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NUTRITION AND BIRTH INTERVAL COMPONENTS: THE GUATEMALAN EXPERIENCES

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INTRODUCTION

A birth interval is defined as the period between one live birth and the next (1). Beginning with a live birth, it can be divided into several components: the period of postpartum amenorrhea, the menstruating interval, and the next period of gestation (2,3). Lactation, initiation of menstruation and ovulation after delivery, conception and intrauterine development of the fetus each place a large demand on the nutritional status of women; thus, malnutrition may lower the biological capacity to conceive, bear, and deliver a live child (4).

Evidence that these intermediate fertility variables are partially dependent upon nutrition is diverse, and often indirect, but not unconvincing. Several authors have suggested that the nutritional status of the mother affects the duration of postpartum amenorrhea in lactating women (5,6,7,8,9). Furthermore, the duration of postpartum amenorrhea is apparently associated with per capita income; mothers from high socioeconomic groups (5,7,10) are amenorrheic for less time than mothers from low socioeconomic groups (11,12,13). Aside from the implication of a nutritional impact suggested by socioeconomic comparisons, the possibility that nutrition may be related to the duration of postpartum amenorrhea is given additional support by the increased prevalence of amenorrhea reported during times of severe food shortage and famine (14, 15).

Some experimental evidence to date also supports the plausibility of the above hypothesis. Chavez and Martinez (16) compared the postpartum amenorrhea of a small group of lactating women receiving food supplementation through pregnancy and lactation to a control group of lactating women receiving no supplementation. Their results suggest that one of the effects of supplementing the diet is to significantly reduce the duration of postpartum amenorrhea. They reported that postpartum amenorrhea lasted 7.5 months in the supplemented group and 14.0 months in the control group, although retrospective information on prior pregnancies showed that both groups had similar lengths of postpartum amenorrhea before food supplementation.

LONGITUDINAL STUDIES IN GUATEMALA

Over the past seven years the Division of Human Development at the Institute of Nutrition of Central America and Panama (INCAP) has been carrying out longitudinal research in four communities of eastern Guatemala (17,18). This study examined the major hypothesis that mild to moderate protein-calorie malnutrition adversely affects the physical growth and mental development of infants and preschool children. The longitudinal study is a multidisciplinary project involving in depth analyses of the sociocultural, psychological, physical and nutritional condition of the children in these communities.

The study of nutrition, physical growth and mental development began in January 1969. Since its initiation, basic demographic data have been collected in the form of a bi-annual census. Moreover, bi-weekly home visits have collected data on the timing and incidence of various reproduction related events such as births, conceptions, menstruation, migration and changes in family composition. A core working group of demographers, epidemiologists, and other related professionals have recently begun to analyze these data and to extend research efforts in the demographic area.

Population

The population under study live in four Spanish speaking, subsistence agricultural villages in the department of El Progreso, Guatemala. The villages were originally chosen on the basis of their relative isolation, and homogeneity with respect to language, culture, size and general economic and social structure.

The ethnic background of the population is Ladino, or mixed Indian and Spanish. The main crops of these agricultural communities are corn and beans, most of which is consumed in the same village. The median annual income is approximately $200.00 per family, with most expenditures allocated for food and clothing. Although schools exist in all of the communities, the average adult schooling is about 1.5 years and functional literacy is low. Modern contraception is uncommon. There is little permanent migration, and contact with the outside world is generally limited to trips to nearby markets. Seasonal migration occurs once a year when some of the men harvest cash crops in the coastal zones.

The entire population of the four villages was 3359 in the 1975 census. In the period 70-74 the crude birth and death rates were respectively 42.5 and 6.9 per 1,000. Total fertility rate was 7.1. The percentage of females age 15 to 45 living in consensual or formal marriages was 68% (average of the 1969 and 1975 censuses). Largely as a result of the free basic medical care and food supplementation, the infant mortality dropped from between 150 and 200 in the 1960's to about 50 per 1,000 in the early 1970's.

Study Design

To test the basic hypothesis of the longitudinal study, a quasi-experimental design was employed. Experimental treatment consisted of food supplementation in the four villages. In two of the villages, a high protein calorie drink was made available daily in a central dispensary. This beverage is similar to a popular local gruel, atole. In the other two villages, a non-protein, low calorie drink, similar to a local cold drink known as fresco was provided daily. The nutrient content of both supplements is shown in Table 1.

The low calorie supplement, or fresco, contained no protein and provided only one-third of the calories contained in an equal volume of atole. Both supplements contained the vitamins and minerals which were limited in the normal diet. Atole and fresco were carefully measured daily and recorded to the centiliter at the distribution center in each village. Since consumption of the supplements was free and voluntary, a wide range of supplement intake was observed in mothers and infants. In addition, in all four villages, free outpatient preventive and curative medical services were provided. These services also provided nutritional rehabilitation when prescribed.

Methods

The analyses presented here included as subjects all pregnant and lactating women with infants less than two years of age in the four villages. The principal data gathered during the prenatal and postnatal period are presented in Table 2.

The use of the terms dependent and independent variables in Table 2 is an attempt to describe the hypothetical causes and

Table 1

Nutrient Content of Dietary Supplements
(per 180 ml)

Nutrients	Atole[1]	Fresco[2]
Total calories (KCal)	163	59
Protein (g)	11	--
Fats (g)	0.7	--
Carbohydrates (g)	27	15.3
Ascorbic Acid (mg)	4.0	4.0
Calcium (g)	0.4	--
Phosphorus (g)	0.3	--
Thiamine (mg)	1.1	1.1
Riboflavin (mg)	1.5	1.5
Niacin (mg)	18.5	18.5
Vitamin A (mg)	1.2	1.2
Iron (mg)	5.4	5.0
Fluoride (mg)	0.2	0.2

[1]The local name of a gruel commonly made with corn.

[2]Spanish for refreshing, cool drink.

effects of the interrelationships discussed later. A brief description of the dependent and independent variables considered in the present analyses follows.

Dependent Variables. The duration of postpartum amenorrhea and of lactation was obtained prospectively by monitoring menstruation and lactation every 14 days in all women in the study population. The duration of postpartum amenorrhea was defined as the interval, in months, between a birth date and the first incidence of two menses occurring within a three-month period. The duration of lactation was defined as the interval, in months, between a birthdate and weaning.

Independent Variables. Because the measurement of nutritional status is difficult and critical to our analyses, we utilized several different proxies of this variable:

a) The assessment of supplement intake was expressed in terms of calories because the normal dietary intake appeared to be more limited in calories than in proteins. We have previously found that this food supplementation program increases variability in

Table 2

Relevant Data Collected in INCAP's Longitudinal Study. Maternal and Child Information

1. Independent Variables:
   - Measurement of subject's attendance at supplementation center and quantity of supplement ingested
   - Dietary survey: 24-hour recall
   - Anthropometry
2. Dependent Variables:
   - Birth interval components
3. Additional Variables:
   - Obstetrical history
   - Information on delivery
   - Morbidity survey
   - Clinical examination
   - Socioeconomic survey of the family

nutrient intake and represents a true supplement to the habitual diets.

b) Information on home diet was obtained through a 24-hour recall done once during each trimester of pregnancy. For the present analyses, this information was summarized for the last two trimesters of pregnancy and was expressed as the mean home caloric intake.

c) Finally, we used a summation of both home dietary intake and supplement consumption as an estimation of total nutrient intake.

In summary, food supplementation during pregnancy is the main experimental treatment and groups of mothers were categorized by: a) the amounts of supplemental calories and proteins they ingested during pregnancy, b) their home diet, and c) their total calorie-protein intake. While nutrient intake measures are reflective of current nutritional status, anthropometric variables are utilized not only as current but also as long-term indicators of maternal status.

Sample Size

The total sample for analysis was made up of all mothers in the four communities who had a delivery between January 1, 1969 and February 28, 1973, and who had been followed up to January 1975. Because reliable information on menstruation and lactation was not collected prospectively until the end of 1970, we have prospective information for only 438 intervals. It is important to point out that in this sample a woman may contribute more than one interval to the total sample.

RESULTS

Potter, et al. (3) distinguished two types of prospective intervals. If the start and end of an interval fell within the prospective period of data gathering, the interval was called "entirely prospective." The "truncated prospective" intervals started in the prospective period but were truncated by outmigration or termination of the study. Following Potter's approach, we will present our results in two sections: a) results based on entirely prospective intervals, biased toward interval brevity; and b) life table results, which combine entirely prospective and truncated prospective intervals. Furthermore, attention will be confined to the duration of postpartum amenorrhea, because this period has the largest possible variability of any of the components of the birth interval in a non-contracepting population (3). In all of the following analyses we excluded stillbirths and infant deaths.

Entirely Prospective Information. The mean duration of lactation in the study communities is 18 months; the mean duration for postpartum amenorrhea is 14 months. The two variables are highly associated, the correlation coefficient being .62 (377 cases, $p < .01$). The median duration of postpartum amenorrhea in nursing women in our study is comparable to those reported in other rural populations. Potter et al. (3) in a prospective study in India found a median of 11 months. A study of Eskimo women (19) showed a median of 10 months, and Chen, et al. (20), in Bangladesh, reported a median of 18 months.

As shown in Table 3, data from the longitudinal study reveal a negative association between the duration of postpartum amenorrhea and anthropometric measures of the mother taken 3 months after delivery, such as height, head circumference, weight, skinfolds, arm circumference, weight for height and arm circumference for height. Although none of these associations were statistically significant, there was a consistent negative trend. Recently we constructed an index of women's nutritional status by combining standardized measures of weight, arm circumference and triceps

Table 3

Relationship Between Length of Postpartum Amenorrhea and Anthropometric Measures of the Mother

Variable	Correlation Coefficient	Number of Cases
Height	-.10	395
Head Circumference	-.09	298
Weight	-.14	160
Skinfolds: biceps	-.07	160
triceps	-.08	160
subscapular	-.07	160
mid axillary	-.05	160
Arm circumference	-.13	160
Weight/height	-.12	160
Arm circumference/height	-.07	160

skinfold. We found that this index of nutritional status showed a statistically significant negative association with the duration of postpartum amenorrhea ($p<.05$) (4).

Negative associations were found between the length of postpartum amenorrhea and both home caloric intake and caloric supplementation ingested during pregnancy. As shown in Table 4, we also found a negative association between total caloric intake during pregnancy (sum of home caloric intake and caloric supplementation) and the duration of postpartum amenorrhea in both atole and fresco villages. However, in atole villages this correlation was significant, whereas in fresco villages it was not. The reduction in the duration of postpartum amenorrhea for the same number of supplemented calories, or slope value, was not significantly different between fresco ($b = -.0005$ months/Calorie) and atole ($b = -.0027$ months/Calorie) villages.

Another way of looking at these data consists of comparing the durations of postpartum amenorrhea in three groups (terciles) categorized by increasing total caloric intake within atole and fresco villages. As shown in Table 5, there is a consistent trend towards shorter postpartum amenorrhea in atole communities, but not in fresco communities, within categories of total nutrient intake. Although these results suggest an added effect of protein calorie supplementation over caloric supplementation, these differences were not statistically significant.

All these data suggest that better nutritional status during

Table 4

Relationship Between Length of Postpartum Amenorrhea and Maternal Nutrient Intake During Pregnancy

Variable	Correlation Coefficient	Standard Regression Coefficient	Number of Cases
Caloric supplementation	-.0694	-.0665	398
Home dietary intake	-.0982	-.0934	339
Total caloric intake (TCI)	-.1163*	-.1151	339
TCI (Fresco villages)	-.0362	-.0345	153
TCI (Atole villages)	-.1780*	-.1756	186

* $p < .05$

pregnancy results in somewhat shorter lengths of postpartum amenorrhea.

Further indications can be obtained by comparing the duration of postpartum amenorrhea in these groups (terciles) with increasing total caloric intake within several comparable categories of duration of lactation. Table 6 shows clearly the strong association between duration of lactation and length of postpartum amenorrhea. Within all lactation categories, the length of postpartum amenorrhea was shorter in the groups with high calorie intake than in the group with low calorie intake.

Some of the indicators of nutritional status of the infant have also been found to be associated with the duration of postpartum amenorrhea. Weight gain of the infant during the first 9 months after birth was positively related to the duration of postpartum amenorrhea ($r = .15$, $n = 301$) and caloric supplementation ingested by the lactating infant during the first nine months was negatively related to the length of postpartum amenorrhea ($r = -.14$, $n = 401$). These results could be interpreted in two different ways:

a) If a mother starts supplementing the breastfed infant, the frequency of suckling will decrease. It is known that frequency of suckling is an important determinant of the duration of postpartum amenorrhea (10,21).

b) If a mother starts supplementing the breastfed infant, the nutritional demand of lactation will decrease, improving the nutritional status of the mother. It has been suggested that improved nutritional status of the mother would reduce the duration of postpartum amenorrhea (6). As we discuss later, the lack of specific

Table 5

Mean Durations of Postpartum Amenorrhea in Three Different Total Caloric Intake Groups Within Atole and Fresco Villages

Total Caloric Intake[1]	Atole	Fresco	Total
	Months	Months	Months
Low	14.33 (64)[2]	14.38 (50)	14.35 (114)
Middle	13.60 (70)	14.04 (48)	13.78 (118)
High	12.29 (66)	14.21 (42)	13.04 (108)

[1]Total caloric intake = sum of home caloric intake and caloric supplementation during pregnancy.

Low = $\leq$ 1,308 Cal/day; Middle = 1,309-1630 Cal/day; High = $\geq$ 1,631 Cal/day.

[2]Numbers in parentheses are number of cases.

information does not permit us to differentiate between these two alternative explanations.

Finally, other variables such as parity, length of previous birth interval and age of the mother were found to be positively and significantly correlated with the duration of postpartum amenorrhea. The last two associations have been previously reported in the literature (7,22). Salber et al. (22) found no significant association between parity and duration of postpartum amenorrhea. In our study, the association may be explained by the high association between parity and age in these mothers.

Life Table Analysis

In order to correct for the bias toward interval brevity expected in the entirely prospective intervals, we applied a life table technique so that we could use the truncated prospective intervals. By this technique we compute the monthly probabilities of resuming menstruation in two groups of mothers: a group who ingested less than 10,000 calories during pregnancy and those who consumed equal to or more than 20,000 calories during pregnancy.

As shown in Table 7, there is a consistent trend towards a higher monthly probability of remaining amenorrheic in the poorly supplemented group than in the highly supplemented group. It should be noted that the approximately one month reduction in the median

Table 6

Mean Duration of Postpartum Amenorrhea in Three Different Total Caloric Intake Groups Within Categories of Duration of Lactation

Total Caloric Intake[1]	Categories of Lactation (Months)				
	0 - 6 Months	7 - 12 Months	13 - 18 Months	19 - 24 Months	25 & more Months
Low	-	6.54 (13)[2]	12.03 (35)	16.44 (45)	19.93 (14)
Middle	-	6.31 (13)	11.64 (33)	15.47 (57)	18.90 (10)
High	-	5.47 (14)	11.13 (30)	14.60 (47)	19.64 (11)

[1]Total caloric intake = sum of home caloric intake and caloric supplementation during pregnancy.

[2]Numbers in parentheses are number of cases.

length of amenorrhea in the highly supplemented group cannot be attributed to a reduction in the duration of lactation between the two groups. As shown in Table 7, high and low supplemented groups exhibited virtually identical lactation intervals. The differences found in these comparisons are not statistically significant, but, as before, give support to the hypothesis that nutrition can have an effect on the duration of postpartum amenorrhea.

DISCUSSION

In combination, the data presented here support the hypothesis that improved maternal nutrition is associated with a decrease in the duration of postpartum amenorrhea. This can result in a shorter birth interval. This decrease in birth interval appears to be occurring in our populations. Analyses of the entirely prospective birth intervals (not presented here) showed a 3.1 month reduction in the duration of the birth interval in the highly supplemented group ($\geq$ 20,000 calories during pregnancy) as compared to the poorly supplemented group (< 10,000 calories during pregnancy).

Although our results showed an association between maternal nutritional status and duration of postpartum amenorrhea, some weaknesses should be mentioned:

1. One of the major difficulties in inferring causality in the association between nutrition and postpartum amenorrhea from

Table 7

Life Table of Postpartum Amenorrhea and Lactation in Two Groups of Caloric Supplementation During Pregnancy[1]

Months of Exposure	Number of Cases Exposed	Probability of Remaining Amenorrheic X months P_A (X)	Standard Error of P_A (X)	Probability of Remaining Lactating X Months P_L (X)	Critical Ratio: Difference Between P_A (X) Low and P_A (X) High
		Low Supplemented Group (< 10,000 Cal/pregnancy)			
1	192	0.99478	0.00519	0.99582	
3	186	0.98421	0.00904	0.99582	
6	173	0.91011	0.02098	0.98723	
9	158	0.83248	0.02540	0.96117	
12	130	0.71121	0.03270	0.89454	
15	88	0.49014	0.03768	0.77202	
18	60	0.29409	0.03509	0.54266	
		High Supplemented Group (≥ 20,000 Cal/pregnancy)			
1	169	1.00000	0.00000	1.00000	-1.00261
3	165	0.95815	0.01548	1.00000	1.45309
6	151	0.88613	0.02459	1.00000	0.74184
9	132	0.78295	0.02738	0.97734	1.32624
12	115	0.65550	0.03425	0.91483	1.17650
15	84	0.43093	0.03746	0.78848	1.11462
18	50	0.24278	0.03299	0.54902	1.06519

[1]Based on "entirely prospective" and "truncated prospective" intervals. It excludes all stillbirths and infant deaths.

these data derives from the fact that the allocation of subjects in the different categories of caloric supplementation depends upon the level of their cooperation with the intervention program. Thus, there has been no means of controlling for possible factors which might predispose a woman to choose to take both high levels of supplementation and to have short periods of postpartum amenorrhea.

2. Since the longitudinal study was not originally designed to investigate the relationship between nutrition and the birth interval, another difficulty arises from our lack of data on confounding factors which might cause a spurious association between them. For example, it has been postulated that prolactin, secreted by the anterior pituitary as a response to suckling (23-32) may be the mechanism by which lactation inhibits ovulation. If that is the case, supplemental feeding of the infant, by reducing the frequency of suckling, may affect the duration of postpartum amenorrhea. In our study, we do not have information regarding home dietary intake of the infant, frequency of breastfeeding, or suckling frequency, duration and intensity; all important potentially confounding factors in the association between nutrition and duration of postpartum amenorrhea.

3. Another lack of data is apparent when we try to define the nutritional status of lactating mothers. Our analyses could only explore the effect of nutrition during pregnancy on the duration of postpartum amenorrhea because, in the longitudinal study, home dietary intake, an important parameter of nutritional status, was not collected during lactation nor during the rest of the birth interval.

4. Available evidence indicates that the longer the duration of lactation, the longer the period of postpartum amenorrhea. Our previous data (33) suggested that better nutrition was associated with a longer period of lactation, and therefore, through this mechanism, would prolong the duration of postpartum amenorrhea. These results were not replicated in a larger sample. There could be several reasons for this, one being a change in breastfeeding patterns for social reasons. It is important not to regard the length of lactation as an isolated variable, since it may be partially determined by some of the same behavioral and environmental factors which affect the desired number and spacing of births. If that is the case, it is imperative to study in depth the attitudes and behavior related to fertility and family size in the same population in which the biological aspects of fertility are being studied. The longitudinal study is missing information on these types of variables.

5. Finally, we are concerned with the relative importance of proteins and calories on fertility. Although some of our results indicate a higher impact of a combination of proteins and calories than calories alone, the experimental design and the study sample size do not permit us to differentiate the effect of proteins as compared to calories on the duration of postpartum amenorrhea.

FINAL COMMENTS

In this paper we presented data which indicate that maternal nutrition is associated with the duration of postpartum amenorrhea and, consequently, on birthspacing. We discussed in some detail the weaknesses of our results and believe that more investigation is needed before we can clearly understand the impact of nutrition on fecundity and fertility. We consider a longitudinal study with nutritional interventions and adequate controls for biological, attitudinal and behavioral variables the only way to test the hypotheses that our work and the work of others have generated.

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