# History, design, and objectives of the INCAP follow-up study on the effects of nutrition supplementation in child growth and development

Reynaldo Martorell and Juan Rivera

## Abstract

*The 1988–1989 INCAP follow-up study on the effects of early nutrition supplementation in child growth and development was the first long-term, comprehensive follow-up of a nutrition intervention. The subjects were former participants in the longitudinal study of 1969–1977, who were 10–26 years old at the time of measurement. The hypothesis of the follow-up study was that improved nutrition in early childhood leads to enhanced human capital formation. Cross-sectional data were collected on physical growth and body composition, maturation, work capacity, intellectual performance, and school achievement.*

## Authors' note

*This paper, undertaking to review the salient features of the design and methods of the INCAP Guatemalan follow-up study of 1988–1989 on the effect of early nutrition supplementation in child growth and development, is a companion to the history of the longitudinal study of 1969–1977 [1]. In preparing the latter, Read and Habicht had difficulty at times in reconstructing events and recalling details. The availability of complete documentation and the shorter period of recall involved has made writing the present paper considerably easier for us.*

## Hypothesis of the follow-up study

The follow-up study was a cross-sectional evaluation of former participants of the INCAP longitudinal study of 1969–1977. The longitudinal study sought, by means of a nutrition intervention, to test the hypothesis that malnutrition has adverse effects on mental and physical development. Two villages received a protein-energy liquid supplement, *atole*, and two others a low-energy beverage, *fresco*. At the time of the follow-up study, the participants in the longitudinal study ranged in age from 10 to 26 years. Also included in the follow-up study were subjects of the same age living in nearby communities, described in project documents as control 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: *Improved nutrition in early childhood leads to enhanced human capital formation.*

The richness of the longitudinal study data set allows for several ways of establishing improved nutrition in early childhood. Foremost, this can be done relative to the intervention by classifying subjects as belonging to atole, fresco, or control villages. Also, daily attendance and intake of supplement were measured for all individuals in the atole and fresco villages, permitting estimates to be made of energy and nutrient intakes from the supplements over any time period. Finally, the study permits many alternative definitions of childhood nutrition status that are not based on the intervention but rely on available longitudinal information. Although not anchored in an experimental design, measures such as growth rates and degree of stunting, by virtue of being responsive to the full range of factors that influence child health, provide a wider range in nutrition status than measures of supplementation. Also, anthropometric measures are the most widely used indicators 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 considered to be 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 [2]. Productivity data such as labour participation and earnings were obtained for all subjects for the previous year. Nonetheless, many of the follow-up study subjects, particularly those exposed to supplementation during gestation and the first three years of life, were too young in 1988–1989 to allow for a valid exploration of the links between early nutrition and later productivity. These aspects will be studied more adequately as the subjects become older and settled into occupations.

In elaborations of the hypothesis in proposals to the US National Institutes of Health (NIH), the agency that funded the research, a range of effects was predicted depending on age at exposure to the nutrition intervention. Maximum effects at follow-up were predicted for subjects born from 1969 to 1974. These subjects were exposed to supplementation during what were referred to in the proposals as critical phases of growth and development, namely, gestation and the first three years of life. The bases for this claim were the greater degree of growth retardation observed at that time and that age, and the lack of demonstrated effect of the supplement on physical growth rates after three years of age [3].

The investigators argued that the follow-up study was novel and original. The NIH was told that the study represented a "unique opportunity for carrying out the *first* long-term, *comprehensive* follow-up of a nutrition intervention." Furthermore, it would result in substantial contributions to knowledge. Specifically, it was expected (1) to address whether the benefits of nutrition interventions on growth and development in early childhood persist into adolescence and beyond, (2) to provide information about effects and functions that can only be measured later in life, and (3) to contribute to understanding the importance of early growth and development for future status.

Finally, the investigators argued that the policy implications were clear and compelling. The following statement was included in the abstract of the first proposal submitted to the 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.

## Design considerations

The follow-up study, as noted earlier, was a cross-sectional assessment of adolescents and young adults, some of whom had been studied by INCAP as young children (in the atole and fresco villages) and some of whom had not (in the control villages). When designing the study, the investigators were concerned about whether it should be longitudinal or cross-sectional and whether it should be carried out some time in the future when most of the subjects had reached maturity or as soon as possible.

The limitations of a cross-sectional evaluation were readily recognized. It is well known that the dynamic process of growth and maturation during adolescence cannot be studied adequately through such a 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 the complexity and cost of the study dramatically, and the cost estimates even for a cross-sectional survey were already high. Therefore, a cross-sectional approach was selected.

The next question had to do with the timing of the study. It could proceed immediately while the subjects were adolescents or young adults, or it could be postponed until most were adults. The advantages of studying adults were understood. One would be the elimination of the need to control for maturity in the analyses. 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 conditions might not be suitable later. At this time, a team of interested researchers was in place, enthusiasm was high, and funding prospects looked reasonable.

The study included data collection in three control villages. A list of villages that had been considered for inclusion in 1969 was available. They were of interest because they were presumably similar to the atole and fresco communities as all were selected from a larger set of villages. Since they were not included in the earlier study, they offered the theoretical possibility of shedding light on what might have occurred in the study villages in the absence of INCAP's intervention. However, it was not clear why they had not ultimately been selected for the longitudinal study. Clearly, they were not thought to be ideal choices. Still, the decision was made to include three of these communities in the follow-up study. To reduce costs and travel time, they were ones that were closest to the four longitudinal study villages.

Another issue that was carefully considered was migration. In January 1986 a list of 100 families was randomly selected from the study files (25 families per village). Of the 240 children born to these fami-

lies during the earlier study, 21 (8.8%) were lost for follow-up on account of death, mostly in infancy. Of the 219 who had not died, 179 (81.7%) were still in the villages and 40 (18.3%) had migrated. Clearly, the latter were an important group, nearly one-fifth of the sample. It was feared that to leave them out would open the possibility of selection bias. On the other hand, including them would complicate the logistics of data collection and increase the costs of the study. A compromise was reached. Migrants were included, but only those who had migrated to Guatemala City, Sanarate, and El Jícaro (the last two being the provincial towns nearest to the study villages). Tracking migrants to more dispersed areas, it was decided, would be too costly.

## Synopsis of the history of the follow-up

The process of funding a study is often long and arduous, and the follow-up study was no exception. The following is a list of key project events and dates. Information of this type is rarely published, but it is included here as it may help future users of the data set to understand how ideas evolved over time. All the documents mentioned in the list are available from R. Martorell.

1983–1984. Preliminary discussions of the follow-up study took place at Cornell University during R. Martorell's sabbatical there from Stanford University. The first preliminary draft of the study was prepared by Martorell and discussed with J. Haas and J-P. Habicht.

Oct. 1984. A comprehensive draft of the study was written by Martorell and circulated among colleagues at Stanford, Cornell, and INCAP.

Mar. 1985. During an unrelated meeting at Bellagio, Italy, Martorell and the late Víctor Valverde designed a pilot study to address the feasibility of locating participants of the longitudinal study and planned a meeting at INCAP to write a proposal to be sent to NIH.

Apr. 1985. INCAP carried out a study of 100 families to determine how many subjects actually could be found in their villages of origin or in the places to which they had migrated. Martorell obtained support, from seed money funds available at Stanford University from the Alfred Sloan Foundation, for a meeting to prepare the proposal.

May 1985. A meeting took place at INCAP to reach a consensus on study design, to begin drafting the proposal, and to plan the submission of the proposal to NIH.

Jan. 1986. The first proposal was submitted to NIH, listing Martorell as principal investigator with Haas (Cornell) and Hernán Delgado (INCAP) as co-principal investigators.

June 1986. The proposal was reviewed by a special study section at the request of Martorell, who argued that no specific section had the broad expertise required for a proper evaluation of the merits of the study. The proposal was deferred for a site visit, and the investigators were asked to respond to a series of written questions.

Nov. 1986. The answers were sent to reviewers. The reviewers were notified that Ernesto Pollitt had joined the research team. He became the principal investigator of the behavioural component and added cognitive information processing to the already ambitious data-collection plans in that area. J. Rivera (INCAP) joined the project as technical coordinator.

Dec. 1986. The site visit took place at Stanford, and most issues of concern to the review team were resolved. A very favourable review was sent to NIH.

June 1987. The three-year study (June 1987–May 1990) began with three phases: preparation (9 months), data collection and cleaning (12 months), and analysis and publication (15 months). The study was carried out as planned, but delays in the data collection left only eight months for data analysis.

Aug. 1988. Funds were received to collect data on iron status (Aug. 1988–June 1989) as a result of a supplement proposal submitted to NIH in which a strong case was made for the need for such information in order to understand work capacity and behavioural outcomes more fully.

Oct. 1989. Rivera replaced Delgado as principal investigator at INCAP, and Delgado became INCAP's director on 1 Jan. 1990.

Nov. 1989. A competing continuation proposal was submitted to NIH to extend the analyses for an additional two years beyond May 1990.

Feb. 1990. This proposal was reviewed by the Epidemiology and Disease Control, Section I (EDC-1), study section of NIH and sent back to the investigators with questions.

Apr. 1990. Detailed answers to the questions were sent to NIH.

Apr. 1990. Pollitt as principal investigator and Martorell as co-investigator submitted a proposal to the Pew Charitable Trusts and obtained funding for a two-year project. This effort was devoted entirely to analyses of data in the area of school performance.

June 1990. The EDC-1 study section approved the competing continuation proposal effective 1 Dec. 1990. Some funds (July–Nov. 1990) were obtained to deal with the hiatus in funding caused by delays in the review process.

July 1990. Rivera (principal investigator), Habicht, and Martorell obtained monies for three years from the Thrasher Research Fund to extend the follow-up to the third generation: newborns of the women who had participated as young children in the longitudinal study. As part of this project, reproductive behaviour, pregnancy, and perinatal data were collected.

30 July–3 Aug. 1990. A workshop was held at Bellagio, bringing together project investigators and outside experts to review the preliminary findings of the study. A publication plan was drafted which includes this volume and a second to be submitted to the *Journal of Nutrition*.

Aug. 1991. Martorell transferred the project to Cornell, where he took a faculty position.

Feb.–Mar. 1992. Two proposals were submitted to NIH with Martorell as principal investigator. One was for a second two-year competing continuation and the other for a longitudinal study of the children of the subjects of the follow-up. The second proposal sought to extend the Thrasher-funded effort to study newborns and their growth and development during the first three years of life.

Apr. 1992. A symposium summarizing the findings of the follow-up study was held at the FASEB meeting in Anaheim, Calif., USA. Participants included Martorell, Habicht, Pollitt, Haas, and Rivera.

In addition to these efforts, at the invitation of Martorell, John Himes, of the University of Minnesota, submitted an independent proposal to NIH in 1986 to study aspects related to bone growth and metabolism. This component was added successfully to the follow-up study programme of data collection. Also, Alan Goodman from Hampshire College, Amherst, Mass., added a small component on dental anomalies and morphology. In both these efforts, data collection was limited to Cornell's work capacity sample.

## Conclusion

It has become increasingly difficult to obtain funding for research, particularly for large and ambitious projects such as the follow-up study. As the chronology of events suggests, considerable time and effort were devoted to proposal preparation and to answering reviewers' questions. Although excessively burdensome at times, the process improved the design and data collection of the follow-up study, and for this the scientists are grateful. Also, the project's staff is appreciative of the NIH's programme of peer-reviewed, unsolicited research funding, as it provided the opportunity to compete openly with other biomedical scientists for support. Were it not for the NIH, the follow-up study would have been difficult if not impossible to carry out, since resources available for international nutrition research are limited, particularly for investigator-initiated proposals.

## References

1. Read MS, Habicht J-P. History of the INCAP longitudinal study on the effects of early nutrition supplementation in child growth and development. Food Nutr Bull 1992;14(3):169-75.
2. Rivera J, Martorell R, Castro H. Data collection of the INCAP follow-up study: organization, coverage, and sample sizes. Food Nutr Bull 1992;14(3):258-69.
3. Martorell R, Klein RE. Food supplementation and growth rates in preschool children. Nutr Rep Int 1980;21:447-54.