A RAND NOTE

DEMOGRAPHIC AND SOCIOECONOMIC CORRELATES OF INFANT GROWTH IN GUATEMALA

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PREFACE

This Note was prepared with support from The Rand Corporation's Family in Economic Development Center and from the Rockefeller Foundation. The Center is funded through Grant No. OTR-G-1822 from the U.S. Agency for International Development. Its purpose is to provide effective policy research by integrating technical research with training of, and collaboration with, Third World scholars and government officials. The Center's research emphasizes the role of human resources in the process of economic development, and individual and family responses to development programs and policy.

The Note documents research on the socioeconomic and demographic correlates of infant growth in Guatemala. It is an exploratory effort to analyze infant growth with multivariate techniques using data from a developing country. The Note should interest researchers and nutrition, health, and development planners who are involved in program design and implementation.

At the time of writing the Note, the author held a postdoctoral fellowship supported by the Population Sciences Program of the Rockefeller Foundation and Rand's Family in Economic Development Center.

SUMMARY

The exploratory analyses in this Note have used data from a longitudinal nutrition study and cross-sectional socioeconomic survey taken in four rural villages in eastern Guatemala. A multivariate model of infant growth was posited which took into account as far as possible biological and socioeconomic factors and focused specifically on how family size variables relate to growth.

The sample consists of 301 infants (aged 0 to 1 year) born between 1973 and 1975. By six months they fall into the mildly malnourished classification and by twelve months into the moderately malnourished classification.

Ordinary least squares (OLS) regression equations for 0 to 6 month and 6 to 12 month growth were estimated. The results indicate that the following factors relate to growth: (a) number of live pregnancies, (b) short birth interval, (c) number of preschoolers, (d) number of 15+ year olds, (e) mother's weight and height, (f) length of partial breastfeeding, (g) calories from a supplementary food, (h) initial weight, (i) child's sex, and (j) number of rooms.

The analyses suggest that we must not think simply in terms of some general concept of "family size" but must understand the mechanisms through which family size relates to growth. These mechanisms might include maternal health, available child care time, food resources, and crowding.

The results also suggest that the relation of infant growth to these mechanisms and the other factors included in the analysis may vary depending on the age of the infant. Presumably they also vary with the economic, social, and public health context; however, we looked only at four homogeneous villages.

Finally, some of the significant relations suggest easily measured indicators of high risk or target populations for nutrition intervention. In these villages, high risk infants include those (a) whose mothers are short or underweight for their height, (b) who are not partially breastfeeding for whatever reason, (c) who have several preschool aged siblings, (d) who are conceived within 12

months of a previous sibling, and (e) who are fourth born or greater. To the extent that women are made the focus of infant nutrition interventions, high risk women are small in stature, have low weight for height, and have had numerous pregnancies.

Though the data do not allow us to attribute causality or to determine relative benefits and costs of various interventions, they suggest that if we had to make hunches about appropriate nutrition programs we might do well to focus on family planning programs (with emphasis on spacing) and on programs aimed specifically at improving the health of childbearing age women and increasing their child care time and productivity. Because of data limitations, it is harder to make recommendations about breastfeeding and supplementary feeding programs. Since we will be implementing interventions without perfect information we should incorporate evaluation components into development programs directly or indirectly related to infant growth. This will improve our ability to design effective programs and will increase our understanding of complex relations.

This exploratory study has provided insight into some of the model-building limitations and data problems for these sorts of interrelated health and population questions. We hope to be able to learn from these analyses to begin to resolve some of these issues in future studies. One valuable addition to our understanding would be analysis of a sample with a wider range of more favorable growth (not just malnourished children) and with greater heterogeneity on such crucial factors as income, environmental sanitation, and access to potable water.

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I. INTRODUCTION

We have known for years that in Central America many (70 to 80 percent) children under five suffer from malnutrition, but we do not seem to know how to reduce the suffering. As Wray (1978) put it, "Dozens of national and international conferences have been held; thousands of articles and probably scores of monographs have been published, yet in many parts of this hemisphere the problems remain essentially the same."[1]

A number of studies show that malnourished children come from larger families. However, depending on the point of view, one can see the mechanisms underlying this relation in very different lights:

- o Medical researchers tend to focus on the biological mechanisms of the relation; producing large families has consequences for a woman's physiological status which in turn affects pre- and postnatal growth of subsequent offspring.
- o Some social science researchers focus on the food allocation mechanisms of the relation; the more mouths there are in the family, the less food available per person.
- o Other social science researchers focus on the child care time mechanisms; the more young children there are, the less time a mother spends feeding and caring for any one child, which results in poorer growth.
- o Public health researchers focus on environmental mechanisms of the relation. The more people there are in the home, the greater the exposure to infectious diarrheal disease that adversely affects infant growth.

The different points of view frequently lead to the same policy conclusions: reductions in family size would reduce malnutrition, so we should establish programs to do this. I see at least two problems with this as it applies to Central America. First, in many settings

[1] Some studies indicate that it has grown even worse (Teller, 1978).

people do not want to or cannot reduce family size. Reasons for this may include: high infant mortality (related to malnutrition), machismo, the Church, and children's contributions to household income. Second, even if we could reduce family size in the long run, we need to know what to do in the short run to help the already large families. If we better understand how the mechanisms outlined above relating family size to infant growth interact and which are relatively more important, then we could suggest more effective nutrition programs.

In this exploratory study I develop a model of infant (0 to 1 year) growth that attempts to incorporate some of the family size mechanisms outlined above, and I test the model using data from four rural villages in eastern Guatemala. My goal is to explore, using a multivariate framework, the characteristics of infants and their families associated with greater growth over the first year of life.

The sample infants lived in four small (500 to 1000 inhabitants) relatively isolated subsistence farming villages. The data on the infants and their families were collected as part of (a) a nutrition study carried out by the Institute of Nutrition of Central America and Panama (INCAP) between 1969 and 1977, [2] and (b) a socioeconomic survey made by INCAP in collaboration with The Rand Corporation between 1974 and 1975. Infants suffered from mild to moderate malnutrition evidenced primarily by growth retardation.[3] At one year of age, half of the sample infants weighed less than the weight evidenced by 95 percent of the children from middle and upper income Guatemalan families.

The most salient findings of this study are the following. The 0 to 6 month infant growth relates to birth weight, house size, and variables which characterize the health status of the mother such as short birth interval, mother's weight and height, and the number of previous pregnancies. The 6 to 12 month growth relates to 6 month weight, mother's height, food availability, and the presence of preschool aged and adult aged siblings.

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[2] A partial description of the study can be found in Martorell (1980) and Lechtig (1975).

[3] The more severe forms of malnutrition involve severe stunting or wasting and biochemical changes within the organism. The most widespread malnutrition problem in Latin America is mild to moderate malnutrition, which results in growth retardation and increased disease incidence, and is associated with high infant and child mortality.

Because of data limitations, not all relations found can be said to be strictly causal nor can we be completely sure of the relative size of each. Nonetheless, these exploratory analyses do enable us to specify high risk or target populations for nutrition interventions and to form some hunches about usable nutrition interventions. It is hoped the relations found to be important here will be the focus of future research and evaluation designed to specifically assess the relative cost and effectiveness of programs for influencing infant growth.

Section II provides a brief review of the literature. Section III presents the theoretical framework. Section IV describes the study designs, data collection procedures, and empirical problems related to the study designs. Section V describes the sample children and their mothers. Section VI describes in more detail the actual variables used in the empirical model and discusses other limitations imposed by the data set. Section VII contains a discussion of the results and conclusions. Section VIII contains a brief summary. Appendixes A to C contain the correlation matrix of all variables in the empirical model, a description of supplementary food intake, and a description of the cases with missing data.

II. LITERATURE REVIEW

Empirical work frequently indicates a negative relation between family size and child growth. Omran (1976) reports a negative relation between family size and children's heights and weights in studies done in India, Lebanon, and the Philippines. Wray (1969), using t-tests of differences in proportions, finds for a sample of Columbian children aged 0 to 6 years that a significantly greater proportion of malnourished children than adequately nourished children come from large families (five or more living children). Muñoz de Chávez et al. (1974), using t-tests of differences in proportions, find for a sample of 0 to 4 year old Mexican children that family size of the malnourished children is not significantly different from the family size of the well-nourished children. However, the child/adult ratio in the household of the latter tends to be lower than that for the malnourished children.

These bivariate analyses tell us that in some settings a family size/growth relation exists, but they do not tell us whether it is through the effect family size has on food availability, child care time, maternal health, or disease exposure. The few available multivariate analyses offer some insight into how these mechanisms may operate in particular settings.

Levinson (1974) uses multivariate techniques to relate economic and social factors to calorie intake, disease, and the nutritional status of 0 to 2 year olds from two different castes in rural India. Considering both castes together, he finds significant positive relations between nutritional status and family size, and between diarrhea and family size (independent of the influence of family size through per capita income). He believes the latter result may be due to crowded household conditions and/or poorer care received by later born children whose mothers are busier with other things.

The results for higher caste alone show no significant relation between family size and calorie intake or diarrhea. For the lower caste, he finds evidence that family size, by reducing income per capita, contributes to reduced calorie intake and increased diarrheal disease. His findings provide evidence of several of the family size mechanisms mentioned above and suggest that whether or not they operate may depend on the family's other environmental and socioeconomic conditions.

Finally, Popkin (1978), in a multivariate analysis using data from households in rural Philippines, relates family composition to an aggregate measure of weight of all 0 to 6 year olds in the household. He finds a positive relation between aggregate weight and income per capita, and the presence of other adults such as grandparents in the household. Aggregate weight relates negatively to the number of females aged 7 to 12, number of females aged 13 to 15, and number of males aged 7 to 12 in the household, independent of the effect they have on available household resources per person. He suggests that young girls and boys take care of their younger siblings, and to the extent that they are less capable child caretakers, the health and nutritional status of the infant suffers.

To summarize briefly, children from larger families frequently experience poor physical growth. Family size may affect growth through several mechanisms including its effect on food availability, child care time, maternal health, and disease exposure. The few available multivariate analyses provide evidence of these mechanisms and suggest that their relative importance varies depending on other socioeconomic and environmental factors.

III. GENERAL THEORETICAL FRAMEWORK

BIOLOGICAL COMPONENTS OF GROWTH

In very simplified terms, infant growth depends on (a) genetic factors, (b) food, including but not limited to mother's milk, and (c) prevalence of prolonged or recurring disease. Genetic factors determine to some extent an individual's growth pattern and ultimate size. Food provides protein for body growth and repair, calories for normal activity and maintenance, and vitamins and minerals, essential for proper functioning of various organs and physiological processes. Infectious disease, especially diarrhea, alters the body's ability to absorb nutrients and increases the nutrient requirements for repair of damaged tissue.

HOUSEHOLD PRODUCTION OF INFANT GROWTH

Families attempt to influence their infants' growth using inputs of income and time. Income buys food and medical attention and we expect that, all else equal, more will produce better growth. Time is required for food preparation, infant feeding, and general preventive and curative health care.[1] We expect that, all else equal, additional child care time will result in additional growth.

FAMILY SIZE MECHANISMS

Family size may relate to infant growth through its effects on the following:

1. Availability of food and medical resources.
2. Availability of child care time.
3. Maternal health and depletion and quality of mother's milk.
4. Prevalence of disease.

[1] More food preparation time may yield higher quality food or a better mix of nutrients; more time spent feeding an infant can ensure that he eats frequently enough and gets enough at each feeding. More time devoted to general child care means more attention is given to the infant's hygiene and to health and safety factors in the environment.

The way in which family size might affect each of these factors is discussed briefly below.

1. Availability of Food and Medical Resources

We cannot say unambiguously how family size affects availability of food and medical resources. Availability of food and medical resources is determined by the number and age of family income-producers and consumers. In addition, families decide about food distribution patterns to its various members.

At low income levels, where 50 to 80 percent of income goes to food, an additional family member at a given income will reduce food and medical attention available per family member. On the other hand, the possibility that children might undertake income-earning or housekeeping activity suggests that food and medical resources need not always decline with additional family members. In many developing countries, young children participate in income-producing activity or they do housework that frees the mother to undertake income-earning activity. This may have unfortunate consequences for school attendance, but it may allow the larger family to maintain or even to raise the per person income available for food and medical expenditures compared with a smaller family.

In addition, families may not distribute food equally across all their members. For example, income producers may continue to receive the same amount regardless of how much is available. Women frequently reduce their food intake before that of their children. These distribution decisions, often influenced by practical considerations and cultural norms, determine whether food available to a particular infant declines when food available per person in the family declines.

2. Availability of Child Care Time

Suppliers of child care time. Additional family members increase the supply of time for food preparation, infant feeding, and general child care. They may also free a mother from other time-consuming housekeeping activity (e.g., carrying water, fetching firewood, etc.) so that she has more time for child care.

The productivity of the time will vary by the age of the family member supplying the time. For example, 7 to 10 year old children and 11 to 14 year old children may not have the same judgment and experience in child care activity as adults (15 or older). They are not as big or as strong and, therefore, cannot substitute as well for the mother or other adults in all housekeeping activities.

The positive contributions family members, including fairly young children, can make to income, child care, and housekeeping activity imply that one need not expect a negative relation between child growth and family size. Their positive contribution to income and child care might outweigh the negative effect on per person food availability, maternal health, and crowding.

Consumers of child care time. All else equal, a family with more children aged 0 to 6 years old will have less time to devote to each child. Despite the fact that there are some economies of scale in child care activities (especially supervisory ones), the net effect of additional preschool children in the family will be to reduce the amount of time a family can devote to any one child.

3. Maternal Health and Depletion and Quality of Mother's Milk

Family size reflects to some extent a woman's pregnancy experience (e.g., the number of pregnancies and spacing between pregnancies). In settings where maternal nutrition is inadequate, investigators find that repeated pregnancies, close spacing, and extended periods of breastfeeding result in (a) reduced quality of mother's milk [2] and (b) general decline in maternal health (maternal depletion) evidenced in part by progressive weight loss and a prematurely aged appearance (Jelliffe, 1978).

Reduced quality of mother's milk means the infant receives less adequate nutrition. General decline in maternal health may imply poorer quality child care. Just as the productivity of industrial and agricultural workers declines when they are ill or underfed, the

[2] Biomedical research generally suggests that the quality of mother's milk depends on diet during the lactation period, the adequacy of maternal nutritional reserves, including subcutaneous fat normally laid down during pregnancy, and the extent of "maternal depletion" caused by continual child bearing and prolonged lactation.

efficiency with which a women cares for her children also declines with ill health.

4. Prevalence of Disease:

A larger family sharing a given living space increases crowding. More crowded conditions often imply less sanitary conditions, and crowding increases contact with infectious disease, especially if there are several preschool aged children in the house who share communicable diseases with each other.

IV. DATA COLLECTION AND STUDY DESIGNS

The sample consists of 301 infants (aged 0 to 1 year) born between January 1, 1973 and December 31, 1975 in four subsistence farming villages in eastern Guatemala. The four villages were part of a longitudinal nutrition study carried out by the Institute of Nutrition of Central America and Panama (INCAP) between 1969 and 1977. In 1974 and 1975 INCAP in collaboration with The Rand Corporation made an extensive socioeconomic survey of the households in the four villages. Data from both of these studies were included in these analyses so each is described briefly below.

INCAP LONGITUDINAL NUTRITION STUDY

All children in each of the villages were eligible for the nutrition study. Weight data were collected within 24 hours of birth and within three days of the 6 and 12 month anniversaries of birth, if the child was in the villages within these time spans. As part of the nutrition study, the villages were provided with primary health care services and free supplementary food at a center established within each village. The medical services were comparable in all villages, but the protein and calorie content of the supplementary food available differed between villages. Villages 03 and 08 received a calorie drink called "fresco." Six ounces of this Kool-aid like beverage contained 59 calories of energy and no protein. Villages 06 and 14 received a protein drink called "atole." Six ounces of atole contained 163 calories of energy and 11.5 grams of protein. Both drinks were equivalent in terms of vitamin and mineral contents.

Since the supplementary food was consumed only at the supplementation center, center personnel could measure actual intake quite accurately each time the child attended the supplementation center. The supplementary food was available to all villagers, but the center personnel recorded only the quantities consumed by children and child-bearing age women. Patterns and quantities of supplementary food intake are shown in the tables in Appendix B. In general the data indicate that differences in volume consumed varied with the infant's age and sex. Infants consumed greater quantities from 6 to 12 months and boys consumed more than girls. Children in atole villages consumed more and were more likely to take supplementary food earlier than children in the fresco villages.

THE INCAP/RAND HOUSEHOLD SOCIOECONOMIC SURVEY

In 1974 and 1975 socioeconomic and demographic data on the infants and their families were collected in a series of special interviews obtained during a number of separate visits with the families. Each interview consisted of a different instrument designed to obtain data on some specific aspect of socioeconomic status (e.g., income, schooling, household composition, fertility history, etc.).

DATA LIMITATIONS

First, these two data sets were not designed specifically to look at the particular question of the socioeconomic and demographic correlates of infant growth. This has meant that the choice of variables for inclusion in the empirical model was somewhat restricted. As will be seen in the discussions of the empirical model, in most cases the two data sets were broad enough to provide proxies when the ideal variable was not available. This is not seen as a serious limitation especially since this is an exploratory analysis undertaken both to provide insight into the particular relations and to enable us to refine our thinking about the issues for future analyses.

A second problem encountered in using data from the two different surveys was missing data, either on weight, due frequently to seasonal or temporary migration, and/or on the socioeconomic characteristics because not all families were administered all the different socioeconomic questionnaires. By using data from only several of the socioeconomic and demographic questionnaires, and by limiting the number of health and growth related variables used, I could minimize missing data, but at a cost of restricting the variety of variables that could be included in the analysis.

Even with these restrictions, some cases had to be excluded because of missing data. Appendix C describes the cases in more detail. A comparison of means of socioeconomic characteristics and weights between children with and without missing data for either six month period suggested that those who were excluded as a result of missing data do not differ significantly from those who were included in the sample.

In addition to cases excluded because of missing data, some cases were lost on account of death. Eighteen and seven infants died before six and twelve months, respectively. Appendix C describes their characteristics in more detail. In general, those who were excluded because of death tended (a) to be higher parity children, (b) have a shorter previous birth interval, and (c) have a lower birth weight than the survivors. In interpreting the results it is important to remember that the sample is composed of those who survived throughout the growth period (i.e., 0 to 6 months or 6 to 12 months

V. CHARACTERISTICS OF THE SAMPLE INFANTS

SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS

The four villages in which the 301 sample infants lived are typical of Spanish-speaking agricultural communities in Guatemala and other countries in Central America. Families obtain most of their income from subsistence farming or agricultural day labor. They live in one or two room adobe or bamboo homes with mud floors. Women cook over a wood fire and the diet consists primarily of corn tortillas and beans. At the time of the study, no village had potable water, adequate sanitation, or waste disposal systems. Prevalence of diarrheal and respiratory disease was high and, as will be seen shortly, mild and moderate malnutrition characterized by poor growth was common.

Demographic

About half the children in the sample are male. About 64 percent of the mothers are between ages 20 to 34, 14 percent are between 14 to 19, and 22 percent are aged 35 and older. As indicated in Table 1, families are not all that large--about 3.7 children present.[1] However, they tend to have more than two preschool aged children.

Socioeconomic

About half the mothers read and write; many have completed no formal schooling. The few women who work are engaged primarily in cottage industry weaving products of straw and rope and a few women are involved in agricultural activity or tend a small store, usually in front of the house. Based on observations in the villages, most of the women's income-earning activity is "compatible" with child care; it is done in or near the home and can be put down if a child needs attention.[2]

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[1] Women frequently have had more pregnancies than indicated by this average; some children may have died or may not be present in the home.

[2] Housekeeping tasks (e.g., carrying water, collecting fire wood, washing clothes at a river about 5 kilometers from the home, etc.) may be less compatible with child care than their income-earning activity.

Table 1

MEANS ON SELECTED DEMOGRAPHIC AND SOCIOECONOMIC VARIABLES FOR CHILDREN WHO HAD GROWTH DATA 0-6 MONTHS BY SUPPLEMENT TYPE

	Fresco	Atole	Total
Number of pregnancies	4.6	5.1	4.9
Previous birth interval (months)	29.0	26.0	27.0
Mother's age (years)	27.8	28.3	28.0
Number children 0-6 years old in the nuclear family	2.4	2.6	2.5
Number children 7-14 years old in the nuclear family	1.1	1.1	1.1
Number adults aged 15-65 in the nuclear family	2.1	2.2	2.1
Total number people in the extended family	6.3	6.5	6.4
Mother's height (centimeters)	149.0	149.0	149.0
Mother's weight[a] (kilograms)	55.3	54.1	54.7
Mother's literacy (yes/no)	.4	.4	.4
School grades completed by mother	1.1	1.0	1.1
Mother's employment (yes/no)	.4	.1	.2
Father's literacy (yes/no)	.7	.6	.6
Highest school grade completed by any nuclear family member	2.7	2.0	2.3
Extended family income ($)	543.0	465.0	502.0
Income per equivalent adult consumer in extended family ($)	136.0	106.0	120.0
Number of rooms in house	1.8	1.5	1.7
Land value ($)	316.0	151.0	543.0
Total	144	157	301

[a] Weight at the end of the last trimester of pregnancy.

The average family income implies that a household has about $42 per month to spend on food, clothing, shelter, and medical care in a setting where the cost of living is comparable to the United States.

In general, a radio is their only "consumer durable" and land holdings are generally between 0 and 5 acres (Valverde, 1977). Since most of the families obtain much of their income from agricultural activity, the flow of income to the household varies by season. In bad harvest years, all or some of the family migrates to the coast to work as day-laborers on cotton and coffee plantations. During economic hard times they also depend heavily on other relatives.

Mother's Pregnancy Experience and Weight

On average, the children's mothers have had five previous pregnancies. Eleven percent of the children in the sample were first born, about half were second to fifth born children, and 35 percent were born to women who had six or more previous pregnancies. Birth interval is relatively short; about 15 percent of the children were conceived within a year of the previous pregnancy.

The average mother is shorter than most U.S. women and tends to weigh 14 and 16 pounds less than a U.S. woman of her height. The average sample mother is about 59 inches tall, which falls below the 5th percentile height of U.S. women of childbearing age in 1974 and provides evidence of her own childhood growth retardation. She weighs between 107 and 109[3] pounds when she is not pregnant, whereas the average U.S. woman of her height normally weighs 122 pounds.

GROWTH DURING THE FIRST YEAR

Figures 1 and 2 show the sample children's first year growth curves superimposed on the National Center for Health Statistics (NCHS) standard growth curves.[4] At birth and three months, their weights fall within "standard" ranges. Between three and six months, their growth slows slightly relative to children in generally more favorable

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[3] Calculated by subtracting normal weight gain during a pregnancy (5-6 kilograms from Arroyave, 1975) from weight given in Table 1.

[4] This is an appropriate standard since research has shown that upper income class Guatemalan children grow as large as well-nourished U.S. children (Habicht, 1974). This indicates that observed size differences between populations in different countries are not due to ethnic differences but to food intake and health differences, and suggests that under more favorable conditions the sample children would have a weight distribution more like that seen for the NCHS standard children.

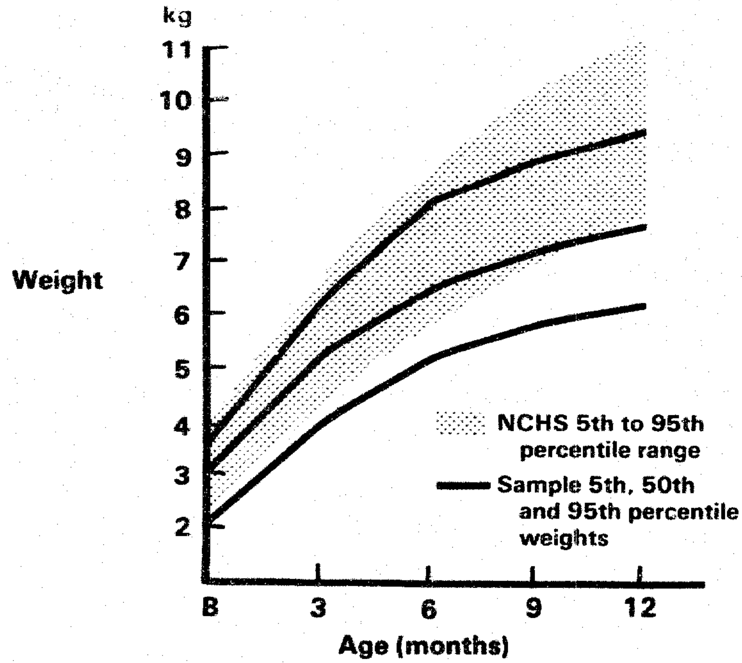

Fig. 1—Sample girls' weights relative to NCHS weights

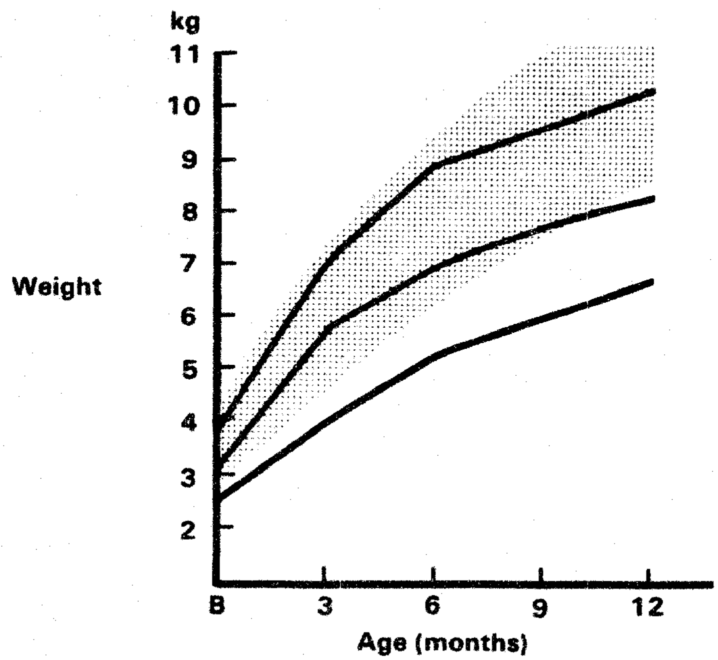

Fig. 2—Sample boys' weights relative to NCHS weights

environments. Between six months and a year, their growth slows more noticeably, so that by one year, 50 percent of the sample children's weights lie below the 5th percentile standard weight. This growth pattern is typical of developing country infants from low income families.

Table 2, which shows mean weights and growth of the sample infants by sex and village, indicates that growth during the first six months is least for girls in the fresco (calorie supplement) villages and greatest for boys in the atole (protein supplement) villages. Within each village boys grow significantly more than girls, and children in the atole village grow significantly more than children in the fresco villages. We see the same pattern of village and sex differences for 6 to 12 month growth. However, the differences are considerably smaller and are not statistically significant. We explore these village and sex differences further in the multivariate analyses.

Table 3 shows the weights of children by number of live pregnancies. In general, we see a tendency for higher parity children to weigh more at birth. They tend to gain less weight during the first year so that by 12 months they actually weigh less than the lower birth weight first born children. The tendency is stronger in the fresco villages than in the atole villages. In the multivariate analyses, we look again at this sort of compensating or catch-up growth.

Table 2

MEAN WEIGHT AT BIRTH, 6, AND 12 MONTHS AND WEIGHT CHANGES DURING THE PERIOD BY SEX OF CHILD AND SUPPLEMENT TYPE
(In Kilograms)

	Fresco		Atole		NCHS[a] 50th/5th Percentile Weight	
	Female	Male	Female	Male	Female	Male
Birth weight	2.96	3.11	3.02	3.12	3.20/2.40	3.25/2.60
(Std. dev.)	.50	.42	.42	.44		
6-month weight	6.43	6.83	6.71	7.37	7.20/5.80	7.80/6.20
(Std. dev.)	.89	1.18	.77	.90		
12-month weight	7.46	7.95	7.88	8.57	9.60/7.80	10.20/8.40
(Std. dev.)	.93	1.24	.86	1.12		
Growth 0-6 months[b]	3.47	3.72	3.69	4.24	4.00/3.40	4.55/3.60
(Std. dev.)	.80	1.18	.72	.86		
Growth 6-12 months[c]	1.02	1.08	1.15	1.21	2.40/2.00	2.40/2.20
(Std. dev.)	.52	.69	.60	.55		
Growth 0-12 months[d]	4.50	4.83	4.86	5.45	6.40/5.40	6.95/5.80
(Std. dev.)	.80	1.23	.88	1.06		
Total (N)	69	75	73	84		

[a]National Center for Health Statistics growth charts, 1976

[b]The difference between weight at six months and birth weight.

[c]The difference between weight at twelve months and at six months.

[d]The difference between weight at twelve months and birth weight.

Table 3

MEAN WEIGHT AT BIRTH, 6, AND 12
MONTHS BY NUMBER OF LIVE PREGNANCIES
(In Kilograms)

	Fresco		Atole		NCHS 25th/10th Percentile Weight	
	Female	Male	Female	Male	Female	Male
First Born						
Birth weight	2.98	2.98	2.78	2.83	2.95/2.40	3.00/2.80
6-month weight	6.66	7.55	6.77	7.29	6.60/6.20	7.20/6.80
12-month weight	7.64	8.79	8.22	8.98	8.80/8.20	9.50/8.82
N	5	10	12	6		
Second to Fifth Born						
Birth weight	3.02	3.05	2.91	3.04		
6-month weight	6.67	6.92	6.61	7.30		
12-month weight	7.67	8.01	7.55	8.36		
N	33	45	33	45		
Sixth and Greater						
Birth weight	2.89	3.29	3.24	3.29		
6-month weight	6.14	6.27	6.81	7.47		
12-month weight	7.22	7.43	8.10	8.77		
N	31	20	28	33		

VI. EMPIRICAL MODEL

The preceding section provided a general picture of the magnitude and pattern of growth over the first year. In order to understand more precisely how the factors discussed earlier relate to growth, multivariate analysis techniques were applied. In this section, I discuss the form of the empirical model used and describe the variables used to represent the growth related factors discussed earlier. Since this is an exploratory analysis, I devote some discussion to the model limitations with the hope that future researchers will be able to devote some of their efforts to resolving many of these problems. A glossary of the variables follows this section.

MODEL FORM AND ESTIMATION PROCEDURE

A single equation ordinary least squares multiple regression analysis was used to explore the relation of the various factors discussed earlier to infant growth. The implicit assumption with this single equation formulation is that all the explanatory variables are exogenous. Undoubtedly, some factors such as current income, household composition, breastfeeding, and attendance at a supplementation center are endogenous and determined at least in part by a child's growth. For example, bigger children may consume more supplementary food. Bigger children may nurse longer and harder, prolonging a woman's physiological capacity to nurse, and in these villages women tend to withhold food if a child is sickly and growing poorly. This suggests that because certain explanatory variables in the empirical model are behavioral, they may not be causing the growth we observe, but may themselves be caused by growth. Ideally, a simultaneous system of equations would be specified; however, it proved impossible with the variables available to me in this data set to adequately identify the system. In fact, because so many of the inputs to child nutrition are interdependent, I was unable to conceive even on a theoretical level of factors that would truly identify the interrelated system. This is not to say that it is impossible; it may be. I point it out here as one of the important issues we must continue to grapple with in trying to model household behavior related to health and population issues. For the purpose of this study, the use of a single equation means that we must be careful about attributing causality when interpreting the empirical relations.

A second limitation of the estimation model was its essentially additive nature. For some variables, I tried several nonlinear specifications and interactions, but none performed as well as those reported here. I report those variables for which nonlinear specifications were tried in the results. Because of small sample size, testing of a wide range of nonlinear and interactive relations awaits further work. Appropriate model specification and design will require greater collaboration between biomedical and social science researchers. I have tried in the discussion of the results to point out where such nonlinear relations might exist.

DEPENDENT VARIABLES

The dependent variables are change in weight in kilograms (2.2 pounds) between (a) birth and six months, (b) six and twelve months, and (c) birth and twelve months. Weight change was used as an indicator of growth because weight has been shown to be a reliable measure of infant nutritional status (Martorell, 1980). The 0 to 6 and 6 to 12 month periods were considered separately since the influence of the various factors on 0 to 6 month growth may differ from their influence on 6 to 12 month growth.

EXPLANATORY VARIABLES

Variables Reflecting Availability of Food and Medical Inputs

Income and Food and Medical Expenditures. A family income (INCOME) measure was used to reflect total food resources in the family.[1] The measure includes income from salaries and wages, income from

[1] Ideally, a measure of actual home diet would be used to measure food intake. Unfortunately, the only such measure was on 24-hour recall measure taken at about eight months. Because there was a great deal of variability in food intake in any one 24-hour period, it was felt that a single observation would not be a particularly good measure of actual food intake for either 6-month period.

household enterprise or farm, and the inputed value of crops grown for home consumption. Since in these villages families devote the major portion of their income to food[2] and free medical care was available through INCAP's nutrition study, this measure of family income presumably reflects total food resources in the family.

We predict a positive relation between infant growth and income, since, all else equal, children from higher income families can consume more food and presumably will grow more. Nursing mothers from higher income families also will be likely to consume more. This can result in greater infant growth through greater production of higher quality breast milk and improved maternal health, resulting in better child care.

Mother's Milk. In the empirical models a measure of the number of months the infant was breastfed during the first six months or the first year of life (LENLAC) is used as a proxy for the quantity of mother's milk the infant receives. We expect that, all else equal, an infant who has been breastfed longer, and thus has received more mother's milk, will grow more than one who has been breastfed less time.

Supplementary Food. Since the free supplementary food represents an important source of food not reflected in a measure of income, measures of quantity of calories from the calorie drink (FRESCO) or the protein drink (ATOLE) appear in the empirical model. All else equal, one expects that (a) a child who consumed more calories from either supplementary food to grow more than the child who received fewer or no calories from supplementary food and (b) a child who consumed a given number of calories from atole would grow more than a child who consumed the same quantity of calories from fresco.

Village Variables. The village dummies (VILLAGE 3, VILLAGE 6, VILLAGE 8)[3] have been included in the empirical specification to control for differences in protein content of the two types of

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[2] Using figures from Pivaral (1972), I estimate that the amount needed simply to supply the average family with sufficient corn and beans for subsistence is $215, or a little under 50 percent of average income. This calculation does not include costs of salt, sugar, and coffee, which are also staples in the diet.

[3] Village 14 is the excluded village.

supplementary food received in the villages. ATOLE and FRESCO reflect calorie intake in the presence or absence of protein. They do not control for the independent effect that protein may have on growth.

If protein has an independent effect on growth and if the only differences in growth-related factors between villages is the presence of protein in the supplementary food available, then we would expect the following:

- o Villages 03 and 08 will have lower growth relative to villages 06 and 14.
- o Village 03 will not differ significantly from village 08 and village 06 will not differ significantly from village 14.

The village dummies may have embedded in them a number of other factors that relate to child growth; thus absence of differences between the fresco villages (03 and 08) and the atole villages (06 and 14) will not necessarily disprove the hypothesis regarding protein presence/absence.

Variables Reflecting Extent of Maternal Health/Depletion

The following proxies for mother's health/depletion are included in the empirical model:

- o Total number of live births (LIVEBRT)
- o Total number of stillbirths (STILLBRT)
- o Birth interval between the previous child and the current child (INTERVAL)
- o Mother's weight at the end of the last trimester of pregnancy (WGTMOM)
- o Mother's height (HGTMOM)

Since we expect pregnancy experience to influence the quality of a mother's child care and of her milk, we expect negative relations between infant growth and number of live pregnancies controlled for mother's age, number of stillbirths controlled for age, and birth interval. Live births and stillbirths enter separately since they may affect the mother differently. For example, a live birth is accompanied by an extended breastfeeding period which may further contribute to maternal depletion, whereas a stillbirth is not.

We expect a positive relation between mother's weight controlled for her height and infant growth since the quality of mother's milk also depends on fat stores laid down during pregnancy. Mother's height (HGTMOM) also should be positively related to infant growth. The mother's height may reflect in small part the child's genetic potential, but most of the recent nutrition literature argues strongly that it reflects her own childhood socioeconomic and nutritional status. Having been raised in more favorable conditions, tall women tend to be healthier and to "have babies of higher vitality than short women" (Thomson, 58, 1963).

Variables Reflecting Availability of Child Care Time

Since the data were collected originally for other purposes, measures were not available of time devoted by each family member to a particular child's care and feeding. Therefore, the following family composition variables are used as proxies:

- o Number of preschool aged (0 to 6 years) children living at home (NUM006).
- o Number of siblings aged 7 to 10 living at home (NUM710).
- o Number of siblings aged 11 to 14 living at home (NUM1114).
- o Number of siblings aged 15 and older living at home (NUM15+).

The age ranges reflect age differences related to child care ability and norms regarding appropriate work of children in Guatemala. Preschool aged children generally do not work. Of the children who are old enough to help out, children aged 7 to 10 are least able to substitute for mother's time in child care, housekeeping, and income-earning activity. Children aged 11 to 14 and adults are increasingly effective substitutes for mother's time in any of these activities.

Suppliers of Child Care Time. We cannot predict *a priori* the net relationship between the presence of older siblings (NUM710, NUM1114 and NUM15+) and infant growth since the older sibling variables reflect the net effect of older siblings on child care time supply, environmental crowding, and per person food availability. The contribution of older siblings to child care time tends to increase infant growth. The increased crowding, owing to their presence, tends to decrease infant growth. Their presence has an ambiguous[4] effect on infant growth through per person food availability. Since these effects work in opposite or ambiguous directions, we cannot predict what signs the older sibling variables will have in the empirical model.

Consumers of Child Care Time. We predict that the number of preschool children (aged 0 to 6) will have a negative relation with infant growth. The presence of more preschool aged children will reduce the child care time available for any one infant, reduce food available per person, and increase crowding. All these factors tend to reduce growth. Since the food consumption requirements of children these ages are small relative to the requirements of other ages, it is assumed that the major impact of greater number of preschool aged children will be on child care time and on crowding.

A Note on Mother's Employment Status Variable. A measure of mother's employment status reflects to some extent the availability and quality of time inputs to child care. A measure of whether or not the woman worked in 1974 was available in the data set, however, its meaning was questionable. It did not provide adequate data on how compatible the work actually was with child care, nor did it provide a meaningful estimate of how long the woman actually did work

[4] Since we control, empirically at least, for their contributions to income, the effect of older siblings on per person food availability is probably negative, implying a negative relation to infant growth. However, because we do not know anything about intra-family distribution of available food (and knowledge of the communities provides no clues), we cannot say unambiguously what effect older siblings will have on the amount of food which actually reaches the infant.

and was not simply available to work. Therefore the measure was not included in the equations presented here.[5]

Variables Reflecting Disease Prevalence and Genetic/Socioeconomic Relations

Number of Rooms. We predict that the number of rooms in the house (NUMROOM) will be positively related to growth, and assume that the number of rooms reflects the size of the house. A smaller house for a given family size reflects greater crowding and increased prevalence of infectious disease. Number of rooms also reflects a family's wealth and presumably its ability to provide adequate food and medical care to a growing infant.

Sex of Child. We predict that infant boys (SEX) will grow more than infant girls. From other studies we observe differences in growth for boys and girls during the first six months of life, with boys growing more than girls (U.S., 1976). In addition, in a society like Guatemala in which males are favored over females, one would expect boys to receive more food than girls and consequently to grow more.

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[5] For example, several women indicated they worked 14 to 16 hours a day. In checking their questionnaires, I found that they were tending a store in front of their house. Customers came to such stores only occasionally, so the woman goes about her housework and child care, tending the store only when a customer calls. She may even have a child tend the store when she wants to leave. It is not clear to me that just because the store is open 16 hours a day, this provides a good estimate of hours worked. Essentially our concepts for measuring women's work as it might affect child health are inadequate for the employment situations of women in these villages.

GLOSSARY OF VARIABLES

AGEMOM: Mother's age in months

ATOLE: The average number of calories per day from atole consumed by the infant during the period.

BRTWGT: Weight of the infant in kilograms within 24 hours of birth.

FRESCO: The average number of calories per day from fresco consumed by the infant during the period.

HGTMOM: Mother's height in centimeters.

INCOME: The 1974 net income (including regular transfers) for the extended family measured in quetzales (1Q = 1$). The measure includes imputed values of agricultural crops produced for home consumption.

INTERVAL: A dummy variable with a value of 1 if the infant was conceived within 12 months of his next oldest sibling. It has a value of 0 otherwise.

LENLAC: The number of months infant was fully or partially breastfed.

LIVEBRT: The number of live pregnancies (including current infant) the infant's mother has had.

NUMROOM: The number of rooms in the house in which the infant's family lived in 1975.

NUM006: The number of the infant's siblings aged 0-6 years present in the family's house within the year after the infant's birth.

NUM710: The number of the infant's siblings aged 7-10 years present in the family's house within the year after the infant's birth.

NUM1114: The number of infant's siblings aged 11-14 years present in the family's house within the year after the infant's birth.

NUM15+: The number of infant's siblings aged 15 years or older present in the family's house within the year after the infant's birth.

SEX: A dummy variable with a value of 1 if the infant is male and 0 if the infant is female.

STILLBRT: The number of stillbirths the infant's mother has had prior to the infant's birth.

VILLAGE3: A dummy variable with a value of 1 if the infant lives in village 03 (a fresco village). The variable has a value of 1 otherwise.

VILLAGE6: A dummy variable with a value of 1 if the infant lives in village 06 (an atole village). The variable has a value of 1 otherwise.

VILLAGE8: A dummy variable with a value of 1 if the infant lives in village 08 (a fresco village). The variable has a value of 1 otherwise.

WGTMOM: The mother's weight in kilograms at the end of the third trimester of pregnancy.

WGT06: The infant's weight in kilograms at 6 months ± 3 days.

WGT12: The infant's weight in kilograms at 12 months ± 3 days.

VII. RESULTS

OVERVIEW

The regression results appear in Table 4. Based on the estimated coefficients in Equation II in Table 4, a girl from village 08 who had a long birth interval and mean values on all continuous variables would grow about 3.4 kilograms from 0 to 6 months. A boy would grow about 3.9 kilograms from 0 to 6 months. Both their 6-month weights would fall between the 10th and 25th percentile NCHS standard weights, and they would both have to grow about 20 percent more from 0 to 6 months to attain the 50th percentile NCHS standard weight. Based on the estimated coefficients in Equation III, both would grow about 1.2 kilograms from 6 to 12 months and both their 12-month weights fall below the 5th percentile NCHS standard weights. They would have to grow about 160 percent more from 6 to 12 months to attain the 50th percentile NCHS standard weight.

The differences between boys and girls in the Guatemala sample are significant but they are not significantly different from the sex differences in the NCHS standard weights. This suggests that the Guatemalan infant boys do not have any greater advantage over the Guatemalan infant girls than the NCHS boys had over the NCHS girls.

We note from Table 4 that all explanatory variables relate to infant 6- and 12-month weights in the hypothesized direction; however, some work in one 6-month period and not in the other. Table 5 makes this point more clearly by presenting the direction of only the significant relations found for each 6-month period. Variables reflecting mother's characteristics (e.g., her pregnancy experience, her weight and height), number of older siblings, and birth weight are related to 0 to 6 month growth. Variables reflecting numbers of siblings in the home, measures of food availability, 6-month weight, and mother's height relate to 6 to 12 month growth.

Below I discuss the coefficients on the various explanatory variables in some detail. In doing so I frequently translate the estimated relations into percentages of average growth during the

Table 4

OLS REGRESSIONS OF INFANT GROWTH ON FAMILY SIZE MECHANISMS: FOUR GUATEMALAN VILLAGES

Explanatory Variables	Equation I Growth 0-12 Months		Equation II Growth 0-6 Months		Equation III Growth 6-12 Months	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Availability of Food and Medical Inputs						
Household Income (INCOME)	.0002	(.0001)[a]	.0001	(.0001)	.0001	(.0001)
Calories of Atole (ATOLE)	.0031	(.0010)[b]	.0007	(.0011)	.0022	(.0005)[b]
Calories of Fresco (FRESCO)	.0003	(.0090)	-.0124	(.0102)	.0063	(.0041)
Length of Breastfeeding (LENLAC)	.0115	(.0039)[b]	.0084	(.0098)	.0055	(.0024)[c]
Village 03 (VILLAGE 3)	-.4898	(.2071)[b]	-.4622	(.1779)[b]	-.1010	(.1279)
Village 06 (VILLAGE 6)	.0269	(.1592)	.0399	(.1409)	.0272	(.0981)
Village 08 (VILLAGE 8)	-.2026	(.1820)	-.1946	(.1559)	-.0465	(.1120)
Maternal Health						
Mother's Weight (WGTMOM)	.0208	(.0110)[a]	.0237	(.0099)[c]	.0025	(.0065)
Number of Live Pregnancies (LIVEBRT)	-.0765	(.0436)[a]	-.1182	(.0391)[b]	.0127	(.0273)
Number of Still Births (STILLBRT)	.2354	(.1474)	.1964	(.1380)	.1111	(.0907)
Mother's Age (AGEMOM)	.0002	(.0012)	-.0001	(.0010)	.0005	(.0007)
Short Birth Interval (INTERVAL)	-.3804	(.1537)[b]	-.428	(.1394)[b]	-.0037	(.0969)
Availability of Child Care Time						
Number of Preschoolers (NUM006)	-.2012	(.0696)[b]	-.0012	(.0610)	-.1598	(.0425)[b]
Number 7-10 Year Olds (NUM710)	.0688	(.0959)	.0843	(.0865)	.0002	(.0593)
Number 11-14 Year Olds (NUM1114)	.0231	(.0996)	.0556	(.0901)	-.0049	(.0607)
Number 15+ Year Olds (NUM15+)	-.0340	(.1406)	.2363	(.1288)	-.2044	(.0874)[c]
Environmental, Genetic, Socioeconomic						
Number of Rooms (NUMROOM)	.1546	(.0792)[c]	.1442	(.0687)[c]	.0599	(.0492)
Birth Weight (BRTWGT)	-.3966	(.1445)[b]	-.4521	(.1256)[b]		
Six Month Weight (WGT06)					-.1550	(.0401)[b]
Child's Sex (SEX)	.5487	(.1121)[b]	.4828	(.1006)[b]	.1471	(.0719)[c]
Mother's Height (HGTMOM)	.0394	(.0120)[b]	.0282	(.0109)[b]	.0163	(.0074)[c]
Intercept	-1.9882	(1.7235)	-.6142	(1.6241)	-1.1296	(1.0472)
R^2	.3721		.3009		.2307	
(F)	6.34		5.18		3.21	
df	246		277		246	
N	270		301		270	

[a]Significant at p<.10
[b]Significant at p<.01
[c]Significant at p<.05

Note: Dummy variables were used to flag cases with missing data on LENLAC, WGTMOM. In addition, a dummy was included for six cases who received a special milk supplement through the INCAP program (because of more serious retardation). For ease of exposition, these dummies are not shown in Table 4.

Table 5

SUMMARY OF SIGNIFICANT RELATIONS BETWEEN EXPLANATORY VARIABLES AND INFANT GROWTH

	Growth Period		
Explanatory Variables	0-12 Months	0-6 Months	6-12 Months
Availability of food and medical inputs			
Household income	+		
Number 15+ year olds[a]			-
Calories of atole	+		+
Length of breastfeeding	+		+
Maternal health			
Number of live pregnancies	-	-	
Short birth interval	-	-	
Mother's weight	+	+	
Availability of child care time			
Number of preschoolers	-		-
Number of 15+ year olds[a]		+	
Environmental, genetic, and socioeconomic			
Number of rooms	+	+	
Mother's height	+	+	+
Child's sex	+	+	+
Initial weight	-	-	-

[a]As discussed in the text, this variable represents the net effect of two relations working in opposite directions.

period. This may seem to convey more precision than we actually have about the exact size of the relations, especially in light of the bias resulting from the single equation estimation system. This is done simply to provide a better feel for the relations, since the explanatory variables reflect such a variety of dimensions.

MATERNAL HEALTH AND DEPLETION

Relation of Mother's Previous Pregnancy Experience to Infant Growth

Both birth interval and number of live pregnancies, reflecting a mother's pregnancy experience, have a significant relation to infant growth over the twelve month period (see Equation I in Table 4). These factors have their greatest impact during the first six months of life when a child is more dependent on mother's milk[1] and the effects of prenatal growth factors might be strongest. The negative and significant coefficient on birth interval in the 0 to 6 month growth equation (Equation II in Table 4) suggests that an infant who is conceived within a year of his next oldest sibling's birth grows about 12 percent less from 0 to 6 months than an infant with a longer previous birth interval.[2]

The negative and significant coefficient on number of live pregnancies for 0 to 6 month growth indicates that, all else equal, a fifth born infant (the mean number of live pregnancies for the sample) grows about 12 percent less during the 0 to 6 month period than a first born infant. Several nonlinear specifications of number of live pregnancies were tried, but the results suggested a linear relation for this sample.

The coefficient on the number of stillbirths is significantly different from the coefficient on the number of live pregnancies. If

[1] After 4 to 6 months, women in these villages generally supplement mother's milk with other foods (partial breastfeeding).

[2] Both birth interval and number of live pregnancies relations may be understated since children who died within the first six months of life tended to be higher parity and closer spaced children.

we assume that the relation between number of pregnancies and growth is causal and that pregnancy contributes to maternal depletion, then the difference between the effects of stillbirths and live births suggests that something about live births and not stillbirths relates to poor growth. One most obvious difference is the extended period of breastfeeding which accompanies a live birth, and which could contribute considerably to the depletion of a woman's physical capacity for adequate child care and/or milk production.[3] On the other hand, a woman who had had more stillbirths might have greater fear of not being able to replace children, should a currently living child die, so she might take better care of her infant. Finally, stillbirths could reflect a certain amount of induced abortion used as a method of birth control. It may be that women who are consciously trying to limit births are doing so in order to produce healthier children. The data available and the small sample size did not allow me to explore these questions further.

After controlling statistically for the number of pregnancies a woman has had, the coefficient on mother's age is not significantly different from zero. I tried several nonlinear specifications and specifications with interactions. The results did not suggest non-linearities nor did they indicate differences depending on mother's age in the relation of infant growth to birth interval, number of pregnancies, mother's height or weight. In these communities, birth control is fairly uncertain and ineffective, if it is used at all, and mother's age and number of pregnancies are highly correlated. I am not sure that with this small sample it was fully possible to disentangle age effects from number of pregnancies. Presumably, both affect mother's health and child care effectiveness.

Relation of Mother's Weight and Height to Growth

The coefficients on mother's weight and height further emphasize the important relation of mother's health to infant growth, especially

[3] A lactating woman requires 3000-3200 calories per day and evidence from other studies in similar Guatemalan villages shows that lactating women consume between 1500 and 1700 calories daily.

during the first six months. Women who weigh more, for a given height, have infants who grow more. The positive and significant coefficient on mother's weight[4] in Equation II indicates that if a sample mother weighed at the end of pregnancy what doctors recommend[5] for an average U.S. woman of her height (about 66 kilograms), her infant would grow about 7 percent more during the 0 to 6 month period.

Taller women's children also grow more during the first year of life. The coefficient on mother's height in Equation I indicates that, all else equal, each additional 2.5 centimeters (about 1 inch) of a mother's height results in an additional .10 kilogram of infant growth over the first year of life. This suggests that if a sample woman were as tall as the average U.S. woman of childbearing age in 1971-1974 (about 100 centimeters or 64 inches), the child would grow about 9 percent more over the first year.

In addition to genetic factors, height reflects a mother's early childhood socioeconomic and nutritional status. To the extent that it reflects socioeconomic status, it may reflect other characteristics that make her a more capable mother. For example, she may have attended school longer or done better in school. In order to test this, I included a measure of literacy in the equations. However, it did not change the sign or significance of mother's height or any of the other explanatory variables and the coefficient on literacy itself was not significant.

Unfortunately, this probably was not a wholly adequate test of the meaning of height for infant growth nor of the relation of mother's intellectual abilities to infant growth. First, the literacy measure may not be a particularly good measure of a woman's child care ability. In addition, her ability would affect indirectly a number of variables

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[4] We saw earlier that the average mother in the sample stands about 59 inches tall and weighs 119 pounds at the end of the third trimester of pregnancy.

[5] It is currently recommended that women gain 10-12 kilograms (24-26 pounds) during pregnancy. Owing to inadequate food intake, women in rural Guatemalan villages similar to the ones studied here gain 5-6 kilograms (11-13 pounds) by the end of pregnancy (Arroyave, 1976).

in the model, again suggesting the need for a simultaneous system of equations. More detailed measures of knowledge and attitudes as they pertain to infant health and nutrition as well as more precise indicators of early socioeconomic status would be needed to explore these relations more fully.

OTHER FAMILY SIZE RELATIONS

Food Availability, Crowding, and Presence of Older Siblings

The coefficients on NUM710, NUM1114, NUM15+ in Equation I indicate that once we have controlled for the possible consequences to maternal health of having borne an infant's older siblings, the number of older siblings present in the family has no net effect on infant growth over the first year of life. The coefficients on NUM710 and NUM1114 are not significantly different from zero for either the 0 to 6 month or 6 to 12 month period (Equations II and III, respectively). If we assume that the coefficients reflect a causal relation, they suggest that siblings aged 7 to 14 may contribute enough to child care time (either directly or indirectly, by freeing the mother) to offset the negative effect their presence has on the availability of food and on crowding.

The coefficient on NUM15+ in Equation I is not significantly different from zero, suggesting that over the 0 to 12 month period their net relation to child growth is essentially zero. The coefficient on NUM15+ is positive and significant on 0 to 6 month growth and negative and significant on 6 to 12 month growth. Again, if we assume a causal relation, this could suggest that during the first six months of an infant's life, adult aged siblings may substitute for the mother in other activity, freeing her for child care, especially breastfeeding. From 6 to 12 they may begin competing with the child for scarce food resources or the mother may begin leaving the child with them and the quality of care declines.

Presence of Preschool Aged Children in the Family

The coefficients on NUM006 in Equations I and III indicate that the number of preschool aged children in the family has a significant negative relation to infant growth during the first year of life, but the relation is much stronger during the 6 to 12 month period. The negative and significant coefficient on NUM006 for the 6 to 12 month weight (Equation III) indicates that an infant with a preschool aged sibling grows about 14 percent less from 6 to 12 months than one who does not have a preschool aged sibling. As suggested in the theoretical discussion, several preschoolers present in a family may compete with the infant for child care time and/or increase the infant's exposure to infectious diseases.

AVAILABILITY OF FOOD AND MEDICAL INPUTS, ENVIRONMENT/GENETIC

Mother's Milk. The positive and significant coefficients on breastfeeding in the 6 to 12 months and 0 to 12 months equations indicate that an additional month of breastfeeding is associated with a 4 percent increase in average 6 to 12 month growth, and a 2 percent increase in 0 to 12 month growth. We do not observe a significant relation of breastfeeding in 0 to 6 month growth since there is very little variation in the six-month measure; nearly all women said they breastfed during the entire 6-month period.

Ideally we would distinguish full breastfeeding from partial breastfeeding[6], but data on pattern and intensity of breastfeeding were not available in this data set. Initially I tried using information about length of lactation beyond the first year of life as a proxy for inadequate data on breastfeeding patterns. (The reasoning was based on the fact that the mother's physiological capacity for producing milk is, in part, determined by the intensity and frequency of the child's sucking occurring during nursing.) This is probably a poor proxy and for this reason inclusion of this information did not significantly increase the model's ability to explain growth.

For the estimated models shown here, the most we can say is that probably by six months most women had introduced other food. An ethnographic study (Pivaral, 1972) reports that other food is introduced

[6] This is because extended periods of full breastfeeding can also be detrimental because a child begins to need nutrients not available in mother's milk between 4 and 6 months of age.

into a child's diet between three and six months of age, and this sample's pattern of supplementary food intake suggests that at least 85 percent of the women had introduced food other than mother's milk by six months of age.

As indicated earlier, care must be taken in attributing a causal relation to breastfeeding. Indeed, increased breastfeeding may increase growth but increased growth might also result in longer breastfeeding, if larger babies who consume more nurse longer each time they nurse and/or nurse more often. In addition, since reliance on breastfeeding reduces exposure to contaminated water in these villages, breastfeeding may be acting to some extent as a proxy for the infant's health, reflecting the presence of intestinal parasites and diarrheal disease in the infant.

Supplementary Food, Calorie Effect. The positive and significant coefficient on ATOLE indicates that the daily consumption of 6 ounces of the protein drink is associated with 9 percent increase in 0 to 12 month growth. It appears that the calorie drink also is associated with increased 0 to 12 month growth. This is suggested by the positive coefficient on FRESCO and by the fact that a test of the difference between coefficients on ATOLE and FRESCO would not allow us to reject the null hypothesis that the coefficient on FRESCO is significantly different from the coefficient on ATOLE. We cannot be more confident about the relation of FRESCO calories lone to growth because quantities consumed varied little across infants.

Care must be taken in attributing all of this relation to supplementary food intake since supplementary food intake may be correlated somewhat with use of the medical clinic for curative and preventive care. This would suggest that the calorie consumption measure may reflect to some extent the level of good health the child enjoys. Unfortunately no measures of medical clinic attendance were available nor were satisfactory measures of illness available to test this.

Supplementary Food, Protein Effect. The coefficients on the village dummies (VILLAGE 3, VILLAGE 6, VILLAGE 8) are not significantly different from each other, suggesting that we cannot reject the hypothesis that the protein contained in ATOLE (offered in villages 06 and 14) has no independent relation to growth. This is consistent with the nutritionists' general view that diets in many Central American rural areas are calorie-limited, not protein-limited. We base our conclusion that protein has no independent relation on the assumption that the villages do not differ systematically on any other factors which could also affect infant growth.

Income. Equation I indicates that within the ranges of income represented here, small changes in income do not relate substantially to infant growth. The coefficient on income in Equation I indicates that twice the average annual sample income would be associated with a 2 percent increase in infant growth over the 12 months.

There are several possible reasons for the small coefficient on income. First, the income variable may measure actual income poorly. Measurement error arises from the following: (a) much of family income in these agricultural villages consists of nonmarket production for home consumption, which is hard to measure and hard to recall, (b) this particular income measure does not reflect the value of certain payments and transfers in kind (usually food) to families, and (c) this income measure does not reflect the amount of supplementary food and free medical care received by other members of the family through the nutrition intervention.

Second, the only income measure available in the data set refers to the 1974 agricultural year. Since a high proportion of families have subsistence agricultural activity as a major source of income, income is very unstable across years and a measure of only one year may not accurately reflect the family's access to income over a longer period. As suggested below, the number of rooms used in these equations may serve as a better reflection of family's economic resources because it is a more permanent measure.

Third, there are a variety of factors that may intervene between increased incomes and improved infant growth which might help explain this. Berg (1970) cites a few: (a) mix of foods purchased may change, (b) infants may not receive additional available food, and (c) families may spend the money on other items that now become possible. Finally, income may indirectly affect infant growth through maternal health, supplementation, center attendance, household composition, breastfeeding behavior, etc., so that the coefficient on income may not be a full reflection of the income relation to child growth.

<u>Number of Rooms</u>. The coefficient on number of rooms in Equation I suggests that each additional room is associated with a 3 percent increase in 12-month growth. Without further analysis, we cannot say if number of rooms measures crowding or wealth. In the empirical model the number of rooms was used to control for crowding and consequent exposure to infectious diseases. The variable also reflects family wealth and may reflect even more accurately than income the family's long-term ability to provide food and medical care to the infant. Number of rooms is correlated with income and when the number of rooms was excluded from the equations, the coefficient on income became significant for the 0 to 6 month period and rose slightly in all periods.

<u>Initial Weights</u>. Birthweight and six-month weight were included in the model to control for the child's weight at the outset of the growth period and the negative and significant relations were not expected, although subsequent reading showed that the relations have been reported in other studies. The relation could reflect individual variations in the timing of growth. For birthweight, if low birthweight babies tend to be premature babies, some of this growth may reflect the growth spurt which occurs during the later months of pregnancy. A behavioral hypothesis for this relation suggests the possibility that mothers could tend to take special care of smaller babies.

Care must be taken in interpreting the results for birthweight because children who were excluded from the analyses owing to death tended, on average, to weigh significantly less at birth than those who survived. This suggests that if a child survives, he tends to catch up with his peers over the first year of life. The fact that the children who died tended to be low birthweight babies suggests that low birthweight (2.5 kilograms or less) should still be a major policy concern.

VII. DISCUSSION AND CONCLUSIONS

SUMMARY OF RESULTS

What Factors Seem To Matter

Summarizing the above discussion, I found that the following factors have a significant relation to infant growth: (a) number of live pregnancies, (b) short birth interval, (c) number of preschoolers, (d) number of 15+ year olds, (e) mother's weight, (f) mother's height, (g) length of breastfeeding, (h) calories from protein supplement, (i) initial weight, (j) child's sex, and (k) number of rooms in house. The village dummies, calories from the calorie supplement, number of stillbirths, number of 7 to 10 and 11 to 14 year olds, and the mother's age were not significantly related to growth. Income was significant at the 10 percent level and the coefficient suggested a fairly unimportant relation with growth. As indicated in the discussion, income was one of the more poorly measured variables and number of rooms may be a better indication of permanent income. There was little variation in the quantity of the calorie supplement consumed, and mother's age and birth order of the infant are highly correlated. The other nonsignificant relations are probably nonsignificant because there is little or no systematic relation to infant growth for this sample.

When Do Various Factors Matter

The results indicate that the significant relations differ for the two 6-month growth periods. For example, 0 to 6 month growth relates significantly to: (a) mother's weight, (b) mother's height, (c) number of live pregnancies, (d) short birth interval, (e) number of 15+ year olds, (f) number of rooms, (g) child's sex, and (h) birth weight. Growth from 6 to 12 months relates to: (a) number of 15+ year olds, (b) number of preschoolers, (c) calories from protein supplement, (d) length of breastfeeding, (e) mother's height, (f) child's sex, and (g) 6-month weight. We note that a number of the growth factors which appear to be significant from 0 to 6 months concern maternal characteristics that could affect a child's growth indirectly through breastfeeding and the mother's capacity for good child care through her health and stamina. In contrast, the significant relations for 6 to 12 month growth suggest factors external to the mother and child that could affect food availability and child care time.

The picture that emerges suggests that during the first 6 months of life when the child is highly dependent on the mother and relatively immobile, (s)he is relatively isolated from external influences and the mother's characteristics play an important role in growth. After 6 months the child becomes more mobile and less physically dependent on the mother. One senses from these empirical results that the child has begun to compete with others in the household for scarce time and food resources, and factors external to the close mother-child relation begin to have a more important effect on growth.

POLICY IMPLICATIONS

The Role of Family Size

The findings suggest that thinking in terms of the global concept of "family size" may reduce our ability to understand the mechanisms underlying infant growth. Data limitations preclude precise specification of the mechanisms; however, the finding that different indicators of family size (e.g., number of pregnancies, number of preschoolers) related at different times in different ways or not at all to growth suggests that understanding these mechanisms would allow us to expand program options for dealing with the impediments which family size frequently seems to have on infant growth. For cost efficient nutrition programs we will want to recognize these different mechanisms and seek to understand which ones are operating in various settings for different aged children.

Timing of Interventions

Differences in factors relating to 0 to 6 and 6 to 12 month growth suggest that appropriate nutrition interventions will depend, to some extent, on the age of the child who is the target of the intervention. For example, to improve 0 to 6 month growth we might focus on maternal health;

to improve 6 to 12 month growth we might focus on influencing conditions within the household that affect food availability, crowding, and child care time.

Identifying Target Groups for Nutrition Interventions

Frequently we want to know how to easily identify appropriate target groups for nutrition interventions. These analyses suggest some easily measured indicators of infants at high risk of growth retardation--mother's weight and height, length of partial breastfeeding, number of preschool aged siblings, parity, and birth interval.

High risk infants include infants whose mothers are short or underweight for their height, who do not partially breastfeed during the first year of life for whatever reason, who have several preschool aged siblings, who are conceived within 12 months of a previous sibling, and whose mothers have had four or more previous pregnancies.

We may also want to think in terms of mothers as target groups for infant nutrition programs. Easily measured indicators of women at high risk of having growth retarded infants include short stature, low weight for height, and numerous pregnancies (four or more).

Potentially Effective Nutrition Interventions

As indicated earlier, care must be taken in interpreting the results for program design since, strictly speaking, the data do not allow us to attribute causality to the observed relations or to assess relative costs and benefits of particular nutrition interventions. However, if I had to guess which interventions might work, I would suggest the following: (a) family planning programs, (b) programs for improving maternal health, and (c) interventions that increase child care time. Family planning programs should focus not simply on reducing the number of pregnancies but also on helping young women in the process of building a family to space their children at appropriate intervals. We might improve maternal health and increase child care time and productivity with such interventions as health care programs designed specifically for pregnant and lactating women, introduction of labor and energy saving devices or appropriate technology for tasks done by women, introduction of potable water, and other such means.

What Can We Say About Supplementary Feeding Programs

Supplementary feeding accompanied by free medical care like that introduced in these villages might increase 6 to 12 month growth. We cannot tell from these analyses how effective supplementary feeding without medical care would be or how cost effective food supplementation programs would be relative to other possible interventions. In addition, we cannot evaluate the social costs in terms of the dependency created by people being served. Finally, these data were collected after the program had been operating 4 to 5 years. Therefore, it is impossible to say what the relation of infant growth to a shorter-term supplementary feeding program would be.

What Recommendations Can We Make About Patterns of Breastfeeding?

We cannot infer from these analyses specific recommendations about length and patterns of breastfeeding for any one child or across a woman's childbearing years for several reasons. First, no data were available on when the mother introduced other food besides mother's milk (full vs. partial breastfeeding), nor do we know why she stopped breastfeeding (i.e., whether she chose to or whether her milk stopped). In addition, we noted that lengthy periods of breastfeeding may contribute to a negative relation between number of live pregnancies and growth. Finally, breastfeeding may be a proxy for other inputs to child health such as exposure to parasites and consequent ill health due to contaminated water, in which case we would do better to make recommendations about water and environmental sanitation.

Income Redistribution and Provision of Potable Water

The more I visited rural areas and talked to rural villagers and development and health workers in Central America, the more I became convinced that provision of potable water and substantial increases in income are essential for truly adequate infant growth. Unfortunately, these issues could not be looked at adequately with these data. The fact that the study villages were homogeneous and all had contaminated water precluded analysis of the relation of water to growth. I suspect also that the fact that we looked only at low levels of growth (none of the infants exceeded the 50th percentile standard weight by 12 months of age) may have obscured some of the effect income may have on favorable infant growth. For example, we may not find an important relation between income and growth until we look at a sample containing children who are not classified as mildly to moderately malnourished and who presumably are characterized by wider income ranges.

In future studies it would be valuable to use a sample of children who evidence somewhat more variation in a number of growth related dimensions and who evidence somewhat higher levels of growth. This might provide some insight into whether the same factors operate at all levels of growth or whether additional programs will be needed to improve nutritional levels even further.

THOUGHTS ON FUTURE MODEL BUILDING

These analyses have been exploratory. They have probably raised more questions than they have answered and they have brought to light a number of problems involved in developing adequate empirical models of complex health and population issues. It is worth listing the problems and data limitations here so that future studies can build from our experience. Planning evaluation components into actual interventions will also provide insight into the relations.

Data Problems and Limitations

The problems include (a) the difficulty of identifying a simultaneous equation system incorporating the health of a woman and her infant when the concepts are so highly interdependent, (b) the small sample size precluded disentangling certain biological relations (e.g., we would like to look more closely at number of pregnancies by different age groupings of mothers), (c) the usual problems of missing data created by the longitudinal nature of the data collection and by a sampling framework for the socioeconomic survey that did not collect data from all families on each questionnaire in the survey, compounded by the seasonal and temporary migration of the study communities, (d) availability of data on low levels of growth only (none of the children manifested 6 or 12 month weights above the 50th percentile NCHS standard), which means we do not know what factors relate to more favorable growtn, and (e) fairly homogeneous communities, making it hard to specify the relation of more general environmental and public health factors.

The Importance of Intervention Evaluation

We cannot hold off on nutrition interventions until we have resolved (if we ever can) all these conceptual/empirical problems. We have to design interventions based on best hunches derived from common sense and less-than-perfect empirical analyses. This argues strongly for incorporating evaluation components into actual field interventions so that we can evaluate consequent growth and nutrition against pre-intervention levels.

We could also begin thinking about incorporating evaluation of growth and nutrition effects into other development programs that are not aimed directly at improving nutrition but which could be expected to have spill-over growth effects. For example, electrification may reduce the time and energy required for tasks women normally do, thereby improving their nutrition and health status and increasing child care time. This might result in improved infant growth. When the evaluation component is absent, as it frequently seems to be, we are not using all the information we know how to get on this very complex set of biological and behavioral relations and interactions.

INTERGENERATIONAL TRANSFERS OF HEALTH

To end this discussion on an optimistic note, the results for mother's height suggest intergenerational nutritional effects. A mother who was apparently well-nourished in her childhood (reflected by height) tends to have children who grow more. Although we cannot affect the childhood nutritional status of current mothers, the relation suggests that what we do now to improve growth will have both short-run and long-run payoffs in terms of improved health and nutrition for this generation of children and for their children.

Appendix A

DESCRIPTIVE STATISTICS: CORRELATION MATRIX AND MEANS AND STANDARD DEVIATIONS OF VARIABLES USED IN REGRESSION ANALYSES

TABLE A.1

CORRELATION MATRIX OF VARIABLES USED IN REGRESSION ANALYSES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
Growth 0-6 Months	1.00																											
Growth 6-12 Months	-.12	1.00																										
Growth 0-12 Months	.83	.45	1.00																									
Household Income	.10	.08	.13	1.00																								
Calories of Atole (0-6 Months)	.14	.19	.23	.01	1.00																							
Calories of Atole (6-12 Months)	.10	.26	.24	.03	.84	1.00																						
Calories of Atole (0-12 Months)	.12	.24	.25	.02	.94	.97	1.00																					
Calories of Fresco (0-6 Months)	-.16	.00	-.13	-.01	-.24	-.23	-.24	1.00																				
Calories of Fresco (6-12 Months)	-.12	.04	-.07	-.01	-.27	-.26	-.27	.81	1.00																			
Calories of Fresco (0-12 Months)	-.13	.03	-.10	-.01	-.27	-.26	-.27	.92	.97	1.00																		
Length of Breastfeeding (0-6 Months)	.01	.02	.02	-.01	-.22	-.17	-.20	.05	.05	.05	1.00																	
Length of Breastfeeding (6-12 Months)	.11	.02	.09	-.04	-.15	-.24	-.18	.06	.05	.07	.72	1.00																
Length of Breastfeeding (0-12 Months)	.06	-.01	.01	-.10	-.16	-.23	-.19	.04	.08	.07	.32	.60	1.00															
Mother's Weight	.08	.08	.13	.13	.07	.11	.10	.13	.09	.11	.02	-.05	-.12	1.00														
Number of Live Pregnancies	-.21	.05	-.16	.04	.19	.19	.20	.05	-.01	.01	-.08	.02	.13	.21	1.00													
Number of Stillbirths	.05	.11	.10	.03	.17	.16	.17	-.04	-.06	-.06	-.27	-.14	-.03	.13	.21	1.00												
Mother's Age	-.17	.09	-.10	.05	.17	.18	.19	.04	.00	.02	-.10	.04	.20	.10	.82	.26	1.00											
Short Birth Interval	-.14	.05	-.11	.01	.06	.09	.08	-.07	-.08	-.08	.05	-.05	-.20	.12	.03	.09	-.07	1.00										
Number of Preschoolers	-.16	-.15	-.24	-.13	.12	.07	.09	.06	-.03	.00	-.04	.09	.05	.09	.46	-.04	.29	.10	1.00									
Number of 7-10 Year Olds	-.10	.05	-.07	.06	.08	.08	.08	.11	.08	.10	-.10	.00	.15	.13	.67	.16	.60	-.06	.27	1.00								
Number of 11-14 Year Olds	-.11	.01	-.09	.06	.03	.06	.05	.12	.05	.08	-.08	-.04	.12	.14	.59	.13	.52	-.08	.18	.50	1.00							
Number of 15+ Year Olds	-.03	-.02	-.04	.17	.15	.23	.21	.01	-.02	-.01	-.05	.00	.03	.06	.51	.17	.46	-.02	.05	.28	.38	1.00						
Number of Rooms	.05	.08	.07	.31	-.06	-.05	-.05	.16	.17	.17	.04	.06	.11	.06	.14	-.10	.15	-.02	-.07	.12	.09	.20	1.00					
Birth Weight	-.11	.00	-.07	.09	.10	.06	.07	.11	.12	.12	-.05	-.01	-.02	.45	.20	.14	.13	-.03	.14	.15	.22	.14	.04	1.00				
Six Month Weight	.90	-.11	.75	.10	.18	.12	.15	-.10	-.05	-.07	-.01	.10	.04	.28	-.11	.11	-.10	-.14	-.09	-.03	-.01	.03	.06	.34	1.00			
Twelve Month Weight	.75	.43	.92	.14	.25	.24	.25	-.07	-.01	-.03	.00	.07	.02	.30	-.07	.15	-.05	-.12	-.16	-.01	.01	.02	.08	.31	.85	1.00		
Child's Sex	.22	.05	.22	-.10	.17	.09	.12	.03	.03	.03	-.09	.00	.00	-.02	.00	.02	-.02	-.06	.08	.06	-.03	-.05	-.02	.14	.27	.27	1.00	
Mother's Height	.18	.14	.25	.09	.01	.06	.04	.11	.10	.11	.04	-.01	-.01	.52	.05	.13	-.02	.07	-.00	.07	.09	-.00	.05	.17	.24	.31	-.04	1.00

Table A.2

MEANS AND STANDARD DEVIATIONS ON VARIABLES USED IN REGRESSION EQUATIONS

	Mean	Standard Deviation
Growth 0-6 Months (kilograms)	3.80	.95
Growth 6-12 Months (kilograms)	1.11	.59
Growth 0-12 Months (kilograms)	4.93	1.06
Household Income (quetzales)	502.00	457.00
Calories of Atole (0-6 Months)	32.90	57.97
Calories of Atole (6-12 Months)	46.57	84.94
Calories of Atole (0-12 Months)	38.82	67.68
Calories of Fresco (0-6 Months)	2.49	5.90
Calories of Fresco (6-12 Months)	4.63	9.95
Calories of Fresco (0-12 Months)	3.50	7.44
Length of Breastfeeding (0-6 Months) * 10	59.38	5.60
Length of Breastfeeding (0-12 Months) * 10	114.98	16.22
Length of Breastfeeding * 10	174.17	57.47
Mother's Weight (kilograms)	53.74	6.60
Number of Live Pregnancies	4.78	2.92
Number of Still Births	.09	.40
Mother's Age (months)	336.00	86.00
Short Birth Interval [a]	.15	.36
Number of Preschoolers	2.52	.97
Number of 7-10 Year Olds	.64	.79
Number of 11-14 Year Olds	.39	.70
Number of 15+ Year Olds	.15	.48
Number of Rooms	1.68	.79
Birth Weight (kilograms)	3.06	.45
Six Month Weight (kilograms)	6.86	1.00
Child's Sex	.53	.50
Mother's Height (centimeters)	149.00	5.28

[a] Conceived within 12 months of previous sibling

Appendix B

SUPPLEMENTARY FOOD INTAKE

The volume of supplementary food consumed varied with infant age and sex. As indicated in Table B.1, infants generally consumed greater volumes of supplementary food during the 6-12 month period than during the 0-6 month period. Atole village boys consumed a significantly greater quantity than atole village girls during the 0-6 month period. The differences are not significant for fresco boys and girls.

Supplementary food consumption patterns also differ in the atole and fresco villages. As seen in Table B.2, by the end of three months 87 percent of atole village infants and 61 percent of fresco village infants had consumed at least one calorie of supplementary food, suggesting that atole village infants tended to visit the supplementary food center earlier than fresco village infants.[1]

Table B.2 also indicates that atole village infants consumed greater volumes of supplementary food than fresco village infants. These means reflect only those who consumed some calories during the period and therefore presumably exclude those who did not attend. This suggests that the atole village infants attended more regularly and/or consumed greater quantities of supplementary food during any one visit.

These descriptive findings support the subjective evaluations of some of the supplementation center personnel and researchers involved in the supplementary feeding aspects of the study. They felt that fresco was viewed as a refreshing drink, whereas atole was viewed as nutritionally valuable. Unfortunately, no empirical data were collected which would allow us to further explore this issue. Since lactating mothers from both the atole and fresco villages consumed approximately the same volume of supplementary food, suggesting they came about as often, it may be that fresco was regarded as a less appropriate infant food than atole.

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[1] Daily attendance figures were not available for the sample at the time of this analysis.

Table B.1

MEAN NUMBER OF CALORIES THROUGH SUPPLEMENTARY FOOD BY INFANTS[a] DURING 0-6 MONTH AND 6-12 MONTH PERIODS AND BY LACTATING MOTHERS BY SEX AND VILLAGE TYPE

	Fresco		Atole	
	Female	Male	Female	Male
Calories of Infant's Supplementary Food (0-6 Months)	8.25	7.15	51.29	75.20
Grams of Protein in Infant's Supplementary Food (0-6 Months)	0	0	3.62	5.30
Implied Volume (ml.) Consumed (0-6 Months)	25.17	21.75	56.64	83.04
Calories of Infant's Supplementary Food (6-12 Months)	12.33	12.93	91.92	105.83
Grams of Protein in Infant's Supplementary Food (6-12 Months)	0	0	6.48	7.46
Implied Volume (ml.) Consumed (6-12 Months)	37.62	39.45	101.51	116.87
Calories of Mother's Supplementary Food (Lactation)	70.72	77.78	177.20	216.15
Grams of Protein in Mother's Supplementary Food	0	0	12.50	15.25
Implied Volume (ml.) Consumed (Lactation)	215.8	237.3	195.7	238.7

[a]Means were calculated only for those infants who consumed at least 1 calorie of supplementary food during the specified time period.

Table B.2

PROPORTION OF INFANTS CONSUMING AT LEAST ONE CALORIE OF SUPPLEMENTARY FOOD DURING PERIOD BY SEX AND VILLAGE TYPE

Growth Period	Fresco Female	Fresco Male	Atole Female	Atole Male
0-3 Months	.58	.64	.84	.90
0-6 Months	.78	.80	.92	.90
6-12 Months	.91	.87	.95	.94
Total N	69	75	73	84

Appendix C

DESCRIPTION OF CASES OMITTED DUE TO MISSING DATA AND DEATH

The sample used in the foregoing analyses consists of 301 infants born in four rural villages between January 1, 1973 and December 31, 1975. Three sets of twins were excluded. Of the 392 children born during this period 19 and 6 died between birth and six months and six and twelve months, respectively. Twenty six were excluded on account of missing socioeconomic data. Forty seven and twenty five, respectively, were excluded on account of missing weight data in the periods birth to six months and six to twelve months. Seasonal migration may account for the fairly large amount of missing growth and socioeconomic data. Also some women left the community to have the child. If they did not return within three days of birth, birth weight data could not be obtained.

Tables C.1 and C.3 provide means on selected socioeconomic characteristics for children who were excluded from the sample on account of missing data and death, respectively. Table C.2 provides weight and growth measures for children who had missing data on socioeconomic characteristics.

Comparisons of means of socioeconomic characteristics between children with and without missing data for either six month period suggested that those who were excluded because of missing data do not differ significantly from those who were included in the sample.

Similar comparisons for children who died indicate the following. The children who died during the first six months tended to (a) be higher parity children, (b) have a shorter previous birth interval, and (c) have a lower birth weight than the survivors. These results are consistent with the biomedical literature. Children who died between six and twelve months grew significantly less during the first six months of life than those who survived and were included in the sample.

Thus, the empirical results may understate the relation of 0 to 6 month growth to birth weight, birth interval, and number of pregnancies. They may understate the relation of 6 to 12 month growth to weight at six months.

Table C.1

MEANS ON SELECTED DEMOGRAPHIC AND SOCIOECONOMIC VARIABLES FOR CHILDREN WITH MISSING GROWTH OR SOCIOECONOMIC DATA BY SUPPLEMENT TYPE

	Six Month	Twelve Month
Number of Pregnancies	4.7	4.8
Previous Birth Interval	27.0	27.2
Mother's Age (years)	27.6	27.8
Total Number of People in the Extended Family	6.3	6.2
Mother's Height (centimeters)	149.0	149.0
Mother's Weight (kilograms)	54.3	53.8
Mother's Literacy (yes/no)	.5	.4
School Grades Completed by Mother	1.3	1.0
Mother's Employment (yes/no)	.2	.2
Father's Literacy (yes/no)	.6	.6
Highest School Grade Completed by any Nuclear Family Member	2.0	1.9
Extended Family Income ($)	435.0	447.0
Income per Equivalent Adult Consumer in Extended Family ($)	102.0	105.0
Number of Rooms in House	1.7	1.7

Table C.2

MEAN WEIGHT AND GROWTH MEASURES FOR CHILDREN WITH MISSING GROWTH OR SOCIOECONOMIC DATA

	Six Month	Twelve Month
Birth Weight	3.00	3.00
N	44	69
Weight at 6 Months	6.65	6.76
N	43	68
Weight at 12 Months	7.96	7.96
N	50	50
Growth 0-6 Months	3.66	3.80
N	24	49
Growth 6-12 Months	1.24	1.24
N	35	35
Growth 0-12 Months	5.08	5.08
N	32	32

Table C.3

MEAN ON WEIGHT AND SELECTED DEMOGRAPHIC AND SOCIOECONOMIC VARIABLES FOR CHILDREN WHO DIED BEFORE REACHING SIX AND TWELVE MONTHS OF AGE BY SUPPLEMENT TYPE

	Six Month Sample	Twelve Month Sample
Number of Pregnancies	6.4	5.0
Previous Birth Interval	18.8*	21.0
Mother's Age (years)	29.1	27.3
Total Number People in the Extended Family	6.5	6.4
Mother's Height (centimeters)	148.0	149.0
Mother's Weight (kilograms)	52.0	55.9
Mother's Literacy (Yes/No)	.7	.3
School Grades Completed by Mother	1.3	1.1
Mother's Employment (Yes/No)	.1	.3
Highest School Grade Completed by any Nuclear Family Member	2.5	2.3
Extended Family Income ($)	600.0	757.0
Income per Equivalent Adult Consumer in Extended Family ($)	125.00	161.00
Number of Rooms in House	1.9	1.6
Birth Weight (kilograms)	2.77[a]	3.37
6-Month Weight (kilograms)		6.33
Growth 0-6 Months (kilograms)		3.03[a]
TOTAL N	15-18	7

[a]t-test of difference of means between children who died and children in the analysis sample significant at $p < .01$.

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