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INTEGRATING FOOD SUPPLEMENTATION AND HEALTH CARE PROGRAMS TO STIMULATE CATCH-UP GROWTH IN DEVELOPING COUNTRIES

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INTRODUCTION

Studies carried out in hospitals and metabolic wards have shown that when food is given ad libitum to acute malnourished children, catch-up in weight is possible at a very rapid rate. Weight increments from 15 to 20 g/kg/d make it possible for acute malnourished children to recuperate to normal weight-for-age in a three to six month period [1-3]. Catch-up in length or height, on the other hand, follows catch-up in weight, and the normal length or height-for-age is reached after approximately ten months of nutritional rehabilitation[4].

At the community level, pilot nutritional rehabilitation projects, in which the normal diet of acute malnourished children was supplemented, have also been successful in normalizing weight-for-age after a three to six month period[5,6].

Although these results are useful for understanding catch-up growth, they are based on small samples of children living in conditions different to those prevailing in free-living populations in which infection and mild-to-moderate malnutrition are characteristic.

The present paper reviews information related to growth and catch-up growth in mild-to-moderate undernourished populations, analyzes data from a longitudinal study carried out in rural Guatemala and discusses some of the alternatives to link food aid with integrated health care services to bring about catch-up growth, both in chronically and malnourished children as well as in those who have suffered recently from infections.

NUTRITION, INFECTION, GROWTH, AND CATCH-UP GROWTH

Studies pointing to the importance of energy for growth have long been reported in scientific literature[7,8]. As indicated by Sinclair[9], energy intake, expenditure, and losses remain in equilibrium with the mass and composition of the individual, so that increments in total mass or changes in composition imply changes in energy intake. The relevance of energy as a limiting factor for growth, moreover, is underscored by its relationship with nitrogen metabolism. and the efficient use of protein intake[10]. Although other nutrients also play a role and should be available in sufficient quantities for tissue synthesis to occur, positive energy and nitrogen balance are essential for tissue accretion.

Data from developing countries suggest that the effect of these nutritional factors on growth is more critical during early infancy. In these populations, a rapid decline in growth status, relative to the World Health Organization reference population, occurs during the first two years after birth. Weight retardation usually shows a peak prevalence in the second year of life, while the prevalence of height retardation increases with age[11]. The factors responsible for poor infant growth in developing countries also affect preschool children. Surviving older children, nonetheless, achieve adequate growth rates, although not sufficient to significantly reduce the consequences of earlier growth retardation.

The factors responsible for infant and preschool growth retardation are those related to the utilization of available energy and protein resources and the impact of infections and calorie-protein insufficiency relative to requirements. The maintenance energy requirements and the amount of energy required for growth, physical activity, and infections have considerable variability between and within individuals.

The energy requirements of a child are largely a function of body mass and body composition[12]. All tissues have a requirement for energy, but the various components of the total cell mass have different metabolic rates. Furthermore, these cell mass components possess specific growth rates and hence form varying proportions of total body composition as growth proceeds. For instance, muscle mass represents about 20-25 percent of body weight during the first 18 months, and about 35-40 percent at five years of age[13].

The very high metabolic requirements of the major organs, such as the brain, and the rapid growth of the brain during infancy and preschool age explain why brain metabolic rate forms the larger part of the basal requirements during most of the first five years of life[12,13].

The proportion of energy intake required for growth in healthy children at different ages is dependent upon variations in the quantity and quality of weight gain. The proportion of energy intake allocated to growth declines from 44 percent at three weeks of age to 17 percent at four months and to three percent at 12 months of age[14]. When energy requirements are not met by intake, body energy stores will be utilized, specially body fat, with body protein stores affected only minimally and after continued hypocaloric states[15].

The main cause of energy expenditure above maintenance energy requirements in healthy children is physical activity. Physical activity constitutes an increasingly important and variable component of energy requirements with age. Payne and Waterlow[16] have estimated that physical activity requires 10.4, 14.9, 25.0, and 28.2 percent of energy intake in children 0-3 months, 0.75-1 year, 2-3 years, and 4-5 years respectively. These authors also underscore the wide individual variability existing in energy requirements and the important role that physical activity plays in determining such variability. Studies on the interaction of growth and physical activity[15,17,19] suggest that reduced physical activity may represent a significant energy conservation measure in the child faced with inadequate caloric intake relative to current metabolic needs.

The consequences of infectious illnesses, especially diarrheal diseases, for the metabolism and utilization of nutrients are numerous[20-22]. The nutritional impact of diarrhea is postulated to operate through at least four basic mechanisms: reduction in food consumption[23-26], interference with the absorption of macro and micro nutrients[22,27-29], disturbance of virtually all normal metabolic and endocrine functions, and increments of direct loss of protein and other nutrients in the gastrointestinal tract.

The magnitude of physical growth retardation associated with diarrheal diseases in developing countries is significant[30-34]. In addition, it has become increasingly clear that insufficient catch-up growth during recovery from infection is primarily responsible for the poor growth status of children in developing countries. Children generally cannot recover from infectious episodes because of inadequate nutrition and repeated infections[35-36].

In the joint FAO/WHO/UNU Expert Consultation on Energy and Protein Requirements, Waterlow presented estimations of requirements for catch-up from wasting, from stunting, and after infections[37]. He estimated that the extra protein and energy requirements for catch-up growth of a one year old child at the rate of 3 g/kg/d should be 0.8g of protein and 15 calories per kilogram body weight per day. The nutrient requirements for catch-up after infections corresponds to an extra daily requirement of 3.75 kcal/kg/d and 0.2g protein/kg/d. In the case of stunted populations, Waterlow recommends that the requirements for children one to five years of age be increased by 20 percent for protein and ten percent for energy.

In summary, the information reviewed in terms of the patterns of energy used indicate the special sensitivity of children during infancy and the preschool age. Given the high metabolic requirement, and a high proportion of energy intake dedicated to growth and physical activity, it is clear that chronic energy deficits will be reflected on growth retardation. When infection elevates requirements and reduces intake and absorption, the result is child growth failure. The children in developing countries are unable to replete catabolized tissue after an infection because they lack high-nutrient density foods and the probability of new infectious episodes is high.

INSTITUTE OF NUTRITION OF CENTRAL AMERICA AND PANAMA LONGITUDINAL STUDY IN EASTERN GUATEMALA

The Institute's longitudinal study has been well described elsewhere; however, a brief description follows[38].

Population, Design, and Methods

In 1969, a longitudinal study of the biologic and socioeconomic determinations of physical growth and mental development in rural Guatemala was begun. The project involved four small villages of eastern Guatemala. The ethnic background of the population is *Ladino*, or mixed Indian and Spanish. These are agricultural villages and the main crops are corn and beans, most of which are consumed in the same village. The total population of the four communities was 3359 inhabitants in 1975, half of them being below 15 years of age.

The basic hypothesis of the study was that mild-to-moderate protein-calorie malnutrition adversely affects the mental development of infants and preschool-aged children. To test the hypothesis, a quasi-experiment design was employed. Experimental treatment consisted of food supplementation in four closely matched villages. In two of the villages, a high protein-calorie supplementation drink called "atole" containing 11.5g of protein and 163 kcal per 180 ml was made available. The other two villages were provided with a fruit-flavored drink called "fresco", which contained no protein and supplied only 59 kcal per 180 ml. The supplements also contained vitamins and minerals. Attendance at the food supplementation centers and consumption of the supplements were free and voluntary, and as a result, a wide range of supplement intake in mothers and in children was observed. The supplement was given twice daily, seven days a week. Subjects were provided with a cup containing 180 ml, and more was given if requested. Leftovers were measured and actual intake on an individual basis was recorded to the nearest 10 ml. Because dietary intake was more limiting in energy than in protein, supplement intake was expressed in terms of calories.

No medical care services were included in the original experimental design, but a real and felt need for these was detected as the project progressed. Thus, a health care program was implemented in each community with services provided by physicians. After this study was through, this system was simplified in such a way that the physician's role became that of supervisor for Auxiliary Nurses, who took charge of the primary health services. In addition to the management of common diseases, the Auxiliary Nurses were responsible for the implementation of maternal and child care activities and vaccination programs for mothers and children. The primary health care was integrated to the food supplementation activities of the program.

The longitudinal data collection on nutritional, socioeconomic, health, and demographic aspects of the population began in early 1969. The principal examinations made in pregnant and lactating mothers and children seven years old and under and analyzed in this report include anthropometry (every three months during pregnancy, lactation, and in children less than 24 months of age; every six months thereafter), morbidity (obtained through fortnightly surveys). The survey was symptom-oriented and utilized retrospective home interviews, and supplement intake.

Results

A marked reduction in neonatal and postneonatal mortality rates occurred during the first six years of the project. According to the data obtained from pregnancy histories for the 1960-1968 cohort, before the study began, neonatal mortality rate was 104.8 and postnatal mortality was 47.0 per thousand live births. The stillbirth death ratio was 24.8 per thousand live births during the same period. The stillbirth death ratio and the neonatal and postneonatal mortality rates for the 1969-1975 cohorts, during the study period, were 21.7, 24.1, and 32.2 per thousand live births, respectively. Information recently collected in the four communities, after the health and nutritional interventions took place, revealed that infant mortality continued to be low, 27 per thousand live births, for the 1977-1980 period. The reduction in mortality rates in the longitudinal study could be attributed to the food supplementation and health care programs, given that no other intervention was concurrently instituted in these communities[39].

Regarding the impact of the food supplementation program on physical growth, we have published results showing that caloric supplementation given to the pregnant mothers is causally related to birth weight and to the length of pregnancy. The magnitude of the association is such that the proportion of low birth weight (≤ 2.5 kg) and short gestational age (<37 weeks) babies in the group of low supplemented mothers was 19 percent and 18 percent as opposed to nine and four percent in high supplemented mothers, respectively[40,41].

An association between the caloric supplementation consumed by the mother during pregnancy and lactation and by the infant during lactation on infant's growth in weight and length has also been reported[42]. Moreover, the impact of additional calories and proteins on children's growth has been communicated by Martorell *et al.*[43]

In the following section we will examine information on the effect of food supplementation and morbidity on physical growth. For those analyses, cohorts of all children who reached 18, 30, and 36 months of age during the study period, 1969-1977, and who were followed during one year, were selected. In total, 793 children at 18 months, 763 at 30, and 746 children at 36 months were identified and studied.

The information included in these analyses are anthropometry (weight and length), morbidity (percent time ill with diarrhea per semester) and food supplementation (mean daily calorie intake from supplementation during each semester). The absolute anthropometric measurements were converted to Z-score, in relation to the WHO reference population, and the semestral weight and length changes expressed as semestral Z-score changes. In theory, healthy children growing normally maintain their Z-score in consecutive weight and length measurement and their semestral Z-score change should approach zero.

Table 1 indicates that in this population, the growth deficits, relative to the WHO reference population tends to decrease at older ages. In both, weight and length, as well as in weight-for-length, there is a statistically significant reduction in growth retardation from younger to older ages.

The six-month increments in weight, length, and weight-for-length in children living in "atole" and "fresco" villages are presented in Table 2. In all cases, semestral Z-score changes are positive, and at 18 to 24 months, they are significantly higher in "atole" than in "fresco" villages. In addition, at 18 to 24 months, the changes in length are greater than in weight, in both "atole" and "fresco" villages.

Tables 3 to 5 present the semestral changes in weight, length, and weight-for-length Z-scores, according to the initial length and weight Z-scores. In general, at all ages, the semestral Z-scores changes in weight and in weight-for-length are greater in children with low weight at the beginning of the interval, and especially in those children with low weight and high length. The semestral Z-score changes in length are greater in children with low length and high weight at the beginning of the semester, especially at younger ages. These results support the existence of an effect of prior patterns of growth on subsequent growth, and are consistent with Fergusson *et al*[44], who reported that growth in the postnatal period acts in a redistributive fashion which tends to stabilize the relationship between the child's length and weight[42].

Tables 6 to 8 present attained and incremented weight and length information, by year of the study, in the three cohorts. Attained weight and length Z-scores at 18 months of age and the 18 to 24 month

Z-score length tend to decrease from the beginning to the end of the program. The six-month changes in weight and length are also significantly smaller at later years of the project, without significant changes in the attained weight and length measurement.

The association between diarrheal diseases and physical growth is explored in Tables 9 and 10, for weight and length respectively. The study sample was categorized in two groups: children with low and children with high diarrhea in two consecutive semestral periods (low diarrhea: zero percent time ill with diarrhea during each semester; high: five percent or more time ill with diarrhea), in each of the three cohorts and in the "atole" and "fresco" villages. According to morbidity experience in the first and second semester, children were grouped as follows: children without diarrhea in the two consecutive semesters, children with high diarrhea during the first semester and without diarrhea during the second, and children without diarrhea during the first and with diarrhea during the second semester. As shown in Tables 9 and 10, in all cases, children with diarrhea in the first semester and without diarrhea in the second have greater six-month changes during the second semester in weight and length than those without diarrhea in both semesters. In most cases, the six-month Z-score changes in weight and length during the second semester are negative in those children who had diarrhea during the second semester but not in the first. These data suggest that growth velocity in weight and length is greater after a period with diarrhea than what could be identified as normal growth in those cases without diarrheal disease. It is also evident from these results that weight changes are greater than length changes at all ages and that length changes are greater at younger ages.

Finally, Table 11 presents information on the six-month changes in length, according to the pattern of morbidity and the level of energy supplementation in the "atole" villages. As in Table 10, children were grouped according to their morbidity experience, and were divided in two categories, based on the daily mean amount of supplemented calories consumed during the second semester. As clearly shown in this table, the length increments in well-supplemented children is significantly greater than the low supplemented group in the 24 to 30 month age interval. In addition, the length increment in children with high supplementation and diarrhea during the first semester and no diarrhea during the second is significantly greater than the group of children without high supplementation and no diarrhea in the two consecutive semesters. At olders ages, 36 to 42 and 42 to 48, the effect of supplementation is not significant.

In summary, the integrated food supplementation and health care programs had important effects on the infant and child mortality rates and on physical growth. The food supplementation project was responsible for an increment in birth weight and in weight and length of children at older ages. This was more obvious at the beginning than at the end of theproject. It was also found that the effect of the food supplementation was greater in children with low weight and length than in heavier and taller children, as well as in those who had suffered from diarrheal disease in the past. The conclusion from the data is that the food supplementation project carried out in these villages was successful in stimulating catch-up growth in preschool children.

Based on the experience previously presented, and others in which we have been participating, a generalized model for food supplementation programs that utilizes a system of health as a vector for operationalizing intergrated development programs was planned. In the next section, some of these ideas are discussed.

DISCUSSION

Food aid resources available in a developing nation should be used to strengthen government efforts to expand primary health care services to the most deprived and isolated communities within a country. This strategy was used successfully in Costa Rica in the last decade with the initiation of the Rural Health Program (RHP) and the Community Health Program (CHP). The health and nutritional consequences of linking food aid to an integrated health care program gear to those segments of the populations in most need of these services have been well documented in the literature[45,46]. The latter example should not be overlooked, particularly in the Central American countries. A series of anthropological reports on health seeking behavior in Central America and Panama, carried out by INCAP and scientists of its member countries[47], have singled out the low utilization by rural populations of government health services. While it is recognized that existing sociocultural practices in rural communities may preclude a better use of these services, it is also true that in the initial stages of provision of health services to isolated rural communities, certain material stimulus besides health (i.e., food aid) need to be present while the confidence between health providers and recipients is established. Our own data[34] have singled out the positive impact on subsequent growth of those children who consulted the health service due to diarrhea as opposed to those who did not make use of the program. Therefore, food aid can serve as a tool to promote the extension and use of medical care services in rural areas, particularly when the recipient populations have not been exposed to modern medicine.

The link of food aid to integrated medical care services, oriented to provide health to deprived communities of developing nations, can be established mainly through two types of food aid programs: supplementary feeding schemes through the maternal and child care programs and food for work activities. The former will fulfill objectives such as avoiding deteriorations or improving the health and nutritional conditions of vulnerable demographic and physiological groups (mothers and children) and/or of vulnerable groups within high risk poor families. They will also propose other broader objectives such as being an income transfer or becoming a tool to improve the utilization of health services as it has already been described.

However, at least in the Latin American context, food aid in the form of food for work has seldom been linked to integrated efforts of delivering health services to deprived and undernourished populations. Construction or maintenance of roads and certain agricultural-related activities have accounted for most food aid provided in Central America as food for work. If food aid is to be integrated to efforts to provide comprehensive health services in developing countries, certain resources to be allocated to food for work activities need to be invested to support the strengthening of the health infrastructure in dispersed rural communities. These potential food for work projects include not only the construction of health posts but, more importantly, projects geared to prevent the occurrence of the most important plague diseases affecting children in rural communities: improvements to existing houses with adequate sanitary conditions, introduction of potable water, improvements to garbage and excreta disposal systems, adequate sewage systems. Thus, the expansion of present food for work activities to improve the infrastructure for health and sanitary services in isolated rural communities of developing nations may be an important contribution of food aid to the health and nutritional status of mothers and their children in the developing world.

By no means a larger allocation of resources of food for work programs to strengthen the health and sanitary infrastructure is in conflict with the broad objective of food for work project, which is to make use of surplus labor in certain periods of the year to promote development projects while providing to unemployed or underemployed families some economic means to fulfill basic needs. However, trade-offs should be carefully analyzed if resources are to be diverted from other existing developmental projects as well as the government capacity to handle efficiently more food aid if the new projects are going to be financed with additional resources.

How, in practice, can food aid be efficiently linked to promote, within integrated health services, catch-up growth? The answer to this question, besides taking into consideration the general nutritional policy issues on food aid and health care services already discussed, rests on effective program selection, design, and control of program performance (process). Other papers in this workshop will be dealing at length with targeting and evaluation of food aid programs and therefore we will only discuss the pertinent aspects of targetting and evaluation of process and impacts related achievement of catch-up growth.

The probability to observe catch-up growth may be enhanced if food aid programs operating in the health or any other government sectors are better targetted. The means for that exist, particularly in the Central American isthmus and other Latin American countries, where permanent food and nutrition information systems of mapping and monitoring the prevalences of malnutrition for the smallest political-administrative units are operating[48]. In Panama, which is divided in 505 *corregimientos*, for political and administrative purposes, a total of 34 *corregimientos* exhibited a proportion of less than 3% of children below -2 Standard Deviation of the NCHS reference pattern. Conversely, 59 *corregimientos* (11.7%) showed a prevalence of height retardation above 50%, while 6 *corregimientos* had more than 75% of their children with height retardation[49]. For ethical and cost-effectiveness reasons, one may select the worst-off *corregimientos* as target communities for food aid programs. If that is so, either as a true catch-up growth and/or as part of a regression to the mean effect, one would expect a greater impact of the program in those communities exhibiting the worst conditions.

The same argument holds true for targeting the food aid program to those families and individuals in the most precarious conditions within selected communities. To maximize the efficiency of selecting the worst-off within the communities, nutritional status criteria can be complemented with information about the functional occupation of heads of households as has been proposed in the Central American isthmus[48,49]. Thus, better targeting of food aid and other food, nutrition, and health programs by regions, subregions, areas, and communities, and within communities by families and individuals are feasible nowadays to be carried out in some developing countries and are not an impossible task in many others. The selection of the most deprived and undernourished (thinnest, sickest, and smallest) through food aid and health care services will enhance any possibility to produce catch-up growth.

Seasonal factors are commonly overlooked in food aid program design. If food aid is properly designed within health care systems, it may have important implications in buffering periodic scarcity of foods coupled with higher occurrence of diseases which are commonly found in rural areas of developing nations. Thus, in many developing nations, the peak of diarrhea and other diseases usually coincides with the months where less food is available at home. Therefore, with knowledge of these patterns for different agricultural communities in a country, both the coverage and the amount of foods per participant can be modified. The latter will accommodate, at the individual level, for the additional demands of energy and nutrients imposed by the higher proportion of children in the selected communities who during these periods exhibit diarrhea and other diseases.

Besides policy definitions with regards to the utilization of food aid and better targeting of existing resources to the most deprived and undernourished families, the possibility to link food aid with health care programs to produce catch-up growth will have to face a critical revision of existing norms and procedures of these programs. This revision will have to include the criteria for selecting a child to enter the program, instruments and interpretation of growth monitoring curves, type, quantity, and quality of foods to stimulate catch-up growth, length of child participation in a program, follow-up of discharged children. The above issues should be addressed in the circumstances in which food aid programs operate in developing nations and will be the subject of a research project to be conducted in 1985 as part of INCAP's efforts in the next five years to support the efficient operation of food aid programs in Central America and Panama[51]. The following are examples of the type of revisions to be made on the criteria for selecting participant children, if we expect to maximize the potential to see catch-up growth. No food aid out of 26 programs operating in the Ministries of Health in Central America and Panama have, within the criteria for incorporating a child to the program or for determining his length of participation, the presence or antecedents of diarrheal diseases. Furthermore, the amounts of food given to a family do not take into consideration the initial nutritional status of the child and/or his recent morbidity events.

To recapitulate, the field evidence reviewed in this paper and our experiences supporting national food aid programs in the health sector, particularly in Central America and Panama, lead us to suggest that the measures to improve food aid program efficiency in the health sector, in general, are the very same measures which will maximize the effects of food aid on catch-up growth. They entail the use of food aid, both as a basic element of a strategy to expand the coverage and effective use of health care services and to strengthen the health and environmental sanitation infrastructure to prevent or reduce the occurrence of diseases. With regards to program design, better targeting (political-administrative, within selected communities, seasonal criteria) and a revision of existing norms and procedures should be carried out to maximize the achievement of clear-cut program objectives, one of which may be to stimulate catch-up growth. Existing permanent data collection mechanisms for food and nutrition planning and operational research in national food aid programs are essential tools for improving design and program performance and, therefore, for increasing program efficiency which will, in turn, be reflected in catch-up growth in some participant children chronically malnourished as well as in others who had suffered recently from acute morbidity events.

Finally, as will be discussed in another session by Dr. John Mason, it is feasible but difficult and costly to ascribe nutritional impacts to a national food aid program. Thus, the evaluation of impact of food aid programs on catch-up growth can be addressed as part of field studies on nutritional effects of national food aid programs.

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[1] Waterlow, J.C., A. Hill and D. W. Spady. "Energy Costs and Protein Requirements for Catch-up Growth in Children." In *Early Nutrition and Late-Development*. Edited by A. W. Wilkinson. Tunbridge Wells, England: Pitman, 1976.

[2] Oretega, F. *Tratamiento dietetico de la desnutrición proteínico calórica a nivel hospitalario*. Guatemala: INCAP/CESNA/Escuela de Nutrición, 1972.

[3] Murillo, S.; J. C. Waterlow, W. Vargas, and L. Mata. "Recuperación del desnutrido severo en Costa Rica mediante alimentacion hipercalórica." *Bol. Med. Hosp. Infant. Mex.* 37 (1980): 483.

[4] Ginies, J.L. and C. Ricour. "Catch-up Growth in Children under Artificial Nutrition." *Arch. Fr. Pediatr.* 39/Supple. 2 (1982): 745.

[5] Delgado, H.L. and V. Valverde. *Nutritional Rehabilitation of Severely Malnourished Children at the Community Level*. Manuscript in preparation, 1985.

[6] Winslow, C., A. Lechtig, B. Newman and R. E. Klein. "Impact of a Feeding Program on Preschool Children with Severe Malnutrition." *Arch. Latin. Nutr.* 30 (1980): 273.

[7] Payne, P.R. "Safe Protein-Calorie Ratios in Diet. The Relative Importance of Protein and Energy as Causal Factors of Malnutrition." *American Journal of Clinical Nutrition* 28 (1978): 281.

[8] Gopalan, C., M. C. Swaminathan, V.K.K. Kamari, D.H. Rao, and K. Vijayaraghavan. "Effect of Calorie Supplementation on Growth of Undernourished Children." *American Journal of Clinical Nutrition* 26 (1973): 563.

[9]Sinclair, J.C. "Energy Balance of the Newborn." In *Temperature Regulation and Energy Metabolism in the Newborn.* Edited by J.C. Sinclair. New York, New York: Grune and Stratton, 1978.

[10]Calloway, D.H. "Nitrogen Balance in Men with Marginal Intakes of Protein and Energy." *Journal of Nutrition* 105 (1975): 914.

[11]Keller, W. "Choice of Indicators of Nutritional Status." In *Evaluation of Nutrition Education in Third World Communities.* Edited by Beat Schürch. Vienna, Austria: Nestlé Foundation Publication Series, 1983.

[12]Holliday, M.A. "Body Composition and Energy Needs during Growth." In *Human Growth* Volume II. Edited by F. Falkner and J.M. Tanner. New York, New York: Plenum Press, 1978.

[13]Fomon, S.J. "Body Composition of the Male Reference Infant during the First Year of Life." *Pediatrics* 40 (1967): 863.

[14]Bergmann, R.L. and K.E. Bergmann. "Nutrition and Growth in Infancy." In *Human Growth* Volume III. Edited by F. Falkner and J.M. Tanner. New York, New York: Plenum Press, 1979.

[15]Kerr, D.S., M.C.G. Stevens and H.M. Robinson. "Fasting Metabolism in Infants. I: Effect of Severe Under Nutrition on Energy and Protein Utilization." *Metabol.* 27 (1978): 411.

[16]Payne, P.R. and J.C. Waterlow. "Relative Energy Requirements for Maintenance, Growth and Physical Activity." *Lancet* 210 (1971)

[17]Rutishauser, I.H.E. and R.G. Whitehead. "Energy Intake and Expenditure in 1-3 Year Old Ugandan Children Living in a Rural Environment." *British Journal of Nutrition* 28 (1972): 145.

[18]Torun, B., Y. Schultz, R.B. Bradfield, and F.E. Viteri. "Effect of Physical Activity upon the Growth of Children Recovering from Protein Calorie Malnutrition." In *Proceedings of the Xth International Congress of Nutrition.* Kyoto, Japan: Victoria-Sha Press, 1976.

[19]Kerr, D.A., and M.C.G. Stevens and H.M. Robinson. "Fasting Metabolism in Infants." In *Effect of Severe Undernutrition on Energy and Protein Utilization. Metabol.* 27 (1978): 411.

[20]Beisel, W.R. "Magnitude of the Host Nutritional Response to Infection." *American Journal of Clinical·Nutrition* 30 (1977): 1236.

[21]Chen, L.C. "Interaction of Diarrhea and Malnutrition. Mechanisms and Interventions." In *Diarrhea and Malnutrition.* Edited by L.C. Chen and N.S. Scrimshaw. New York, New York: Plenum Press, 1983.

[22]Scrimshaw, N.S., O. Brunser, G.T. Keush, A. Molla, I. Ozalp, and B. Totun. "Diarrhea and Nutrient Requirements." In *Diarrhea and Malnutrition.* Edited by L.C. Chen and N.S. Scrimshaw. New York, New York: Plenum Press, 1983.

[23]Mata, L.J. *The Children of Santa Maria Cauque.* Cambridge, Massachusetts: M.I.T. Press, 1978.

[24]Molla, A.M., A. Molla, S.A. Sarker and M.M. Rahaman. "Food Intake During and After Recovery from Diarrhea in Children." In *Diarrhea and Malnutrition.* (Op. Cit.).

[25]Martorell, R., C. Yarbrough, S. Yarbrough and R.E. Klein. "The Impact of Ordinary Illnesses on the Dietary Intake of Malnourished Children." *American Journal of Clinical Nutrition* 33 (1980): 345.

[26]Hoyle, B., M. Yunus and L.C. Chen. "Breastfeeding and Food Intake Among Children with Acute Diarrheal Disease." *American Journal of Clinical Nutrition* 33 (1980): 2365.

[27]Lindenbaum, J. "Malabsorption During and After Recovery from Acute Intestinal Infections." *British Medical Journal* 2 (1965): 326.

[28]Rosenberg, I.H. and N.S. Scrimshaw. (Editors). "Workshop on Malabsorption and Nutrition." Parts I and II. *American Journal of Clinical Nutrition* 25 (1972): 1046.

[29]Rosenberg, I.H., N.W. Solomons and R.E. Schneider. "Malabsorption Associated with Diarrhea and Intestinal Infections." *American Journal of Clinical Nutrition* 30 (1977):..1977.

[30]Morley, D., J. Bicnell, and M. Woodland. "Factors Influencing the Growth and Nutritional Status of Infants and Young Children in a Nigerian Village." *Trans. Roy. Soc. Trop. Med. Hgy.* 62 (1968): 164.

[31]Mata, L.J., R.A. Kromal and H. Villegas. "Diarrheal Diseases: A Leading World Health Proclem." In *Cholera and Related Diseases.* Switzerland, Basel: Karger, 1980.

[32]Martorell, R., C. Yarbrough, A. Lechtig, J-P. Habicht and R.E. Klein. "Diarrheal Diseases and Growth Retardation in Preschool Guatemalan Children." *Am. J. Phys. Anthrop.* 43 (1975): 341.

[33]Rowland, M.G.M., T.J. Cole and R.E. Whitehead. "A Quantitative Study into the Role of Infection in Determining Nutritional Status in Gambian Village Children." *British Journal of Nutrition* 37 (1977): 441.

[34]Delgado, H.L., V. Valverde, J.M. Belizan and R.E. Klein. "Diarrheal Diseases, Nutritional Status and Health Care: Analyses of Their Interrelationship." *Ecol. Food Nutr.* 12 (1982): 229.

[35]Rohde, J.E. "Preparing for the Next Round: Convalescent Care after Acute Infection." *American Journal of Clinical Nutrition* 31 (1978): 2258.

[36]United Nations University *Protein Requirements Under Conditions Prevailing in Developing Countries: Current Knowledge and Research Needs.* Tokyo, Japan: United Nations University, 1979.

[37]Waterlow, J.C. "Adjustment of Requirements for Observed Growth and Anthropometric Data." Presented at the Joint FAO/WHO/UNU Expert Consultation on Energy and Protein Requirements. Rome, 1981.

[38]Klein, R.E., J-P Habicht and C. Yarbrough. "Some Methodological Problems in Field Studies of Nutrition and Intelligence." In *Nutrition Development and Social Behavior.* Edited by D.J. Kallen. Washington, DC: U.S. Government Printing Office. DHEW Pub. No. (NIH) 73-242, 1973, pp 61-75.

[39]Delgado, H.L., V. Valverde, and E. Hurtado. *Case Study on Infant Mortality, Primary Health Care and Nutrition in Rural Guatemala.* United Nations/UNFPA, 1985. (In press.)

[40]Lechtig, A., J-P. Habicht, H. Delgado, R.E. Klein, C. Yarbrough and R. Martorell. "Effect of Food Supplementation during Pregnancy on Birth Weight." *Pediatrics* 56 (1975): 508.

[41]Delgado, H.L., R. Martorell, E. Brineman and R.E. Klein. "Nutrition and Length of Gestation." *Nutrition Research.* 2 (1982): 117.

[42]Delgado, H.L., V. Valverde, R. Martorell and R.E. Klein. "Relationship of Maternal and Infant Nutrition to Infant Growth." *Early Human Development* 6 (1982): 273.

[43]Martorell, R., R.E. Klein and H. Delgado. "Improved Nutrition and Its Effects on Anthropometric Indicators of Nutritional Status." *Nutrition Reports International* 21 (1980): 219.

[44]Fergusson, D.M., L.J. Horwood and F.T. Shannon. "Length and Weight Gain in the First Three Months of Life." *Human Biology* 52 (1980): 169.

[45]Jaramillo, J. *Los problemas de la salud en Costa Rica.* San José, Costa Rica: Litografía Ambar., 1983.

[46]Valverde, V., H.L. Delgado, A. Noguera and R. Flores. "Malnutrition in Tropical America." In *Malnutrition: Determinants and Consequences.* Editors: P.L. White and N. Selvey. New York, New York: Alan R. Liss, 1984.

[47]Hurtado, E., G. Sanchez and A. Esquivel. *Health Seeking Behavior Case Studies in Central America.* Manuscript in preparation, 1985.

[48]Valverde, V., H. Delgado, A. Nogerua, M. Palmieri, R. Flores, R. Sibrian and P. Palma. "Revision de las experiencias del censo de talla de escolares." In *Memorias, Seminario-Taller Regional: Aporte de los Censos de talla de Escolares a los Sistemas de Vigilancia Alimentario-Nutricional.* Publicación INCAP L-21, 1984.

[49]Ministerio de Salud/Ministerio de Educación de la República de Panamá. *Resultados del primer censo de talla en niños de primer grado escolar en Panamá.* Guatemala City, Guatemala: INCAP, 1982.

Table 1

ANTHROPOMETRIC INDICATORS IN THE STUDY SAMPLE

Age months	N	Z-score weight $\bar{x}$	Z-score weight S.D.	Z-score length $\bar{x}$	Z-score length S.D.	Z-score weight-for-length $\bar{x}$	Z-score weight-for-length S.D.
18	731	-2.11	.90	-2.78	1.06	-.71	.84
24	793	-2.03	.96	-2.46	1.10	-.61	.68
30	704	-1.83	.89	-2.41	1.10	-.45	.71
36	762	-1.66	.85	-2.34	1.03	-.33	.73
42	746	-1.56	.82	-2.32	.99	-.23	.76
48	664	-1.53	.77	-2.26	.98	-.23	.73

Table 2

SIX-MONTH CHANGES IN WEIGHT, LENGTH, AND WEIGHT-FOR-LENGTH IN "ATOLE" AND "FRESCO" VILLAGES

			Six months changes in		
Age (months)	Type supplement	N	Z-score weight	Z-score length	Z-score weight-for-length
18-24	Fresco	346	.01	.26	.06
			*	*	
	Atole	373	.15	.37	.12
30-36	Fresco	341	.17	.06	.11
	Atole	342	.14	.05	.12
36-42	Fresco	329	.11	.01	.10
	Atole	338	.05	.02	.05

Comparion between "Fresco" and "Atole" villages

* t-test > 1.96; $p < .05$
* t-test > 2.58; $p < .01$

Table 3

CHANGES IN WEIGHT, LENGTH, AND WEIGHT-FOR-LENGTH FROM 18 to 24 MONTHS ACCORDING TO INITIAL LENGTH AND WEIGHT MEASUREMENTS*

Categories of length	Categories of weight	N	Six-month changes in Z-score weight	length	weight-for-length
Low	Low	40	.19	.45	.12
	Mid	31	.22	.63	-.09
	High	6	-.04	.77	-.74
Mid	Low	17	.41	.07	.86
	Mid	49	.10	.41	.10
	High	27	.09	.36	-.18
High	Low	4	.60	-.20	1.43
	Mid	43	.28	.33	.54
	High	156	.08	.32	.02

*In Atole Villages

<u>Table 4</u>

CHANGES IN WEIGHT, LENGTH, AND WEIGHT-FOR-LENGTH FROM 30 TO 36 MONTHS, ACCORDING TO INITIAL LENGTH AND WEIGHT MEASUREMENTS*

Categories of length	Categories of weight	N	Six-month changes in Z-score weight	length	weight-for-length
Low	Low	25	.30	13	18
	Mid	23	.11	35	-14
	High	5	-.01	29	-16
Mid	Low	22	.31	5	28
	Mid	55	.24	4	24
	High	37	.11	16	4
High	Low	3	.48	-.02	.59
	Mid	37	.21	-.02	.24
	High	135	.02	-.04	.07

*In Atole Villages

Table 5

CHANGES IN WEIGHT, LENGTH, AND WEIGHT-FOR-LENGTH FROM 36 TO 42 MONTHS, ACCORDING TO INITIAL LENGTH AND WEIGHT MEASUREMENTS*

Categories of length	Categories of weight	N	Six-month changes in Z-score weight	length	weight-for-length
Low	Low	23	.22	.14	18
	Mid	·22	04	.10	-.03
	High	10	.14	.38	-.03
Mid	Low	7	.18	-.07	.06
	Mid	42	.12	.00	.25
	High	48	.07	.06	.13
High	Low	3	15	.03	.10
	Mid	26	.08	-.02	.13
	High	157	-.01	-.03	.08

* In Atole Villages

Table 6

ATTAINED WEIGHT AND LENGTH AT 18 MONTHS OF AGE AND CHANGES FROM 18 TO 24 MONTHS, BY YEAR OF THE STUDY

	Years of the Study							
	1969-70	1971	1972	1973	1974	1975	1976	
Z-score weight	2.23	2.12	2.17	2.27	2.02	1.93	2.00	F 2.60; p: 0167
Change in Z-score weight	.00	.13	.05	.08	.04	.06	.14	F 1.08; $p > .05$
Z-score length	2.94	2.63	2.98	2.96	2.73	2.60	2.59	F 3.86; p: 0011
Change in Z-score	.56	.28	44	52	24	.09	.17	F 11.69; p: .0000

Table 7

ATTAINED WEIGHT AND LENGTH AT 30 MONTHS OF AGE AND CHANGES FROM 30 to 36 MONTHS, BY YEAR OF THE STUDY

	Years of the Study 1969-70	1971	1972	1973	1974	1975	1976	
Z-score weight	-1.87	-2.04	-1.76	-1.89	-1.89	-1.69	-1.72	F 0.82; $p > .05$
Change in Z-score weight	.14	.18	.04	20	18	.20	.12	F 2.73; p: .0127
Z-score length	-2.36	-2.60	-2.38	-2.40	-2.51	-2.33	-2.35	F .21; $p > .05$.
Change in Z-score length	.56	.28	.44	.52	.24	.09	..17	F 11.69; p: .0000

Table 8

ATTAINED WEIGHT AND LENGTH AT 36 MONTHS OF AGE AND CHANGES FROM 36 to 42 MONTHS, BY YEAR OF THE STUDY

	Years of the Study							
	1969-70	1971	1972	1973	1974	1975	1976	
Z-score weight	-1.69	-1.59	-1.73	-1.72	-1.69	-1.58	-1.57	F: .88; $p > .05$
Change in Z-score weight	.17	.08	.04	.10	.06	.07	.04	F: 2.06; p: 0549
Z-score length	-2.36	-2.16	-2.47	-2.37	-2.42	-2.20	-2.37	F: 1.80; $p > .05$
Change in Z-score length	.11	-.08	.06	.06	.00	.01	-.02	F: 3.39; p: 0030

Table 9

SIX-MONTH CHANGES IN WEIGHT ACCORDING TO THE PATTERN OF MORBIDITY

Pattern of morbidity	Calorie Supplementation Months 24-30	Calorie Supplementation Months 36-42	Calorie Supplementation Months 42-48	Protein-calorie Supplementation Months 24-30	Protein-calorie Supplementation Months 36-42	Protein-calorie Supplementation Months 42-48
Low diarrhea* - 1st semester	.26	.17	.01	.31	.04	.01
Low diarrhea - 2nd semester	(44)	(87)	(122)	(51)	(126)	(143)
High diarrhea** - 1st semester	.27	.21	.18	.32	.16	.11
Low diarrhea - 2nd semester	(36)	(26)	(23)	(46)	(28)	(25)
Low diarrhea - 1st semester	-.16	-.10	-.21	.04	-.13	-.08
High diarrhea - 2nd semester	(9)	(12)	(5)	(12)	(6)	(12)

*Low diarrhea: 0 percent time ill with diarrhea during each semester.
**High diarrhea: 5 percent or more time ill with diarrhea.

Table 10

SIX-MONTH CHANGES IN LENGTH ACCORDING TO THE PATTERN OF MORBIDITY

	Calorie Supplementation Months			Protein-calorie Supplementation Months		
Pattern of morbidity	24-30	36-42	42-48	24-30	36-42	42-48
Low diarrhea* - 1st semester	.17	.04	.08	.07	.02	.03
Low diarrhea - 2nd semester	(44)	(87)	(122)	(51)	(126)	(143)
High diarrhea** - 1st semester	.25	.07	.11	.26	.08	.07
Low diarrhea - 2nd semester	(36)	(26)	(23)	(46)	(28)	(26)
Low diarrhea - 1st semester	-.14	.01	--56	0.04	-.17	.03
High diarrhea - 2nd semester	(9)	(12)	(5)	(12)	(16)	(12)

*Low diarrhea: 0 percent time ill with diarrhea during each semester.
**High diarrhea: 5 percent or more time ill with diarrhea.

Table 11

SIX-MONTH CHANGES IN LENGTH, ACCORDING TO THE PATTERN OF MORBIDITY AND LEVEL OF ENERGY SUPPLEMENTATION IN "ATOLE" VILLAGES

Pattern of morbidity	Supplementation during 2nd semester	Six-month changes in Z-score length Months 24-30	36-42	42-48
Low diarrhea 1st semester	Low (0-99 kcal/day)	-.01 (21)	.02 (51)	.04 ([illegible]
Low diarrhea 2nd semester	High (>99 kcal/day)	.13 (30)	.01 (75)	.02 ([illegible]
High diarrhea 1st semester	Low	.14 (15)	.12 (11)	.07 ([illegible]
Low diarrhea	High	.31 (31)	.05 (17)	.06 ([illegible]

In parenthesis, number of cases