Nutrition, lactation, and birth interval components in rural Guatemala[1-3]

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ABSTRACT The effects of maternal nutritional status and food supplementation ingested by the infant on the duration of postpartum amenorrhea and on the duration of the menstruating interval was examined. A significant negative association was found between the nutritional status of the mother during the 3rd trimester of pregnancy and infant supplementation, on the one hand, and the length of postpartum amenorrhea on the other hand. These associations remained significant after controlling for each other and for other potentially confounding factors for which data were collected. These results support the hypothesis that maternal nutritional status, by determining the amount of breast milk available, hence the frequency, duration, and intensity of suckling, is indirectly, negatively associated to the length of postpartum amenorrhea. Furthermore, no association between maternal nutritional status and the length of the menstruating interval was found. *Am J Clin Nutr* 1982;35:1468–1476

KEY WORDS Maternal nutrition, pregnancy, lactation, postpartum amenorrhea, menstruating interval, infant supplementation, prolactin, breast milk

Introduction

A birth interval is defined as the period between one live birth and the next. Beginning with a live birth, the birth interval can be divided into several components: the period of postpartum amenorrhea, the menstruating interval, and the following period of gestation (1, 2). The length of the birth interval is dependent on the duration of each component, with the postpartum amenorrhea and the menstruating interval components having greater variability in their duration than the other.

The first component of the birth interval, postpartum amenorrhea, has been the subject of considerably more study than the others during recent years (3–6). Preliminary results from the Institute of Nutrition of Central America and Panama (INCAP) Longitudinal Study of Nutrition and Mental Development revealed that improved nutritional status of the mother during pregnancy is associated with decreased duration of postpartum amenorrhea. In addition, food supplementation ingested by the infant, a proxy for frequency of suckling, was negatively associated with the duration of postpartum amenorrhea. The fact that these associations remained significant after controlling for each other, and for other correlates of postpartum amenorrhea, was considered to be evidence of the existence of independent effects of both food supplementation to mother and to the infant on postpartum amenorrhea (7). Recent publications by other investigators (8, 9) are in agreement with the hypothesis that improved nutritional status results in a shortened period of postpartum amenorrhea. In addition to the relationship between maternal nutritional status and postpartum amenorrhea, these results give partial support to the hypothesis of

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a hormonal mechanism related to prolactin secretion as a response to suckling and of an interaction between hormonal and nutritional mechanisms in the determination of postpartum amenorrhea.

Others (10, 11) have also reported high levels of prolactin during prolonged lactation in women with postpartum amenorrhea, which supports the hormonal mechanism hypothesis. A very recent report by Lunn et al. (12) sheds new light on the mechanism by which nutrition and breast-feeding could affect postpartum amenorrhea. These authors show that an improvement in maternal diet produces significant reductions in plasma prolactin concentration during all stages of lactation.

Relatively less attention has been given to the menstruating interval, the period of menstruation after postpartum amenorrhea and preceding the next conception. A few reports have shown statistically significantly positive correlations between the age of the woman; parity, the husband's absences, and length of lactation on the one hand, and the length of the menstruating interval on the other hand (13, 14). However, no associations have been found between indicators of maternal nutritional status and nutritional intake and the length of the menstruating interval (5, 14).

The goal of this paper is to analyze further the effects of maternal nutrition, infant nutrition, and frequency of suckling on two birth interval components: duration of postpartum amenorrhea and menstruating interval, in the context of INCAP's prospective study carried out in a chronically malnourished population in rural Guatemala.

Materials and methods

In January 1969, the Division of Human Development of INCAP initiated a prospective study of the physical and mental development of infants in four small Spanish-speaking villages in Eastern Guatemala (15, 16). This study was experimental with nutritional and health interventions conducted in four villages with similar demographic, ethnic, socioeconomic, and nutritional characteristics.

The population of the four villages was 3358 in 1975 and increased at an average annual crude rate of 2.7% between the 1969 and the 1975 census. In the 1970 to 1974 period, the crude birth and crude death rates were 42.5 and 6.9/1000, respectively.

In two of the villages, a high protein-calorie drink called "atole" (6.4 g of protein and 91 cal/100 ml) was made available daily to all residents. In the other two villages, a nonprotein, low calorie drink called "fresco" (33 cal/100 ml) was also provided daily to the entire population. In addition, all four villages received preventive and curative medical care from auxiliary nurses under the supervision of a physician.

Largely as a result of the provision of free primary health care and the food supplementation program, the infant mortality rate dropped from between 150 and 200 in the later 1960's to 50/1000 in the early 1970's. Contraceptive practice was virtually absent. Furthermore, within the study villages, moderate chronic malnutrition was endemic.

Food supplementation began in January 1969 with the introduction of the two types of liquid supplements. The food supplementation centers were open mornings and afternoons, 7 days a week and attendance and consumption of the supplement was free and voluntary. As a result, a wide range of supplement intake during pregnancy and lactation was observed. Subjects were provided with a cup containing 180 ml; more supplement was given if requested. Leftovers were measured and actual intake, on an individual basis, was recorded to the nearest 10 ml.

Herein we review data for all mothers during the postpartum period who had a delivery between January 1969 and February 1977 (n = 1106) and who were followed-up until September 1977. However, because reliable information on menstruation and lactation was not collected prospectively until the end of 1970, there is prospective information for only 806 completed birth intervals.

The dependent and independent variables included in the analyses and the data collection procedures are described below.

Dependent and independent variables

The duration of postpartum amenorrhea, the menstruating interval, and lactation practices were obtained by monitoring menstruation and lactation every 14 days in all women of reproductive age, who were pregnant or had been pregnant in the last 7 yr. As in a previous report (7), the duration of postpartum amenorrhea is defined as the interval (in months) between a birth date and the first incidence of two menses occurring within a 3-month period. The duration of lactation is defined as the interval (in months) between a birth date and full weaning. The menstruating interval is defined as the number of full calendar months from the first postpartum menses to the month of conception.

Food supplementation is the main experimental treatment. The ingestion of the supplements is expressed in terms of calories, because the usual dietary intake of these villagers appeared to be more limited in calories than in proteins. The groups of mothers to be studied will be defined by *1*) the amount of supplemental calories consumed by trimesters during pregnancy and lactation, *2*) the estimates of daily home diet intake, and *3*) the summation of both home dietary intake and supplement consumption as an estimate of total calorie intake.

Home diet information was collected from 1969 to 1977 at the end of each trimester of pregnancy. The 24-h recall dietary survey was used (17). Home dietary intake in the last two trimesters of pregnancy was averaged to provide estimates of the usual home energy intake for each woman. After March 1974, dietary recall information was collected monthly for lactating women and infants and averaged for each trimester of lactation.

In addition, the recall method was used to collect information on frequency of suckling. At the end of each trimester of lactation the mother was asked the number of times the child was put to the breast during the preceding day.

A variety of maternal anthropometric measures was taken at the end of each trimester of pregnancy and lactation. From these data, maternal height and head circumference during pregnancy were selected as proxies for past nutritional status, and maternal weight change from the 3rd to the 9th month of lactation was selected as an indicator of present nutritional status.

Obstetrical variables collected, in addition to maternal age at delivery, were parity and birth interval from the prior delivery. These were obtained through census and pregnancy histories.

Information on maternal morbidity during pregnancy and lactation was obtained through surveys carried out every 2 wk. The survey was symptom-oriented and used retrospective home interviews of mothers. For these analyses, a morbidity indicator, combining the incidence of diarrhea, anorexia, and headache, was used as a proxy for maternal morbidity during pregnancy and lactation.

A family socioeconomic scale was devised summarizing construction materials and the number of rooms in the family dwelling. This standardized scale was used as an indicator of the family's socioeconomic status. Other variables, including birth weight, gestational age, sex of the newborn, and age of the father were also included in the analyses.

Results

Two types of postpartum amenorrhea and menstruating intervals are distinguished—the "entirely prospective" (or closed) interval and the "truncated prospective" (or open) interval. If the start and end of an interval fell within the prospective period of data gathering, the interval is called "entirely prospective." The "truncated prospective" interval starts in the prospective period but is truncated by out-migration or termination of the study.

A life table procedure was applied to all intervals that started during the study period, regardless of whether they were open or closed. **Table 1** shows the life table analyses for the lactation, postpartum, and menstruating intervals of the study group. The mean lengths of lactation, postpartum amenorrhea, and menstruating interval in this group of women are typical when compared to those of other natural fertility populations (18). In these analyses as well as in the following analyses, still births and infant deaths are excluded. Also, since no differences in the distribution of the dependent variables between atole and fresco populations were found, they are combined in this report.

In order to examine in detail the effect of nutrition on the duration of postpartum amenorrhea and the menstruating interval, this study concentrates on the entirely prospective intervals. The fact that these analyses could be biased toward short intervals is recognized. However, because of the low attrition rate ($\leq$10%) and the prolonged follow-up of the study sample, this bias should not substantially affect comparisons of interval length by nutritional status, nutritional intake, or other variables.

Mean daily supplemental, and home energy and protein intake during pregnancy and lactation is shown in **Table 2**. The mean weight of women in the study villages is 50 kg; thus, requirements would be about 2300 kcal/day and 45 g of protein per day (net protein utilization = 70%) during pregnancy and about 2550 kcal/day and 61 g of protein per day throughout the first 6 months of lactation (19). The data suggest that during pregnancy, energy, rather than protein, is more likely to be a limiting nutrient in the diet of these villagers. Nevertheless, the likelihood of the diet also becoming protein deficient is increased during the first months of lactation.

Regarding the patterns of weight changes in pre- and postpartum women, it was found that prepartum weight gain in these women (from 3 to 6 months) averages 7.5 kg. The weight changes from the last month of pregnancy to 3 months postpartum, including the weight loss associated with delivery, is 5.9 kg. Weight loss continues from 3 months postpartum until some time after 12 months postpartum.

Table 3 presents a number of additional characteristics for the combined atole and fresco population. No statistically significant differences were found between the atole and fresco villages for the parameters presented in Table 3.

As shown in **Table 4**, obstetrical characteristics, lactation, nutritional status of the mother, and food supplement ingested by the infant affect the duration of postpartum

TABLE 1
Probability of full weaning, first postpartum menstrual flow and conception not occurring by end of trimestral periods

Months since beginning of interval (birth or menstruating interval)	Probability of remaining lactating	Probability of remaining amenorrheic	Probability of remaining menstruating
3	0.993051	0.959848	0.491118
6	0.982965	0.889550	0.383988
9	0.959945	0.818108	0.308990
12	0.893519	0.681243	0.264971
18	0.494402	0.266922	0.216264
24	0.143472	0.078694	0.121708
Median duration (months)	17	14	3

TABLE 2
Maternal and infant energy and protein intake in the study population

	Energy (kcal/day)			Proteins (g/day)		
	Total energy intake*			Total protein intake*		
	n	$\bar{x}$	*SD*	*n*	$\bar{x}$	*SD*
Maternal intake						
Pregnancy	723	1562	440	720	47	13
Lactation†						
3 mo	338	1766	573	342	55	22
6 mo	402	1764	615	408	55	22
9 mo	394	1739	591	401	54	21
12 mo	381	1709	599	390	54	22
Infant intake†						
3 mo	440	71	101	429	2.3	3.2
6 mo	483	133	167	467	4.0	5.7
9 mo	492	248	220	494	7.1	7.5
12 mo	442	434	252	488	10.9	8.3

* Total nutrient intake equals the sum of home dietary intake and food supplementation.
† Home dietary information began to be collected after 1974.

amenorrhea. The menstruating interval is affected by obstetrical characteristics and the length of lactation. However, complex interrelationships between the nutritional, demographic, and socioeconomic factors that affect fertility were found. Thus, it may well be that the observed correlations are spurious.

In order to determine the relative impact of each variable on the length of postpartum amenorrhea and the menstruating interval, after controlling for all potentially confounding factors for which data are available, multiple regressions were performed. This procedure is based on a general linear model in which the dependent variable, either the length of postpartum amenorrhea or the length of the menstruating interval, is assumed to result from a linear (additive) combination of some independent variables, some of which are discrete and others which are continuous variables, and the effect of random error. In the regression equations the independent variables were total nutrient intake of the mother during each trimester of pregnancy, supplemental caloric intake for both mother and infant during the first 9 months after birth, maternal characteristics including parity, age, and birth interval for the previous delivery, maternal anthropometric measures during lactation (maternal height, head circumference, and weight change during lactation), infant characteristics (sex, birth weight, gestational age, and weight changes during lactation), husband's age and height, and family socioeconomic status. Finally, "dummy variables" such as the type of supplement consumed by the mother (0 = fresco; 1 = atole) and sex of the infant (1 = male; 2 = female) were also considered in the model. In summary, the multiple regression equations considered a set of independent and dummy variables to predict the length of postpartum amenorrhea or menstruating interval. This statistical proce-

TABLE 3
Descriptive statistics for selected maternal and infant characteristics in the study population

Characteristics		n	x̄	SD
Obstetrical variables	Parity	1208	3.4	3.0
	Interval from previous birth (mo)	953	28.9	14.3
	Maternal age (yr)	1206	26.9	7.1
Maternal anthropometry	Height (cm)	1224	149.1	5.2
	Head circumference (cm)	1223	51.1	1.3
	Weight change 3–9 mo postpartum (g)	536	−1274	2346
Maternal morbidity during pregnancy (%)		773	14.6	21.6
Infant anthropometry	Birth weight	778	3056	461
	Weight change birth-9 mo (g)	685	4395	969
Frequency of suckling/day at 3 mo of age		189	10.4	3.8
Frequency of suckling/day at 6 mo of age		244	10.1	3.8
Frequency of suckling/day at 9 mo of age		260	10.1	4.0
Frequency of suckling/day at 12 mo of age		271	9.6	4.2
Height of the father (cm)		719	160.7	6.0
Age of the father (yr)		1089	32.6	8.5
Socioeconomic indicator*		989	−8.2	102.3

* Standardized measure ($\bar{x} = 0$ for all families in the four villages).

dure has been described in great detail elsewhere (20).

In the regressions with the length of postpartum amenorrhea as the dependent variable (n = 736 cases), total nutrient intake of the mother during the 3rd trimester of pregnancy and supplemental caloric intake of the infant during the first nine months after birth are significantly negatively associated with the length of postpartum amenorrhea (slope = −1.1 months per 100 kcal/day, p ∠ 0.05; and slope = −0.7 months per 100 kcal/day, p ∠ 0.05, respectively), after controlling for each other and for the other independent variables. In addition, supplemental caloric intake of the mother during the first 9 months after delivery, parity and birth interval are positively associated with the length of postpartum amenorrhea. Furthermore, head circumference of the mother is negatively associated to the duration of postpartum amenorrhea. It is important to mention, moreover, that in this sample the amount of supplemental calories consumed by the mother during the first 9 months after delivery is significantly positively associated with the length of lactation (slope = 0.2 months per 100 kcal/day, p ∠ 0.05).

Nonetheless, only birth interval from previous delivery and gestational age of previous pregnancy are statistically positively associated with the length of the menstruating interval (n = 557 cases). When the duration of lactation and the length of postpartum amenorrhea are entered as independent variables in the regression equation, both are significantly related (p ∠ 0.01) to the length of the menstruating interval after controlling for all other factors. The relationships are in the expected directions; longer postpartum amenorrhea is associated with shorter menstruating intervals and longer lactation is associated with longer menstruating intervals. The nutritional indicators used (anthropometric measurement and nutrient intake) are not significantly associated with the length of the menstruating interval, and the statistically significant simple correlations found between the length of the menstruating interval and characteristics of the mother and father disappear when controlled for in the multiple regression analysis.

Finally, analyses were performed on data for a subset of the study sample which includes all mothers who delivered after 1974, and for whom more complete information on

TABLE 4
Relationship between maternal and infant characteristics and the length of postpartum amenorrhea and menstruating interval

Characteristics		Postpartum amenorrhea		Menstruating interval	
		n	*r*	*n*	*r*
Obstetrical variables	Parity	789	0.12**	592	0.18***
	Interval from previous birth	786	0.21***	590	0.16***
	Maternal age	789	0.15***	592	0.19***
Maternal nutrient intake	Caloric supplementation during pregnancy	789	−0.05	592	−0.09*
	Home caloric intake during pregnancy	554	−0.10*	471	0.03
	Home caloric intake at 6 mo lactation	240	0.02	162	0.21**
	Total caloric intake during pregnancy	554	−0.11**	417	0.00
	Total caloric intake at 6 mo lactation	180	−0.05	130	0.28**
Infant nutrient intake	Caloric supplementation during lactation 0–9 mo	745	−0.11**	561	0.01
	Home caloric intake at 6 mo	280	−0.15*	159	0.02
	Total caloric intake at 6 mo	280	−0.14*	167	0.09
Length of lactation	Mo	759	0.58***	583	0.16**

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Only variables with at least one significant association are included. Maternal height, maternal head circumference, maternal weight change 3 to 9 months pregnancy and 3 to 9 months postpartum, maternal morbidity during pregnancy, maternal calorie supplementation during lactation 0 to 9 months, birth weight, and socioeconomic indicators were not statistically associated with the length of postpartum amenorrhea or the length of the menstruating interval.

home dietary intake during lactation and frequency of suckling was available.

In these analyses, the multiple regression was expanded to include measures of total nutrient intake of the mother and of the infant during lactation, and a measure of the frequency of suckling.

In the regression with the length of postpartum amenorrhea as the dependent variable (n = 170) there is a significant negative association between total nutrient intake of the child and the length of postpartum amenorrhea (slope = −0.7 months per 100 kcal/day), while no association was found between maternal nutritional intake and the length of amenorrhea. Total nutrient intake of the infant is negatively associated with the number of breast-feedings ($r = -0.16$, $p \angle 0.05$). This supports the use of supplementary nutrient intake as a proxy for frequency of suckling.

Data for this subsample are also useful for exploring the association between frequency of suckling and the length of postpartum amenorrhea. Table 5 presents the results of life table analyses for the combined entirely prospective and truncated prospective postpartum amenorrhea periods. As shown in Table 5, in all groups, there is a higher probability of remaining amenorrheic in the higher tercile of frequency of breast-feeding than in the lower tercile.

Furthermore, only the interval for previous birth and the father's age are found to be significantly associated with the length of the menstruating interval, when multiple regression analysis is carried out on this subsample.

Discussion

The findings presented herein and the results of previous investigations discussed in the introduction are in general agreement concerning a negative relation between nutritional status and nutrient intake and the length of postpartum amenorrhea, and a positive relation between frequency of suckling and the length of postpartum amenorrhea. It has been shown, however, that the reduction in the length of postpartum amenorrhea attributable to indicators of nutritional status and nutrient intake is small when compared to the strong negative correlation between infant supplementation during lactation, a proxy for frequency of suckling, and the length of postpartum amenorrhea. The latter results would also be in agreement with those of Lunn et al. (12), who report lower levels of prolactin in well-nourished lactating mothers, with both groups having the same frequency of suckling, if it were shown that malnutrition reduces the volume of breast milk available to the infant, which in turn, determines how long and how hard the baby sucks at the breast. Diminished breast-milk production would tend to prolong the period of amenorrhea, because the more suckling it takes to satisfy the infant's nutritional needs, the lower the probability of resuming menstruation (21).

TABLE 5
Probability of remaining amenorrheic at 15 months postpartum* by terciles of frequency of suckling at 6, 9, and 12 months postpartum

Frequency of suckling (terciles)	Months postpartum		
	6	9	12
Low	0.531 ± 0.070†	0.549 ± 0.084	0.648 ± 0.070
0–8 times/day	(72)	(43)	(46)
Middle	0.621 ± 0.070	0.632 ± 0.063	0.860 ± 0.052
9–11 times/day	(75)	(69)	(44)
High	0.679 ± 0.067	0.751 ± 0.056	0.761 ± 0.062
>11 times/day	(63)	(65)	(46)

* The value 15 months was chosen because it gives the $P(x)$ value closest to 0.500.

† Mean probability of remaining amenorrheic ± SE. Number of cases are in parentheses. Statistically significant differences between high and low tercile were found at 9 months postpartum using the following critical ratio:

$$CR = \frac{P_1(x) - P_2(x)}{\sqrt{(SE_1)^2 + (SE_2)^2}}$$

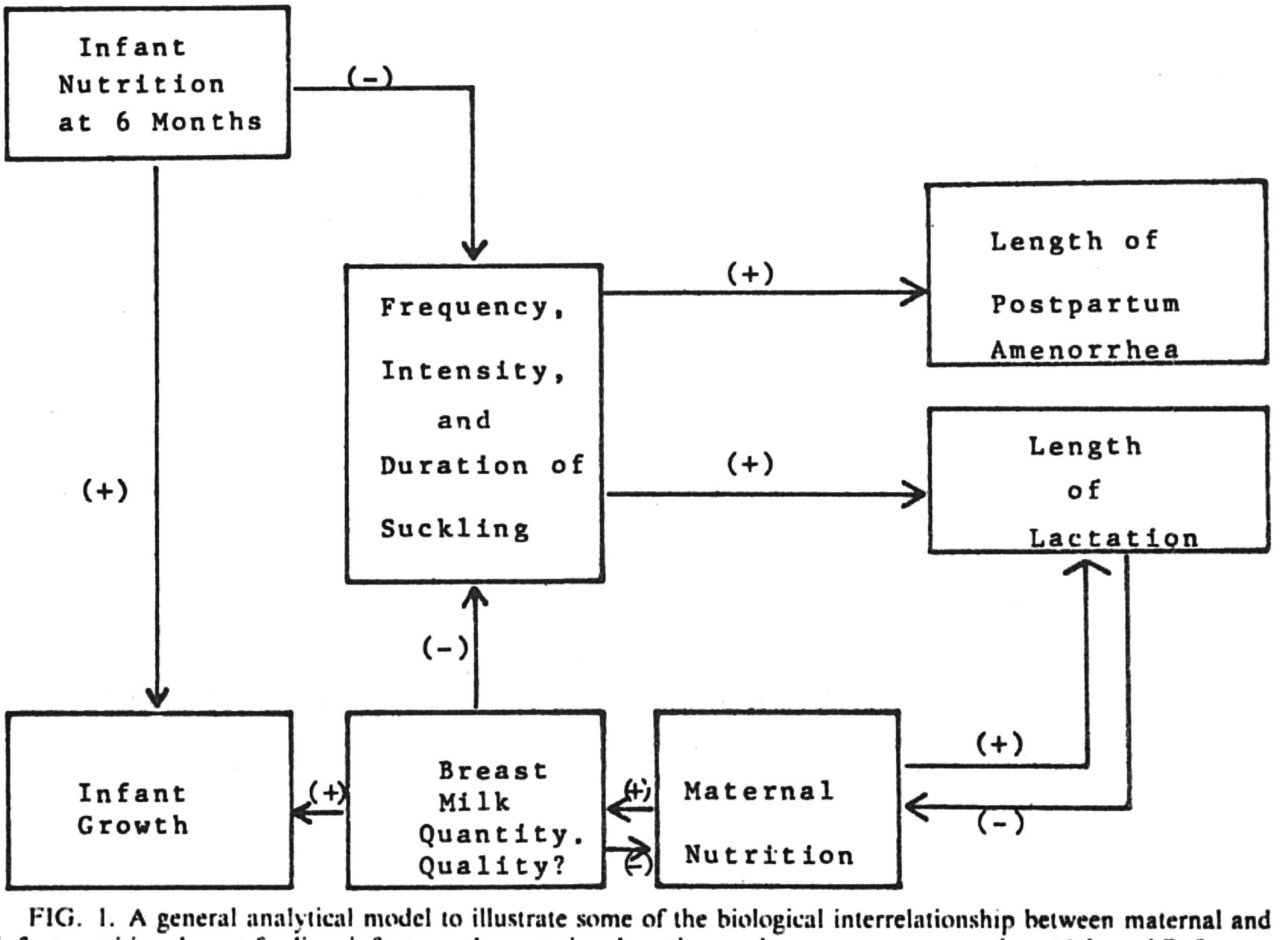

FIG. 1. A general analytical model to illustrate some of the biological interrelationship between maternal and infant nutrition, breast-feeding, infant supplementation, lactation, and postpartum amenorrhea. (Adapted Reference 24.)

Present knowledge gives some support to the above interpretation of our results. It has been shown that the principal effect of maternal nutritional deficiency on milk secretion is a decrease in its volume (22) which determines the intensity of the nursing stimulus, hence, the prolactin response (23). A general analytical framework to illustrate some of the complex interrelationships between maternal and infant nutrition, infant growth, breastfeeding, lactation, and the length of postpartum amenorrhea is presented in **Figure 1** (24). The *arrows* in Figure 1 point to the direction of the association between these variables. The *plus* and *minus* correspond to the positive and negative associations, respectively, found in this study.

However, data do not support the hypothesis of the minimum standardized weight required for the return of menses (25). As shown in our preliminary analysis (5) and confirmed in this large sample, women in the study population tended to lose weight throughout their lactation period. Typically, women were still losing weight, rather than reaching the minimum standardized weight, when their menses returned.

Regarding the length of the menstruating interval, the findings in this study show that it is not related to maternal nutritional status and nutrient intake. This is consistent with previous INCAP publications and with data from rural Bangladesh (14). Moreover, in the present study a strong positive association between the length of lactation and the length of the menstruating interval was found after controlling for all other confounding factors on which data were collected. Furthermore, a statistically negative association between the length of postpartum amenorrhea and the length of the menstruating interval was detected after controlling for all the other independent variables. These results lend support to the hypothesis of a higher probability of anovulatory cycles when menses return shortly after birth than when menses take longer to reappear. In addition, the association between lactation and the menstruating interval suggests that some of the factors affecting the length of lactation may also affect ovulation and/or implantation of the ovum. An effect of lactation on the probability of a successful implantation of the ovum has been previously suggested (26).

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