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History and Design of the INCAP Longitudinal Study (1969–77) and its Follow-Up (1988–89)[1,2]

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ABSTRACT This is an overview of the design and methods of the INCAP longitudinal study (1969–77) and its follow-up study (1988–89). The first study had the objective of assessing the effects of intrauterine and preschool malnutrition on growth and mental development. To achieve this, food supplements were provided to pregnant women and young children residing in four Guatemalan villages. Two villages were given a high-protein, high-energy drink and two were provided a no-protein, low-energy drink. Both supplements contained vitamins and minerals. Longitudinal information was collected during the first seven years of life on physical growth, mental development, attendance and consumption of supplement, home diet, morbidity and on characteristics of the family. Health and nutrition data on mothers also were collected. The INCAP follow-up study was a cross-sectional evaluation of former participants of the first study and was carried out when the subjects were 11–27 y old. The hypothesis of the INCAP follow-up study was that improved nutrition in early childhood leads to enhanced human capital formation in adolescents and adults. Data were collected on physical growth and body composition, maturation, work capacity, intellectual performance and school achievement. J. Nutr. 125: 1027S–1041S, 1995.

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• *malnutrition* • *supplementation* • *field methods* • *growth and development*

The INCAP longitudinal study (1969–1977) continues to be one of the richest sources of information about the importance of nutrition for growth and development in children from developing countries. One of two key objectives of this paper is to provide an overview of the objectives, design and methods of this study, drawing heavily on a review by Habicht and Martorell (1992). In 1988–89, the children of the study were revisited when they were adolescents and young adults in what has come to be known as the "INCAP follow-up study". The second objective is to review the characteristics of the follow-up study, this time using material presented in Martorell and Rivera (1992) and in Rivera, Martorell and Castro (1992).

The INCAP longitudinal study (1969–77)

Objectives and design. The design eventually implemented in the INCAP longitudinal study called for comparison of outcomes in pregnant and lactating women and in their children between two pairs of villages exposed to different supplements. Read and Habicht (1992) state that the major motivation for the INCAP longitudinal study was to assess the impact of intrauterine and preschool malnutrition on behavior. Thus, food supplements were provided and their consumption measured in pregnant women and in children younger than 7 y of age.

Nutritional supplementation was to produce an unambiguous contrast between well and poorly nourished children. Because protein deficiency was perceived to be the major cause of malnutrition at the time the study was being planned (Scrimshaw and Behar 1965), major emphasis was placed on improving protein malnutrition while assuring enough extra energy to allow for protein utilization. The feeding in-

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tervention took advantage of INCAP's extensive experience with Incaparina (Bressani and Elias 1968), a nutritious gruel with a high-protein and moderate-energy content that was widely accepted in Guatemala. Thus, the pregnant mothers' and childrens' diets were improved with an Incaparina-based drink, referred to as *"Atole"*, the Guatemalan name for a hot, maize gruel. This drink had to be prepared at the time of ingestion and therefore required a central kitchen and feeding hall.

The centrally located feeding stations precluded random allocation of treatment to individuals within a village; instead, allocation to treatment was by village within pairs chosen to be as similar as possible. One pair was large (~900 people per village) and one was small (~500 people per village).

The comparison beverage to this gruel was a sweet, cool, colored and fruit-flavored drink called *"Fresco"*. Drinks of this type were much appreciated in the area. The Fresco was intended originally to be devoid of any nutritional value, in effect to be a placebo. It was envisaged as a control for the social stimulus and other factors associated with supplementation. The use of cyclamates for sweetening was considered but concern about carcinogenicity led to sugar being used instead, which of course introduced energy. Finally, other nutrients were introduced as discussed below in an attempt to narrow the contrast between the Atole and Fresco groups to differences in energy and above all in protein. Consequently, the Fresco should not be viewed as a placebo control to the Atole because it contained some energy and important concentrations of micronutrients. Instead, both drinks are referred to as "supplements".

Originally, three pairs of supplementation villages were specified, but budgetary constraints reduced the number of pairs to two. A less accessible pair of "large" villages was dropped early in the study with dire consequences for statistical power. As implemented, the effects of improved protein nutrition were to be ascertained through comparisons of results before and after the intervention in the two Atole and two Fresco villages. The before-after comparison was, however, only possible for selected variables collected with adequate sample sizes in 1968, before the intervention began, or for those variables collected in the first months of the study that could not be immediately affected by supplementation (e.g., height of 7-y-old children). Issues of statistical power and analytic strategies in the study are discussed extensively by Habicht, Martorell and Rivera (1995).

The effect due to the study activities per se on behavior was to have been estimated by contrasting outcomes before and after the study in the villages not receiving protein (i.e., Fresco villages) to those in villages not visited in the interim, termed "Supercontrol" villages in project documents. However, budgetary constraints curtailed baseline data collection in these "Supercontrol" villages, nor were data collected in these communities in 1977, at the end of the INCAP longitudinal study.

Although the allocation of treatment across villages was random, ingestion of the supplements was voluntary and therefore subject to self-selection. The implication of this combination of random error and self-selection bias for data analysis and interpretation is discussed by Habicht, Martorell and Rivera (1995).

Finally, it is important to consider that conducting the study involved intensive contact between data collectors and villagers. The data-collection activities were designed and implemented to affect all villages equally and therefore cannot be a source of bias in the Fresco versus Atole contrasts. However, the study setting does affect the validity of extrapolations to other populations if its activities impacted on outcomes synergistically with the supplements. These same concerns apply to the medical care that was provided to the study villages; it too may have potentiated or diminished the impact of the supplements.

Village selection and description. Several needs were considered in selecting villages: population size, relatively compact settlements to allow easy access to the centrally located feeding station and stability and homogeneity among villages. A further limitation was imposed by the psychometric testing. To find a large enough sample of mutually isolated villages speaking the same language, the study had to be located in the Spanish-speaking (i.e., Ladino) region of Guatemala instead of in the more picturesque Maya-speaking area where most previous INCAP research had been done. The selection and matching criteria that were used are presented in **Table 1.**

Ultimately 10 villages were found to fulfill best these selection criteria from among 300 Ladino villages identified from maps as being within the selection radius and from the Guatemalan Census as having population sizes of 500–1000 inhabitants (Canosa et al. 1972). This was a time-consuming process entailing data collection in as many as 45 villages. Most of these data are lost except for some of the dietary, anthropometric, census and socioeconomic data collected in the four villages finally selected for the study. Some useful baseline information about the four study villages is given by Mejía-Pivaral (1972).

Analyses of baseline data indicated that three pairs of villages were most similar to each other: two pairs of villages within an hour's jeep ride from each other and a third pair of villages much further away. As noted earlier, the study was never fully implemented in the third pair of villages, Tapalapa and Santa Gertrudis. The final two pairs of villages selected were San Juan de las Flores and Espíritu Santo with ~500 inhabitants each and San Miguel de Conacaste and Santo Domingo los Ocotes with ~900 inhabitants each. All were far enough apart from each other to make intervillage contact unlikely.

TABLE 1

***Criteria for selecting and matching villages in the INCAP Longitudinal Study*[1]**

Area	Criteria
Ethnicity	100% Spanish-speaking, Ladino culture (i.e., not Indian)
Population	500–1000 inhabitants
Birth rate	35–45/1000 live births annually
Death rate	14–18/1000 population annually
Age distribution	Birth–6 ys: 24–30% Birth–15 ys: 35–50% 16–45 y: 40–45% ≥55 ys: 5–10%
Family composition	Average of five family members per nuclear family
Population mobility	80% or more born in area; 2% annual migration, with little likelihood of change
Social isolation	50–150 km from Guatemala City; any village included in the study should be ≥10 km from other selected villages and under the jurisdiction of a different municipality (i.e., county)
Transportation	Accessible by four-wheel drive vehicles
Compact nuclear settlement	80% of homes within 1-km radius from the community research center
Housing and community services	60% similarity across villages
Annual income	$200 ± $50 per family unit
Education level	30% literacy among population ≥8 y
Basic foods	Corn and beans
Health and nutrition	High levels of malnutrition and of gastrointestinal and respiratory disorders. Anthropometric, dietary and morbidity information of 10 villages which satisfied best the above criteria were considered in selecting the most similar pairs of large and small villages.

[1] Adapted from Canosa et al. 1972.

The four villages selected are located in the Department of El Progreso, a dry, mountainous area northeast of Guatemala City. The large Fresco village (Santo Domingo) is closest to Guatemala City, at 36 km, whereas the small Fresco village (Espíritu Santo) is furthest, at 102 km. The elevation of the large Fresco village is 1250 m above sea level, whereas both Atole villages are at 860 meters, and the small Fresco village is at 275 meters. The average temperature range for the small Fresco village is 24–38°C, and for the other three villages it is ~14–32°C with the rainy season occurring from June to October. Two of the major crops in each village were corn and beans, with tomatoes also being a major crop in the large Atole (Conacaste) and small Fresco villages, sorghum in the large Fresco village, and manioc, locally known as "yuca," in the small Atole village (San Juan).

In 1967, <10% of the families in the four villages had a source of water in their homes. Almost everyone obtained water from open, unprotected hand-dug wells, and in the small Fresco village from a nearby river. Few households had a latrine, and no one had a sewage or drainage system.

In three of the four villages, the typical house had one to two rooms with adobe walls, dirt floors and a tile or metal roof. However, poorer families lived in houses with reed walls and thatched roofs. In the small Fresco village, where the climate is warmest, most houses, even those of better-off families, had thatched roofs, walls made of reeds and mud, and dirt floors. Families usually prepared food in either a separate room or in a separate area located just outside the house. Most people owned their homes, as well as at least some of the land around their homes. About one-third of the families had radios; only a few (<5%) owned a television, record player, refrigerator or bicycle. No homes were equipped with electricity.

The primary income for most villagers was from agricultural production. Almost all were tenant farmers or small-land owners. No one in any of the villages reported being a large landholder, and very few reported being merchants. Wage labor was reported as a principal occupation by 21% of the men in the small Fresco village and by 15% of the men in the small Atole village. Wage labor was not a significant source of income in the large villages. Very few women reported having occupations outside the household except in the small Fresco village, where they had the opportunity to make money independently through basket weaving.

Literacy was self-reported, usually by the mother of the family, for all family members. The percent of mothers at least partially literate in each village ranged from 25 to 40%. The large Fresco village had the highest literacy rate for mothers (40%). Literacy levels of the fathers ranged from 38 to 60% with those in the small Fresco village having the highest literacy rate. Additional data about the social, economic and demographic development of these villages are given by Bergeron (1992) and Engle et al (1992a).

TABLE 2

Formula and nutrient content of beverages per cup serving (180 mL)[1]

	Atole		Fresco	
	For subjects >4 mo in age	For older subjects	From 69–71	From 71–77[1]
Ingredients (g/180 mL)				
Incaparina (g)	—	13.5	—	—
Dry skim milk (g)	28.8	21.6	—	—
Sugar (g)	3.6	9.0	13.3	13.3
Flavoring (g)	—	—	2.1	2.1
Nutrients (per 180 mL)				
Energy (kJ)	498	682	245	247
Energy (kcal)	119	163	59	59
Protein (g)	10.3	11.5	—	—
Carbohydrates (g)	15.3	27.8	13.3	13.3
Fats (g)	0.2	0.8	—	—
Calcium (g)	0.4	0.4	—	—
Phosphorus (g)	0.3	0.3	—	—
Iron (mg)	0.2	1.2, 5.0[2]	—	5.0
Fluoride (mg)	—	0.0, 0.2[2]	—	0.2
Thiamin (mg)	0.1	0.4, 1.1[2]	—	1.1
Riboflavin (mg)	0.5	0.5, 1.5[2]	—	1.5
Niacin (mg)	0.3	1.3, 18.5[2]	—	18.5
Ascorbic acid (mg)	—	0.0, 4.0[2]	—	4.0
Vitamin A (mg)	0.4	0.5	—	0.5

[1] Higher values as of October 1, 1971.
[2] Values differ slightly for some ingredients and nutrients in project documents. Those given here are from the Manual de Operaciones issued by the División de Desarrollo Humano (1971).

The interventions: supplementation and medical care. *Supplementation.* The intervention design calls for comparisons of villages in which pregnant and lactating mothers and their children up to 7 y of age received verified and recorded amounts of either Atole or Fresco. **Table 2** presents the ingredients and the energy and nutrient concentration of the supplements per one-cup serving (i.e. 180 mL) as given elsewhere (División de Desarrollo Humano 1971; Martorell et al. 1982). The Atole contained a high-quality protein mixture whereas the Fresco contained none. The energy concentration of Atole for children older than 4 mo was 2.8 times greater than for Fresco.

There were two formulations of Atole depending on age: one for children <4 mo of age made up of powdered skim milk and sugar (28.8 and 3.6 g, respectively, per 180 mL) and one for older children and mothers containing Incaparina, skim milk and sugar (13.5, 21.6 and 9.0 g, respectively, per 180 mL). Very little of the milk supplement was consumed by children <4 mo of age. The Atole for older children was pale gray-green, and tasted smooth but slightly gritty and sweet; it was served hot. The energy, protein and micronutrient contents of the Atole are shown in Table 2.

In October of 1971, the riboflavin content of the Atole for children >4 mon was raised from 0.5 mg to 1.5 mg per serving after noting that the biochemical indices of riboflavin were not satisfactory in 2-y-old children consuming Atole (Habïcht et al. 1973). Iron and a small amount of ascorbic acid to facilitate iron absorption also were added because anemia was common in pregnant mothers; however, anemia was not found in unsupplemented 2-y-old children (Habicht et al. 1973). The thiamin and niacin contents increased because they were present in the iron-vitamin mix. On the basis of calculations from knowledge about water fluoridation (Infante 1975), fluoride was also added at this time because the drinking water had a low fluoride content at the end of the dry season (0.166–0.384 ppm compared with the recommended 1 ppm) when the concentrations should be highest and because of the high incidence of dental caries in the communities (Infante and Gillespie 1976; Infante and Gillespie 1977).

The comparison beverage, Fresco, was a low-calorie supplement containing 247 kJ (59 kcal) and no protein per serving. It was a cool, clear-colored, fruit-flavored drink similar to KoolAid™ sold in the USA. The ingredients and nutrient content of the Fresco are given in Table 2. Previous to 1971, it contained only flavoring, color and sugar. In October 1, 1971 other nutrients

TABLE 3

Children with anthropometry[1] *by birth cohort in Atole and Fresco villages*

Cohort number	Birth cohorts	Exposure period	Atole	Fresco	Total
I	≥1 March 1974	Gestation, partial birth to 3 y	260	280	540
II	1 March 1969–28 February 1974	Partial during gestation[2]; all birth to 3 y	374	395	769
III	1 January 1966–28 February 1969	Partial birth to 3 y	185	194	379
IV	≤1 January 1966	No exposure during gestation or birth to 3 y	151	153	304
	Total		970	1022	1992

[1] With data for birthweight or for any of the anthropometric postnatal examinations.
[2] Some cases in the early part of the study may not have had full exposure to supplement during pregnancy.

were added to make it more similar to the Atole. Many of these nutrients had been found to be marginal after review of biochemical indicators in blood and urine in children who drank the Fresco regularly (Habicht et al. 1973).

In all villages, the supplements were distributed and consumed in a centrally located, feeding hall for 2–3 h during midmorning and midafternoon, including weekends. These times were chosen because they were easiest for mothers and children to attend and because they did not interfere with usual meal times.

Medical care. Curative medical care was available on week days and free of charge throughout the duration of the study at a clinic adjacent to the beverage feeding halls. These services were available for all residents and were not tied to participation in any aspect of the study. The medical care program was justified not only on ethical grounds but on design considerations as well. For example, immunizations would prevent an epidemic from striking one village and not another as had happened in a previous INCAP nutrition field trial, with dire consequences for data interpretation.

The new system of curative care was implemented in the fall of 1969 (Working Group 1973). Effective but affordable medical care was provided through auxiliary nurses instead of physicians and by streamlining the purchasing and use of medicines. It featured continuous supervision of adequacy of the quality of history taking, diagnosis and treatment (Habicht 1979). Cases that could not be diagnosed by the auxiliary nurses were referred to the supervisory physician (<1% of cases). Furthermore, arrangements were made with Hospital Roosevelt, a teaching hospital in Guatemala City, to honor referrals (0.4% of cases) and keep INCAP informed of patients' progress and discharge. By early 1971, the quality of care had stabilized and >99% of cases were managed correctly (Working Group 1973).

The local traditional midwives were funded to attend midwifery courses given by the Guatemalan public health authorities. Their care complemented that given on demand by the nurses.

All children were examined 15 d after birth by a well-trained pediatrician for diagnosis and treatment of any neonatal ills. The pediatrician also examined the children at 3 mo and at 1, 3 and 7 y to detect any remediable pathology that had escaped the clinic's attention. Pregnant mothers were immunized against tetanus and children against tuberculosis, diphtheria, whooping cough, tetanus, measles and poliomyelitis (Habicht et al. 1979). Deworming medicines were offered twice a year, but the medical program did not give health or nutrition education, except to encourage attendance to the supplementation feeding stations and to participate in immunization campaigns. The curative and preventive health care services were the same in all the villages, and any preventive campaigns such as deworming or immunization were done simultaneously in all the villages.

Compared with rates for the period previous to 1969, infant mortality had declined by 1970–72 from 139 to 55 deaths per 1000 births and preschool mortality had decreased from 28 to 6 deaths per 1000 children at risk, at a total cost for primary health care of < $5 per villager per year. National death rates in Guatemala remained constant during this comparison period. Data collected in 1988–89 confirmed these declines in mortality rates (Rose et al. 1992).

Other influences of the study team. The intensity of data collection and the supplementation and medical interventions required the continuous presence of four to eight well-educated persons in each village. Although they did not live in the villages, at least one of them visited each family twice a month. The influence of these contacts could be variable depending upon the personalities of the personnel and therefore could have affected the outcomes of the study differentially across villages. Therefore all personnel were rotated through all the villages for equal durations of time.

Sample persons, data collection and data availability. All women who were pregnant or lactating and all children from birth to 7 y of age were included in the original design of the INCAP longitudinal study if they lived in the study villages from January 1, 1969 to February 28, 1977. Absence from the village was the most common cause for missing data. Refusal to participate in the study was rare; <2% of all families declined participation. Anthropometric data are available for 517 different women for one or more of their pregnancies and corresponding lactation periods. The distribution by birth date cohort of the children with one anthropometric examination or more (n = 1992) is presented in **Table 3** by village type. The cohorts identify children with different exposure to supplementation during the critical periods of gestation and the first 3 y of life.

Details of data collection are shown in **Table 4**. Most data collection began January 1, 1969 in the large villages and somewhat later (range March to May) in the small villages. All data collection ceased in September 1977 but cessation occurred as early as March 1977 for some types of information. Data-collection methods are described in detail in a manual of standard operating procedures in which the forms used are also presented (División de Desarrollo Humano 1971). Table 4 also lists data collected in cross-sectional surveys conducted in collaboration with the Rand Corporation in 1974–76; additional details are given elsewhere (Corona 1980). Short descriptions of the type of data collected in key areas are presented below.

Census and socioeconomic data. A census was conducted in the four villages at the end of 1968. This was updated whenever the dietary-morbidity interviewers in their fortnightly home visits identified

TABLE 4

Data collected in the INCAP longitudinal study, 1969–1977

Type of data	For whom (Target)	When collected	Where collected	By whom	Collection dates
Supplement intake	Children 0–7 y and pregnant and lactating women	Everyday	Feeding Centers	Supplementation supervisors	1969–77
Morbidity, breastfeeding and menstruation recall	Children 0–7 y and pregnant and lactating women	every 15 days	Home	Dietary and Morbidity Interviewers	1969–77
Diet: 24-h recall in large villages and 72-h recall in small villages	Children 0–12 mo	Monthly	Home	Dietary	1973–77
	Children 15–36 mo	Every 3 mo	Home	Morbidity	1969–77
	Children 42–60 mo	Every 6 mo	Home	Interviewers	1969–77
	All pregnant women	Every trimester	Home	Dietary and morbidity interviewers	1969–77
	Lactating mothers				
	0–12 mo	Every 3 mo	Home	Dietary	1969–77
	15–36 mo	Every 3 mo	Home	Morbidity interviewers	1973–77
	Other mothers	3, 6, 9 & 18 mo post partum	Home	Dietary and morbidity interviewers	1973–77
Birth weight, birth process and Apgar anthropometric indicators of nutritional status	Children 0–7 y	At birth	Home	Perinatologist	1969–77
	Children 15 d–24 mo	Every 3 mo	Clinic	Child Anthrop.	1969–77
	Children 30–48 mo	Every 6 mo	Clinic	Child Anthrop.	1969–77
	Children 60–84 mo	Every year	Clinic	Child Anthrop.	1969–77
	Pregnant and lactating women	During each trimester of pregnancy or lactation	Clinic	Maternal anthropometrist	1971–77
Hand-wrist x-rays	All children	At 3 mo. From 6 to 48 mo every 6 mo. At 60, 72 and 84 mo	Clinic	Child anthropometrist	1969–77
Mental development					
Cognitive infant scale	Children 6–24 mo	At 6, 15 and 24 months	Test room in village	Psychometrist	1969–77
Preschool battery	Children 36–84 mo	Every year	Test room in village	Psychometrist	1969–77
Physical examination	Children 0–7 y	15 d; 3 mo; 1, 3 and 7 y	Clinic	Pediatrician	1971–77
Prenatal examinations	Pregnant women	Each trimester of pregnancy	Clinic	Auxiliary nurses	1969–77
Reproductive histories	Pregnant women	First prenatal examination	Clinic	Auxiliary nurses	1969–77
Records of visits to outpatient clinics	Children 0–7 y and pregnant and lactating women attending the medical clinic for any reason	For all visits for therapeutic care; Monday through Friday	Medical clinic	Auxiliary nurses	1971–77
Census and socioeconomic information	Families in community	Twice	Home	Census interviewers	1968–1969, 1974
Changes in household composition through census updates	Families in community	Every 15 days	Home	Dietary and morbidity interviewers	1968–1969
Father's anthropometry	Fathers of children in study	Once (cross-sectional)	Home	Child anthropometrist	1973–75
Retrospective life history of women (fertility, infant mortality and maternal employment)	Women 15–49 y ever in a marriage/union or ever a mother	Once (cross-sectional)	Home	Interviewer	1974–75
Income and wealth	Heads of household	Once (cross-sectional)	Home	Interviewer	1974–75
Attitudes and expectations of women	Women 15–49 y ever in a marriage/union or ever a mother	Once (cross-sectional)	Home	Interviewer	1975–76
Attitudes and expectations of men and retropective life history of men	One-half of the husbands of respondents to the "retrospective life history of women" and one-half of all single men	Once (cross-sectional)	Home	Interviewer	1975–76

changes in household composition, new families (new marriages/unions or in-migrants), changes in residency within the village and out-migration. This updating of the census was verified by a cross-sectional census in 1974.

The informant was the mother or other primary caretaker. Data collected included information about family structure, marital status, religion, number of pregnancies, number of children alive and relation of the nuclear family to the head of the extended family, and about ownership of items such as radios, sewing machines, refrigerators, bicycles and motor vehicles. Information about parental literacy was obtained through interviews and also through tests. Status (e.g., alive, dead, immigrated), birth order, kinship (e.g., father, son, adopted), parity (for mothers), schooling and occupation (for those older than 10 y) were recorded for each household member. Observations were noted about the house such as the types of walls, floor and roof, availability of electricity, type of water source and of grey water and feces disposal. Whenever a change occurred in the location of the home or in the status or kinship of a family member, the date of the change was noted.

Psychometric data. Full descriptions of the psychometric tests are given by Klein et al. (1977) and by Engle et al. (1992b). Neonates were tested within 10 d of birth with the Brazelton Neonatal Scale and then at 6, 15 and 24 mo with an infant scale composed of items compiled from the Bayley, Cattell, Gesell and Merrill-Palmer Infant Scales. From 3–7 y of age the children were tested annually on a battery of 24 tests chosen to tap memory, language, perceptual reasoning, learning and abstract reasoning ability.

Supplementation. Supplementation and measurement of attendance and consumption began on January 1, 1969 in the large villages and on May 1, 1969 in the small villages. Attendance at the supplementation feeding station was recorded for all sample persons. The supplement was poured into cups calibrated to 180 mL. Cups were filled as often as requested. Individual intake was measured by recording the number of cups given and subtracting any leftover supplement measured to the nearest 10 mL.

All leftovers were poured into a large vessel. At the end of the serving period, the total amount recorded as ingested and the total amount served minus the volume of leftovers were compared. Calculations based on these data showed that reliability for supplement ingested was better than 99% per cup served. The reliability of concern in this study is of intakes during a week or longer periods; that reliability is almost perfect.

Home diet. Information on the home diets of children, pregnant and lactating women was collected according to the schedule indicated in Table 4. Daily home diet was estimated from 24-h recall surveys in the large villages and from 3-d recall surveys in the small villages. The amounts of food ingested were recorded in grams according to the usual INCAP recall method (Flores et al. 1970) and then converted to energy and nutrients using the INCAP food composition tables (Flores et al. 1960; Flores et al. 1971). The reliability of the dietary data was, however, found to be equally poor for both recall methods (División de Desarrollo Humano 1971; Habicht et al. 1974; Klein et al. 1973; Lechtig et al. 1976). Energy and protein had the highest reliabilities of all nutrients but these were only of the order of 0.15–0.30.

Medical care. Records of the presenting complaints, diagnoses and treatments were kept for all visits for use in the quality control system but, unfortunately, are no longer available. As of 1971, the symptomatology was recorded for each visit on the same form as the fortnightly morbidity data collected in the home and those data are available.

Morbidity, breast feeding and menstruation. Morbidity data were gathered every 14 d through retrospective interviews of mothers in the home by four home visitors, one for each village. The home visitors were rotated periodically among the four villages to offset interviewer bias. Interviews took place Monday through Friday, the families being so divided that routinely the entire population of each village was interviewed every 2 wk. During the interview, the mother was asked to recall any symptoms that she and any of her children younger than 7 years might have had in the previous 2 wk. Each subject's information was recorded in a separate questionnaire. The beginning and ending dates of a symptom were always noted. A routine quality-control system was applied allowing the method to be standardized, using a supervisor, and validated, using a physician. Information on menstruation in the mother (beginning and ending dates) were recorded or noted as absent in the morbidity questionnaire for the youngest child. Also noted was whether or not the child was breast fed.

To validate the morbidity survey, a physician examined children half a day after the morbidity visit without previously informing the morbidity interviewer. This study generally showed satisfactory sensitivities and specificities for the symptoms recorded. Sensitivity and specificity were 66% and 99%, respectively for diarrhea and 75% and 99% for fever (Martorell et al. 1975b).

A study of the prevalence of recalled symptoms over the 14 d between periodic surveys showed a fall in prevalence with respect to the day of interview indicating memory loss over the 2-wk period (Martorell et al. 1976). In spite of an average underreporting of 22%, diarrhea was nevertheless reported reliably enough to reveal statistically significant associations between percent of time ill with diarrhea and growth (Martorell et al. 1975b; Schroeder et al. 1995).

Anthropometry. Body measurements were taken at specific ages by trained and standardized anthropo-

metrists. A single person measured mothers throughout the study but three persons measured children at different times. All changes in personnel were preceded by rigorous standardization sessions.

The techniques of measurement are given in Martorell et al. (1982) and the quality control procedures used are described in Martorell et al. (1975a). Each week the data collected in the field were brought to the INCAP headquarters, computerized and analyzed. All children with values beyond two standard deviations from the age-specific means were remeasured for all variables to determine whether or not there had been an error in measurement, recording or punching. There was a weekly calibration of instruments, frequent standardization exercises for the anthropometrist at an urban orphanage and field replications. These exercises permitted the monitoring of precision and reliability; results of these exercises are given in Martorell et al. (1975a).

The anthropometry standardization method (Habicht 1974) is widely used today. Comparison of the reliability and precision achieved during the longitudinal study to results from others (Lohman et al. 1988; Marks et al. 1989;) speak favorably of the quality of the INCAP data.

Hand-wrist roentgenograms. The anthropometrist also took an X-ray of the left hand and wrist of children using a General Electric X-ray machine (model 100–15) set at 15 mA and 65 kV and using power from a gasoline generator. The X-ray head was set at 76 cm above the third metacarpal of the left hand with the fingers moderately splayed and the forearm placed at a right angle to the X-ray beam. Exposure was 48/60 of a second for children <2 y, and one second for older children. X-rays were taken at the ages specified in Table 4 concurrently with anthropometry.

Great care was taken to protect the children from stray X-rays. The X-ray film was placed in a lead lined box attached to the head of the X-ray machine. The seated child placed the hand into the box through a lead curtain. A film was placed on the child's seat and developed every month to be sure that there was no stray radiation.

The films were read for the number of ossification centers and the thickness of compact bone. Initially bone age also was determined according to the Tanner-Whitehouse and the Greulich and Pyle methods. These detailed assessments were discontinued when analyses showed that the simple counting of ossification centers provided as much information (Yarbrough et al. 1973).

Physical examination. A pediatrician examined children at 15 d and at 3, 12, 36 and 84 mo of age to identify developmental and other problems and gave special attention to neurological function and minor anomalies indicative of congenital mental retardation or neurological impairment. This information would permit one to identify children whose association between less adequate nutrition and impaired mental development was probably due to the latter—impaired behavior leading to inadequate bonding and poor coping, both of which might result in malnutrition. It was also thought that the neurological data might reflect improved nutrition from the supplement. None of these data have been analyzed and published.

The INCAP follow-up study (1988–89)

Objectives and design. The INCAP follow-up study of 1988–89 was a cross-sectional evaluation of former participants of the INCAP longitudinal study of 1969–77. At the time of the measurement, former participants of the longitudinal study ranged in age from 11 to 27 y. Also included in the follow-up study were subjects of the same age living in three nearby communities that INCAP had identified as potential study sites in the 1960s but which were not chosen in the end (referred to as "comparison" villages).

The main hypothesis of the follow-up study was as follows: *Nutritional improvements in the critical period of gestation and the first three years of life ultimately produce adolescents with a greater potential for leading healthy, productive lives.* An equivalent, but briefer statement of the central hypothesis is that *"improved nutrition in early childhood leads to enhanced human capital formation"*.

The richness of the longitudinal study data set allows for several ways of operationalizing improved nutrition in early childhood. Foremost, this can be done relative to the nutrition intervention by classifying subjects as belonging to Atole, Fresco or comparison villages. Also, information about daily attendance and intake of supplement permit estimates to be made of energy and nutrient intakes from supplement over any time period for all individuals. Finally, the study permits many other alternative definitions of childhood nutritional status which are not based on the nutrition intervention but that rely instead on the longitudinal information available for children. Although not anchored in an experimental design, measures such as growth rates or degree of stunting, by virtue of being responsive to the full range of factors which influence child health (i.e. diet, infection and their determinants), provide a wider range in nutritional status than measures of supplement. An advantage of anthropometric measures is that they are widely used as indicators of nutritional status and hence are familiar to the international nutrition community.

The central hypothesis of the follow-up study refers to *"greater potential for leading healthy, productive lives"* in recognition of the fact that *productivity*, particularly in an economic sense, was not measured as well as *potential*. Greater *potential* was operationalized as improved status in terms of measures of physical growth and body composition, maturation, work capacity, information processing, intelligence,

functional competence (reading, numeracy, general knowledge) and educational achievement (Rivera et al. 1992). Some *productivity* data were collected; labor participation and earnings were obtained for all subjects for the previous year. Nonetheless, many of the follow-up study subjects, particularly those exposed to supplement during pregnancy and the first three years of life, were too young in 1988–89 to allow for a meaningful exploration of the links between early nutrition and productivity. These aspects can be more adequately studied as the subjects become older and settled into an occupation.

A range of impact was predicted depending upon age at exposure to the nutrition intervention. Maximum effects at follow-up were predicted for subjects born from 1969–1974 (Table 3). These subjects were exposed to supplement during "critical phases" of growth and development, namely pregnancy and the first 3 y of life. The basis for this claim was the greater degree of growth retardation observed at these ages and the lack of demonstrated effect of the supplement on physical growth rates after 3 y of age (Martorell and Klein 1980; Schroeder et al. 1995).

The investigators argued to NIH, the agency that funded the research, that the follow-up study was unique because it was the first long-term, comprehensive follow-up of a nutrition intervention. Specifically, the follow-up study was expected to address whether the benefits of nutrition interventions on growth and development in early childhood persist into adolescence and beyond, to inform about effects and functions that can only be measured later in life and to contribute to understanding the importance of early growth and development for future status. Also, the investigators argued that the policy implications were clear and compelling. The following statement was included in the abstract to the first proposal submitted to NIH:

If valid, it will demonstrate that there are strong linkages among malnutrition, human capital formation and poverty which justify investments in health and nutrition as components of economic development strategies.

In designing the study, the investigators were troubled by two questions: should the study be longitudinal or cross-sectional and should the study be carried out sometime in the future when subjects reach maturity or should the study take place as soon as possible? The limitations of a cross-sectional evaluation were recognized readily. It is well known that the dynamic process of growth and maturation during adolescence can not be adequately studied through a cross-sectional design. Also, important areas such as fertility, employment history and wage earnings are difficult to collect accurately from single interviews. Although a longitudinal design would have provided better data for many outcomes, it would have increased dramatically the complexity and the cost of the study. Cost estimates, even for a cross-sectional survey, were already very high. For these reasons, a cross-sectional approach was selected.

The next question had to do with the timing of the study, when to do it? The study could proceed immediately while the subjects were adolescents or young adults or it could be postponed till most subjects were adults. The advantages of studying adults were recognized. One would be the elimination of the need to control for maturity in the analyses. By virtue of studying adults, information about truly long-term outcomes would be collected and the assessment of effects on fertility, occupation and earnings would be more definitive. Nonetheless, it was decided to proceed as soon as possible even though many subjects were still adolescents, partly to learn about effects on maturity and adolescence but more importantly, because the opportunity to carry out the study existed and it was feared that suitable conditions may not present themselves later. At this time, there was a team of interested researchers in place, enthusiasm was high and funding prospects looked reasonable.

The follow-up study, as noted, included data collection in three comparison villages chosen from six villages considered but not selected for in the longitudinal study in 1969. These villages were of interest because they were presumably similar to the Atole and Fresco and offered the theoretical possibility of shedding light on what might have occurred in the study villages in the absence of INCAP. However, it was not clear why they were not ultimately selected for the longitudinal study. Clearly, they were not felt to be the ideal choices. Still, the decision was made to include three of the previously unselected communities in the follow-up study. To reduce costs and travel time, three of the villages that were closest in distance to the four longitudinal study villages were included for study (i.e., Subinal, Las Ovejas and El Caulote).

Another issue that was carefully considered was that of migration. It was feared that to leave migrants out of the study would leave open the possibility of selection bias. On the other hand, the inclusion of migrants would complicate the logistics of data collection and increase costs. A compromise was reached. Migrants were included but only those who migrated to Guatemala City, Sanarate and El Jícaro (the last two being the provincial towns nearest to the study villages). Tracking down migrants to more dispersed areas, it was felt, would have been too costly.

Subjects studied. Census data were collected between October 1 and December 1, 1987 and included general information about the family (e.g., religion, number of family members, characteristics of the dwelling) and about each family member (e.g., birth date, place of birth, migration history, education and occupation). Follow-up data collection took place between May 1988 and June 1989; the census was continuously updated throughout this period. The prin-

cipal targets of the follow-up study were adolescents and young adults but other groups were studied as well as noted below.

Adolescents and young adults (follow-up cohorts). These subjects were born between January 1962 and February 1977. Records for 2393 children meeting these criteria were generated from a computer master file prepared jointly by Cornell University and INCAP in 1983. Of the 2393 children included in the master file 224 (9.4%) had died when the follow-up study began, for the most part in early childhood. The 2169 subjects alive in 1988 were the target sample in the supplemented villages, a number greater than that given in Table 3 (i.e., 1992) because it includes subjects with no anthropometric measures available from the longitudinal study. The target sample in the three comparison villages (929 individuals) were subjects who had lived in these villages between January 1969 and February 1977, according to information obtained in the 1987 census. The total target sample therefore, including subjects from supplemented and comparison villages, consisted of 3098 subjects. For simplicity, these subjects are referred to hereafter as the "follow-up cohorts". The functional domains measured in the entire follow-up cohorts included physical growth and body composition, maturation, strength, physical health and retrospective life history.

Special sample for the behavioral component. Measures of information processing, intelligence, functional competence and educational achievement were collected on all subjects born in 1966 and later. A large number of outcome variables in the behavioral area were of interest; therefore, the time demands for testing each subject were high. To reduce costs and the duration of the study, the cohorts born between 1962 and 1965 were excluded. These cohorts had received supplementation at noncritical developmental periods (ages 4–7) and thus, minimal effects were expected. Their exclusion was unfortunate because they would have been a useful contrast group to that selected.

Special work capacity sample. This is a sample of ~25% of the follow-up cohorts, excluding migrants, (539 subjects) for whom measurements of work capacity, bioelectrical impedance, bone density and physical activity were obtained. Based on the 1987 census, a stratified random sample of 25% of the follow-up cohorts was selected. Details about the selection of these subjects are provided by Haas et al. (1995).

Parents of follow-up cohorts. Anthropometric measurements of *resident* parents of the follow-up cohorts were obtained to better interpret growth patterns in the follow-up study cohorts.

A retrospective life history was conducted through interviews of mothers, including those who had migrated to Guatemala City and to the two provincial cities closest to the study villages (Sanarate and El Jícaro). This information was required to complete the reproductive histories of women for the entire reproductive period and to obtain information about events that took place in the families of the follow-up cohorts between 1977 and 1988, and that could have influenced the outcomes of interest at adolescence. All parents were included in the study, irrespective of whether their follow-up cohort child (or children) still lived with them or had formed an independent family.

Wives of the follow-up cohorts. All wives of the follow-up cohort males, whether or not they were former participants of the INCAP longitudinal study, were interviewed for the collection of retrospective life history information.

Heads of households. All heads of households in which at least one of the spouses or dependents was a follow-up cohort subject were interviewed to obtain information on income and wealth of the family. The sample of households included the newly formed households as well as the parents' households.

Children <5 y of age. Anthropometric measurements were obtained on all children <5 y of age in the seven villages to assess their nutritional status. These data were seen as useful for estimating the degree of secular change in the study villages through comparisons of the results with those collected earlier in children in the longitudinal study.

Tests, exams, measurements and interviews. The tests, exams, measurements and interviews made on the different groups are described briefly below. For a more detailed description of the methods and a presentation of the data forms used see Rivera (1989) and Castro and Rivera (1992).

Follow-up cohorts. The following measurements and examinations were made in the follow-up cohorts:

1) Anthropometric measurements, including height, sitting height, and weight; five body breadths: biacromial, bicristal, knee, elbow and wrist; six circumferences: head, arm, waist, hip, thigh and calf; and seven skinfolds: biceps, triceps, subscapular, midaxillary, suprailiac, anterior thigh and medial calf. Indirect estimates of body composition (fat-free mass, percent body fat) were obtained using predictive equations from a validation study conducted at INCAP as part of the follow-up study (Conlisk et al. 1992).
2) A clinical examination by a physician, including a medical history, a detailed physical examination, the measurement of blood pressure, heart and respiratory rates, body temperature and the assessment of age at menarche (status quo and history). In addition, a vision test was performed and examination for signs of vitamin A deficiency and goiter were made. Abnormalities and diagnoses of diseases were recorded and treatment was provided when needed.
3) A blood sample was collected, that was further used to determine anemia and iron status.

4) A hand-wrist X-ray was obtained in males and in nonpregnant females 18 y and younger. The X-rays were later used to assess skeletal age by the Tanner and Whitehouse-2 method of rating. A gravindex test on urine was performed in females 18 y and younger who had reached menarche to identify early pregnancies. Pregnant women were not exposed to X-rays.
5) Hand strength was measured for right and left hands using a dynamometer.
6) Follow-up cohorts were interviewed for the collection of retrospective life history information. Spouses of follow-up subjects also were interviewed. The female retrospective life history included information about current reproductive status, parity and gravidity; a detailed reproductive history (for every pregnancy: pregnancy outcome, newborn birth date, mortality, feeding mode at time of death, prenatal care and delivery care); breast feeding and weaning practices for any child in the last 5 y, contraceptive use, marital/union status and history; education, occupation and migration history; and the characteristics of the dwelling where the women had lived. The male life history included income, occupation, education and migration history as well as some information about accumulated wealth. In addition it contained information about marital/union status, dependents and their ages and sexes.
7) School performance. Information from school records was recorded including: age at first enrollment, grades attended, attendance rate and test scores.

Sample for the behavioral component. Full details about the behavioral data collected are given by Pollitt et al (1993). The following tests were included:

1) *Information processing.* This test was applied using a microcomputer. Computer programs were designed specifically for the purposes of this study. Test of simple and choice reaction time, a short memory task, and a paired associates test comprised the computerized battery.
2) Tests of functional performance. The battery included tests of literacy, numeracy and general knowledge, which were developed locally, and two standardized educational achievement tests of reading and vocabulary. The achievement tests were part of the Interamerican Series used extensively in Guatemala by faculty from the Universidad del Valle.
3) Intelligence. Intelligence was assessed with the Raven's Standard Progressive Matrices.

Work capacity sample. Physical work capacity was determined as the oxygen consumption at maximum physical exertion (VO_2 max) on a motorized treadmill.

Besides the work capacity test, measurements of bioelectrical impedance and bone density, using photon absorptiometry, were made in the work capacity sample. In addition, physical activity was investigated through a questionnaire.

Parents of follow-up cohorts.

1) Anthropometric data were collected in men and women. Men: height, sitting height, weight, six circumferences (head, arm, waist, hip, thigh and calf) and five skinfolds (biceps, triceps, subscapular, anterior thigh and medial calf). Women: as detailed above for follow-up cohorts.
2) A retrospective life history was completed, identical to the one obtained by interview in follow-up subjects.
3) Heads of households. A detailed questionnaire regarding the family's income during the previous year, as well as accumulated wealth over the years was applied to heads of households. Information obtained included land tenure, crops produced, agricultural inputs (including labor, production and operation costs), time spent in agricultural jobs by crop produced and family member, production, revenue and income from agriculture and other sources and inventory of livestock ownership.

Preschool children. The following anthropometric measurements were obtained: length, crown-rump length, weight, knee breadth, three circumferences (head, arm and calf) and five skinfolds (biceps, triceps, subscapular, midaxillary and medial calf).

Organization and logistics of data collection. Six working teams conducted the tests, exams, measurements and interviews: two focused on the follow-up cohorts, one on parents of the follow-up cohorts, one on children's anthropometry, one on work capacity and one on migrants. Details about the composition of these teams and about coordination and supervision of their work are given in Rivera, Martorell and Castro (1992).

Logistics of data collection. *Rotation of teams.* The data collection teams were rotated among villages. Also, data collection in each village was staggered over the study to include both rainy and dry seasons.

Program of appointments for follow-up cohorts. The order in which subjects were measured was random. Subjects were scheduled to complete all tests, measurements and interviews in three visits but most subjects chose to complete them in 2 d and in some cases, in 1 d.

Informed consent was followed. When possible, the behavioral tests were done before the medical examination, which involved blood collection, because this procedure caused anxiety in some subjects. When possible, the behavioral tests were spread across visits to avoid fatigue.

Average durations of testing were as follows: Anthropometric measurements, hand-wrist X-rays and hand strength tests (25 min), medical examination and collection of urine and blood samples (25 min), func-

tional competence and intelligence tests (60 min) and life history interview (20 min). In general, subjects tolerated the time involvement in the study better than expected.

Some subjects (3.6% of participants) refused to visit the testing center but were willing to be measured at home where all but X-rays and information processing tests could be completed. In contrast, most of the income and wealth interviews of heads of households and a large number of life history interviews of mothers and anthropometric measurements of parents of follow-up cohorts were made at home, because these subjects had less time to attend the centers.

The teams worked ~8 h/d but schedules were flexible to accommodate the preferred hours of participation of the subjects in each village and season. In all the villages, the teams had to work some weekends to allow for participation of subjects who worked in the fields during weekdays until late in the afternoon, subjects who worked out of the villages and returned during the weekends and migrants who visited their families during the weekends.

Training, supervision and data flow. *Training.* Training took ~2 mo and rigorous standardization exercises were held in all areas. Technical errors of measurement in anthropometry were equal or better than those reported in the literature (Pareja et al. 1989). For life history and income and wealth questionnaires as well as for functional performance tests, the percent agreement among interviewers usually exceeded 95%. Detailed results of the standardization procedures are given elsewhere (Rivera 1989; Castro and Rivera 1992).

Supervision and quality control. Supervision was continuous. All supervisors spent ≥2 or 3 d/wk in the field, providing direct supervision to field workers and examining and correcting data collection forms.

Ranges of permissible values in anthropometry were used to detect outliers; then, either obvious errors were corrected or subjects were reexamined. Errors in the behavioral area, the life history and the income and wealth interviews were detected through the review of data forms. In the work capacity area, the supervisors participated directly in data collection. After each test, the team reviewed the results and in this manner detected and corrected obvious errors.

Repeated measurements were made in ~10% of cases in anthropometry and in ~4% of cases in other areas. Analyses of these data are reported in the methods sections of papers in this volume.

Data flow, entry, verification and cleaning. Data were key punched twice at the INCAP computer center. The data then were cleaned using valid ranges of values and consistency checks across variables to detect errors and outliers. Values suspected to be incorrect were sent back to the field where the supervisor of each area corrected coding errors. For anthropometry and the life history questionnaires, subjects were reexamined whenever errors other than coding were found.

Primary health care activities. Efforts to strengthen the primary health care in each of the villages were implemented in coordination with the Ministry of Health.

A physician, hired by INCAP, instructed the nurses in several areas, especially the government's child survival program. He visited each village once a week to examine cases referred to him by the nurses as well as to attend to anyone in the village wishing to see him. Drugs and medicines were donated to the clinics to make up for the unpredictability of government supplies. In the two villages lacking clinics, INCAP established clinics in buildings donated by the community and hired nurses to staff them. At the end of the study, all medical equipment in the new clinics was donated to the communities.

Minimal dental services were provided through an arrangement with the University of San Carlos' dental school.

Coverage rates. Coverage is defined as the rate "participants/target sample." Participants being subjects for whom data were available for at least one study area (Tables 5–7).

Table 5 shows rates of coverage by village and type of village. Overall coverage was 71.7% with rates being slightly greater for supplemented villages (72.6%) than for comparison villages (69.5%). Coverage rates did not differ significantly between Atole and Fresco villages.

Overall coverage rates were greater for females (74.5%) than for males (68.9%); this pattern was similar in supplemented (females: 799/1060 = 75.4% and males: 775/1109 = 69.9%) and comparison villages

TABLE 5

Overall coverage in the follow-up cohorts

Village type	T	P	%
Fresco[1]			
Santo Domingo	594	411	69.2
Espíritu Santo	423	322	76.1
Atole[2]			
Conacaste	675	488	72.3
San Juan	477	353	74.0
Supplemented Combined	2169	1574	72.6
Comparison			
Subinal	238	165	69.3
Las Ovejas	386	280	72.5
El Caulote	305	201	65.9
Comparison Combined	929	646	69.5
ALL VILLAGES	3098	2220	71.7

[1] Large Fresco village, Santo Domingo; small Fresco village, Espíritu Santo.

[2] Large Atole village, Conacaste; small atole village, San Juan; T, target sample; P, participants; % = coverage.

TABLE 6

Coverage in the follow-up cohorts by migration status

Village type	Migrants			Nonmigrants		
	T	P	%	T	P	%
Fresco[1]						
Santo Domingo	212	79	37.3	382	332	86.9
Espíritu Santo	138	66	47.8	285	256	89.8
Atole[2]						
Conacaste	201	80	39.8	474	408	86.1
San Juan	176	71	40.3	301	282	93.7
Supplemented Combined	727	296	40.7	1442	1278	88.6
Comparison						
Subinal	61	28	45.9	177	137	77.4
Las Ovejas	98	44	44.9	288	236	81.9
El Caulote	76	33	43.4	229	168	73.4
Comparison Combined	235	105	44.7	694	541	78.0
ALL VILLAGES	962	401	41.7	2136	1819	85.2

[1] Large Fresco village, Santo Domingo; small Fresco village, Espíritu Santo.

[2] Large Atole village, Conacaste; small Atole village, San Juan; T, target sample; P, participants; %, coverage.

(females: 343/473 = 72.5% and males: 303/456 = 66.4%).

Table 6 presents coverage rates by migration status. Coverage rates differed between supplemented and comparison villages; among nonmigrant subjects, coverage rates were ~10% greater in supplemented (88.6%) than in comparison villages (78.0%). This is probably the result of the good rapport built by INCAP during the 9 y of the longitudinal study. On the other hand, coverage for migrants was slightly less in supplemented (40.7%) than comparison villages (44.7%). This may be due to differences in how the target sample was defined in supplemented and comparison villages. The target sample of migrants in the comparison villages was identified using information available in the 1987 census. Therefore, only adolescent migrants whose families were still living in the villages at the time of the follow-up census were selected. In contrast, in the supplemented villages, follow-up cohorts whose entire families had migrated before the beginning of the follow-up study also were selected, using records from the longitudinal study. Some of these migrant families were located using information provided by neighbors and relatives; however, as a result of the absence of parents or close relatives, follow-up cohorts belonging to these families were much more difficult to locate than migrants whose families were still living in the villages.

Coverage rates for migrants were overall much lower than those for nonmigrants because of the difficulty of locating migrants and because data collection in migrants was restricted to those living in Guatemala City and two provincial cities. The decision to focus on these locations was based on resource restrictions and the fact that information available at the beginning of the study indicated that ~64% of the subjects for whom locations were known lived in one of these three cities. Coverage for migrants known to have moved to these three cities was 62%. For the entire migrant sample, coverage was 42% (Table 6).

Coverage rates for females were greater in both migrants and nonmigrants. In migrants, coverage rates were 45.6% and 36.9% for females and males respectively; these patterns were similar in supplemented

TABLE 7

Percent coverage in the follow-up cohorts by birth cohorts and gender

Cohorts[1] / Village type	Females				Males			
	I	II	III	IV	I	II	III	IV
Fresco[2]								
Santo Domingo	84.1	73.0	56.4	68.8	82.3	70.9	61.5	50.0
Espíritu Santo	90.4	74.4	65.9	69.2	87.5	77.3	55.8	62.1
Atole[3]								
Conacaste	84.8	74.1	79.4	81.4	87.5	65.7	55.8	53.8
San Juan	76.3	79.0	67.9	67.9	90.8	74.0	58.5	57.1
Supplemented Combined	83.8	75.1	67.9	73.1	87.1	71.2	60.3	54.5
Comparison								
Subinal	89.2	83.3	54.2	58.3	90.9	67.4	46.7	42.9
Las Ovejas	83.8	81.2	64.7	66.0	85.7	81.4	61.9	49.0
El Caulote	87.8	76.6	55.2	47.6	91.7	70.6	38.5	42.4
Comparison Combined	87.0	80.4	58 6	57.5	88.8	73.7	51.8	45.5
ALL VILLAGES	84.8	76.6	65 2	67.5	87.6	71.9	57.9	51.2

[1] See Table 3 for cohort definitions. Values are percentages.

[2] Large Fresco village, Santo Domingo; small Fresco village, Espíritu Santo.

[3] Large Atole village, Conacaste; small Atole village, San Juan.

(females: 176/394 = 44.7% and males: 120/333 = 36.0%) and comparison villages (females: 65/134 = 48.5% and males: 40/101 = 39.6%). In nonmigrants, coverage for females was 89.7% and for males 81.2%. Coverage rates were greater in females in supplemented villages (females: 623/666 = 93.5% and males: 655/776 = 84.4%) as well as in comparison villages (females:278/339=82.0% and males:263/255=74.1%).

Subjects were classified into four birth cohorts according to ages of exposure to supplementation (Table 3). **Table 7** presents coverage rates by cohort and village. In general, Cohort I has the highest coverage rates, followed by Cohort II and finally by Cohorts III and IV. Younger subjects may have had more time to participate in the various tests and interviews than older subjects.

Table 8 presents coverage rates for the different study domains by village type. Coverage rates were ~70% for most domains. The low coverage for blood collection deserves comment. Interviews of subjects who had refused to participate and of their families revealed that anxiety related to blood collection was one of the principal reasons for nonparticipation. Some subjects felt that the very small amount of blood collected (5 mL) was very large relative to the total blood volume in an adult. In one village, there were rumors that the blood was being sold. To remedy the situation, subjects were informed that blood collection was not essential for participation in the rest of the tests, measurements and interviews. In addition, subjects were reminded that blood samples also were used for the diagnosis of anemia, with treatment provided when necessary. Subsequently the refusal rate declined, though refusals to provide a blood sample among participants in the study remained high.

Table 8 also presents coverage rates for the different study domains in the comparison villages. Coverage rates were slightly less than found in the supplemented villages, but follow the same patterns. For the work capacity test, more subjects than originally planned were examined in comparison villages (see Haas et al. 1995).

Coverage rates for anthropometric measurements of parents of the follow-up sample was 82.4%, with no difference between supplemented (809/979 = 82.6%) and comparison villages (386/472 = 81.8%). Similar coverage rates were obtained for the life history of mothers of the follow-up samples (82.7%), with similar coverage rates for supplemented (452/543 = 83.2%) and comparison villages (207/253 = 81.8%). In contrast, coverage of the income and wealth questionnaire applied to heads of households was lower (62.0%), with rates being similar in supplemented (62.5%) and comparison villages (60.7%). The low coverage rates for the income and wealth interviews were due in part to the long time required to obtain the information and the fact that most of the heads of households worked in agriculture and were away during most of the day.

TABLE 8

Coverage rates by study domain and village type for the follow-up cohorts

	Supplemented villages			Comparison villages		
Study area	T	P	%	T	P	%
Anthropometry	2169	1554	71.7	929	633	68.1
Medical Exam	2169	1543	71.1	929	630	67.8
Hand-wrist x-rays	1149	920	80.1	459	337	73.4
Blood sample	2169	1196	55.1	929	425	45.7
Psychology tests						
Functional competence and intelligence	1897	1367	72.1	766	532	69.5
Information processing	1897	1331	70.2	766	521	68.0
Life history						
Males	1109	742	66.9	456	282	61.8
Females	1060	730	68.9	473	311	65.8
Work capacity subsample	388	361	93.0	152	178	100.0[1]

T, target sample; P, participants, %, coverage.
[1] More subjects were examined than originally planned.

Concluding remarks

Full details about design and methods, such as contained in this article, are often not readily available in the literature. The INCAP longitudinal and follow-up studies are among the most important sources of information from developing countries about child growth, development and nutrition and it is likely that there will be continued analyses of these data for years to come. It is important to have a faithful record of the design, objectives, methods and procedures, particularly for the benefit of analysts who may not have been directly involved with the studies.

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