7 for whom the new food was an addition continued breast-feeding longer.

TABLE IV.16--Test for the Presence of a Population-Wide Decline in Number of Breast-Feeding Bouts per Day during Months 2 and 3.

Introduction of First Non-Breast Milk Food			
	Months 2 and 3	Month 4 or Later	Totals
Apparent Role of Non-Breast Milk Food in Diet of Months 2 and 3			
Addition ¹	3	22	25
Replacement ¹	18	23	41
Total	21	45	66

Chi Square Test: $\chi^2 = 7.41$, $p < .01$

¹For those introducing the first non-breast milk in Month 4 or later, these labels represent an assessment of the dietary role such a food would have had, had one been introduced. As explained in the text, this is based on the comparative frequencies of number of feedings per day in Months 1 and 2.

TABLE IV.17--Introduction of Formula and Solids Relative to Median Date for
Introduction of First Non-Breast Milk Food.

Food	≤ 3 Months	> 3 Months	Totals
Solids	11	35	46
Formula	25	2	27
Totals	36	37	73

Median Test: Median = Month 3, $\chi^2 = 32.19$; $p < .001$

TABLE IV.18--Role of New Food in Infant Diet, by Sex and Month of Introduction.

		Month						
		1	2	3	4	5	6	
Addition	Males	% N	.50 (4)	.17 (1)	.25 (1)	.86 (6)	.80 (8)	1.00 (3)
	Females	% N	.30 (3)	.00 (0)	.17 (1)	.80 (4)	.89 (8)	.67 (2)
Replacement	Males	% N	.50 (4)	.83 (5)	.75 (3)	.14 (1)	.20 (2)	.00 (0)
	Females	% N	.70 (7)	1.00 (5)	.83 (5)	.20 (1)	.11 (1)	.33 (1)

TABLE IV.19--Month of Weaning for Infants Given Formula or Solids in Month 1, by Addition and Replacement Categories.

Month of Weaning							
	1	2	3	4	5	6	Totals
Addition	-	1	4	1	-	1	7
Replacement	7	3	-	-	-	1	11
Totals	7	4	4	1	0	2	18
Median Test: Median = Month 3; Fisher's Exact Probability = .002							

None weaned until the second month; the majority weaned in Month 3. Using Fisher's Exact Test to compare frequency of weaning at or before the median of 2 months with that after 2 months, the difference is highly significant ($p = .002$).

Major Dietary Patterns

The interaction of dietary components, maternal infant feeding behaviors, and certain demographics as discussed above facilitates the identification of major dietary patterns for these infants. These patterns permit the breakdown of this heterogeneous sample into relatively homogeneous groups to be used in a number of analyses presented later in this chapter. This section will present the rationale for group differentiation and describe the groups so formed.

The primary basis for defining the most common dietary patterns is length of exclusive breast-feeding. Whether or not causal relationships exist (and regardless of the direction of any causality), length of exclusive breast-feeding has been found in this study to be concordant with variables from a wide variety of domains. These include parental socio-economic status, details of breast-feeding behaviors, and the impact of introduction of non-breast milk foods on the overall diet.

Using length of exclusive breast-feeding as the criterion, there are three main groups of infants (Figure IV.9):

- Group 1: 4 weeks or less exclusive breast-feeding. N=18
- Group 2: more than 35 days but less than 94 days exclusive breast-feeding. N=21
- Group 3: more than 101 days exclusive breast-feeding. N=41

Group 1--Most of the infants in Group 1 were exclusively breast-fed for a very limited time--shorter than the four weeks used to define the group. However, because of differences in data collection between Studies I and II and because of the necessity of drawing on various sources of information to reconstruct the perinatal period, four weeks is used here as a conservative estimate of the end of exclusive breast-feeding. Mothers and infants in Study I were first seen at home only one week after parturition. At that time most were newly discharged

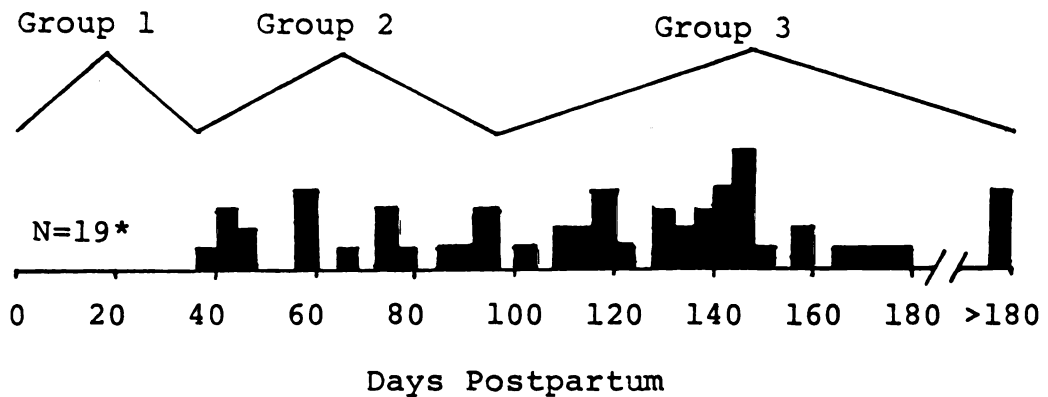


FIGURE IV.9--Length of Exclusive Breast-Feeding and Infant Feeding Groups.

*Because the length of exclusive breast-feeding in this group was determined by a combination of methods, its duration as reported on diet diaries is only approximate and reflects the timing of the early diet diary rather than actual feeding behavior.

from the hospital and had not had time to settle into any routine. Some cases of mixed formula and breast milk feeding were identified at that point, but most were still determined to establish exclusive breast-feeding. Although diet diaries were sent to these women at approximately ten days postpartum, some were not completed and returned until two weeks later. When mixed feeding was reported at that point, additional details on the events of that first month were obtained retrospectively at the one month measuring session and even later. The latest date for modification of the breast milk diet for any case is in the fourth week. Had data collection been more precise, the four week cut off could probably have been made earlier. Thus the fact that these infants had been fed breast milk exclusively for a very short time came from the first diet diary. The date of this diary was used unless interview data could pinpoint the date more accurately.

Because of the difficulties in obtaining early feeding data in Study I, the first at-home contact in Study II was at two weeks postpartum. In all cases but one, the infants in Study II in "Group 1" were receiving mixed diets or had already been weaned by the second week visit. In the remaining case, a diet diary at 20 days listed formula and included a note explaining that exclusive breast-feeding had ended two days earlier. In addition to limited exclusive breast-feeding, Group 1 is

characterized by a high frequency (89%) of the use of formula rather than solids within the first month. As discussed above, there is no clear preference for addition over replacement or vice versa. However, since each of these categories correlates with later differences in time of weaning, two subgroups will be identified for some of the later growth analyses. These subgroups are:

- 1a less than four weeks exclusive breast-feeding. Introduced food is an "addition."
N=7
- 1b less than four weeks exclusive breast-feeding. Introduced food is a "replacement." N=11

In Group 1a the average amount of formula consumed per feeding in Month 1 was 2.2 ± 1.1 ounces. The total daily consumption ranged from 2 to 20 ounces, with a mean of 10.8 ± 7.6 ounces. In comparison, the average formula consumed per feeding by infants in Group 1b was 4.0 ± 1.4 ounces. The daily total ranged from 13.5 to 39 ounces, with a mean of 24.5 ± 8.0 ounces.

Group 2--This group consists of infants who had at least 35 days of exclusive breast-feeding. This is in contrast to Group 1 in which exclusive breast-feeding never became established as a feeding pattern. The upper limit of 94 days reflects both the end of this relatively long period in which exclusive breast-feeding was terminated at scattered ages and the upper limit of the clustering of "replacements" for breast milk by formula or solid food. Within this group two subgroups will be

distinguished in later analyses, based on the first food introduced. These subgroups are:

- 2a exclusive breast-feeding of more than 35 and less than 94 days with formula the first non-breast milk food introduced. N=9
- 2b exclusive breast-feeding of more than 35 and less than 94 days with solids the first non-breast milk food introduced. N=12

In Group 2a the quantity of formula first introduced per day varied from 6 to 15 ounces, with a mean of 10.9 ± 3.2 ounces. In Group 2b, the most commonly consumed first solid was cereal mixed with formula, cows milk, apple juice, or water. When the nutrient content of each mixture is computed and compared with that of the average intake of formula in Group 2a, the nutritional contribution of solids or formula to the diet is markedly different (Table IV.20).

TABLE IV.20--Nutrient Values for Average Daily Intake of Non-Breast Milk Foods at their First Introduction; Mean $\pm$ Standard Deviation.

Nutrient	Infant Feeding Group (N)	
	2a (9)	2b (12)
Energy (kcal)	213.9 $\pm$ 63.5	66.9 $\pm$ 51.8
Protein (gm)	4.8 $\pm$ 1.4	2.0 $\pm$ 2.3
Fat (gm)	11.5 $\pm$ 3.4	1.5 $\pm$ 1.7
Carbohydrate (gm)	22.8 $\pm$ 6.8	11.2 $\pm$ 7.8

Source: Nutrient values used in Tables IV.21 and IV.22 for commercial formulas come from Michigan Dept. of Public Health (1980). Values for other foods come from Gerber Products Company (1977).

Group 3--These infants were exclusively breast-fed for at least 102 days. After that time the first non-breast milk food was introduced to 35 infants. One infant first consumed formula; 34 first consumed solids or fruit juice. In 28 cases, the new food was a dietary addition. In only 7 cases was it a replacement. Estimated nutrient values per day are shown in Table IV.21.

TABLE IV.21--Nutrient Values for Average Daily Intake of Non-Breast Milk Foods at their First Introduction for Feeding Group 3; Mean $\pm$ Standard Deviation.

	Role of Food in Diet	
	Replacement (N=7)	Addition (N=28)
Energy (kcal)	101.6 $\pm$ 77.0	47.8 $\pm$ 71.1
Protein (gm)	3.3 $\pm$ 1.8	1.2 $\pm$ 1.6
Fat (gm)	3.8 $\pm$ 4.1	1.9 $\pm$ 4.2
Carbohydrate (gm)	13.7 $\pm$ 8.3	6.7 $\pm$ 8.4

Four infants did not consume any non-breast milk food before the age of six months. Two others who had consumed only breast milk left the study during the fourth month. They are also considered part of Group 3, bringing the total number of infants in the group to 41.

Infant Growth

This section presents the results of analysis of infant growth data. After describing the growth of the sample as a whole and the preliminary transformations of

the data, infant growth will be analyzed in terms of four growth-related dietary parameters: length of breast-feeding, age at first introduction of non-breast milk food, the common dietary patterns identified above, and details of the breast-feeding process.

Description of the Sample

At birth the 80 infants studied all weighed more than 2500 grams, the traditional anthropometric boundary between high risk and normality. From birth to six months of age, males were heavier and longer than females (Table IV.22). Females had higher summed fatfold measures at birth and one, five, and six months. Males, in contrast, were leaner at birth, had a somewhat faster increase in adiposity during the first months of life, and then actually decreased in fatness during the later months of the study (Table IV.22).

When compared with the National Center for Health Statistics percentiles for infant growth (National Center for Health Statistics 1976), the sample was consistently heavier and longer for age than the NCHS norms (Table IV.23). Males had higher mean percentile rankings than did females, though these differences were not statistically significant. In weight for height, the sample more closely approximated the NCHS standards, though infants were, on the average, considerably thinner than the norm at one and six months.

TABLE IV.22--Descriptive Statistics for Infants at Birth and at End of each Month.
Mean + Standard Deviation.

Variable	Birth	Month												
		1	2	3	4	5	6							

WEIGHT (kg)														
Males	3.5±	0.5	4.6±	0.7	5.8±	0.7	6.6±	0.8	7.3±	0.8	7.8±	0.8	8.3±	1.0
Females	3.4±	0.4	4.3±	0.5	5.2±	0.6	5.9±	0.6	6.5±	0.7	7.0±	0.7	7.4±	0.7

RECUMBENT LENGTH (cm)														
Males	52.1±	2.4	56.1±	2.6	56.9±	3.0	63.2±	2.2	66.0±	2.3	68.2±	2.6	70.2±	2.3
Females	50.8±	2.0	54.8±	2.3	58.1±	2.4	61.1±	2.4	63.6±	2.6	65.5±	2.6	67.3±	2.7

TOTAL FAT-FOLDS (mm)														
Males	28.8±	6.0	40.8±	7.7	52.7±	10.7	57.3±	11.1	60.0±	13.9	59.7±	14.0	58.8±	15.3
Females	29.4±	5.1	42.7±	7.7	51.5±	8.0	56.7±	8.0	59.8±	11.7	61.0±	12.3	61.0±	11.3

TABLE IV.23--Mean NCHS Percentile + Standard Deviation for Infants at Birth and
at End of each Month.

Month							
Variable	Birth	1	2	3	4	5	6

WEIGHT							
FOR AGE							
Males	60.7+27.7	61.9+26.8	70.1+21.7	69.9+24.4	68.7+23.4	66.8+24.3	60.7+25.6
Females	57.7+28.5	63.7+24.5	68.6+22.5	69.1+21.4	65.8+21.7	60.8+24.2	54.9+24.5

LENGTH							
FOR AGE							
Males	66.9+26.0	64.8+25.0	66.3+27.9	68.8+23.4	70.9+22.6	70.4+26.0	73.6+20.9
Females	61.4+24.9	62.7+28.2	64.3+26.8	62.9+25.7	63.0+25.4	63.0+26.0	61.2+27.5

WEIGHT FOR							
LENGTH							
Males	---	48.2+23.7	53.1+27.9	52.9+22.7	48.1+28.5	44.0+25.3	37.4+24.1
Females	---	---	55.4+26.3	53.8+25.6	49.1+30.4	45.5+27.3	43.1+25.7

*Too few Weight for Length percentiles could be calculated by NCHS program (Goldsby, n.d.)
to be meaningful.

Preliminary Data Transformations

In order to combine males and females into a single sample, several data adjustments were made preliminary to actual data analysis. Weights and lengths for each infant were transformed into three new variables based on their percentage of the NCHS sex-specific medians for weight for age, length for age, and weight for length. These transformations were performed by the computer center of Fels Research Institute under the supervision of Dr. Alex Roche. The growth data analysis program of Goldsby (n.d.) was used. Since the NCHS growth curves for infants from birth to 36 months are themselves computed from the Fels data base, this analysis provided exact and accurate transformations of the data. More readily available representations of the NCHS norms--such as those published by Ross Laboratories (1976) and widely used in clinical settings--were not used. For these, the extreme percentiles have been collapsed, giving the impression of a narrower distribution of infant size than is actually the case.

All results presented below are based on these transformations. "Percent of the median" is used rather than percentiles because the latter cannot be calculated for many of the low infant weights and lengths common at birth and one month of age.

National standards were not available for infant fatfolds. Therefore, within-sample adjustments were made

to take account of sex differences. First, all eight fatfolds for each infant were totaled for each measurement session. Then male and female sex-specific least squares regression lines were computed for the entire sample, using total fatfolds in millimeters as the dependent variable. Residuals were then computed for each infant measurement entered in the equation. These residuals represent the difference between the actual infant measurement and that predicted by the regression equation. They are used as the new data points in all analyses in this chapter. Total fatfolds were used rather than any single fatfold for two reasons. First, since infants are frequently somewhat asymmetrical at birth and for variable periods of time thereafter, using both left and right side measures prevents the confounding of results by biases resulting from the arbitrary choice of either left or right side. Second, the combination of trunk and extremity measures controls for difference in fat patterning.

Weaning

Length of breast-feeding was most significantly related to infant growth in the first several months of life. Table IV.24 presents means and standard deviations for the percent of median for all growth variables. There were no significant differences between groups assigned by month of weaning in length for age or weight for length at any time from birth to six months of age.

TABLE IV.24--Means + Standard Deviations of Four Infant Growth Measures at Birth
and End of Months 1 to 6, by Month of Weaning.

Month of Weaning--Weight for Age (% of NCHS Median)						
(Age) (Months)	1	2	3	4 & 5	6	F (Sig)
Birth	103.0+12.2	99.0+12.1	100.8+14.2	104.5+11.4	106.7+14.6	.68 (.61)
1	105.4+12.4	103.1+10.2	93.3+11.4	105.2+11.1	109.4+13.9	2.75 (.04)
2	111.2+15.7	104.4+ 4.5	98.0+ 8.0	112.4+13.4	111.4+11.8	2.67 (.04)
3	109.6+12.9	105.3+ 5.4	98.9+10.6	110.1+13.8	110.4+10.7	2.13 (.09)
4	110.9+12.8	103.3+ 8.3	100.5+ 8.3	109.5+15.0	109.0+11.1	1.40 (.24)
5	107.8+14.3	102.3+ 9.8	98.9+ 9.1	109.9+15.3	106.5+10.1	1.28 (.28)
6	106.5+14.6	101.4+10.0	98.2+17.6	108.0+17.6	103.5+ 9.9	.90 (.47)

TABLE IV.24--continued

Month of Weaning--Length for Age (% of NCHS Median)						
Age (Months)	1	2	3	4 & 5	6	F (Sig)
Birth	102.2+2.2	101.2+3.0	100.1+5.3	104.4+5.3	102.6+4.6	.98 (.43)
1	101.9+4.6	101.7+2.3	99.1+4.4	102.4+4.5	102.8+4.7	1.17 (.33)
2	102.4+4.8	102.5+3.6	98.6+3.4	104.5+4.9	102.9+4.8	1.77 (.14)
3	101.5+4.8	102.0+2.1	100.9+2.7	103.6+3.4	102.5+4.2	.53 (.71)
4	102.8+4.8	101.5+1.9	101.4+3.1	104.0+3.8	103.0+4.3	.53 (.72)
5	101.4+4.3	100.9+2.9	100.6+3.6	105.6+3.4	102.9+4.2	1.84 (.13)
6	102.3+6.1	102.0+2.5	101.8+2.1	105.5+4.9	102.3+3.7	1.06 (.38)

TABLE IV.24--continued

Month of Weaning--Weight for Length (% of NCHS Median)						
Age (Months)	1	2	3	4 & 5	6	F (Sig)
Birth	94.2±10.5	91.9±7.1	97.0±5.4	88.1±7.9	95.5± 8.2	1.25 (.30)
1	100.0± 6.6	98.8±8.2	96.3±8.4	98.7±7.4	101.1±11.0	.46 (.77)
2	104.2±14.9	98.1±6.6	103.2±9.0	99.6±9.5	103.5±14.7	.32 (.86)
3	104.5± 9.1	99.4±3.5	95.9±8.3	99.2±6.1	102.7± 9.7	1.36 (.26)
4	102.3± 9.6	98.5±3.9	97.3±8.7	98.0±10.7	100.5±12.2	.27 (.90)
5	102.7± 4.9	99.0±4.2	96.6±8.4	95.1± 9.5	98.5± 9.2	.67 (.62)
6	100.7± 5.2	95.9±5.1	93.0±4.8	94.8± 8.7	97.7± 9.4	.93 (.43)

TABLE IV.24--continued

Month of Weaning--Total Fatfolds (Residuals; mm)						
Age (Months)	1	2	3	4 & 5	6	F (Sig)
Birth	-5.7+ 5.2	-5.8+ 6.1	-7.6+ 4.7	-11.3+ 6.2	-7.5+ 5.5	1.03 (.40)
1	6.0+ 8.7	1.2+ 4.9	-5.7+ 7.8	-4.2+ 8.1	.5+ 7.3	2.77 (.03)
2	9.1+11.3	3.1+ 5.3	1.4+ 8.2	6.1+16.8	5.3+ 8.3	.70 (.60)
3	11.4+15.7	6.3+12.1	3.1+ 9.0	5.1+14.6	4.3+10.4	.70 (.62)
4	8.8+18.7	5.5+20.4	1.6+9.1	3.1+16.8	4.4+15.2	.21 (.93)
5	-.6+17.6	.5+21.6	-2.9+ 7.5	-4.0+17.6	1.5+17.8	.22 (.93)
6	-7.6+14.6	-9.3+18.3	-10.6+10.0	-6.4+25.0	-4.1+13.5	.44 (.78)

Significant differences relating to future weaning did appear in weight for age at one and two months ($p < .05$). Reduced weight for age at one and two months was found among infants who would be weaned in the third and, to a lesser degree, the second months. In Month 1, the highest weight for age was of infants who would not be weaned until after six months of age, a continuation of the trend apparent at birth. By two months of age this group had been equalled in size by other groups of infants.

Analysis of total fatfolds for age suggests that the differences between groups in weight do not necessarily reflect similar differences in fatness. At one month of age infants who would be weaned in the third month were the leanest infants ($p < .05$) and, of all weaning groups, had experienced the least fat increase from birth.

Although those who would be weaned after six months did show a marked initial increase in fatness, the fattest infants were those who had been weaned during the first month. Furthermore, this group of infants had experienced the largest increment in total fatfolds from birth.

Introduction of First Non-Breast Milk Food

Age at introduction of first non-breast milk food was more closely associated with weight for age than with any other growth variable (Table IV.25). Figure IV.10 shows that those infants exclusively breast-fed for four or more months were on the average heavier at birth than those exclusively breast-fed for shorter periods of time.

Furthermore, this higher mean weight continued through five months of age. Those infants exclusively breast-fed the shortest period of time were lightest at birth and, in fact, experienced an initial decrease in percent of the median weight for age. Differences between groups in weight for age approach statistical significance at one month ($p < .06$) and two months of age ($p < .08$) (Table IV.25).

Infants exclusively breast-fed longest had a greater mean weight for length from birth to four months (Figure IV.11) and were slightly fatter than other infants in the early months of life, but these relationships are not statistically significant.

Common Infant Dietary Patterns

Infant growth variables were also analyzed by the major dietary patterns identified earlier in this chapter during analysis of the infant feeding data. Table IV.26 shows the average monthly percent of median for each growth measure by dietary pattern group. Although these distributions overlap, trends in weight for age (see Figure IV.12) are consistent with those observed among groups defined by timing of weaning and introduction of first non-breast milk food. Infants in dietary Group 3--those with longest exclusive breast-feeding--were heavier at birth, and maintained this size superiority until five months. Group 1a--experiencing the "addition" of formula by one month of age--had a marked decrease in weight for

TABLE IV.25--Means + Standard Deviations of Four Infant Growth Measures at Birth and End of Months 1 to 6, by Month of First Introduction of Non-Breast Milk Foods.

Month of First Non-Breast Milk Food-Weight for Age (% of NCHS Median)						
Age Months	1	2 & 3	≥ 4	F	(Sig)	
Birth	102.6 + 13.5	104.0 + 13.0	106.4 + 14.4	.52	(.60)	
1	100.8 + 13.9	105.5 + 14.6	109.7 + 12.3	2.92	(.06)	
2	106.9 + 13.1	107.8 + 14.2	112.6 + 11.2	1.77	(.18)	
3	106.5 + 11.7	105.8 + 12.9	111.8 + 10.1	2.56	(.08)	
4	107.9 + 12.0	104.1 + 10.8	109.6 + 10.9	1.57	(.22)	
5	106.2 + 12.7	102.2 + 11.1	107.2 + 9.9	1.29	(.28)	
6	105.0 + 13.3	100.7 + 10.4	103.9 + 9.9	.77	(.47)	

TABLE IV.25---continued

Month of First Non-Breast Milk Food-Length for Age (% of NCHS Median)					
Age (Months)	1	2 & 3	> 4	F	(Sig)
Birth	102.0 + 4.3	102.1 + 4.8	102.5 + 4.4	.10	(.91)
1	101.1 + 4.5	101.9 + 4.7	102.9 + 4.3	1.10	(.34)
2	102.0 + 4.6	101.7 + 4.6	103.0 + 4.7	.63	(.54)
3	101.8 + 3.7	102.2 + 3.5	102.9 + 4.2	.64	(.53)
4	102.8 + 3.6	102.0 + 3.5	103.1 + 4.5	.46	(.63)
5	101.6 + 4.0	102.6 + 4.2	103.1 + 4.2	.78	(.46)
6	102.6 + 4.7	102.7 + 3.2	102.4 + 3.8	.05	(.95)

TABLE IV.25---continued

Month of First Non-Breast Milk Food-Weight/Length (% of NCHS Median)

Age (Months)	1	2 & 3	≥ 4	F	(Sig)
Birth	93.7 $\pm$ 7.6	94.2 $\pm$ 8.7	95.6 $\pm$ 8.5	.36	(.70)
1	97.6 $\pm$ 7.4	100.1 $\pm$ 10.0	101.4 $\pm$ 10.6	.96	(.39)
2	101.5 $\pm$ 11.6	103.1 $\pm$ 10.2	104.6 $\pm$ 15.4	.35	(.71)
3	100.9 $\pm$ 7.8	98.9 $\pm$ 7.0	103.1 $\pm$ 10.0	1.55	(.22)
4	100.1 $\pm$ 8.6	98.2 $\pm$ 9.7	100.9 $\pm$ 12.4	.38	(.68)
5	100.9 $\pm$ 6.6	95.4 $\pm$ 9.2	98.7 $\pm$ 8.8	1.90	(.16)
6	98.3 $\pm$ 6.3	93.9 $\pm$ 7.2	97.9 $\pm$ 9.6	1.71	(.19)

TABLE IV.25--continued

Month of First Non-Breast Milk Food-Total Fatfolds (Residuals; mm)						
Age (Months)	1	2 & 3	≥ 4	F	(Sig)	
Birth	-6.4 + $\underline{\quad}$ 4.8	-8.0 + $\underline{\quad}$ 5.7	-7.5 + $\underline{\quad}$ 5.6	.41	(.67)	
1	.5 + $\underline{\quad}$ 8.8	-2.2 + $\underline{\quad}$ 7.9	1.1 + $\underline{\quad}$ 7.1	1.18	(.31)	
2	6.1 + $\underline{\quad}$ 11.5	1.3 + $\underline{\quad}$ 9.3	6.9 + $\underline{\quad}$ 7.9	2.33	(.10)	
3	8.0 + $\underline{\quad}$ 13.5	1.2 + $\underline{\quad}$ 10.9	5.6 + $\underline{\quad}$ 9.8	1.70	(.19)	
4	7.9 + $\underline{\quad}$ 17.8	.5 + $\underline{\quad}$ 10.6	4.5 + $\underline{\quad}$ 15.5	1.01	(.37)	
5	.6 + $\underline{\quad}$ 16.9	-1.8 + $\underline{\quad}$ 14.4	1.0 + $\underline{\quad}$ 18.3	.16	(.86)	
6	-6.1 + $\underline{\quad}$ 14.7	-7.6 + $\underline{\quad}$ 17.4	-4.8 + $\underline{\quad}$ 13.8	.21	(.81)	

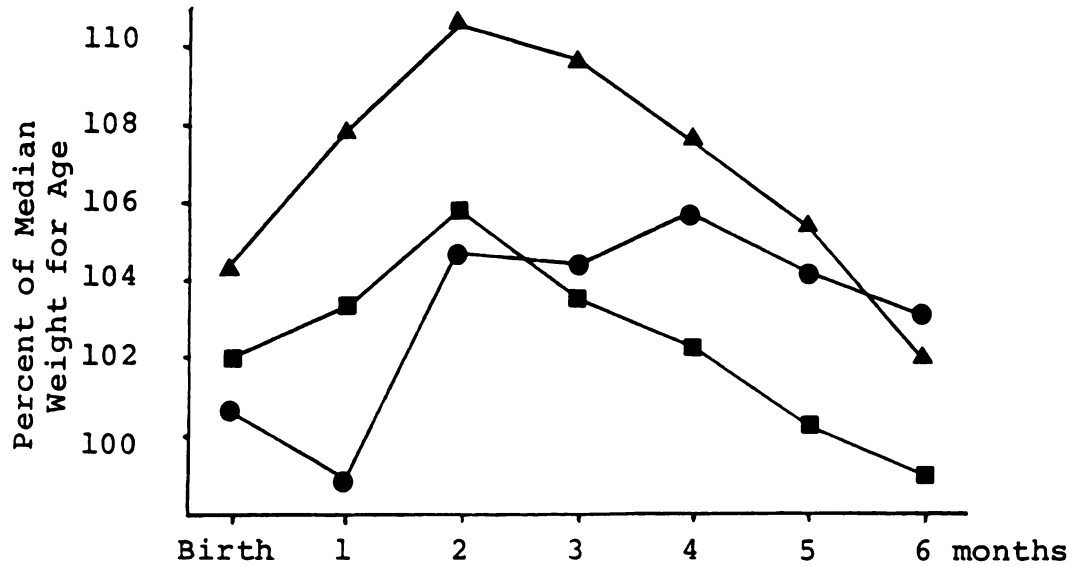


FIGURE IV.10--Mean Weight for Age (Percent of NCHS Median) by Month of Introduction of First Non-Breast Milk Food. Month 1 (●—●), Months 2 and 3 (■—■), Month 4 or Later (▲—▲).

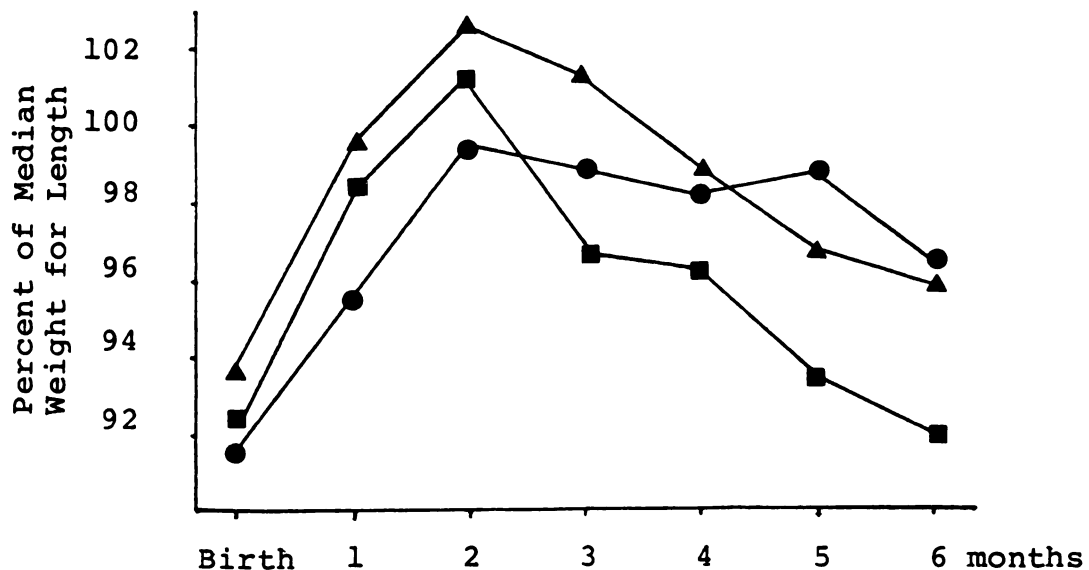


FIGURE IV.11--Mean Weight for Length (Percent of NCHS Median) by Month of Introduction of First Non-Breast Milk Food. Month 1 (●—●), Months 2 and 3 (■—■), Month 4 or Later (▲—▲).

TABLE IV.26--Means + S.D. of Four Infant Growth Measures at Birth and End of Months 1 to 6, by Infant Feeding Groups.

Infant Feeding Groups--Weight for Age (% of NCHS Median)						
Age (Months)	1a	1b	2a	2b	3	F (Sig)
Birth	104.4±16.4	101.5±11.9	101.6±14.7	105.7±11.9	106.4±14.4	.41 (.80)
1	96.6±15.8	103.5±12.5	104.0±15.1	106.5±14.1	109.7±12.3	1.78 (.14)
2	103.1±13.7	109.3±12.7	107.9±16.3	107.8±13.2	112.6±11.2	1.14 (.34)
3	104.9±13.7	107.5±10.8	106.0±13.4	105.6±13.1	111.8±10.1	1.31 (.28)
4	108.0±13.5	107.9±11.6	106.6±12.0	102.2± 9.9	109.6±10.9	.95 (.44)
5	108.3±13.6	104.9±12.6	103.6±10.6	101.1±12.0	107.2± 9.9	.79 (.53)
6	107.1±15.0	103.6±12.6	101.4± 8.7	100.2±12.1	103.9± 9.9	.50 (.74)

TABLE IV.26--continued

Infant Feeding Groups--Length for Age (% of NCHS Median)

Age (Months)	1a	1b	2a	2b	3	F	(Sig)
Birth	102.5+5.9	101.6+3.0	100.7+3.1	103.1+5.6	102.5+4.4	.45	(.77)
1	101.0+5.8	101.2+3.9	101.4+4.2	102.3+5.2	102.9+4.3	.59	(.67)
2	101.9+5.5	102.1+4.3	100.8+4.7	102.4+4.6	103.0+4.7	.47	(.76)
3	102.2+4.0	101.5+3.8	101.0+3.7	103.1+3.3	102.9+4.2	.71	(.59)
4	104.3+2.5	102.0+3.9	100.4+3.2	103.1+3.3	103.1+4.5	1.08	(.37)
5	102.9+4.6	100.7+3.5	100.3+3.4	104.3+4.0	103.1+4.2	1.80	(.14)
6	104.1+4.6	101.5+4.6	101.3+2.4	103.9+3.4	102.4+3.8	1.01	(.41)

TABLE IV.26--continued

Infant Feeding Group--Weight for Length (% of NCHS Median)

Age (Months)	1a	1b	2a	2b	3	F	(Sig)
Birth	93.6+6.0	93.8+ 8.7	95.5+9.3	93.3+ 8.4	95.6+ 8.5	.26	(.90)
1	93.6+6.7	100.1+ 7.0	99.7+9.7	100.3+10.7	101.4+10.6	.95	(.44)
2	98.2+9.2	103.6+12.7	105.4+8.5	101.4+11.4	103.1+12.0	.46	(.77)
3	98.2+7.8	102.7+ 7.6	102.6+6.0	96.4+ 6.7	103.1+10.0	1.66	(.17)
4	97.8+8.3	101.4+ 8.9	104.6+8.6	93.5+ 7.8	100.9+12.4	1.55	(.20)
5	99.9+7.1	101.5+ 6.5	102.0+7.6	90.0+ 6.6	98.7+ 8.8	3.57	(.01)
6	96.6+4.7	99.5+ 7.2	97.6+5.3	90.9+ 7.3	97.9+ 9.6	1.71	(.16)

TABLE IV.26--continued

Infant Feeding Group--Total Fatfolds (Residuals; mm)

Age (Months)	1a	1b	2a	2b	3	F	(Sig)
Birth	-7.7+ 3.4	-5.6+ 5.6	-7.0+ 4.7	-9.2+ 6.7	-7.5+ 5.7	.53	(.71)
1	-4.8+ 7.9	3.8+ 7.9	-.9+ 8.1	-3.7+ 7.9	1.1+ 7.1	2.21	(.08)
2	4.4+14.4	7.2+ 9.9	3.2+ 7.2	-.9+11.4	6.9+ 7.9	1.47	(.22)
3	6.1+11.6	9.2+15.0	3.7+10.4	-1.4+11.5	5.6+ 9.8	1.14	(.34)
4	9.4+18.2	7.0+18.5	.7+ 7.5	.2+13.6	4.5+15.5	.52	(.72)
5	3.6+12.1	-1.3+20.0	-1.6+10.6	-2.1+18.8	1.1+18.3	.16	(.96)
6	-3.3+13.1	-8.0+16.1	-10.3+12.8	-4.6+22.2	-4.8+13.8	.34	(.85)

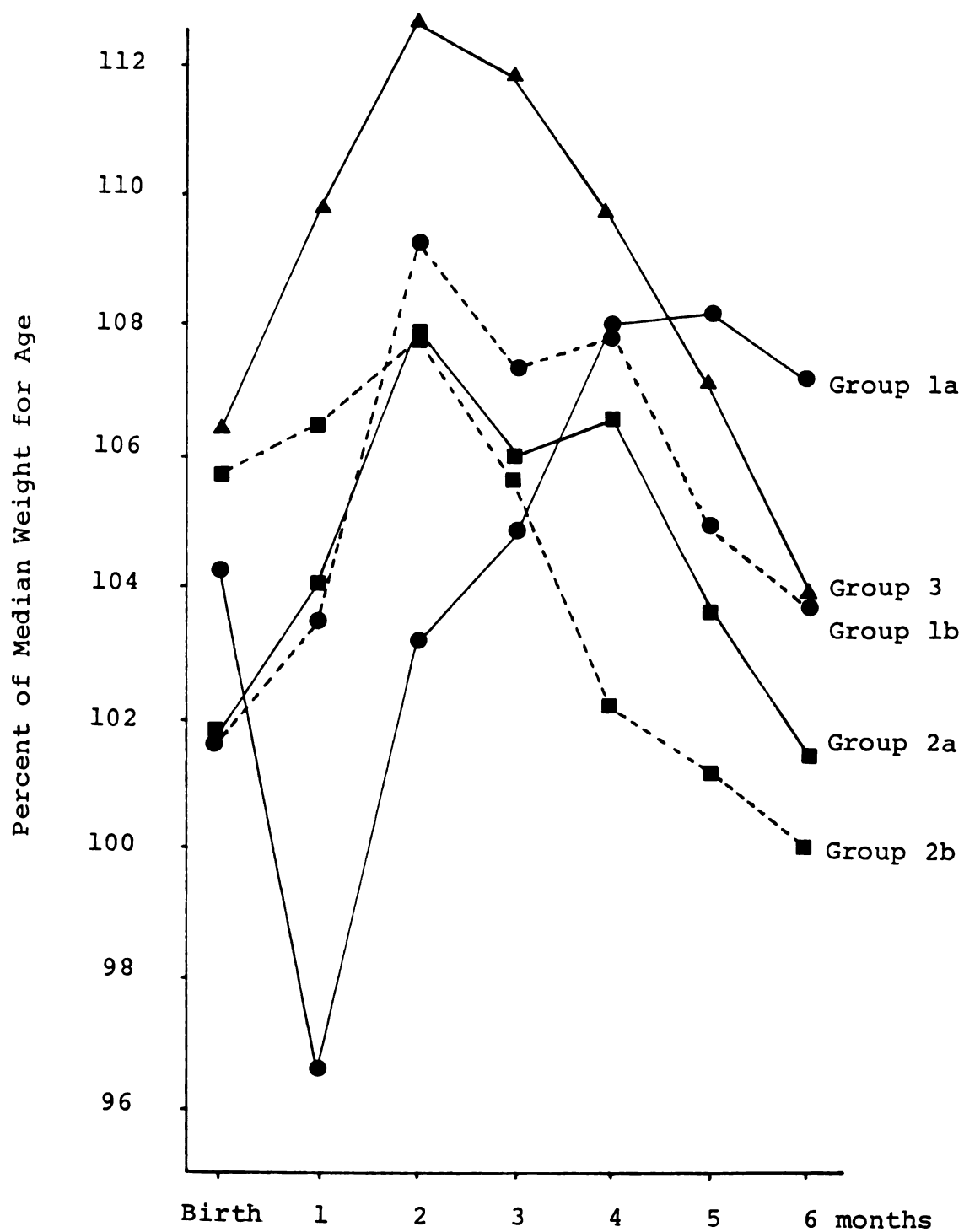


FIGURE IV.12--Mean Weight for Age (Percent of NCHS Median)
for Infant Feeding Groups 1a through 3.

age at one month, but recovered steadily and, in fact, was the heaviest group of infants at Months 5 and 6. Group 2b, which had breast-feeding partially replaced by solids during Months 2 and 3, is notable for its rapid decrease in weight for age after two months. Although these infants were, on the average, heavier at birth than all but Group 3, after three months they were the lightest.

A comparison of mean total fatfolds in the different dietary groups reveals a difference approaching significance at one month ($p < .08$). This reflects the extreme leanness of Group 1a as opposed to the relatively extreme adiposity of Group 1b.

At birth there were no significant differences among the dietary pattern groups in percent of the median weight for length (Table IV.26). Changes in later months indicate possible dietary effects. Group 1a was virtually unchanged until two months, while Group 1b increased substantially in weight for length during the first month (Figure IV.13). Groups 2a, 2b, and 3 were similar to each other in weight for length growth pattern from birth to two months of age (Figure IV.14). After that time all three groups decreased in weight for length. However, the decrease in Group 2b was particularly rapid, resulting in a significant difference among feeding groups at Month 5 (Table IV.26; $p < .01$).

Since Groups 2a and 2b are in fact parts of a larger dietary group subdivided on the basis of first non-breast milk food introduced, the marked difference in pattern of change was further explored. A least squares regression line was calculated for each dietary group, using weight for length measures at Months 1 through 6 as the dependent, and age in months as the independent variable (Table IV.27). The slope--rate of decrease in percent of median weight for length--was over twice as great among those for whom breast milk was replaced by solids (Group 2b) as among those for whom breast milk was replaced by formula (Group 2a).

Shifting the analysis to concentrate on the growth extremes, both weight for age and weight for length were in some way significantly related to the dietary groups. For these analyses, infants were ranked from largest to smallest for each growth measure at each month. Rankings were then divided into quartiles.

Although the heaviest and lightest infants were randomly distributed among the feeding groups in the first few months of life, a significant pattern emerges by Month 3 (Table IV.28). The frequency of lowest weight for age quartile infants in Group 3 declined and that in the upper quartile increased somewhat. At the same time the weight for age of infants in the other groups was skewed toward lighter infants in the later months. These differences are significant ($p < .05$) at three, four, and

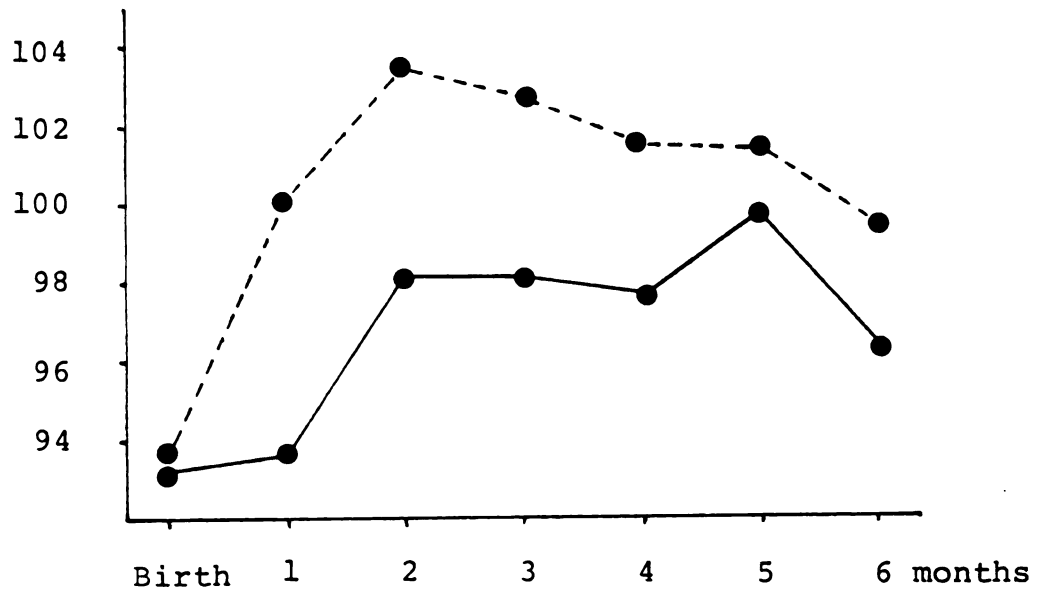


FIGURE IV.13--Mean Weight for Length (Percent of NCHS Median) for Infant Feeding Groups 1a (●—●) and 1b (●----●).

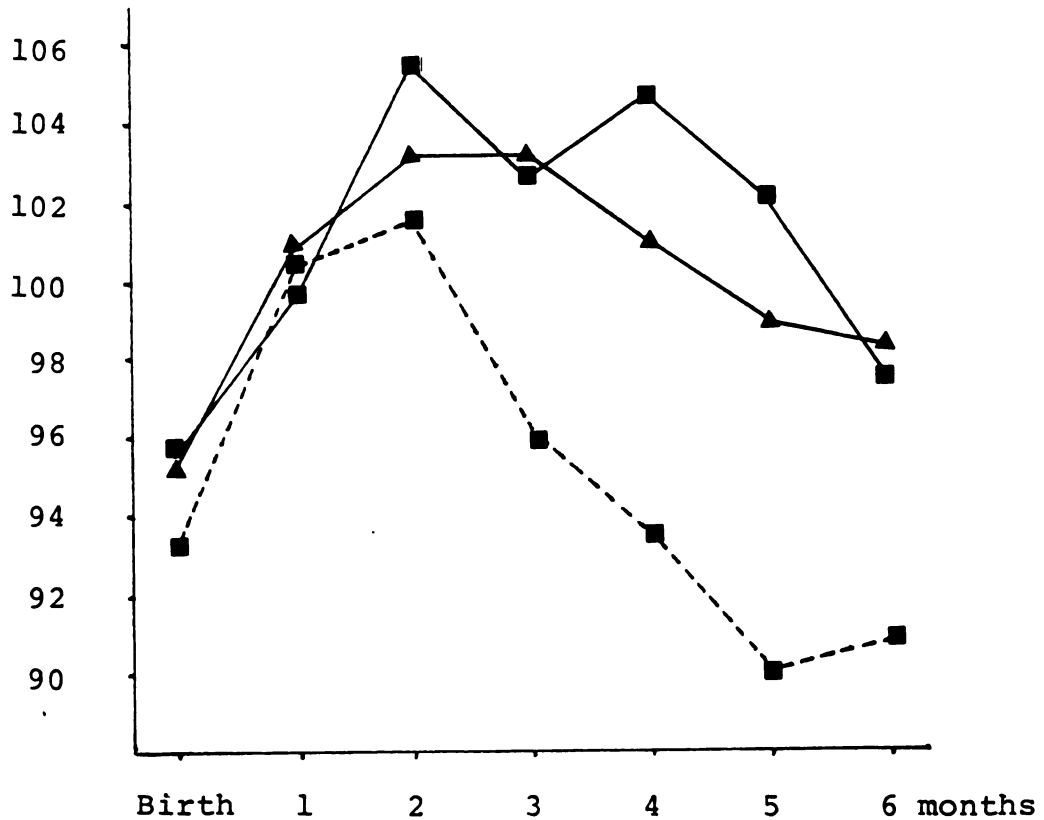


FIGURE IV.14--Mean Weight for Length (Percent of NCHS Median) for Infant Feeding Groups 2a (■—■), 2b (■----■), and 3 (▲—▲).

TABLE IV.27--Regression Equations: Dependent Variable is Weight for Length
and Independent Variable is Month of Age (1 - 6 mo.).

Feeding Group	Regression Equation	r	Number of Measurements
Group 2a	105.40 - (0.98) (Month) = % of Median	-.87	50
Group 2b	103.92 - (2.38) (Month) = % of Median	-.42	67

TABLE IV.28---Comparisons of Number of Infants in Lowest and Highest Quartiles of Weight for Age, at Birth and End of each Month, by Feeding Group.

		MONTH*							
Feeding Group	Birth								
		1	2	3	4	5	6		
la	2	2	3	1	2	2	3	2	4
lb	3	2	4	2	3	2	4	1	5
2a	3	2	2	1	4	3	4	2	3
2b	2	2	2	3	5	5	6	3	5
3	8	12	7	13	5	9	4	10	4
Chi Square**		4.54						6.40	4.11
Significance		.05						.02	.05

*Value on left indicates number in lowest quartile; right, upper quartile.
 **Chi square test for difference in distributions of Group 3 from combined Groups 1a through 2b.

five months of age.

In weight for length (Table IV.29), it is also obvious that distribution of infants into quartiles was non-random with respect to diet groups. However, the pattern of variation between groups was different from that for weight for age discussed above. Groups 1b and 2a, both based on dietary patterns "replacing" breast milk with formula, tended to have a high proportion of infants in the highest weight for length quartile, while Groups 1a and 2b, which did not replace breast milk with formula, had a high proportion of infants in the lowest quartile. These differences were significant in Months 3 through 5 (Table IV.30, $p < .05$).

Details of Breast Feeding

Because early growth appeared to be predictive of both subsequent growth and diet patterns, two aspects of the association of early growth and the breast-feeding process were explored in greater detail. These were length of individual breast-feedings and number of feedings per day. To minimize the confounding effects of other food in the diet, only those infants who were exclusively breast-fed for at least two months were included (N=47). Diet diaries at four weeks were examined and the number and mean length of feedings on this data noted for each infant. Infants were then assigned to two groups according to whether they had long or short and numerous or few feedings on this date. The medians were

TABLE IV.29--Comparisons of Number of Infants in Lowest and Highest Quartiles of Weight for Length, at Birth and End of each Month, by Feeding Group.

Feeding Group	Birth	Month*										
		1	2	3	4	5	6					
1a	1	2	0	3	1	2	0	0	2	1	1	
1b	3	2	2	2	4	1	3	0	3	1	3	
2a	2	2	3	2	0	3	1	2	0	3	1	2
2b	4	3	2	2	4	3	5	0	4	0	8	0
3	8	12	10	12	9	10	9	15	10	12	7	11

*Value on left indicates number in lowest quartile; right, upper quartile.

TABLE IV.30--Fisher's Exact Test of Difference in Number of Infants in Highest and Lowest Weight for Length Quartiles between Groups "Replacing" Breast Milk with Formula (1b and 2a) and those NOT "Replacing" with Formula (1a and 2b).

Feeding Groups	Month 3		Month 4		Month 5	
	quartile		quartile		quartile	
	lowest	highest	lowest	highest	lowest	highest
Groups 1a and 2b	8	1	6	0	8	2
Groups 1b and 2a	2	5	1	6	1	4
Fisher's Exact Probability	.025		.004		.047	

used as the upper limits of the "few" feedings and "short" feedings categories.

Table IV.31 shows the results of t-tests for differences between the groups based on breast-feeding details in size at birth and one month of age. An inverse relationship existed between size at birth and length of nursing bouts. Infants who had short breast-feeds had greater weight, length, and total fatfolds for age than did infants with lengthy breast-feeds. At one month of age, infant size was more strongly associated with the number of feedings per day, than their length. This relationship of size and number of feedings was direct. Infants who had a high number of feedings per day had greater weight for length and were significantly fatter ($p < .01$) than infants nursing a relatively few times per day. Growth velocity in the first month also appeared to be associated with number of feedings per day. Those infants with a high number of feedings had substantially greater increases in weight for age, weight for length, and total fatfolds than did those infants nursing relatively fewer times per day.

Interview Data

A variety of data obtained during pre- and postnatal interviews is compiled here. Portions of it come only from Study II in which the interview portion of the study was expanded and intensified.

TABLE IV.31--Relationship between Growth and Details of Breast-Feeding among
 Infants of Mothers in Groups A and B.

Size at Birth				
	Weight	Weight/Length	Length	Fatfolds
Short Breast-Feedings	112.1 $\pm$ 15.9	95.6 $\pm$ 9.1	104.4 $\pm$ 5.7	-6.1 $\pm$ 6.5
Long Breast-Feedings	101.6 $\pm$ 13.8	93.7 $\pm$ 9.1	101.5 $\pm$ 3.8	-10.2 $\pm$ 4.6
t (significance)	-2.00 (.06)	-.57 (.57)	-1.86 (.07)	-2.04 (.06)
Few Breast-Feedings	109.0 $\pm$ 14.5	95.1 $\pm$ 7.9	103.6 $\pm$ 5.0	-8.3 $\pm$ 5.1
Numerous Feedings	103.4 $\pm$ 13.7	94.3 $\pm$ 9.9	101.9 $\pm$ 4.0	-7.2 $\pm$ 6.8
t (significance)	1.35 (.18)	.29 (.77)	1.36 (.18)	.61 (.55)

TABLE IV.31--continued

Size at One Month				
	Weight	Weight/Length	Length	Fatfolds
Short Breast-Feedings	111.2 $\pm$ 15.3	99.9 $\pm$ 8.1	103.8 $\pm$ 5.9	-.4 $\pm$ 7.5
Long Breast-Feedings	105.1 $\pm$ 12.8	100.8 $\pm$ 10.5	101.6 $\pm$ 3.6	-1.4 $\pm$ 5.7
t (significance)	-1.22 (.24)	.27 (.79)	-1.23 (.24)	-.44 (.66)
Few Breast Feedings	108.7 $\pm$ 14.2	99.5 $\pm$ 11.0	103.2 $\pm$ 5.5	-1.5 $\pm$ 6.0
Numerous Feedings	111.1 $\pm$ 11.6	105.0 $\pm$ 8.9	102.1 $\pm$ 2.8	4.3 $\pm$ 8.0
t (significance)	-.65 (.52)	-1.87 (.07)	.85 (.40)	-2.69 (.01)

Prenatal Plans for Infant Feeding

All mothers in both Studies I and II planned to breast-feed their infants from birth. The earliest age planned for weaning was one month in the case of a mother returning to work at that time. No other mother had a specific length of time for which she intended to breast-feed. Most replied in general terms, with six to nine months being a common answer.

Plans for first feeding of non-breast milk foods were elicited in Study II. Many mothers reported they had not given it much thought. Those mothers were in the highest frequency in feeding Group 1, those infants exclusively breast-fed the shortest time. In comparison, mothers of Group 3, those infants exclusively breast-fed the longest time, were most likely to give a specific age range (Table IV.32).

Infant Feeding in the Parental Generation

Thirty-two women knew whether or not they had been breast-fed as infants. Of these, only nine had been breast-fed. Three knew that, although they had been bottle-fed, their husbands had been breast-fed. Six reported that either their mother or mother-in-law had tried to breast-feed, but had given up after a maximum of two weeks. They reported "insufficient milk" as the main cause of weaning. The remaining fourteen had been bottle-fed, as had their husbands.

TABLE IV.32--Study II Responses to the Question: When will you first give your baby anything but breast milk (or an occasional "convenience bottle") to eat?

Mother's Responses	1	2	3	Total
Have not thought about this	4	1	1	6
When doctor advises	2	1	-	3
Have thought about; not yet decided	-	-	4	4
When returning to work	-	1	1	2
Between 3 months' and 6 months	-	2	-	2
After 3 months	-	3	13	16
Missing data	-	1	-	1
Totals	6	9	19	34

Table IV.33 breaks these categories down by feeding Groups 1 to 3. There is a distinct trend toward feeding Group 3 in cases where one or both parents had a history of being breast-fed. Bottle-feeding predominated in parents of Group 1 and 2 infants.

Spatial Arrangement of Families

The possibility that spatial arrangements of the family might be linked to infant feeding was assessed. It was assumed that intensity of mother-infant interaction might vary with spatial distributions. In order to examine this, two categories of family dwelling types were devised. The first consisted of those dwellings judged

TABLE IV.33--Parental Generation Feeding as Infants by
Feeding Group of Infants in Present Study
(Study II only).

Parental Feeding	Infant Feeding Group			Total
	1	2	3	
Neither Parent Breast-Fed	5	5	4	14
One Parent Unsuccessfully Breast-Fed; Other not Breast-Fed	1	1	4	6
Father Breast-Fed; Mother not Breast-Fed	-	-	3	3
Mother or both Parents Breast-Fed	1	2 ¹	7	9
Feeding Modalities Unknown	-	1	1	2
Totals	6	9	19	34

¹Both of these mothers cut short their infants' exclusive breast-feeding to return to work.

to be compact: one story apartments and small houses with a maximum of four rooms, all on one floor and in a 2 x 2 arrangement. The second category consisted of dwelling arrangements judged to be dispersed: two story townhouses and houses, and one story or split level ranch style homes.

Table IV.34 shows the distribution of dwelling types by infant feeding group. Infants raised in dispersed type dwellings were far more likely to be exclusively breast-fed for a short period of time (Groups 1 and 2) than were those raised in compact dwellings ($\chi^2 = 10.30$; $p < .01$).

This does not appear to be a spurious association resulting from a more direct association of socio-economic status with spatial arrangement. Table IV.35 shows that maternal formal education, the best socio-economic predictor of breast-feeding behavior, is randomly distributed with respect to dwelling type.

TABLE IV.34--Distribution of Infant Feeding Groups by Spatial Arrangement of Family Dwelling.

=====			
Spatial Arrangement			
Infant Feeding Group	Compact	Dispersed	Totals

Group 1	5	13	18
Group 2	5	16	21
Group 3	25	16	41

Totals	35	45	80

Chi Square Test: $\chi^2 = 10.30$; $p < .01$			

TABLE IV.35--Distribution of Spatial Arrangement of Dwellings by Maternal Formal Education.

=====			
Spatial Arrangement			
Education Level	Compact	Dispersed	Totals

High School or Vocational School	9	9	18
Some College (Less than Bachelor's Degree)	6	14	20
Bachelor's Degree	12	14	26
Any Graduate School	8	8	16

Totals	35	45	80

Chi Square Test: $x^2 = 2.16$; Not Significant			

Decision Making Data

Reasons given by mothers of Study II infants for adding the first non-breast milk foods to their infants' diets can be grouped into four general categories. Detailed data are listed in Appendix D. The categories are:

1. Infant behavior
2. External suggestion or prescription
3. Situational
4. Maternal health

Table IV.36 shows the distribution of these categories by month of infant age at first introduction of non-breast milk food. Each is described in more detail in the following paragraphs.

TABLE IV.36--Categories of Maternal Decisions to Introduce First Non-Breast Milk Food

Maternal Decision	Month						Totals
	1	2	3	4	5	6	
Infant Behavior	2	2	1	4	4	0	13
External Suggestion	1	0	0	1	5	1	8
Situational	0	2	1	0	2	1	6
Maternal Health	3	0	0	0	0	0	3
Totals	6	4	2	5	11	2	28

Mothers in the modal category--infant behavior--emphasized the failure of their infants to behave in ways they considered appropriate for infants of that age. This included instances in which infants had not yet begun sleeping through the night, as well as cases in which infants who had previously slept through the night began to awaken again for a night feeding. This category also included infants who cried or exhibited other behaviors interpreted as indicative of a desire to nurse at what the mother considered overly frequent intervals during the day.

Although it is highly likely that many of these mothers had received advice from other persons or from the media which contributed to their introduction of formula or solids, each claimed that she had arrived at

the decision herself. While a few mothers explicitly stated that their infants' behavior indicated a lack of satiety with breast milk, most treated the infants' behavioral state as something unrelated to current diet, but something which the foods introduced had the power to ameliorate. For example, small amounts of cereal were thought to cause infants to sleep through the night, though their precise action was unknown.

Thirteen mothers were placed in this category. Examination of the temporal distribution shows that these mothers augmented the breast milk diet either early--before the end of the second month--or later--at four and five months--after a long period of exclusive breast-feeding.

Mothers in the second most frequent category of reasons attributed their behavior to a suggestion from someone external to the nursing couple that the infant had a biological need not being met by the breast milk diet. These included one instance in which a pediatrician told a mother that her infant's weight gain was inadequate due to insufficient calories in the breast milk. It also included a number of cases in which physicians claimed that breast milk could not provide a specific nutrient--iron--which the infants needed at a particular age. Also included in this category are mothers who responded to pressure from relatives charging that infants of a given age or size could not be adequately nourished on

breast milk alone. Seven infants are in this category. All feeding changes but one took place in or after the fourth month.

Most of these cases share common features. In all but the instance of inadequate infant weight gain, the existence of an unmet need in the infant was diagnosed without a specific means of assessment. Physicians did not test for iron levels and mothers-in-law did not weigh or measure infants. The criteria for recommending a new food was a combination of age and "bigness." Although the mother herself may have been inclined to make the dietary change at the same time, she attributed her behavior to an external source.

The third most frequent category of reasons for introducing new foods was that based on situations external to the nursing couple. They included mothers going back to work or to school and choosing to either replace breast-feedings or wean completely. There were five infants in this category, and the feeding changes occurred randomly from the second through the fifth month.

Three mother-infant pairs fall into the fourth category--maternal health. In these cases some health problem specific to the mother prevented nursing. In two instances mothers were hospitalized again within the first month postpartum. In the other, the mother reported she was unable to nurse due to sore nipples. All these feeding changes occurred by the end of the first month.

The four reasons discussed above account for 28 mother-infant pairs. Of the remaining five mothers, two could not articulate reasons for feeding new foods, one cited a reason which did not match any others given by other mothers (wanting to take advantage of her infant's interest in solid foods so as not to have a "picky eater"), and two exclusively breast-fed throughout their participation in the study.

From inspection of the data it appeared that regardless of reason for feeding the non-breast milk item, the foods themselves followed the patterns of the entire sample. That is, formula tended to be given in the earliest months and solids, in the latest. Furthermore, there appeared to be no effect of decision making category on whether the new food was a dietary addition or replacement (Table IV.37).

Maternal Nutritional Status

Analyses reported here were designed to examine the relationship of breast-feeding practices to changes in maternal nutritional status in the postpartum. These changes include loss of body weight and changes in fat stores. Characteristics of the sample as a whole will be described first. Maternal changes will then be analyzed in terms of the common feeding patterns identified earlier in this chapter, months of breast-feeding, and other details of the breast-feeding process.

TABLE IV.37--Addition or Replacement of First Non-Breast Milk Food by
Decision Categories.

	Month					
	1	2	3	4	5	6
Maternal Decision						Totals
Infant Behavior	RR	RR	A	AAAA	AAAAAR	- 5R/9A
External Suggestion	A	-	-	A	AAAAAR	A 1R/7A
Situational	-	RR	A	-	AR	- 3R/2A
Maternal Health	RRR	-	-	-	-	- 3R/-

Totals	5R/1A	4R/-	-/2A	-/5A	3R/9A	-/1A 12R/18A

Descriptive Statistics for the Total Sample

The amount of weight women lost between the last pregnancy weighing and the first postpartum weighing averaged 8.7 ± 1.6 kg (Table IV.38). After a continued steady loss to three months postpartum averaging 2.7 kg, the weight loss plateaued, with only a slight additional loss (0.6 kg) to six months (Figure IV.15). This loss represents 1.9 ± 3.6 kg above reported prepregnant weight at six months. The degree of variability in weight loss--indicated by the standard deviation--is lowest for that period spanning the birth. Afterwards, it increases rapidly to three months, and then, like the average weight change itself, it stabilizes.

Midarm muscle area was calculated from arm circumference (c) and triceps fatfold (S) using the formula $\frac{(c - \pi S)^2}{4}$ (Gurney and Jelliffe 1973). After a slight initial increase during the first month postpartum, average muscle area declines steadily to five months, followed by a slight increase in the sixth month (Table IV.38). The mean overall loss is 1.0 cm^2 (Figure IV.16). The standard deviation at each point ranges from ± 2.5 to $\pm 6.6 \text{ cm}^2$.

In contrast, the long range trend in midarm fat area $\left(\frac{Sc}{2} - \frac{\pi S^2}{4}\right)$ is an increase. By the end of the third month the average mother has had an increase of 2.4 cm^2 (Table IV.39). There is some fluctuation in the mean fat area increments after that time, but the cumulative effect at six months is an increase of 1.9 cm^2 (Figure IV.16).

TABLE IV.38--Cumulative Measures of Maternal Weight Loss during the Postpartum.

Weight Change Measure	Month					
	$\frac{1}{2}$	1	2	3	4	5
Postpartum Weight Loss						
Mean (kg)	8.7	9.6	10.3	11.4	11.3	11.7
						12.0
Standard Deviation	1.6	2.1	2.9	5.1	3.5	3.5
						3.6
(N)	(78)	(77)	(77)	(76)	(73)	(71)
						(69)
Weight Left to Lose						
Mean (kg)	5.2	4.2	3.6	2.5	2.5	2.3
						1.9
Standard Deviation	3.5	3.2	3.3	5.1	3.4	3.3
						3.5
(N)	(78)	(77)	(77)	(76)	(73)	(71)
						(69)

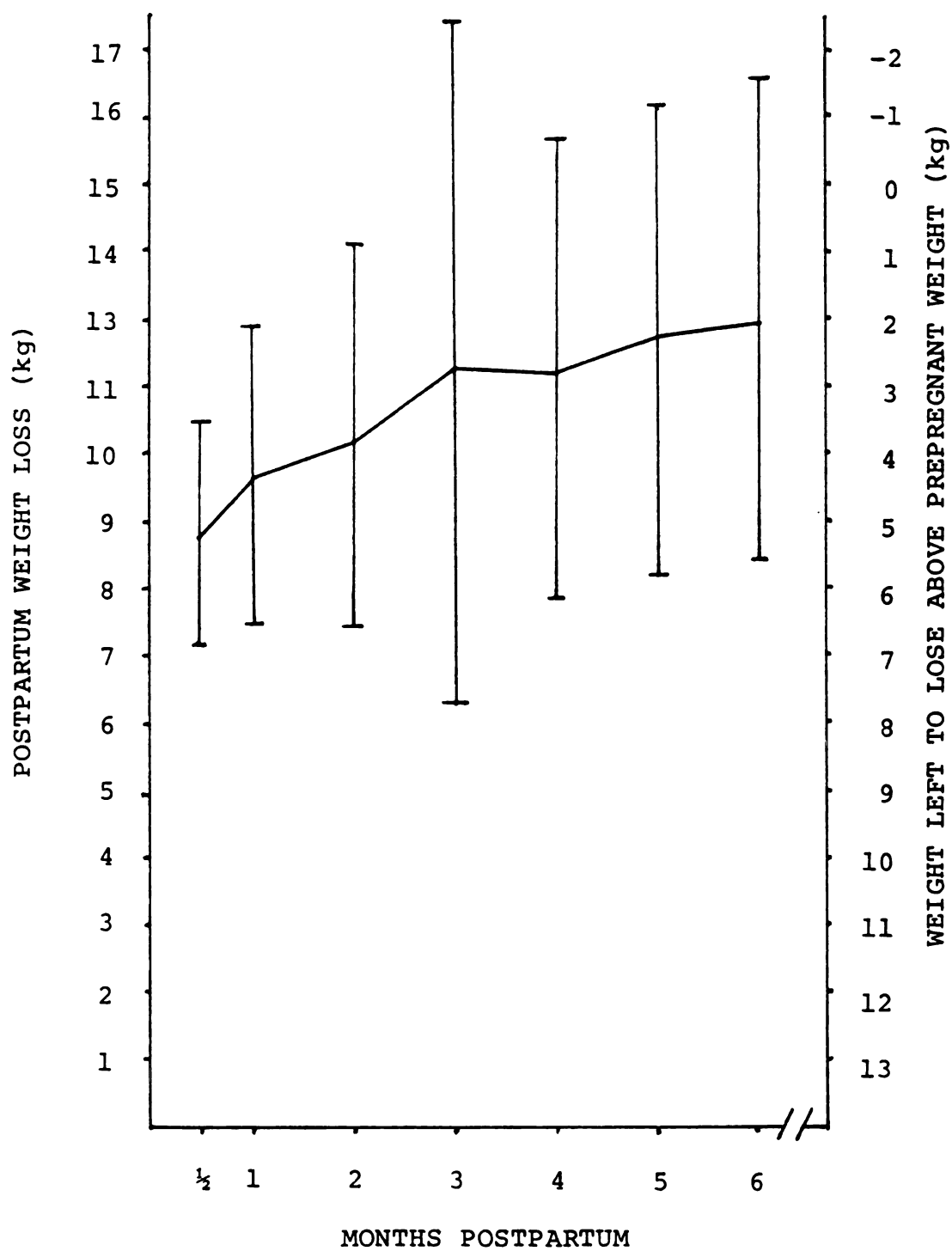


FIGURE IV.15--Maternal Postpartum Weight Status; Mean $\pm$ Standard Deviation.

TABLE IV.39--Cumulative Changes in Midarm Muscle and Fat Areas during the Postpartum.

Months Postpartum						
Maternal Measurement	1	2	3	4	5	6
Muscle Area Change						
Mean (cm ²)	.20	-0.21	-0.21	-0.72	-1.13	-1.00
Standard Deviation	2.88	2.87	5.81	6.64	2.95	2.47
(N)	(77)	(77)	(76)	(73)	(71)	(69)
Fat Area Change						
Mean (cm ²)	.65	1.66	2.44	2.21	2.92	1.94
Standard Deviation	3.28	2.96	2.99	2.43	3.10	2.37
(N)	(77)	(77)	(76)	(73)	(71)	(69)

The variability in fat area changes--represented by the standard deviation--is greater in the first and fifth months, and lowest in the fourth and sixth.

The change observed in midarm muscle area constitutes an average decline of three percent from the first postpartum measurement to the last. The increase in fat area for the same period represents an average change of nine percent.

Although the postpartum change in mean muscle area was fairly smooth, there were enormous month to month fluctuations in the measurements of individual women, resulting in extremely large standard deviations such as those in Months 4 and 5. Such fluctuations were too great to have resulted from gain or loss of muscle mass due to mobilization of pregnancy protein stores. They could have been a reflection of variations in hydration associated with the physiological changes of the postpartum period and lactation. They also could have been influenced by changes in muscles brought about by intensive lifting and carrying of infants. Given these possible confounding variables, the value of muscle area as a measure of nutritional status in such women is questionable. Since adipose tissue is affected by hydration to a far lesser extent, fat area, but not muscle area, will be used throughout these analyses as an assessment of maternal body composition.

Maternal Measures by Common Infant Diet Patterns

Table IV.40 shows cumulative weight loss at each postpartum measurement by infant diet patterns. Using analysis of variance, no statistically significant differences among groups were found at any time. Despite the lack of statistical significance, trends in group weight loss patterns are notable. Group 1b--those mothers who began replacing breast-feedings with formula in the first month--had the lowest rate of loss throughout the study, with a total loss of 10.06 kg. This compared with a mean loss of 12.29 kg in the remainder of the sample. Although Group 2a--those mothers who replaced breast-feedings with formula during months two and three--had an initial weight loss comparable with most other groups, by six months its total loss was only 10.75 kg. Thus, in terms of overall rate of loss, Groups 1b and 2a appeared to lose weight most slowly and Groups 1a, 2b, and 3, most rapidly.

When cumulative changes in midarm fat area were analyzed by infant dietary pattern by month, there were no statistically significant differences between groups (Table IV.41). However, trends similar to those in weight loss discussed above were present. Groups 1b and 2a--those mothers replacing breast-feeds with formula--had the greatest overall increase in fatness. All groups increased in fat area during the first three months. After that time the direction of change was variable.

TABLE IV.40---Cumulative Maternal Weight Loss from Last Prepartum Weighing by
Postpartum Month and Infant Feeding Group. Mean (kg) $\pm$ Standard
Deviation.

Postpartum Month	Infant Feeding Group (N)				ANOVA	
	1a (7)	1b (11)	2a (9)	ab (12)	3 (41)	F (Sig)
1/2	8.97 $\pm$ 2.05	8.53 $\pm$.81	8.71 $\pm$ 1.99	9.10 $\pm$ 1.35	8.66 $\pm$ 1.68	.26 (.91)
1	10.01 $\pm$ 3.06	8.82 $\pm$ 1.32	9.63 $\pm$ 2.71	9.85 $\pm$ 2.35	9.76 $\pm$ 1.94	.51 (.73)
2	10.67 $\pm$ 3.23	8.70 $\pm$ 2.16	10.19 $\pm$ 4.00	10.51 $\pm$ 3.04	10.62 $\pm$ 2.77	.97 (.43)
3	11.21 $\pm$ 3.23	8.83 $\pm$ 2.71	10.91 $\pm$ 5.36	11.26 $\pm$ 3.48	12.29 $\pm$ 6.15	1.00 (.41)
4	11.40 $\pm$ 3.71	9.18 $\pm$ 2.60	11.01 $\pm$ 4.52	12.07 $\pm$ 3.69	11.83 $\pm$ 3.22	1.43 (.23)
5	12.09 $\pm$ 3.66	9.89 $\pm$ 2.63	10.66 $\pm$ 4.24	12.29 $\pm$ 4.32	12.13 $\pm$ 3.21	1.09 (.37)
6	12.59 $\pm$ 3.56	10.06 $\pm$ 2.69	10.75 $\pm$ 3.93	13.02 $\pm$ 4.21	12.38 $\pm$ 3.56	1.31 (.28)

TABLE IV.41--Cumulative Change in Midarm Fat Area from First Postpartum Measurement by Postpartum Month and Infant Feeding Group. Mean (cm²) + Standard Deviation.

Postpartum Month	Infant Feeding Group (N)						ANOVA	
	1a (7)	1b (11)	2a (9)	2b (12)	3 (41)	F	(Sig)	
1	.45+1.44	1.87+4.72	.06+2.94	.60+2.75	.49+3.31	.46	(.76)	148
2	1.46+3.05	3.95+2.31	2.27+3.28	1.15+2.23	1.08+3.24	.89	(.48)	
3	2.59+3.95	4.03+1.54	2.64+4.70	2.21+3.56	2.00+2.66	.24	(.92)	
4	3.05+2.62	3.93+2.81	1.15+3.79	2.43+1.89	1.67+2.20	.64	(.63)	
5	1.59+2.45	3.76+3.39	3.68+1.77	2.91+1.90	2.79+3.41	1.78	(.15)	
6	.62+2.61	2.49+1.77	2.66+2.93	1.65+2.56	1.96+2.41	.08	(.94)	

Maternal Measures by Months of Breast Feeding

Table IV.42 shows cumulative monthly weight loss analyzed in terms of breast-feeding. Although no statistically significant differences exist, mothers who weaned before the third month had a substantially lower mean loss (10.6 kg) than those who weaned later (12.3 kg). The possible connection between overall weight loss and the timing of weaning appears to be the result of differences in weight loss velocity before and after weaning. In all groups breast-feeding less than five months, weight loss velocity before weaning is greater than after (Figure IV.17). In all four of these groups there was either no further weight loss or an actual gain in weight in the month following weaning. Furthermore, the preweaning velocity tended to be greater in those breast-feeding longer. Thus, the net result is the relationship between timing of weaning and weight loss. The sample sizes in those groups being compared in Figure IV.17 are small and the variation in weight change at any point is great. Thus, while the trends in mean weight change are suggestive of an association with weaning, they are not predictive of the postpartum weight loss for any individual woman and analysis of them does not produce statistically significant results.

There were no significant differences in midarm fat area between groups based on months of breast-feeding. Moreover, there was no discernable pattern of change when

TABLE IV.42--Cumulative Weight Loss from Last Prepartum Weighing by Postpartum Month
and Months of Breast Feeding. Mean (kg) + Standard Deviation.

Postpartum Month	Months of Breast Feeding (N)						ANOVA	
	1 (7)	2 (6)	3 (8)	4 (3)	5 (3)	6 (51)	F	(Sig)
1/2	8.70+ <u>.90</u>	8.11+ <u>.74</u>	9.11+1.11	9.85+2.72	7.90+ <u>.62</u>	8.75+1.73	.85	(.52)
1	8.95+ <u>.93*</u>	9.50+ <u>.59</u>	10.16+2.53	11.30+3.35	8.13+1.90	9.67+2.25	1.03	(.40)
2	8.94+1.82	9.27+1.27*	11.61+3.81	12.15+3.18	9.23+1.99	10.67+3.08	1.21	(.31)
3	9.46+2.15	8.90+1.94	12.24+4.45*	13.35+3.61	9.33+1.76	11.85+5.93	.83	(.53)
4	9.87+2.24	9.53+2.00	12.24+4.58	13.00+3.62*	9.93+2.11	11.61+3.57	1.02	(.41)
5	10.73+1.73	9.73+2.19	12.71+4.34	12.85+3.45	10.43+2.63*	11.86+3.69	.77	(.58)
6	10.87+1.84	10.28+2.08	12.97+4.07	12.95+3.25	11.00+1.64	12.17+4.03	.59	(.71)

* Month of Weaning

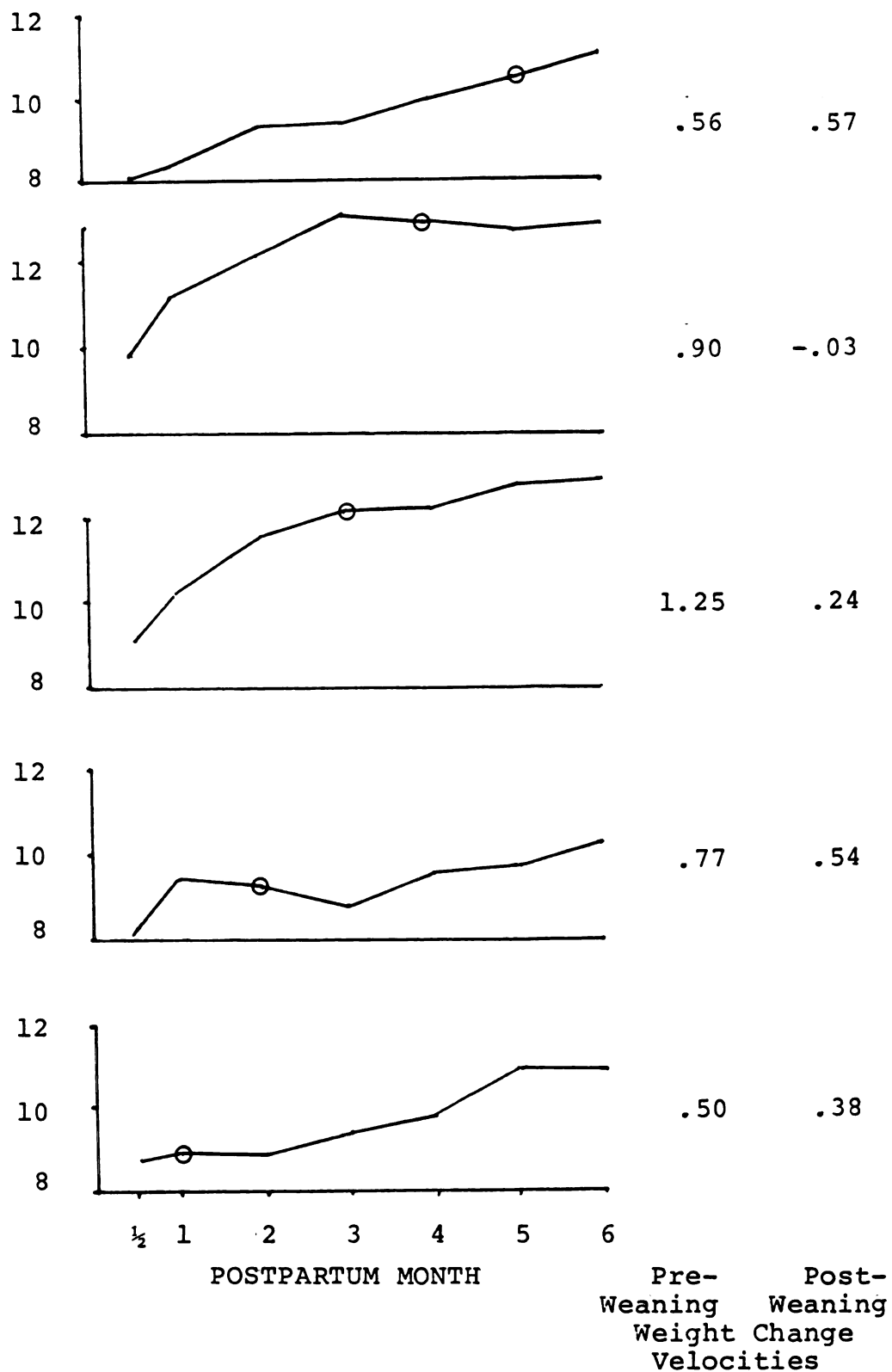


FIGURE IV.17--Cumulative Postpartum Weight Loss by Month of Weaning. Pre- and Post-Weaning Weight Change Velocities (kg/month) Are Indicated. (O = Month of Weaning).

the overall rates of growth in fat were compared (Table IV.43). It appears that early weaning was followed by an immediate increase in fatness whereas later weaning (after two months) was followed by a much lower increase or a decrease. When numbers of women increasing and decreasing in fat area in the month following weaning are compared (Table IV.44), the same result appears. A similar, but stronger, relationship exists between fat change and the timing of the introduction of the first non-breast milk food. Table IV.45 shows that introduction of such food in the early months was followed by an increase in maternal fat, whereas later introduction was followed by a decrease ($p < .01$).

Maternal Measures and Details of Breast Feeding Practices

In order to study the association of maternal post-partum weight and fat changes with the number and length of nursing bouts, a series of Spearman correlation coefficients was computed for the entire sample. The values for the breast-feeding variables were calculated by averaging the number of all feedings and length of all feedings reported within each month. Any woman who reported any breast-feeding during a particular month is included in the computation of the correlation for that month. Thus, the sample size decreases from the first to the sixth month as mothers wean their infants.

TABLE IV.43--Cumulative Change in Midarm Fat Area from First Postpartum Measurement
by Postpartum Month and Months of Breast-Feeding. Mean (cm²) +
Standard Deviation.

		Months of Breast-Feeding (N)						ANOVA	
Postpartum Month		1 (7)	2 (6)	3 (8)	4 (3)	5 (3)	6 (51)	F	(Sig)
1	2.49+5.36*	-.40+1.81	-1.29+3.43	.01+ .91	2.21+3.19	.70+3.05	1.26	(.29)	
2	4.11+1.93	1.59+3.41*	-1.33+2.84	2.25+1.73	.91+6.72	1.63+2.85	.95	(.44)	
3	3.58+2.77	1.90+2.84	1.05+4.33*	.42+3.53	3.21+2.41	2.59+2.73	1.59	(.17)	
4	2.37+1.98	.87+4.33*	1.22+2.56	2.57+1.95*	3.82+1.40	2.26+2.36	1.23	(.30)	
5	3.65+2.35	.54+3.74	2.00+2.97	1.06+2.58	3.79+3.26*	3.35+3.17	.70	(.62)	
6	2.84+2.28	-1.55+2.28	.14+2.34	1.11+ .94	3.16+2.29	2.55+2.52	.62	(.69)	

*Month of weaning

TABLE IV.44--Number of Mothers with Increasing and Decreasing Fat Measures in the Month Following Weaning, by Month of Weaning.

Month of Weaning							
Change in Fat Area	1	2	3	4	5	6	Totals
Increase	7	3	5	1	1	-	17
Decrease	-	1	3	2	1	-	7
Totals	7	4	8	3	2	-	24

TABLE IV.45--Numbers of Mothers with Increasing and Decreasing Fat Measures in the Month Following First Introduction of Non-Breast Milk Food, by Month of Introduction.

Month of Introduction							
Change in Fat Area	1	2	3	4	5	6	Totals
Increase	16	7	5	7	7	-	42
Decrease	1	2	2	3	10	3	21
Totals	17	9	7	10	17	3	63

Median Test: Median = Month 3; $\chi^2 = 10.0$; $p < .01$

The correlations between monthly maternal weight loss and both breast feeding variables were not statistically significant (Table IV.46). A weak positive association existed for Month 1 between weight loss and length of feedings ($p < .09$), but it did not continue into the later postpartum months.

Table IV.46 also shows the correlations of changes in maternal fat area and the breast-feeding variables. The length of feedings was not statistically correlated with change in fat area until the sixth month. At that time long feedings were associated with the greater loss of fat; and short feedings, with the lower loss or gain of fat ($p < .02$). The pattern of interaction of fat area with number of feedings per day is more distinct. Higher numbers of feedings per day are associated with greater loss of fat; lower numbers of feedings, with less loss of fat. The correlation is fairly strong in the second month ($p < .066$) and highly significant in the fourth month ($p < .005$).

To further explore the relationship between number of feedings per day and fat area change, a series of analyses were performed in which several possible confounding variables were controlled for. Mothers were included in these analyses only if they exclusively breast-fed for at least two months and did not wean before the fifth month, and if clear patterns of change in their postpartum fatness could be identified ($N=46$).

TABLE IV.46--Spearman Rank-Order Correlation Coefficients:
Change in Maternal Weight and Fat with Length
and Number of Breast-Feedings.

Monthly Weight Loss with:

Number of Feedings/Day

Correlation Coefficient	.019	.111	-.051	.142	-.033	-.065
(N)	(68)	(68)	(55)	(50)	(45)	(41)
Significance	.434	.185	.355	.164	.416	.343

Minutes/Feeding

Correlation Coefficient	.170	-.029	.045	.068	-.135	.148
(N)	(66)	(68)	(55)	(49)	(44)	(40)
Significance	.086	.409	.374	.321	.193	.182

Monthly Fat Loss with:

Number of Feedings/Day

Correlation Coefficient	-.004	.196	-.067	.394	.194	-.194
(N)	(66)	(61)	(49)	(44)	(37)	(35)
Significance	.487	.066	.325	.005	.126	.133

Minutes/Feeding

Correlation Coefficient	-.099	-.125	-.113	-.037	-.130	.363
(N)	(64)	(61)	(49)	(43)	(36)	(34)
Significance	.219	.169	.220	.408	.225	.018

The means by which such patterns were identified will be described below. The feeding criteria were aimed at limiting unmeasurable differences in the intensity of breast-feeding due to consumption of other foods by the infants. Data on breast-feeding details for these analyses were taken from diet diaries at specific dates of four, eight, twelve, sixteen, and twenty weeks. This was to control for differences between infants in the dates of diet diaries within the same month. Finally, in these analyses changes in maternal fat area were classified according to the overall pattern of such changes. This was designed to control for minor monthly fluctuations in fat area which might have been obscuring overall trends in maternal nutritional status. To define patterns of change in fatness, a least squares linear regression line was first computed for each subject, using days since parturition as the independent, and fat area as the dependent variable. An "r" value was calculated for each of the regression lines and a test of significance was performed. Figure IV.18 shows the distribution of significance levels for those 50 mothers who met the infant feeding criteria described above. There is a clear clustering of subjects at and below the .10 significance level with several outliers at and above the .30 level. Because of this distribution, .10 was used as the cut off for inclusion in these analyses rather than the .05 level which is otherwise used

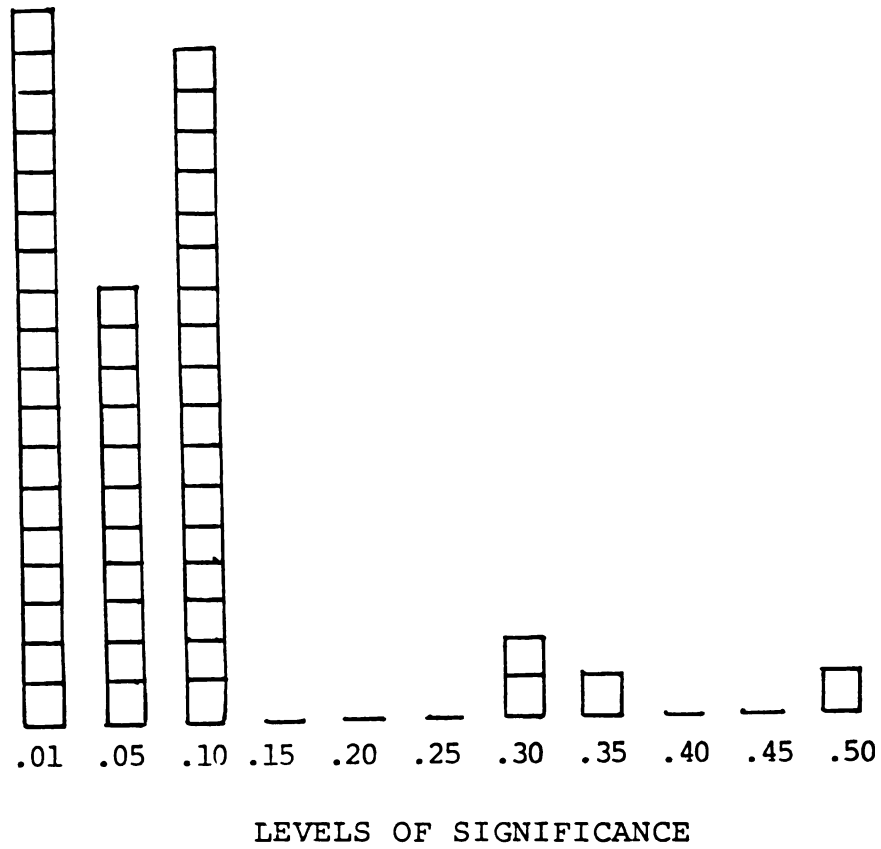


FIGURE IV.18--Distribution of Significance Levels
for Regression of Postpartum Maternal
Fat Area on Days since Parturition.

throughout this dissertation as the upper limit of statistical significance.

After narrowing the sample down to those for whom a consistent pattern of change in fat area could be documented, the group was further subdivided according to the direction of this change. All those women for whom the slope of the regression line was negative formed one group (Group A; N=17). This was the expected pattern, but numerically it was less common. Those with a positive slope formed the second group (Group B; N=29). The following analyses compare these two groups.

A comparison of maternal variables shows no significant differences between these groups in prepregnant weight, height, birthweight of the child, or length of pregnancy (Table IV.47). Group A did gain significantly more weight during pregnancy than did Group B, but after the first month postpartum there was no significant difference between the groups in the amount of weight left to lose. Also, there were no significant differences between the groups in the timing of introduction of non-breast milk foods after two months.

Two major between group differences in breast-feeding behavior were observed. The first confirms the relationship noted in Table IV.46: number of feeds per day is linked to postpartum changes in maternal fatness. Group A reported a significantly higher median number of feeds per day at 4, 8, and 12 weeks than did Group B (Tables IV.48-50).

TABLE IV.47--Maternal Anthropometric and Birth Outcome Variables for
Groups A and B. Mean $\pm$ Standard Deviation.

Variable	Group A	Group B	t	(Sig)
Pregnancy Weight Gain (kg)	16.3 $\pm$ 5.1	13.1 $\pm$ 2.8	2.43	.02
Prepregnant Weight (kg)	58.2 $\pm$ 6.3	57.8 $\pm$ 7.2	.16	.87
Kg above prepregnant Weight:				
End of Month 1 Postpartum	6.5 $\pm$ 3.8	3.5 $\pm$ 2.5	2.93	.01
End of Month 2 Postpartum	5.2 $\pm$ 4.1	3.0 $\pm$ 2.7	1.97	.06
End of Month 3 Postpartum	4.1 $\pm$ 4.7	1.2 $\pm$ 6.4	1.74	.09
End of Month 4 Postpartum	3.5 $\pm$ 4.0	2.1 $\pm$ 3.3	1.19	.25
End of Month 5 Postpartum	2.8 $\pm$ 4.1	2.1 $\pm$ 3.2	.62	.54
End of Month 6 Postpartum	2.3 $\pm$ 4.5	2.0 $\pm$ 3.6	.19	.85
Maternal Height (cm)	165.7 $\pm$ 7.9	166.5 $\pm$ 7.5	.34	.74
Birthweight (kg)	3.4 $\pm$.4	3.5 $\pm$.5	.45	.66
Length of Pregnancy (days)	281.9 $\pm$ 10.2	281.2 $\pm$ 12.0	.14	.85

TABLE IV.49--Number of Breast-Feedings per Day at Eight Weeks for Infants of Mothers in Groups A and B.

	Feedings per Day								
	4	5	6	7	8	9	10	11	Totals
Group A	0	2	4	4	3	2	0	1	16
Group B	2	10	9	3	1	2	0	2	29
Totals	2	12	13	7	4	4	0	3	45

Median Test: Median = 6 Feedings/Day; $\chi^2 = 5.24$; $p < .05$

TABLE IV.50--Number of Breast-Feedings per Day at Twelve Weeks for Infants of Mothers in Groups A and B.

=====										
	Feedings per Day									
	4	5	6	7	8	9	10	11	12	Totals

Group A	1	3	3	3	1	3	0	2	0	16
Group B	2	10	9	2	2	0	0	0	1	26

Totals	3	13	12	5	3	3	0	2	1	42

Median Test: Median = 6 Feedings/Day; $\chi^2 = 6.23$; $p < .02$										

The second difference between Groups A and B is in mean length of individual feedings. Group A has shorter feedings than does Group B at each point in time. These differences approach statistical significance at four weeks and are highly significant from 8 to 20 weeks (Table IV.51). Thus, mothers with decreasing fat area during the postpartum have, in general, more and shorter feedings than do mothers whose fat area increases during the same time. In the combined group of 46, minutes per feeding is significantly and inversely correlated with number of feedings per day at 4, 8, 16, and 20 weeks (Table IV.52).

TABLE IV.51--Minutes per Feeding for Groups A and B.
Mean $\pm$ Standard Deviation.

Week	Group A	Group B	t	Sig.
4	19.1 $\pm$ 7.4	24.4 $\pm$ 11.0	1.89	.07
8	16.4 $\pm$ 5.5	24.0 $\pm$ 10.8	2.65	.01
12	14.8 $\pm$ 4.3	21.2 $\pm$ 8.3	2.89	.01
16	13.6 $\pm$ 5.4	19.7 $\pm$ 9.1	2.42	.02
20	12.2 $\pm$ 3.6	17.1 $\pm$ 7.0	2.60	.01

TABLE IV.52--Spearman Rank-Order Correlation Coefficient:
Minutes per Breast-Feeding with Numbers of
Feedings per Day.

	Age of Infant (Weeks)				
	4	8	12	16	20
Correlation Coefficient	-.514	-.468	-.221	-.424	-.269
(N)	(44)	(44)	(44)	(44)	(42)
Level of Significance	.001	.001	.075	.003	.043

CHAPTER V

DISCUSSION

Emergence of Infant Feeding Strategies

In order to identify major infant dietary patterns, a series of analyses were done which assessed the patterns of interaction of the various food behaviors which comprise infant diets. The following variables were considered: length of exclusive breast-feeding, age at weaning, introduction of first non-breast milk food, and mean duration of nursing bouts and number of feedings per day in early infancy. From these it was apparent that one variable, in a sense, formed the core around which all the other dietary components were arrayed. This variable was the length of exclusive breast-feeding. On the basis of this three major dietary patterns are distinguishable. Although they are defined primarily on the basis of this one variable, the concordance of other variables supports this division.

The first feeding group is composed of 18 infants exclusively breast-fed less than four weeks. Among these, breast-feeding was never well established. In some cases,

maternal health problems precluded the establishment of lactation. In the remainder, a variety of factors working together led to the early introduction of non-breast milk foods. The detailed decision making data from Study II indicate that failure of infants to behave as expected by the mother as well as external suggestion of nutritional insufficiency led to early changes in the infant diet. Data from Study I support this: of twelve infants in Study I with this feeding pattern, four were known to have been diagnosed by physicians as losing weight beyond the expected initial perinatal weight loss. Most of the remaining eight infants were supplemented for other reasons. A large proportion of mothers, for example, reported that their infants cried and fussed too frequently, as if unsatisfied and as a result, the mothers changed the infants' diets.

In both studies, the new mothers were in many cases without "doulas."¹ Their own mothers were frequently there to help in the early postpartum, but, never having breast-fed an infant themselves, either could not give advice appropriate to breast-feeding or suggested using non-breast

¹Raphael (1966) devised the term doula as a label for the person who "mothers the mother." She has noted that such a role is culturally defined in most traditional societies. Furthermore, she attributes the decline of breast feeding in the 1950s and 1960s and increasing incidence of lactation failure in the industrialized countries to the isolation of new mothers from other supportive, experienced older breast-feeders.

milk foods. In Study II where maternal and paternal grandmothers' infant feeding modalities were known, all women in Group 1 were, in a sense, first generation breast-feeders. Five of six had been bottle-fed, and the other had been breast-fed for two weeks until her mother "quit because it was so frustrating." Thus any advice these grandmothers could give from personal experience would have been from their 1950s experience with early solids, rigid schedules, and few feedings per day.

It is possible that these mothers had a set of expectations for infant behavior which differed from those of mothers in the other feeding groups. This seems unlikely, however, since all were raising their first child and most had read the same books and been exposed to the same information in prenatal classes. On the other hand, it is quite possible that due to the inhibition of the let-down reflex by factors such as stress, anxiety, and infrequent nursing as described by Jelliffe and Jelliffe (1979b), these infants really were unsatisfied and therefore behaved in ways indicating it.

Mothers of infants in Group 1 followed two different strategies for coping with the alleged insufficiencies of breast milk. The first was to add food to the existing breast milk diet (N=7). In most cases this was formula, and it was consumed by the infant in small amounts immediately after each nursing session. This feeding pattern was one which physicians usually prescribed to mothers if there was

any question about milk sufficiency. The second strategy was one of replacing entire breast-feedings with formula (N=11). In no case where information was available was this pattern known to have been suggested by a physician.

This distinction between the use of formula and, in two of eighteen cases, solids as additions or replacements roughly predicts the time of weaning. "Replacements" correlate with early weaning--in all but one case, weaning occurred by the end of the second month. In contrast, with "addition" there was only one case in which the infant was weaned by the end of the second month. One possible reason for this difference in length of breast-feeding is physiological. Since milk production is maintained by the hormone prolactin, its production being stimulated by the beginning of each nursing session, the decrease in number of feedings per day in the "replacement" group should be expected to decrease milk supply, thus hastening the weaning process. Since in the "addition" category the number of breast-feedings per day remains unchanged after introduction of formula or other foods, no decrease in breast milk supply would be expected.

One striking feature of the women in Study II who follow the Group 1 feeding pattern is their almost total lack of prenatal planning of their overall infant feeding strategy. All had made the choice of breast-feeding over bottle-feeding, but none had thought any further about the use of other foods. Some seemed rather startled to be

asked about this and reported that family and acquaintances often wanted to know whether or not they intended to breast-feed, but none ever showed any interest in other aspects of infant feeding. Thus, while they had every intention of nursing their infants, they were quite susceptible to suggestions from others about feeding their infants in ways which, at least in the early weeks of life when lactation was being established, could undermine their chances for being successful breast-feeders.

In the remainder of the sample, all infants were exclusively breast-fed over five weeks, and thus lactation might be considered well established. They are divided into moderate length exclusive breast-feeders (N=21) and extended exclusive breast-feeders (N=41), with the division at the end of the third month. This separation is neither arbitrary nor artificial. Instead, it reflects the contribution of the new non-breast milk food to the total diet. In those with the moderate length exclusive breast-feeding referred to as Group 2, the formula or solids introduced were almost always replacements for breast milk feedings, while in the extended exclusive breast-feeding group (Group 3), these foods were additions.

The reason for this differential impact of introducing either solids or formula into the diet may lie in the fact that, although both groups were consuming solely breast milk at the time of the introduction, there were important internal differences in the configuration of

the diets. Group 2 infants had, from birth, had fewer breast-feeding bouts per day than Group 3. In Month 1, for example, the median number of feedings was six for Group 2 infants and eight for those in Group 3. Moreover, the average number of feedings per day tended to decline in Group 2 between the first and second months of life, while at the same time many Group 3 infants actually increased their daily feeding frequency. In some cases this increase may have been unnoticed. However, in at least one case it was deliberate. A mother in Study I, whose pediatrician prescribed formula supplementation because the infant failed to gain weight, instead chose to increase the number of feedings per day to increase her milk supply. (She also chose to change pediatricians to one more supportive of and knowledgeable about breast-feeding!)

Thus when new foods were added to the diets of Group 2 infants, they may have reduced the children's appetites to some extent, thereby reducing suckling. Then through lowered levels of prolactin, the milk supply might well have decreased, hastening a transition from breast milk to a non-breast milk diet. The frequently earlier weaning of Group 2 infants may be an end product of this process. Of twenty-one infants in Group 2, eleven had been weaned by the end of the study, compared with only one infant in Group 3.

Although the new foods fed to Group 3 infants may have had a satiating effect similar to that in Group 2, the

frequency of nursing bouts was already at such a high level that any reduction associated with the addition of new foods may not have appreciably affected prolactin levels. Thus, there would have been no progressive decline in milk production such as that hypothesized for Group 2. This is supported by Delvoye et al.'s observation that a minimum of six feedings per day maintains high prolactin levels (1977).

The actual reasons for the variability in the early months in number of feedings per day are unknown. Although it is tempting to describe Group 2 as implementing a pattern of "scheduled" feedings and Group 3 as feeding "on demand," this distinction cannot be made. A study of individual infants' diet diaries shows that while some nursed at the same time each day, these infants were a definite minority. For most Group 2 and 3 infants, the times of feedings and the intervals between them fluctuated from week to week. Relatively little concern was expressed by mothers over feeding schedules--beyond hoping for an uninterrupted night's sleep. Many claimed to be feeding their infants on demand and among these, the full range of feeding frequencies was represented.

Thus, the term "on demand" may be more useful in describing maternal intentions than in describing actual maternal behavior. It is, in fact, the perception of the infant's demand which initiates a feeding, rather than the demand itself. Many factors can shape this perception.

Vis and Hennart (1978) have attributed the pattern of extremely frequent feedings and apparent contentedness of infants among the Kivu of Zaire to the continuous body contact of mother and child. A mother soon learns to read her infant's smallest behaviors and to react to them. In contrast, in the developed countries such as the United States, numerous factors now serve to distance a mother from her child and thus reduce her ability to perceive hunger or other needs. For example, cribs, strollers, and infant seats now alleviate the need to hold infants. In Lansing, Michigan it was observed that most pediatricians, if asked, strongly discouraged an infant's sleeping in the parents' bed or even in the parents' bedroom. One mother in Study I took this advice so seriously that the infant was given the home's only bedroom and the parent slept on a rather broken down sleep-sofa in the living room.

Although it was not possible in this study to take objective measures of the amount of time mothers spent interacting with their infants, it was possible to separate the families into two categories, based on the degree to which their living situations forced close contact or permitted distancing. Infants in Group 2 were far more likely to live in two story dwellings (76%) than in single story, compact ones (24%). Conversely, a majority of Group 3 infants spent their early months of life in compact dwellings (61%) and a minority, in dispersed ones (39%). Thus, mothers living in situations which forced

them to be in close proximity to their infants fed them more frequently in the first few months than did women in larger dwellings. Among the latter, infants often napped in a second story bedroom while the mother was occupied on the first floor or even in the basement. An infant's quiet fussing which might be audible to a mother in a small apartment and perceived as hunger could go unnoticed in a larger home. The time necessary for an infant to gradually rouse itself to give a loud cry could be sufficient to create a significantly longer interbout interval, resulting in fewer nursing bouts per day.

Another factor which might have affected the frequency of early feeding is breast-feeding advice received during the early postpartum. Like Group 1, most Group 2 mothers from Study II were really first generation breast-feeders. Some recognized this and, while accepting their own mothers' help after the delivery, restricted it to housekeeping activities, choosing to manage all baby care themselves. In Group 3, many of the mothers and fathers had been breast-fed themselves. Others who had not been breast-fed did have sisters or friends who were experienced breast-feeders, and the new mothers often chose these women over their inexperienced mothers for help after coming home from the hospital. Therefore, Group 3 mothers probably received infant feeding advice more appropriate to breast-feeding than did Group 2. This may have contributed to the observed differences in patterns of

breast-feeding.

Thus, the study of infant dietary data clearly shows that breast-feeding is not a unidimensional behavioral category. Within it are several distinctly different infant dietary patterns. These patterns appear to be relatively unplanned, instead evolving through the early months of the infant's life as one action taken by the mother selects certain later possible options for her and eliminates others. Because of this, it is possible to make predictions of later dietary patterns of infants based on early feeding habits. Of the variables examined in this study, number of nursing bouts per day appears to be the best predictor.

Interaction of Infant Diet and Infant Growth

The analysis of infant growth data shows that its relationship to infant diet is a complex and dynamic one. Two types of interaction appear to occur. As has been assumed by much previous research, the foods and feeding habits of infants certainly seem to influence their growth. On the other hand, the way in which infants grow, particularly in the early months of life, appears to affect the manner in which they are fed. Together these form a reinforcing feedback relationship. This section will summarize the results of the data analysis which led to the inference that these two aspects of the infant feeding process exist. It will then show that supporting evidence can be found in some of the most widely cited studies of

infant growth and feeding. Finally, it will attempt to demonstrate that by changing one's assumption from that of a unidirectional causal link between feeding and growth to one of a more dynamic relationship such as that found in these data, some of the inconsistencies which have been the focus of so much attention and debate can be resolved.

Influence of Growth on the Dietary Pattern of Infants

This study demonstrates that, starting at birth, the feeding regime to which any infant is subjected is not a random event with respect to the size and growth of the child. In the most general terms, it appears that the feeding patterns of infants who are large at birth and display rapid growth velocity in the early weeks of life can be contrasted with those of infants which at birth are relatively small and initially grow rather slowly.

Infants in Group 3--that is, those exclusively breast-fed until at least the fourth month of life and not weaned until the sixth--have at birth the greatest mean weight for age (106.4% of NCHS median) and weight for length (95.6% of median) of any of the three feeding groups. Those in Group 1--with the shortest exclusive breast-feeding--have the lowest mean weight for age (102.6% of median) and weight for length (93.7% of median). The size superiority of the Group 3 infants is maintained through five months of age in weight and four months of age in weight for length, though the differences between groups narrows over time. One detail of breast-feeding practice

is also linked to size at birth. Those infants whose mothers settle into a pattern of shorter nursing bouts during the first month tend to be heavier and fatter at birth than those whose mothers report longer feedings.

Not only are Group 3 infants bigger at birth, but their initial growth velocity in weight for age and total fatfolds exceeds that of either of the other two groups. Mean changes in percent of median weight for age in Month 1 were -1.8%, 1.5%, and +3.3% for Groups 1 through 3, respectively. In total fatfolds, the average changes were +5.9mm, +5.8mm, and +6.4mm for the groups. Although Group 1 experienced a major dietary change during that time, Group 2 along with Group 3 was exclusively breast-fed.

There are several possible reasons why the feeding patterns of these infants appear to be a function of their early size and growth. First of all, there may be behavioral differences between large and small infants. If the former were more aggressive nursers or more vocal in communicating their demands to be fed, one would expect them to more rapidly establish the successful lactation which is characteristic of their feeding group. Data to document this are not available here, though when talking about infants in general, many mothers tended to attribute these behavioral traits to certain size infants.

A second possible explanation is that the relationship between infant size and feeding may exist as a part

of a larger complex of variables concerning maternal health and health consciousness. Favorable life-long living conditions and nutritional status (Weinstein 1981) as well as conditions during pregnancy (Philipps and Johnson 1977) have been linked to the birth of larger infants. These factors, in turn, characterize the health-awareness of women most likely to be successful, long term breast-feeders (Sauls 1980). The direct associations in this study of mothers' educational level and length of lactation are consistent with such a link. Thus, the correlation of birth size and feeding modality may in fact simply be incidental to this more direct relationship.

The third possible--and perhaps most readily documented--explanation for the association of growth and diet in this study is that mothers have concerns about and perceptions of infant needs which are specific to particular sizes and shapes of infants. Concern was expressed by a number of mothers in this study, for example, whose infants were relatively low in birth weight. This was particularly true of mothers who had been falsely led to believe they would give birth to larger than average children. The birth of a small infant in such cases seemed to cause considerable anxiety over the child's health. Mothers appeared to handle the infants more tentatively, often having a great deal of trouble dressing and undressing them for the first month or so. One of these mothers (with a husband 6'2" tall and herself 5'7" with a 49 pound

pregnancy weight gain) gave birth to a six pound son. The oversized clothes she had purchased in anticipation of a nine pound infant further accentuated what to her was his abnormally small size. Like other mothers in similar situations, she initially worried a great deal about his health and treated him--and made sure others treated him--as though he were very delicate. On the other hand, mothers of large infants tended to be more at ease with them, treating them as more rugged and less fragile individuals. The mother of the one set of twins studied gave only conditional consent before the birth to allow them to be measured. When each weighed over seven and a half pounds, she readily agreed to participate. She later attributed her earlier hesitation to the fear that they might be small babies.

This variability in concern over the well-being of infants based on size appeared to manifest itself in attitudes toward infant feeding. Despite the growing public awareness that "bigger" infants are not always "better," such attitudes are not universal among new mothers. And even among those who were seriously concerned about obesity, there was a strong feeling that, while fat babies are not necessarily the healthiest babies, smaller ones are even more at risk. In discussing the infant silhouettes used to stimulate discussion of body shape, most mothers chose the fattest and thinnest infants as less healthy and of those, finally chose the

thinnest as the least healthy, saying that it looked malnourished. Some reasoned that a fat infant would probably lose its "baby fat," but an overly thin one might well be seriously ill.

Such concern over thinness was not limited to hypothetical infants. Several mothers referred to their infants' thin limbs and visible ribs as "bird-like" when seen in the hospital after the birth or at home in the early postpartum. Others commented that they would "have to fatten up" their infants. Mothers such as this could easily doubt the efficacy of a feeding method such as breast-feeding with no immediate, tangible evidence (such as an emptied formula bottle) of success or benefit. An infant's cries which might, to a self-assured mother, have a different meaning, might be more likely to be interpreted as indicative of insufficient milk by a mother already anxious about her infant's health. Furthermore, the tension surrounding the feeding event in those cases might well result in inhibition of the let-down reflex. If a non-supportive atmosphere were added to this, the chances of successfully establishing lactation would probably diminish even further.

The later growth of infants whose mothers were unable to successfully establish lactation indicates possible overcompensation. By Month 3, Group 1 infants were fatter than either Groups 2 or 3. In several cases, infants who had had initial weight losses became the

fattest infants in the study. One such mother was told by her pediatrician to overdilute her son's formula at four months. When interviewed after that, she expressed her frustration: "You know, at first I was so worried because he wasn't gaining weight. Now we have to worry because he's gaining too fast. You can't win--you never know what is right."

While the small size of an infant sometimes worked against mothers' efforts to breast-feed, large size was used to advantage by others. Mothers with large infants who wanted to exclusively breast-feed used the issue of their infants' size to silence grandparents or pediatricians who considered breast milk an inadequate source of nutrients or thought supplements of solid food should be added at an early age. When asked if anyone had suggested a dietary change in the preceding month, these mothers (such as one whose child weighed over twelve pounds by one month of age) would laugh and poke at their infants' robust bodies, replying, "Yes, but does he look underfed?"

Thus, infants who were initially small and grew slowly appear more likely to be exclusively breast-fed for short periods of time. This may be due to a combination of factors, including maternal anxiety, inhibition of the let-down reflex, and succumbing to external pressures to supplement the breast milk diet. Larger infants may be less likely to be the objects of anxiety

and their mothers, better able to maintain breast-feeding in a nonsupportive social environment. Since the early feeding of an infant has been shown in this study to be a prime determinant of the future course of feeding, the impact of infant size on early feeding behavior may be an important factor in attempts to understand the dynamics of the infant feeding process.

Influence of Dietary Patterns on the Growth of Infants

While the previous paragraphs have discussed the possible impact of size at birth and early growth patterns on early and important feeding behaviors, the following will examine what is, to some extent, the reciprocal relationship. It will concentrate on the way in which diet seems to affect growth. In a study such as this of a free-living sample of 80 infants consuming almost 80 different diets, it is impossible to try to answer some of the questions which have traditionally been asked in infant nutrition research. The relative impact of formula or breast milk, for example, becomes meaningless when infants are consuming varying amounts, perhaps eating solid foods as well, and, as has been argued above, are of different sizes. However, there is a type of issue which can be explored here better than in more controlled studies. That is the impact on growth of minor variations in dietary patterns in infants where mothers have decided these are the optimal feeding strategies for their children. Two of these variations were identified in the analysis of

the dietary intake data: 1) the use of the same food in diets for the same age children as replacements or additions to the existing diet, and 2) the use of different foods to fulfill the same dietary role in children of similar ages.

Those infants in Group 1, all exclusively breast-fed for less than four weeks, provide the basis for comparing the effects of the use of formula as a dietary addition (Group 1a) and as a replacement (Group 1b). As stated earlier, those infants for whom it served as an addition consumed approximately two ounces after one or more nursing bouts per day. Those for whom it was a replacement consumed larger quantities of formula in place of entire nursing bouts. Generally among the former, weaning occurred after the second month and among the latter, before the end of the second month.

Growth differences between these two groups were marked during the first month. Although the "addition" of formula suggests Group 1a infants might display accelerated growth while "replacement" suggests Group 1b infants would maintain steady growth, practically the opposite was observed. Group 1a fell from an average of 104.4% of median birth weight to 96.6% of the median weight for age at one month, while during the same period Group 1b increased from 101.5% to 103.5%. The decreasing percent of the median for 1a represents an actual loss of weight in at least two cases. Group 1a remained at a

constant 93.6% of weight for length during the first month, while Group 1b rose from 93.8% to 100.1%. While both increased in total fatfolds, that for 1a was slight (+2.9mm), while the average increase for 1b was relatively large (+9.4mm). By one month Group 1a was the thinnest group of infants, compared to Group 1b which was the fattest. Those Group 1b infants which were weaned during Month 1 had the most marked increase in fatfolds during that month.

Undoubtedly these early growth differences were due to differences in caloric intake. The larger amounts of formula in Group 1b provided sufficient calories to maintain growth, but decreasing breast-feeding frequency in almost all cases eliminated any chances of breast-feeding success. The smaller amounts of formula in Group 1a were probably unable to compensate for the apparent insufficiency of breast milk, but, by not interfering with feeding frequency, allowed lactation to become established. In fact, some mothers in Group 1a were later able to reduce the formula supplementation and maintain infant growth and satiety on a diet consisting almost solely of breast milk.

Thus, the introduction of the same food into the diets of similar aged infants produces different patterns of early growth. A closer examination of the role the new food has in the diet and the circumstances surrounding its introduction provide plausible explanations.

The second diet variation noted in this study which appears to have a significant impact on growth is the use of different foods in similar dietary capacities for the same age infants. The distinguishing characteristic of Group 2 was the overwhelming use of newly introduced foods as replacements for breast milk in the diet, rather than as additions. This is consistent with the research of Marlin et al. (1980) who found that before three months of age, most dietary changes are caloric replacements. In the present study, Group 2 has been further subdivided into those mothers who replace breast milk with formula (2a) and those who do so with solids (2b).

The patterns of growth for Groups 2a and 2b began to show differences between one and two months, when the first introductions of non-breast milk foods occurred. From that time on, Group 2b displayed a slower overall growth rate than Group 2a. In weight for age, Group 2a went from 104.0% of the median at one month to 103.6% at five months. At the same time, Group 2b dropped from 106.5% to 101.1%. The difference between the groups was even more striking in weight for length. Between one and five months, Group 2a increased from an average 99.7% of the median to 102.0%, while Group 2b fell from 100.3% to 90.0% in the same time period. The difference between the groups was highly significant at five months.

After one month of age, Group 2b infants were frequently smaller than infants in any other feeding group.

When the extreme growth quartiles were compared, both Groups 2a and 2b tended to be overrepresented in the lowest quartile of weight for age by three months. But of the two, only the infants in Group 2b were overrepresented in the lowest quartile of weight for length. Thus while all the infants in combined Group 2 tended to be small, those in 2b tended also to be thinner, and the difference between the groups increased over time. This plateauing of growth rates among infants consuming breast milk and solids after two months is consistent with that observed by Ferris et al. (1979) for fatfolds.

These differences between the groups in growth seem to reflect the caloric differences in the replacement food. The mean caloric value of the initial replacement formula was estimated to be 218 kcal, while that of the solids was 48 kcal. Thus, the total daily energy intake of the infants consuming solids probably declined immediately. Since breast milk and formula are more nearly equivalent in calories, the energy intake of Group 2a infants probably began to decline only after the decrease in numbers of nursing bouts per day had an impact on milk production.

Two reasons for introducing non-breast milk foods predominate in Study II, where decision making factors were specifically elicited, and in cases in Study I where such information appears in fieldnotes. It was during this period between one and three months that most mothers

who had planned to return to work did so. Also during this time, the remaining mothers began to feel that their infants were demanding to nurse too frequently, waking too frequently at night, or exhibiting other behaviors they deemed inappropriate. Mothers returning to work almost always introduced formula into the diet. Those seeking to change their infants' behavior used both formula and cereal, but the latter was more common.

When the two reasons for the feeding change are compared, the introduction of a new food because of the physical separation of the nursing mothers and their infants clearly implies replacement. When these mothers discussed their plans, they did so in terms of which feedings (usually morning and late evening) they would retain as nursing bouts and which ones would be changed to formula feedings by the caretakers.

The feeding of solids was not discussed in the same way. Although the mothers of infants in Group 2b were never asked, their attitudes and actions seem in retrospect to indicate that they were not consciously trying to decrease their infants' breast milk intakes. They often reported, for example, that they had begun to feed their infants a certain amount of cereal at a specific time of day. In doing so, the event was often described in relation to either parental activities or non-feeding activities of the infant (e.g., before bedtime, after the parents' meal, or before the father came home from work).

Although the feeding categories defined here give the impression that the introduction of solids or formula are comparable options, little was observed to indicate that mothers viewed them as interchangeable. Many mothers in both studies attributed a pacifying effect to solids, particularly cereal, and it appears that it was this quality which those mothers in Group 2b sought. Formula was instead classified as a milk. Thus, those returning to work substituted a similar substance for the unavailable breast milk.

Thus, the use of two different kinds of infant foods with similar impacts on the existing diet produces different patterns of growth. This can be explained by comparing their caloric values. An examination of the situations in which they tend to be used reveals the rationales for their introduction.

Supporting Evidence from the Infant Growth and Diet Literature

Although other authors (Sauls 1980; Himes 1979) have stated that samples of breast-fed infants are highly selected and that those infants not thriving on breast milk automatically drop into other feeding categories, data to support this have never been explicitly presented. However, in reviewing several of the growth studies cited in Chapter II, similarities of data gathered in those studies to those data presented here are apparent.

In three investigations, infants who were either weaned or changed from breast milk to a mixed diet within the first six weeks of life had slower rates of growth during that period than did those infants who continued to be exclusively breast-fed. Fomon et al. (1970) compare the 45 infants who dropped out of their study with those 149 who adhered to the prescribed breast milk diet. "Insufficient milk" was reported to be the reason behind much of the attrition. Female infants who did not complete the study had a weight gain velocity only slightly lower than that of those in the study. However, the difference for males was more pronounced, significantly so in the second month. Holly and Cullen (1977) compare breast-fed infants and those receiving both breast milk and formula by six weeks. While the former had a percentage weight gain of 33% in the first month, the latter increased by only 24%. Saarinen and Siimes (1979) show that infants weaned to either of two types of formula before one month of age had lower weights and lower weight gain velocities from two weeks to two months of age than did infants who continued to be exclusively breast-fed. Thus infants making more significant early weight gains do appear to be more likely to continue to consume a diet composed solely of breast milk than those with slower rates of growth.

The possible overcompensation in feeding by mothers whose infants were either weaned or changed to a mixed

diet before one month of age is supported by evidence from two studies. By six months of age the mixed-feeding infants in Saarinen and Siimes study (1979) had gone from their earlier weight deficit (in comparison to those breast-fed) to a weight advantage. And in Huenemann's study of six month old infants, she finds that those breast-fed less than one month are overrepresented in the upper 10% and underrepresented in the lower 10% of her sample when ranked on an obesity index derived from weight, fatfolds, and girth measures (1974).

Therefore, examples of the interactions of growth and feeding observed in the present study can be found in the infant feeding literature. However, they have normally been presented without comment or statistical analysis, perhaps because of the assumptions about the interactions of infant growth and diet held by the researchers.

Conflicting Evidence for the Impact of Diet on Growth

As shown in Chapter II, the current literature on infant diet and growth is plagued by conflicting results. Evidence can be cited both for and against the argument that formula leads to heavier and fatter infants than does breast milk. The same is true for early or late introduction of solid foods. This section suggests that an approach to the study of growth and diet which does not assume a unidirectional relationship between growth and diet may be useful in trying to resolve these inconsistencies. The

disputes over the effects of formula are perhaps most easily resolved.

When several studies purporting to compare infants "breast-fed" and "bottle-fed" are examined, their results appear to depend on the way in which infants are assigned to feeding groups. Saarinen and Siimes (1979) classify as bottle-fed all infants who were initially breast-fed, but were weaned by one month of age. In contrast, the University of Iowa studies (Fomon et al. 1970; Fomon et al. 1971) and the early study by Thomson (1955) consider as bottle-fed only those infants never breast-fed.

The patterns of growth for breast-fed and bottle-fed infants do not differ in the Fomon et al. (1970; 1971) and Thomson (1955) studies. However, there are differences between the two groups in the Saarinen and Siimes study (1979). Breast-fed infants have a high initial growth rate. Bottle-fed infants recover and surpass the breast-fed group in later infancy. These results look very much like those obtained in the present study: early growth superiority of those infants successfully breast-fed and later overcompensation in cases where lactation was unsuccessful. Thus, differences in growth patterns among the three studies cited above may reflect the feedback relationship of growth on diet and not simple differences between the nutritional impacts of breast milk and formula.

Interaction of Infant Diet and Maternal Nutritional Status

Two assumptions about the relationship of infant feeding and maternal nutritional status were examined: 1) that breast-feeding is associated with postpartum weight loss, and 2) that breast-feeding leads to decreases in maternal fat stores. This section will summarize the results of those analyses. It will then propose possible explanations for the patterns of anthropometric changes observed.

Breast-Feeding and Weight Loss

No clear relationship was found between weight loss and breast-feeding. When the data were analyzed by months of breast-feeding, those weaning within the first two months appeared to have the lowest overall loss during the study. This may be due to the fact that the greatest weight losses for the sample as a whole occurred within the first three months. Those weaning before that showed very little loss during that time. Weaning appears to be accompanied by a temporary stabilization in maternal weight.

When data were analyzed by infant feeding group, the greatest initial loss was among mothers of Group 1a infants and the lowest, among those of Group 1b. Overall, the lowest mean weight losses were in Groups 1b and 2a. However, none of these differences were statistically significant. These results indicate that there may be

some effect of the proportion of the infant diet consisting of breast-feeding on weight loss. Both Groups 1b and 2a replaced nursing bouts with formula feedings, while other groups followed feeding practices which maintained the child's demand on the mother for nutrients at a higher level for a longer time.

The failure of these analyses to clearly confirm the assumed relationship between weight loss and breast-feeding may be due to three factors. First, mothers may have compensated for the nutritional costs of lactation by increasing their own dietary intake. When questioned at six months, virtually none of the women reported dieting or greatly increased activity level. On the other hand, most reported little change in appetite or intake from "normal" levels. However, no dietary intake data are available to substantiate these statements.

The second factor which may complicate attempts to isolate a significant relationship between weight loss and breast-feeding is the absence of a control group of women never breast-feeding. Most of the calculations of nutritional needs during lactation treat it as a physiological state identical to that of the "reference female," with the demands of milk production simply added to an otherwise normal body. Lactation may, in fact, be accompanied by basic alterations in metabolic status. The wide variety of physiological responses of women in

this study to breast-feeding suggests this. Thus women breast-feeding even for a limited period of time may be affected to the extent that they are an inappropriate comparison group in analyses trying to isolate the effects of lactation on weight. In fact, if a change in metabolism accompanies breast-feeding--and the association of altered weight loss velocity with weaning indicates it might--the assumed relationship may not exist. Viewed from an evolutionary perspective, there certainly is no apparent selective advantage for a biological phenomenon which constitutes a progressive and unchecked drain on the mother. There would, however, be a very definite selective advantage in being able to support lactation without physical depletion of the mother, especially in environments with an uncertain food supply, high risk of infectious disease, or high work demands on females. Given this, the lack of a strong relationship between weight loss and breast-feeding makes sense.

Although lactation may have no significant effect on weight loss, the prevalence of the assumption that it does can nonetheless be explained. One explanation is related to the simple input/output model of nutrition which persons in this culture (and many others) have. Mothers in this study frequently mentioned that they should be drinking more milk than usual. While this is a suggestion frequently made by dietitians and physicians, supposedly because certain amounts of whole milk are convenient

measures of the daily nutritional supplement which has been calculated as needed to support lactation (Food and Nutrition Board 1980), this was often interpreted by women to mean that milk input was necessary for milk output. In fact, women with milk allergies or aversions questioned their ability to successfully breast-feed. Women also reported that they felt they should drink a glass of water while nursing their infants, apparently to provide the necessary liquid. An extension of this input/output model is the belief that if a mother is producing breast milk and not significantly increasing food intake, the milk putput must come from her existing body stores, and this will be reflected in weight loss. Other ways by which it may be possible to accomodate the energy drain of lactation are not always considered. Most women, for example, have no notion of the possibility of metabolic alterations accompanying lactation. Nor do they consider the fact that motherhood may bring about reductions in exercise and energy expenditure sufficient to offset the cost of breast-feeding. For a woman used to being active, just the act of breast-feeding may impose restrictions on physical activity. One woman in the present study, for example, reported daily totals of 365 to 423 minutes nursing during the first two months postpartum. There may also be a poor understanding of the relative weights of various body components. While fat may be mobilized to support lactation, it will result

in weight loss only if there is no corresponding increase in the relatively heavier lean body mass. Once a mother begins to habitually carry a growing infant, such an increase in lean body tissue is very likely to occur.

One of the most impressive features of the postpartum weight change data in this study is their high degree of variability. Some women lost weight rapidly. In one case, a mother with a pregnancy gain of 30 pounds was several pounds below her prepregnant weight by two months postpartum. One of the factors influencing her decision to wean her son was her seemingly uncontrollable loss of weight. In other cases, women actually gained weight after the initial perinatal loss. Thus, at a population level, some weight loss probably does accompany breast-feeding. However, such a promise to women is meaningless until the regulating factors of weight change and dietary intake within individuals are better understood.

Breast-Feeding and Changes in Maternal Body Fat

The simple assumption that all women lose body fat while breast-feeding was not confirmed by analysis of data on midarm fat area. On the average, women increased, rather than decreased, in upper arm fatness during the postpartum period. There were variations in the amount of increase, and these coincided with the degree to which breast milk was the sole source of nutrients for the infant. Mothers of infants in Groups 1b and 2a--all of whom replaced breast-feeding bouts with formula--had the

greatest initial as well as cumulative increases in midarm fat area. Variations in postpartum fatness also appeared to be dependent on time since parturition. Weaning or introduction of non-breast milk food in the early months was followed by an increase in fatness. When these same feeding changes occurred late in the period of time studied, they were followed by a decrease in fat.

When the relationship of breast-feeding to maternal body fat was studied among long term breast-feeders who were losing weight, the mean number of nursing bouts per day in the first three months of lactation was found to be closely linked to fat area change. Two patterns emerged. Those with an overall decrease in midarm fat area (Group A) nursed their infants significantly more times per day than did those whose fat stores increased during the postpartum (Group B). There existed a strong inverse correlation of length of breast-feeding bouts with number of bouts per day. Thus, two different nursing styles--short, frequent feedings and long, infrequent feedings--were strongly associated with two patterns of change in maternal fat stores.

Since one of the most direct effects of nursing frequency is on serum prolactin levels, the results of this study suggest that the concordant variation of maternal fat may be a function of the same hormonal system. There are two physiological pathways through which this might occur (Figure V.-1). The first is the mediation of

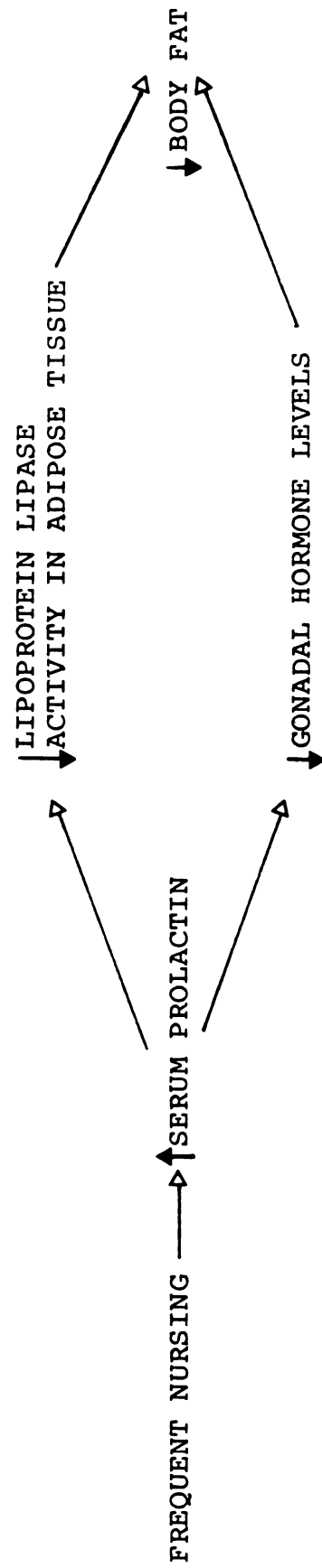


FIGURE V.1--Hypothesized Pathways for the Interaction of Nursing Frequency and Maternal Body Fat.

gonadal hormone production by prolactin. Serum prolactin levels in nursing women are inversely proportional to that of estrogen and progesterone (Donner and Wortman 1980). The level of progesterone, in turn, has been found to be related to fat deposition (Hytten and Leitch 1971). Thus, women who nurse frequently (such as Group A mothers in the present study) should be subject to greater suppression of ovarian hormone production and therefore less disposed to deposit fat in body stores than women who nurse infrequently (Group B).

The second pathway linking nursing frequency and fatness is mediated by the activity of the enzyme lipoprotein lipase, which is responsible for the uptake of lipids into adipose tissue. Since prolactin has been found to induce a decrease in lipoprotein lipase activity in peripheral adipose tissue and a corresponding increase in that in the breast (Zinder et al. 1974), women who nurse frequently and have higher serum prolactin should be less likely to increase in peripheral fatness than women who nurse less frequently.

Thus, possible explanations can be formulated for the observed patterns of fat change. These explanations relate nursing behavior to variations in maternal physiological parameters. Causes of these behavioral variations and the interaction of the hypothesized hormonal patterns with fecundity will be discussed in Chapter VI. Whether the fat changes indicate overall changes in body composition

or fat patterning still needs to be investigated.

Although the interactions hypothesized in Figure V.1 seem to account for the overall trends seen in maternal postpartum fat changes, these trends obscure a high degree of variability. The correlation between fat change and breast-feeding behavior was by no means perfect. Cases were noted in which women nursed their infants only four times per day. Yet their levels of midarm fat plummeted without apparently extreme weight loss. As with the investigation of weight loss and breast-feeding, it is this intra-population variability which is in many ways surprising. The participants in this study were purposely selected by criteria designed to produce as homogeneous a sample as possible. The fact that such variability exists again points to the need to understand the interactions of breast-feeding and maternal body changes in individual women before expecting to understand the impact of these interactions at the population level.

CHAPTER VI

SYNTHESIS AND CONCLUSIONS

Previous chapters have documented and discussed the dynamics within each of three major components of infant feeding systems involving breast feeding: infant diet, infant growth, and maternal nutritional status. The interactions among the three areas have been discussed in only a limited way. This chapter will formulate a more general biobehavioral model for infant feeding and discuss the implications this model has for formulating testable hypotheses for two areas of research. The first is lactation amenorrhea and the critical body composition hypothesis. The second is the adequacy of breast milk as a sole, long term nutrient source for infants.

A General Model of Infant Feeding Systems

The central component in the model presented here is the infant feeding behaviors which make up infant diet (Figure VI.1). These include what is fed to an infant, at what age it is fed, and perhaps most importantly, how it is fed (e.g., the scheduling, frequency, and mode of feeding). Some aspects of the physical environment can

have a direct effect on feeding behaviors. These include factors which impose a physical separation on the mother-infant pair. However, according to the results of the present study, the most profound influence comes from the social environment in which the nursing pair exists. Figure VI.2 amplifies the components of this environment. They include knowledge and beliefs about infant feeding, growth, and behavior, as well as the entire range of interpersonal relationships of which a mother is a part. Together these form the basis for a mother's perception of her infant's needs and of her options in meeting those needs. It is this perception, then, which determines what infant feeding behaviors will be implemented by the mother, within the limits imposed by the physical environment. It is important to note that infant growth and behavior affect feeding behaviors, but this relationship is for the most part mediated by the social environment.

In an infant feeding situation where breast-feeding is the sole source of infant nourishment, variations in feeding behaviors affect infant growth indirectly, through day-to-day changes in the parameters of maternal physiology involved in milk production. The factors involved in these changes are presented in Figure VI.3. Levels of serum prolactin affect the quantity of milk produced and, by regulating the level of lipoprotein lipase activity in the breast, the composition of the milk. Prolactin induced changes in peripheral lipoprotein lipase activity

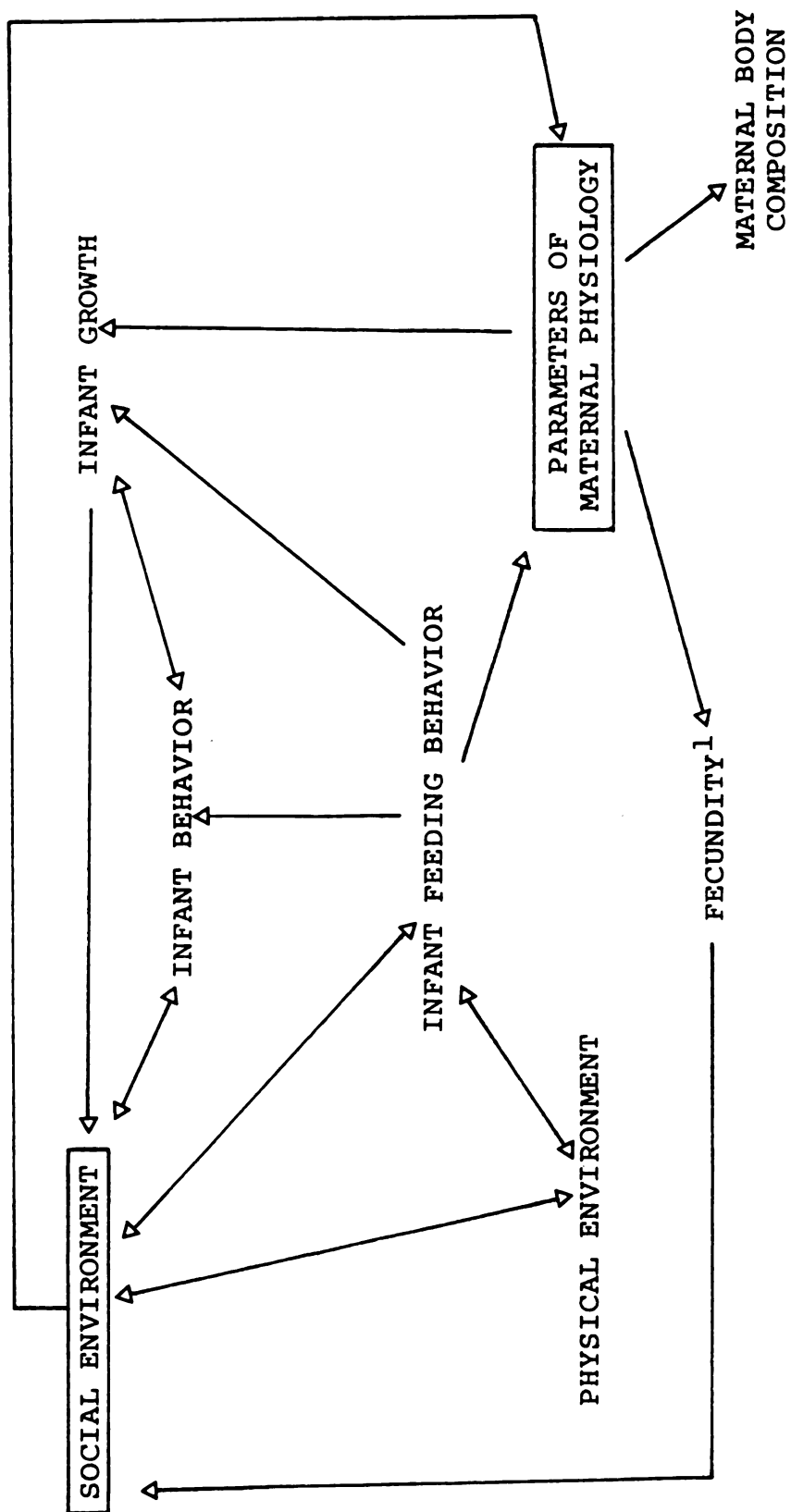


FIGURE VI.1--Model of the Interaction of Infant Feeding Behavior, Infant Growth, and Parameters of Maternal Physiology.

¹Different disciplines use the term fecundity in different ways. It is used here to mean reproductive potential, and not reproductive achievement.

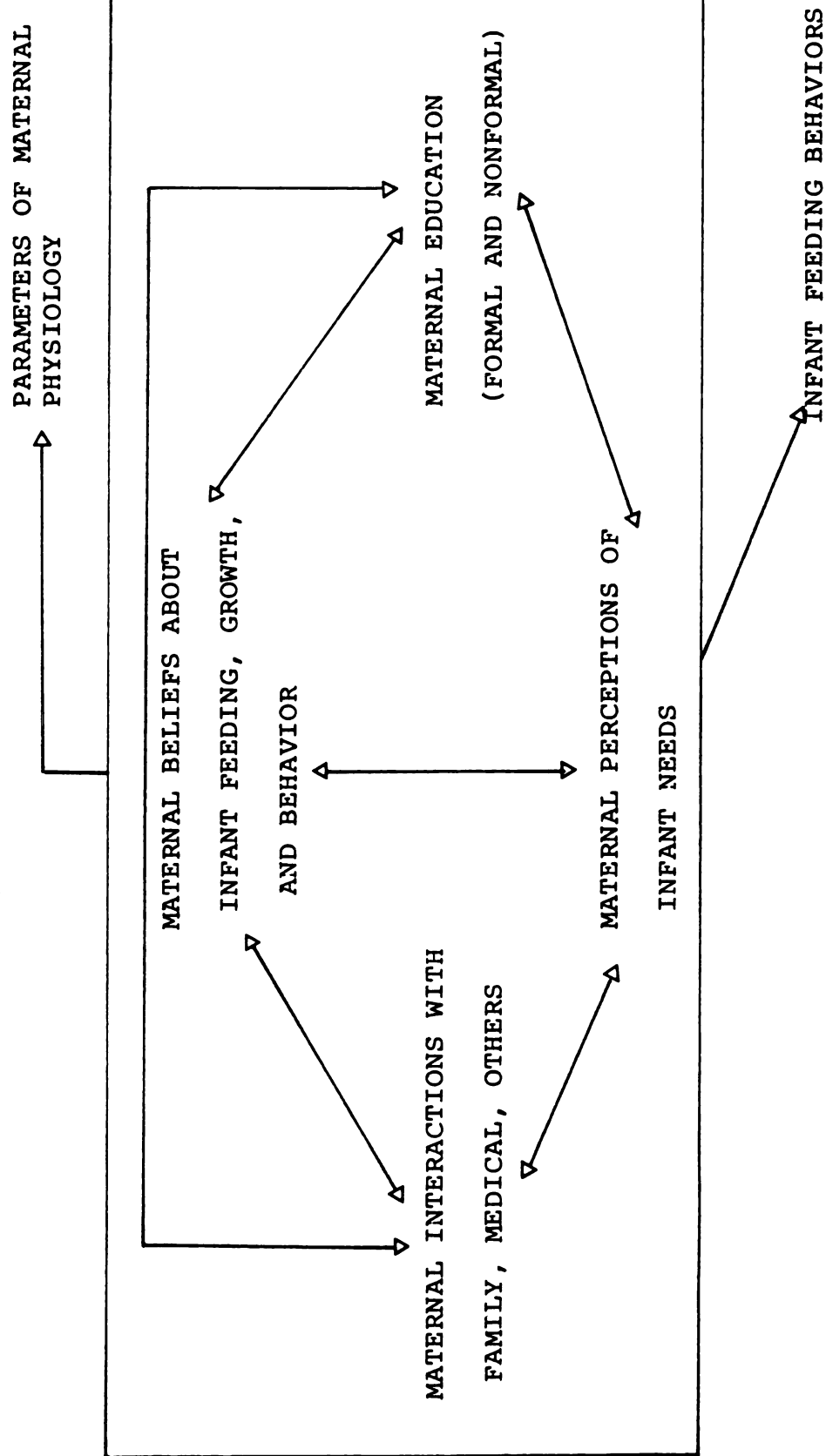


FIGURE VI.2--Components of the "Social Environment". (See Figure VI.1).

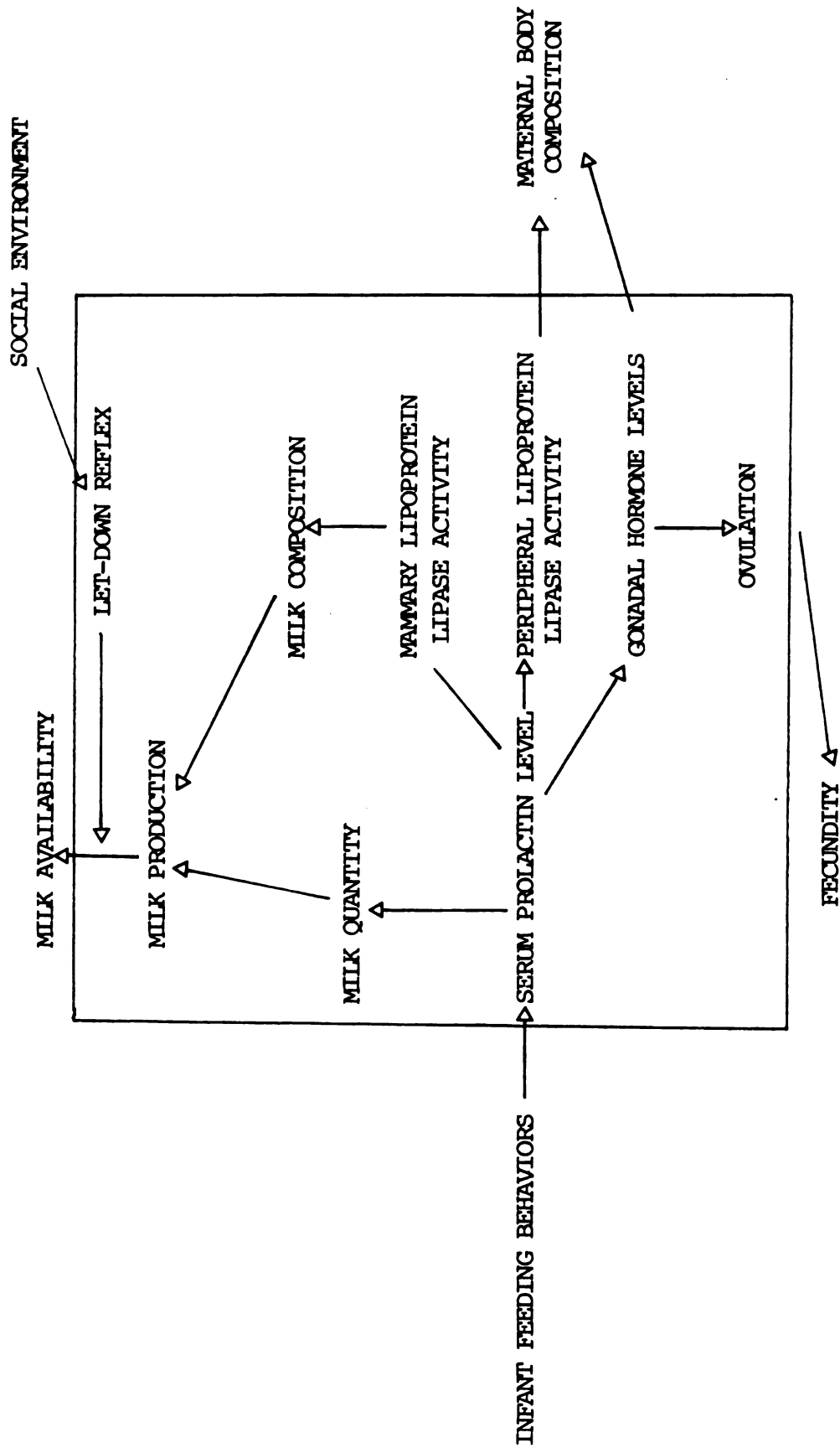


FIGURE VI.3—Components of "Parameters of Maternal Physiology." (See Figure VI.1).

also affect milk composition, by varying the uptake of dietary lipids into non-breast tissue and thus effectively varying the lipids available to mammary lipoprotein lipase. Maternal fatness and fecundity are hypothesized to be byproducts of variations in the serum prolactin levels, which vary themselves with different infant feeding behaviors. According to the proposed model, infant feeding behaviors also affect infant growth directly in cases where non-breast milk foods are fed. And, in addition to feeding behaviors and maternal physiology of lactation, infant growth is influenced by infant behaviors, especially through levels of energy expenditure.

Besides influencing feeding behaviors, the social environment affects maternal physiological parameters directly by either promoting or inhibiting the let-down reflex. In breast-feeding situations which are supportive and free of tension, this conditioned response to the infant readily occurs, causing the release of oxytocin into the bloodstream and the subsequent ejection of milk from the alveoli. However, when the breast-feeding context is one which is non-supportive or stressful, the let-down reflex is inhibited. Milk may be produced, but without an effective let-down reflex it is unavailable to the infant.

Three properties of this model make it a particularly appropriate one for studying the infant feeding complex. First, it can accommodate the full range of feeding

behaviors to which any infant may be subjected, not just those associated with the lactation process. Second, the model stresses the feedback cycle between infant growth and feeding and the fact that this relationship is always mediated by the social environment in which infant feeding decisions are made. Third, it allows for the impact that the whole range of infant feeding behaviors can have on maternal physiological parameters, suggesting that observed differences in maternal postpartum physiology may be explained, in part, by attention to variability in infant feeding behaviors. Thus, as social environments vary both inter- and intraculturally, feeding behaviors, maternal physiology, and infant growth patterns will all vary.

While the different types of data gathered in this research support this model, other variables were not examined which may invalidate the interactions proposed. One of these is maternal diet. It is not known whether variations in nutrient intake would affect the factors entailed in milk production and in the regulation of maternal body composition and fecundity. A second variable not studied is the quality of the mother-infant interaction immediately following birth.

Lactation Amenorrhea and Maternal Body Fat

The results of the present study have suggested underlying patterns of change in the parameters of maternal postpartum physiology (Figure VI.3). Further research

to confirm these patterns may help to resolve one current controversy: that of the relationship of lactation amenorrhea to maternal body fat. This controversy originated with the publication of the "critical body composition hypothesis" by Frisch and colleagues (Frisch et al. 1973; Frisch and McArthur 1974). Frisch cited evidence which she said demonstrated that a minimum percentage of body fat is necessary for ovulation to occur. Although her original argument dealt with menarche, it has been extended to include amenorrhea experienced by victims of starvation, female athletes and dancers, and lactating mothers. Although the etiology of the failure to ovulate is vague in Frisch's work, the hypothesis at first was widely entertained. It appeared quite logical from the perspective of adaptation that an organism--particularly a member of a species which invests high levels of energy in raising only a few offspring--should be fecund only if able to support a pregnancy and the offspring produced.

Nonetheless, Frisch's hypothesis has been severely criticized on a number of grounds. First, it is charged that the measures of body composition on which she bases her conclusions are not adequately sensitive to pick up the small variations in nutritional status she claims are responsible for the presence or absence of ovulation (Johnston et al. 1975; Trussell 1978). Second, it is charged that the work has used inappropriate statistics (Trussell 1980). Finally, she has been criticized because

research by others fails to replicate her findings (Huffman et al. 1978).

The results reported here suggest that female body fat levels are a side effect of a more direct relationship between infant feeding practices and fecundity, mediated by the prolactin induced gonadal hormones. To substantiate this, the following hypothesis and corollary should be tested:

Hypothesis: Lengthening interbout intervals will lead to increased production of gonadal hormones and the resumption of ovulation.

Corollary: If a mother's energy intake exceeds that expended for non-lactation activity and maintenance, ovulation will be accompanied by increase in her levels of body fat.

Therefore, as a side effect of hormonal change and subject to other unrelated influences, body fat may or may not vary with ovulation. If a mother changes breastfeeding frequency, thereby allowing levels of serum prolactin to drop and levels of the hormones necessary for ovulation to rise, ovulation should occur. But body fat levels will probably increase only if there is adequate caloric intake to support this rise (see Table VI.1). Therefore, changes in fatness with ovulation cannot be expected to occur in all populations or even among all women from the same population.

Thus, changes in infant feeding behavior rather than in maternal body fat should show the better correlation with the termination of lactation amenorrhea. While some

TABLE VI.1--Hypothesized Maternal Effects of Decreased Breast-Feeding
Frequency with Varying Levels of Caloric Intake.

Serum Concentration				
Maternal Caloric Intake	Prolactin	Gonadal Hormones	Ovulation	Maternal Body Fat
Exceeds requirements	decrease	increase	yes	increase
Does not exceed requirements	decrease	increase	yes	no change

studies exist which document ovulation and feeding behavior (Knauer 1981; Chen et al. 1974) and others, ovulation and maternal nutritional status (Delgado et al. 1978; Chowdhury 1978), none has collected all three types of data. Doing so may help to provide a satisfactory resolution of the current debate over the critical body composition hypothesis.

The Adequacy of Breast Milk

The second controversy to which the biobehavioral model proposed here is relevant concerns the nutritional adequacy of human milk to provide for maintenance and growth of infants. In 1979, Waterlow and Thomson published a paper entitled, "Observations on the Adequacy of Breast Feeding." In it they cited reports from developing countries which indicated that infant growth frequently faltered at about three months of age. They attempted to show that energy requirements after three months are such that breast milk may be insufficient to meet them. Waterlow and Thomson's paper was not well received, since it appeared at a time when the adequacy of breast milk was a crucial issue in attempts to limit marketing of infant formulas in developing countries as well as in the promotion of late introduction of solids in Europe and the United States. Jelliffe and Jelliffe (1979a), for example, replied by citing other studies in which no growth impairment had been reported and by claiming the nutrient composition of human milk was indeed sufficient

for infant needs to six months of age.

The results of the present study suggest that breast milk may well be nutritionally inadequate (that is, fail to support steady weight gain) at three months in some populations, but that this has less to do with the requirements of infants at this specific age than with changes in feeding habits likely to occur at about this time. To confirm this, the following hypothesis and corollaries can be tested:

Hypothesis: Lengthening the interbout interval will lead to decreased quantity and decreased fat content of breast milk produced.

Corollary I: Infants for whom this breast milk is a sole source of nutrients will manifest indications of reduced growth rates after the interbout interval is lengthened.

Corollary II: In societies where changes in maternal behaviors which affect feeding frequency commonly occur at a particular time in an infant's life, population-wide alterations in infant growth rates will occur at that age.

Declining frequency of breast-feeding has been shown in the second and third months of life. According to the proposed model of infant feeding, two factors may be responsible for this. One is a decrease in total milk output and the other is a decrease in breast milk fat content due to a reduction in mammary lipoprotein lipase activity. Thus, in other populations where similar patterns of decreasing feeding frequency occur, the same infant growth trends might be expected. If these changes

in feeding behavior are imposed by institutionalized patterns of maternal behavior, the trends may be even more pronounced.

Existing studies support portions of the proposed hypothesis and corollaries. Data from the Gambian studies of maternal and child health and nutrition (Rowland 1978; Rowland and Paul 1981; Whitehead et al. 1978), for example, show that the growth of breast-fed infants begins to falter in the third month, regardless of the time of year at which the child reaches this age. The investigators hypothesize that breast milk is inadequate to provide sufficient calories at that age. But when the ethnographic data which Rowland (1978) gives are examined, it is evident that it may not be breast milk per se which is inadequate, but the quantity and composition of that produced by these particular mothers.

Immediately after birth, these infants are fed very frequently--in a true demand pattern. By three months however, their mothers' social roles have changed. They are expected to return to work in the fields, and they leave the infants behind in the care of siblings (Rowland 1978). An infant is nursed thereafter on the mother's schedule of availability. Thus, with a longer interbout interval, milk production may decrease at this time. Rowland and Paul's (1981) data on concurrent changes in maternal body fat further support this line of reasoning. They find that by 13 weeks, mothers' fatfold measures

begin to increase, indicating increases in body fat. If this is indicative of increases in peripheral lipoprotein lipase activity accompanying changes in infant feeding frequency, it also suggests the occurrence of the hypothesized decrease in mammary lipoprotein lipase activity and the consequent decrease in breast milk fat content proposed in the model above. Thus, infant growth retardation at three months of age may be the result of concomitant changes in maternal availability for breast-feeding which in turn causes a change in breast milk quantity and composition.

There are indications from the literature that such an association of maternal breast-feeding behavior and particular ages of infants is not unusual. Other populations have similar demands placed on mothers when infants are about three months old. Chen et al. (1974) note that among mothers in Bangladesh and other South and Southeast Asian areas, conceptions are highly seasonal, occurring shortly after the harvest. Thus, these infants are approximately three months old at the subsequent harvest. It is at this time that mothers devote increasing amounts of time to agriculture, at the expense of infant feeding. Although the effect on the infants is not documented, Chen et al. note that the change in feeding is often sufficient to allow resumption of ovulation (1974). Therefore, apparent inadequacies of breast milk may appear at three months of age in these populations as well.

Collection of the sort of data necessary to test the proposed hypothesis may help to resolve the question of breast milk adequacy by directing attention to sources of variability in the milk produced by individual mothers over the course of lactation. Consideration of pressures exerted on such mothers by their physical and social environments may then help to explain observed differences in the apparent inadequacy of breast milk to provide for satisfactory infant growth.

Conclusions

The original objectives of this research were to identify major infant dietary strategies and to document their interaction with infant growth and patterns of change in maternal postpartum nutritional status. From the results of the analysis, several summary statements can be made:

1. The patterns of infant feeding in the first month of infancy are predictive of later dietary components. The frequency of nursing bouts in the first months of life is one of the best predictors of dietary practices in later infancy.
2. Infant size at birth and early growth are associated with both early and late infant feeding patterns. The less the deviance of an infant from culturally approved patterns of growth, the lower the likelihood that the

infant will experience a change in feeding regime.

3. A non-breast milk food can serve as either a replacement for breast milk or an addition to it. Which of these two dietary roles it takes determines the impact of such a food on infant growth, on the course of breast-feeding, and on maternal nutritional status.
4. The common assumptions of loss of weight and fat during lactation belie the complexity of the associations. Both the frequency and duration of breast-feeding correlate with observed patterns of maternal body change. Hormonal and enzymatic action induced by difference types of breast-feeding practices may be the underlying modifiers of weight and body composition in the postpartum period.

This study was designed to limit known sources of genetic and behavioral variability. Only low-risk, Caucasian primiparae with healthy, normal, full term infants were included. Nonetheless, throughout the study the high degree of variability in both behavioral and biological factors was obvious. That distinct relationships between infant feeding strategies and infant growth on one hand and infant feeding strategies and maternal

nutritional status on the other have emerged from this indicates that in studies of other populations it will be important to document ranges of variability as well as the averages in order to produce a coherent picture of the infant feeding process.

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APPENDICES

APPENDIX A
LETTERS OF INTRODUCTION AND CONSENT FORMS

DEPARTMENT OF ANTHROPOLOGY

EAST LANSING • MICHIGAN • 48824

COLLEGE OF SOCIAL SCIENCE

COLLEGE OF HUMAN MEDICINE

COLLEGE OF OSTEOPATHIC MEDICINE

CONSENT FORM

1. I, _____ authorize the participation of myself and my infant(s) _____ as subjects in the postnatal portion of the project entitled Incremental Weight Gain in Pregnancy which is being conducted by Dr. Cheryl Ritenbaugh of Michigan State University and such qualified female assistants as she may need and employ. I understand that these assistants will be under her supervision at all times during the project.
2. The nature and general purpose of this part of the project have been explained to me. The procedures to be performed (Appendix) have been fully described to me by _____.
3. I understand that no risk to my infant's or my health and wellbeing is associated with our participation in this project.
4. Dr. Ritenbaugh or her assistants have offered to answer any inquiries I might wish to make at any time during the course of the project.
5. I also authorize Dr. Ritenbaugh to obtain from my prenatal and hospital charts and from my infant's hospital chart the information listed in the Appendix. I understand that no other parts of my medical records will be available to her.
6. I understand that at no time will any information obtained regarding me or my infant(s) be made available to anyone not connected with the study. Any published reports on this study will present data in cumulative form, with no references to individual subjects.
7. I understand that I am free to withdraw myself and/or my infant(s) from participation in any part of this project at any time I may wish to do so without penalty or prejudice.
8. I understand that nothing in the above waives any of my legal rights.

Date _____

Signature of individual for consent_____
Signature of representative from
the study

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Appendix
DATA TO BE COLLECTED

Mother

Monthly measurements (also at 7 days post-partum)

weight

minimum ankle and wrist and maximum calf circumferences

mid-arm circumference

fatfold thicknesses at triceps and subscapular locations

maximum abdominal circumference

distance pubic tubercle to xyphoid process

Bimonthly interview

24-hour dietary recall

food habit questionnaire

Infant

Brazelton Behavioral Assessment (at 1 and 7 days)

Monthly measurements (also at 1 and 7 days)

weight

recumbent length

head, arm, and chest circumferences

fatfolds at triceps, biceps, and midabdomen

Materials to be completed by the mother

weekly--one 24-hour diet journal for the infant

monthly--report on eating habits, health, and activity level of infant

At completion of the study

mother's prenatal and hospital chart

urine protein and sugar

hematocrit and hemoglobin

blood pressure

blood sugar, if available

placental weight

infant's hospital chart

birth and daily weight

length

APGAR scores at 1 and 5 minutes

feeding modality (breast, bottle, supplemental sugar water, etc.)

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1. I, _____, authorize the participation of myself and my
(name)
infant(s) as subjects in the study of third trimester pregnancy growth and
infant growth and feeding practices which is being conducted by Sara Quandt
of Michigan State University.
2. The nature and general purposes of the project have been explained to me,
and the procedures to be performed (Appendix) have been fully described.
3. I understand that no risk to my infant's or my health and well being is
associated with our participation in this project.
5. I understand that at no time will any information obtained regarding me
or my infant(s) be made available to anyone not connected with the study.
Any published reports will present data in cumulative form, with no
reference to individual persons.
6. I understand that I am free to withdraw myself and my infant(s) from
participation in the study at any time I may wish to do so.
7. I understand that nothing in the above waives any of my legal rights.

Date _____

Signature of individual giving consent

Investigator -- Sara Quandt

APPENDIX

Data to be CollectedMother

1. Prenatal interview: plans for infant feeding, previous experience with infants, expectations for own infant's behavior
2. Measurements biweekly during pregnancy and post partum at 2 weeks, 3 and 6 months
 - weight
 - height (one time only)
 - midarm and calf circumferences
 - triceps and subscapular fatfold thicknesses

Infant

1. Measurements at 1 day, 2 weeks, and monthly from 1 to 6 months
 - weight
 - recumbent length
 - midarm, head, chest, and thigh circumferences
 - triceps, biceps, subscapula, midabdominal, and thigh fatfold thicknesses
2. One 24-hour diet diary per week
3. Questions on infant growth, behavior, and feeding to be answered by mother at measuring sessions.

Sara Quandt
Department of Anthropology
Michigan State University
353-2950

MICHIGAN STATE UNIVERSITY

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M E M O R A N D U M

TO: Participants in the project, Incremental Weight Gain in PregnancyFROM: Cheryl Ritenbaugh, Ph.D. Assistant Professor
Sara Quandt & Debbie Gregg, Research Assistants

CR

DATE: November 15, 1977

When we wrote the first memorandum asking your help in the study of weight gain in pregnancy, we indicated that we intended to continue monitoring your weight and that of your infant for a short time after delivery. Since that time we have received funding for a longer and more detailed follow up of the infants. In this letter we would like to tell you more about this portion of the project and ask your continued participation.

Previous studies of weight gain in pregnancy have ended at delivery. Those studies which have been conducted on infant development have begun at birth with little information on the preceding pregnancy. Since we have collected such detailed data on the prenatal progress of you and other women, we are in the unique position of being able to study the correlation between this progress and the early growth and development of infants. To do this, we would like to extend the postnatal portion of the project to up to 6 months after delivery. During this period we are interested in gathering data on the normal body adjustments of mothers after birth and on the growth, eating habits, and activity levels of their infants.

One part of the postnatal study mentioned in the first memorandum was an evaluation of your infant's behavior at about a week after delivery. This would involve using a safe, nationally-used rating scale which would be explained to you in detail before asking your permission to do it. Also, we would like to weigh and measure you and your baby once a month. The measurements are similar to those used during your pregnancy, and the new ones for your baby will be explained to you. On several occasions we would like to do a diet recall on a 24-hour period followed by a short questionnaire on your eating habits. Since it will be important to us to know what your baby is eating, we will provide you with a form on which you can record at your convenience what your baby is eating during one 24-hour period each week. If you are breast feeding, we would want you to record the time and length of each nursing session for that day.

We are interested in having you and your infant continue with us in this project. If for some reason you will be unable to do so for the full 6 month period and would still like to help, we would be most grateful for any participation possible.

jr

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MEMORANDUM

To: Potential participants in study of third trimester pregnancy growth and infant feeding and growth

From: Sara Quandt, Graduate Research Trainee, Department of Anthropology

Date: July 25, 1979

I am a biological anthropologist with a strong interest in human growth and nutrition. Currently I am conducting a study which involves pregnant women in the Lansing area. This letter is to explain the project and to ask your help in its completion.

During a study I helped to conduct last year on weight gain during pregnancy and its effect on infant growth, I became quite interested in two different topics. The first is the variability of third trimester weight and body changes in pregnant women and their possible relation to factors such as onset of labor and sex of the child. The second is the interaction of nutrition and growth and the way in which mothers decide on a feeding plan for their infants. When I began reading the scientific literature on this subject, I discovered that most previous studies have looked at infants only in terms of whether bottle or breast-fed. They have generally ignored other factors such as the frequency of feeding and the timing of introduction of solids. For this reason, it is hard to apply the results of these studies to other infants. I think there are probably many different patterns of feeding which lead to healthy babies. What I would like to do is to find out what the variability in infant feeding is and how that relates to growth. Additionally, I would like to learn about the ways mothers decide among various ways to feed their infants.

You and the other women who are being asked to participate in this study were chosen from healthy women having their first babies under the care of several obstetricians in the Lansing area who are cooperating with me. Your participation would involve, first, an interview before your baby is born so I could find out your feelings on infant feeding and you could get to know a little more about me and this study. Also, I would want to weigh you and do a few measurements periodically before delivery. After delivery, I would measure your daughter or son at regular intervals--about every four weeks--until age 6 months. The measurements would include weight, length, and several others which would each be explained to you. When measuring, I would also want to ask a few questions about any changes you had made in your infant's feeding, as well as general questions about how things were going. The measuring would take place at your home--unless you preferred that we met elsewhere--and would take 30 minutes or less. Since it would be important to know what your baby was eating, I would provide you with a form on which to record at your convenience what your baby ate during one 24-hour period every week.

I will be calling you within the next few days to answer any questions you might have. I hope you will be interested in becoming involved with me in this

APPENDIX B

DISTRIBUTION OF MOTHERS RETURNING INFANT DIET DIARIES

APPENDIX B

DISTRIBUTION OF MOTHERS RETURNING INFANT DIET DIARIES

Figure B.1 shows the distribution of number of diaries returned by mothers during the study. For those women who dropped out of the study before six months, a projected number of returned diaries is entered. This is based on rate of return before leaving the study.

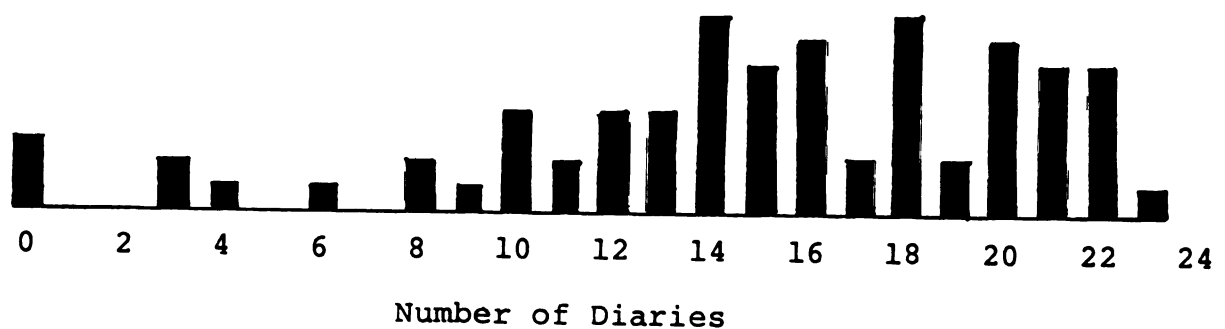


FIGURE B.1--Distribution of Mothers Returning Diet Diaries.

APPENDIX C

INFANT OUTLINES USED IN DATA COLLECTION

APPENDIX C

INFANT OUTLINES USED IN DATA COLLECTION

The six infant outlines on the following pages (Figure C.1) were used to elicit maternal ideas of appropriate and inappropriate body shape. Each was traced on a blank card. These were then shuffled and presented as a group to the mothers.

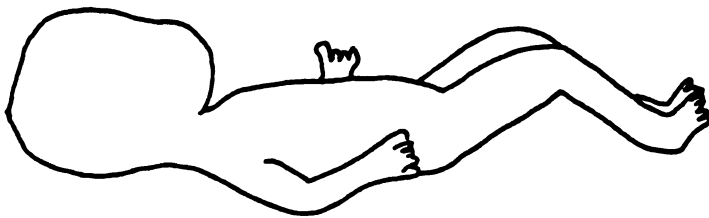
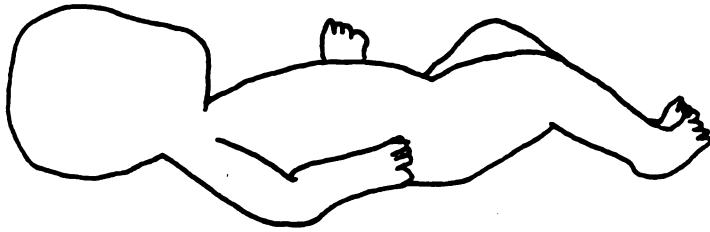
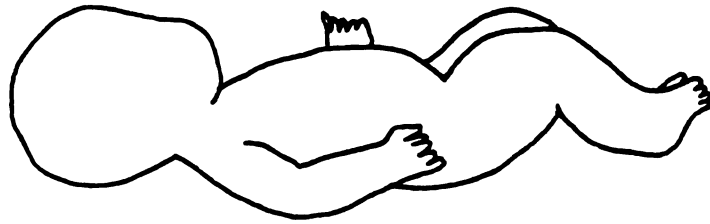


FIGURE C.1--Infant Outlines.

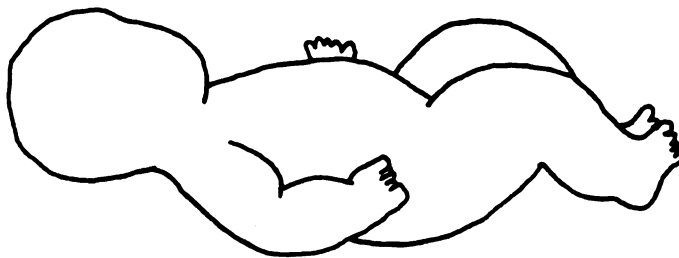
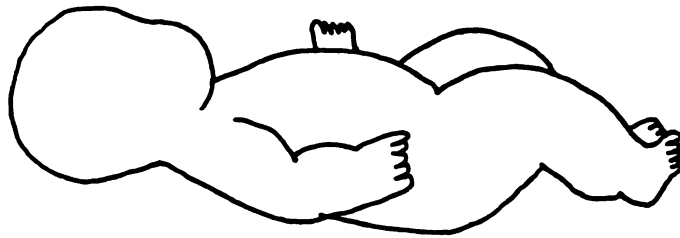
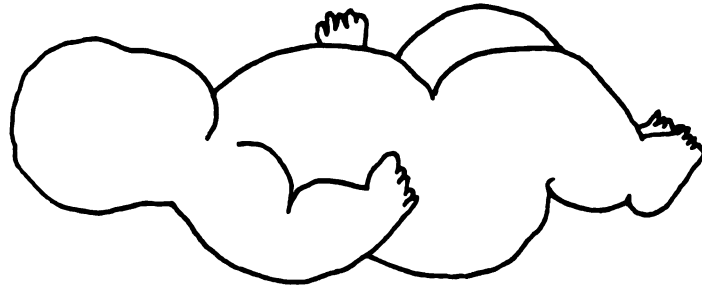


FIGURE C.1 (cont'd).

APPENDIX D

REASONS FOR INTRODUCING NEW FOOD TO A
BREAST MILK DIET

APPENDIX D

REASONS FOR INTRODUCING NEW FOOD TO A BREAST MILK DIET

<u>Infant Behavior</u>	<u>Food¹/=+²/Month</u>
<u>ID#</u>	
48 B ³ had slept through the night at an earlier age; had now stopped sleeping through the night.	C + 4
51 M wants to tide the baby over to four hour feedings. B currently wants to nurse too frequently.	Fr + 4
57 B couldn't go long enough without nursing. Kept crying, making sucking motions with mouth, wanting more food.	C + 4
58 B not satisfied on breast milk. Kept crying, making sucking motions with mouth, wanting more food.	Fo = 1
61 B seemed to want to eat all the time. Because of hot, humid weather this annoyed M.	C + 5

¹C=cereal; Fo=formula; Fr=fruit

²"+" represents addition; "=" represents replacement

³B=baby; M=mother

62	B was crying "constantly." M said, "Not satisfied on breast milk."	Fo	=	1
66	M thought it would get infant to sleep through the night.	Fo	=	2
68	B wanted to nurse frequently--at one to two hour intervals day and night.	C	+	4
72	B crying a lot, colicky, wanted to nurse "all the time."	Fo	=	2
73	B fussy in the evening, breast milk did not pacify.	C	+	3
74	B waking one or more times during the night.	C	=	5
80	M trying to get baby to sleep through the night.	C	+	5
81	B not satisfied after nursing. M thought breast milk not enough. B fussed after feedings.	Fr	+	5

External Suggestion

50	Pediatrician told M to start cereal because infants that age need iron not obtainable from breast milk.	C	+	5
53	Pediatrician noted insufficient infant weight gain; said M's breast milk supply "inadequate" to provide needed calories.	Fo	+	1
54	Pediatrician told mother infants that age need additional iron; M could use cereal or iron drops (told her certain ill effects possible from drops).	C	+	5
55	Pediatrician told mother infants that age need additional iron; gave her choice of cereal or iron drops (told her certain ill effects possible from drops).	C	+	5

- | | | | | |
|----|---|----|---|---|
| 67 | M had been receiving increasing pressure from mother-in-law, who thought the baby was "old enough to need real food." | C | + | 5 |
| 69 | M reports feeling pressure from husband's family, particularly mother-in-law who thought baby "so big he needs food"; mother-in-law also doubted whether the daughter-in-law's small breasts could supply enough breast milk. | C | + | 4 |
| 76 | Doctor told M he thought the baby was "big enough" to need more iron than breast milk could provide. | Fo | = | 5 |
| 77 | Doctor told M that the baby needed iron now and that breast milk did not contain any. | C | + | 6 |

Situational

- | | | | | |
|----|---|----|---|---|
| 52 | M returning to work (teaching); needed to have something for baby-sitter to feed infant during day. | Fo | = | 2 |
| 64 | M returning to work (nurse in hospital); wanted to get infant used to food so the babysitter could feed him during the day. M planned to nurse at night. | C | + | 3 |
| 65 | M returning to work (teaching); wanted to be the person to introduce infant to solid foods which she would eat while at the babysitter's. | C | = | 5 |
| 70 | M going back to graduate school classes; Fr needed something for father to feed infant to tide him over until M returned home to nurse him. | Fr | + | 5 |
| 71 | M returning to work (secretarial); was satisfied she had given infant a good nutritional start; now wanted to wean so babysitter could keep infant content with formula during the day. | Fo | = | 2 |

Maternal Health

- | | | | | |
|----|---|----|---|---|
| 59 | M hospitalized at bout one week postpartum for hemorrhage, D & C; tried to keep nursing baby, but found milk supply affected by anesthetic; hospital staff impeded attempts to have infant in room with mother. | Fo | = | 1 |
| 63 | M hospitalized for appendectomy at 2 weeks postpartum; was not allowed to nurse because of possible effects of drugs on infant; milk supply had diminished by the time allowed to nurse, so continued with formula infant had received while she was in hospital. | Fo | = | 1 |
| 79 | M reported breasts engorged, nipples too sore to nurse. | Fo | = | 1 |

Other

- | | | | | |
|----|---|---|---|---|
| 49 | B was beginning to display an interest in food; picking up parents' food and putting it in mouth; mother wanted to start solids while B was interested to avoid having a picky eater later in life. | C | = | 3 |
| 75 | M could not articulate reason. | C | = | 2 |
| 78 | M could not articulate reason. | C | + | 3 |
| 56 | B exclusively breast fed. | | | |
| 60 | B exclusively breast fed. | | | |