



Supplemental Information to Alive & Thrive “Why Stunting Matters”: The INCAP Longitudinal Study September 2010

From 1969-1977 the Institute of Nutrition of Central America and Panama (INCAP) conducted a large supplementary feeding trial¹ in four rural Guatemalan villages, the INCAP Longitudinal Study. Subsequent follow-up studies occurred in 1988-2007 by tracking the original population up to 40 years later.² This unique, long-term study demonstrated that nutritional intervention before 3 years of age has significant long-term effects on height, as well as human capital and economic productivity in adulthood, and that nutritional supplementation of girls starting in early childhood has significant effects on body size of their offspring.

The trial included two sets of two matched villages. One village in each set was randomly selected to receive either a high-protein (6.4 g/100ml), high-energy (91 kcal/100ml) supplement called ‘Atole’ or a no-protein low-energy (33 kcal/100ml) supplement called ‘Fresco’, the nutrient composition of which has been described elsewhere.^{2,3} From October 1971, both supplements were fortified with several micronutrients (iron, fluoride, thiamine, riboflavin, niacin, ascorbic acid and vitamin A) in equal concentrations by volume.³ Fresco was given as a control for social interaction associated with attending the feeding center, which might have influenced certain outcomes such as cognitive development.

In the INCAP Longitudinal Study, supplements were made available to the villagers from four centrally located feeding stations, one in each village, where supplements were distributed daily at mid-morning and mid-afternoon. Attendance and supplement consumption were open to all villagers but were recorded only for the target population. Routine medical services in each village were established and maintained by INCAP.

All women who were pregnant or lactating and all children from birth to seven years of age living in the study villages between 1 January 1969 and 28 February 1977 were included in the original design of the study.⁴ Supplementation was provided from March 1, 1969 to February 28, 1977. Children were followed up through age 7 years or until the end of the study, whichever came first. Thus all children were exposed either to Atole or Fresco at different ages and for different periods of time: prenatally through supplement intake by the mother, and postnatally through the effects of maternal supplement intake on breast milk content of certain nutrients as well as through the child’s own consumption.⁵ The trial included 643 pregnant and lactating women and 2392 children 0-7 years of age who received supplementation. Several prospective follow up studies were conducted between 1988 and 2007, and some are still ongoing or being planned (figure 1).

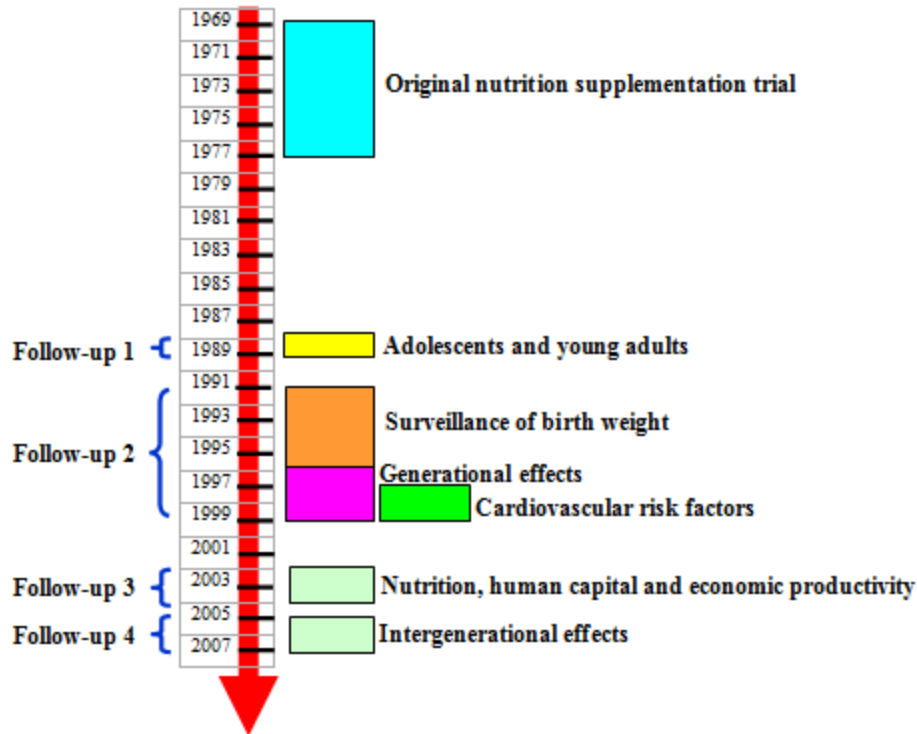


Figure 1: Prospective cohort studies nested in the follow-up of the INCAP trial (source: Adapted from Ramirez-Zea et al, 2010²)

Findings at the end of the supplementation trial in 1977⁶

- Child length gain was greater in 'Atole' villages than in 'Fresco' villages during the first 3 years of life (+0.9 cm in the first year, +1.0 cm in the second year and +0.4 cm in the third year).⁶ This effect persisted even after controlling for initial body size, diarrheal disease, socioeconomic status, gender and energy from home diets during the second year.
- No effect of Atole on length gain was observed when supplementation occurred between 3 and 7 years of age. The greater impact during the first three years of life is probably due to the greater growth potential, greater relative nutritional requirements and relatively frequent infections in younger children.

Findings from the first follow-up study conducted during 1988-89 when the cohort was 11-26 years old

The study documented that improved nutrition in early childhood had significant effects on body size and intellectual functioning.⁷ Specifically:

- At adolescence, subjects from Atole villages were taller, weighed more and had greater lean body mass than subjects from Fresco villages.⁸
- Subjects receiving Atole scored significantly higher on tests of knowledge, numeracy, reading and vocabulary than those given Fresco.⁹

Findings from the 2002-2004 follow-up study, when the cohort was 26-42 years of age

This follow up study focused on the impact on school achievement¹⁰ and economic productivity¹¹ and showed that exposure to Atole supplementation before 3 years of age, but not after 3 years, increased:

- Years of schooling completed by 1.2 grades for women (but not for men).
- Reading comprehension and intelligence score in both men and women. The impact of Atole supplementation on intelligence was independent of schooling.⁵
- Wage rate (income earned per hour worked) by US\$ 0.62-0.67 per hour in men (but not in women). In those exposed to Atole supplementation during the first two years of life, this represented a 46% increase in average wages. The lack of effect on income measures in women could be due to differences in economic activity between men and women. Virtually all men (99%) participated in at least one income-generating activity, whereas the proportion was much less for women (70%), who were mostly engaged in activities that did not generate much income.

Findings from the 2006-2007 follow-up study¹² of intergenerational effects

- Compared with offspring of women exposed to Fresco, the offspring of women exposed to Atole as children (starting before 7 years of age) had greater birth weight (+116 g), height (+1.3 cm), head circumference (+0.6 cm), height-for-age z score (+0.26), and weight-for-height z score (+0.20).
- The effects on height differed by sex of the offspring. Sons of women exposed to Atole were 2.0 cm taller than sons of women exposed to Fresco, whereas the difference for female offspring was only 0.6 cm.
- There was no significant differences in the measures of offspring adiposity (BMI, arm circumference, triceps skinfold thickness, sub-scapular skinfold thickness).
- Paternal exposure to Atole was not associated with any of the 11 anthropometric indicators.

In a subsequent analysis¹³ of the pathways by which Atole supplementation benefitted wage rates in men, it was found that adult lean body mass (which is usually correlated with height) and adult reading comprehension scores were both explanatory variables. However, when both variables were treated as “endogenous” (i.e., potentially reflecting earlier choices), only the reading comprehension scores remained significant in explaining the impact on wage rates. This does not mean that early life nutrition was not important but that it worked through reading comprehension scores and not through adult lean body mass. The lack of impact via lean body mass is probably explained by the relatively low proportion of men in the follow-up study who worked in physically demanding occupations. When analysis was restricted to men with such occupations, lean body mass remained important in explaining the impact of supplementation on wage rates. Thus, the relative importance of improvements in “brains” versus “brawn” may depend on the types of employment available to adults.

Table 1 provides descriptive information about the follow-up studies conducted with this cohort.

Table 1: Follow-up studies for the INCAP Longitudinal Study

Follow-up period	Objectives	Study Participants	Study sample	Age at follow-up	Outcome variables	Potential confounders adjusted for
May 2002-April 2004	To explore the impact of early childhood nutrition on adult human capital formation and economic productivity	Cohort members of INCAP 1969-77 study who remained alive in 2004, living in or near four original study villages or elsewhere in Guatemala City	Targeted: 1855 (78%)* Interviewed=1571 Completed data =1424 For analysis=1107 (Men=602 women=505) Attrition rate=40.5 %	26-42 y	Cognitive function & schooling: -Average years of schooling -Reading comprehension score -Intelligence score Income and wages: -Annual earned income -Hours worked in the last year -Average wage rate	Individual characteristics: sex and age Family characteristics derived from the 1969-77 study: Age of mother when participant was born, mother's height, schooling of father/mother, index of household wealth Community characteristics: Availability of primary school Electricity Natural disasters Increased demand for any agricultural product
Jan 2006-Oct 2007	To assess whether nutritional supplementation of girls aged <7 to 15 years affected their offspring's nutritional status	Cohort members of INCAP 1969-77 study who remained alive in 2007, living in or near four original study villages or elsewhere in Guatemala City, and who had at least one offspring	Targeted: 1090 cohort members Interviewed=1009 (558 women) Of whom 824 (436 women) reported having 1400 living offspring < 12 years -791 biological children of 401 mothers who had been exposed to supplementation and for whom data on all 10 anthropometric indicators were available were included in the analysis	29-44 y old cohort & < 12 y old offspring of cohort	Anthropometric indicators: Birth weight, height, weight, BMI, head circumference, arm circumference, triceps skinfold thickness, subscapular skinfold thickness, height-for-age z score, weight-for-age z score, BMI for age z score	Offspring sex, age. Assessed robustness of findings with regard to: sex of parents, maternal schooling attainment, maternal & paternal height, grandparent's socioeconomic status, grandmother's height, excluding 12 year old offspring

*Among the 2392 original cohort members, 274 (11%) died, mostly from infectious diseases in childhood, 162 (7%) migrated abroad and 101 (4%) were untraceable; Among 1855 eligible for interview, 1133 (60%) lived in the original villages, 155 (8.4%) lived in nearby villages, 419 (22.6%) lived in or near Guatemala City and 168 (9%) lived elsewhere in Guatemala.

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