Village Nutrition in Egypt, Kenya and Mexico: Looking Across the CRSP Projects

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There is a world of luxury foods, and another where food is the only luxury known.

A. H. Boerma
The Hague, 1970

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SUMMARY

BACKGROUND

The research reported here is a continued analysis of data obtained under the Collaborative Research Support Program on Nutrition and Human Function (NCRSP). The original NCRSP involved field studies replicated in three locations, designed to test hypotheses about the impact of chronic, mild-to-moderate food energy deprivation on functional outcomes. The program included binational projects in Egypt, Kenya and Mexico each of which has reported its findings separately. The present study is an analysis of the three archived data sets which looks across the sites for comparability of associations between food intakes and two outcomes -- childhood growth and morbidity.

PLAN AND PROCEDURES

The Egypt research site was a Nile-delta village near Cairo; the Kenya study included three sublocations in Embu, on the slopes of Mt. Kenya; the Mexico project involved six highland communities in the Solis Valley. Each project gathered data from about 300 households, focussing on the lead male and lead female who were parents of studied toddlers (18 to 30 months) and schoolers (7 to 9 years). Each subject was studied for 12 months during 1984-86.

The present research has focused on four principal types of variables: a classification of foods and nutrients; comparative economic, social and hygienic factors; anthropometry; and morbidity. The classification of foods and nutrients can be viewed as a complement or an alternative to energy intake as the independent variable in hypothesis testing. Socioeconomic factors and household hygiene are examined as determinative or explanatory variables. Morbidity served as an intervening and an outcome variable. Descriptive statistics are presented for revised analytical files. Relationships among variables were explored as bivariate correlations and their interrelationships were assessed by multivariate techniques. Principal component analysis was used to examine relationships among food-group intakes of children and to produce new composite variables.

Preliminary results indicated potential associations of growth and dietary quality (as well as quantity). To investigate these more fully, we developed the INT Minilist, a single database with about 50 nutritional factors in class-representative foods. Nutrient intakes were calculated and then assessed by a probability approach in which intakes are compared with average requirements of known (or assumed) variability to predict the prevalence of dietary inadequacy for the population sample.

PRINCIPAL FINDINGS

Although birthweights of these populations were close to reference values, toddler heights were more than 2 SD below the reference (Z score ≅ –2) in all locations but only the Kenya group was also somewhat below reference weight-for-height (about –0.4 to –0.5 Z). Schooler heights also were diminished but not as much as the toddlers (Z scores Egypt –1.0, Kenya –1.6, Mexico –1.5); schoolers were thinner than toddlers in each location but only in Kenya were they much below the reference level. Toddler weight and height related more closely to maternal than paternal weight and height. BMI of women varied directly with age in Egypt and Mexico but Kenya women did not accumulate fat with age. There were strong spousal correlations in fatness measures.

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The household energy intake was sufficient to support a moderate level of activity in Mexico and a lighter activity pattern consistent with occupational and other conditions in Egypt. Energy intake in Kenya was below the level that moderate activity in a rural setting would require, indicating that energy intake probably limited discretionary activity. That finding and the prevalent thinness of adults suggest that total food availability was restricting in Kenya, a conclusion supported by positive correlations between children's growth and energy intake even after controlling for intervening variables.

There were significant associations between children's anthropometry and several markers of dietary quality and/or nutrients. The children's dietary data predict numerous inadequacies in Kenya (e.g. iron, zinc, calcium, vitamin B_{12}) and Mexico (e.g., iron, zinc, riboflavin, vitamins C, A and B_{12}), and some in Egypt as well (iron, calcium, vitamin A). High intakes of fiber and phytate in the Kenya and Mexico diets contributed to the low availability of zinc and iron. There is very limited but confirmatory biochemical evidence of specific deficiencies (iron, zinc, vitamin B_{12}). Associations between nutrients and growth remained significant after adjustment for energy intake.

Intake of specific foods or groups of foods was as strongly correlated with child size as was nutrient intake. Associations were stronger in Kenya and Mexico than in Egypt, providing more evidence for the importance of diet in those countries. In Mexico and Kenya, where maize intakes were very high, maize intake was associated with poorer growth and size of toddlers and usually of schoolers as well. Even after controlling for energy, intakes of fats and sugars were positively related to toddler height and growth in Kenya. Principal component analysis identified a dietary pattern which was higher in dairy/meat and lower in maize; this pattern was a predictor of child growth in Kenya and Mexico.

In Egypt, where basic food commodities were subsidized, food was sufficient and the diet was more diverse. There the household sanitation score is strongly related to toddler height and weight in multivariate analyses. Maternal height and BMI are the only other variables that were consistently related to Egypt toddler size in the basic models; sanitation score is the only variable found to correlate with maternal BMI in Egypt. Sanitation score and more specifically a "child appearance score" was associated with toddler weight but not height in Mexico. Neither growth nor size was associated with sanitation score in Kenya. Analysis of morbidity identified prevalence of diarrhea as adversely affecting attained height of toddlers in Egypt and Mexico and length gain in Kenya. The prevalence of severe illness was negatively related to toddler weight in Kenya.

Children whose anthropometric parameters were low at age 18 months had more severe illness in the subsequent year. Weight-for-length was the strongest predictor of severe illness in Kenya and weight-for-age in Egypt. In these situations, lower growth status of children is a predictor of risk of severe illness; the smallest children are not necessarily sick more often but an illness hits them much harder.

CONCLUSIONS

When food energy intake is insufficient - the Kenya case - it is the first limiting dietary factor, a more powerful correlate of growth than socioeconomic status or household sanitation. However, in the Kenya situation, the children's needs would not be best served by simply making more of the same food available. Although there are situations where deprivation is so severe that any added food would likely be helpful, in chronic mild-to-moderate deprivation food quality probably is low and constitutes a second limitation. In Kenya, what is needed is to add calories as more energy- and nutrient-dense foods, and to reduce dependence on maize. As the Mexico data show, having enough food is not a sufficient condition for growth production; energy adequacy bought by increased intake of coarse, fibrous foods which adversely affect absorption of minerals, leaves these nutrients at risk along with deficits of other nutrients supplied by a more diverse diet. The specific nutrients at risk in regional diets may vary but in both Kenya and Mexico, addition of animal-source foods is desirable - not for their protein contribution which is generally adequate - but for their content of available minerals and vitamins.

In the few countries where basic levels of food are subsidized, as in Egypt, food intake is less likely to be a limiting factor. In the Egypt case, it is the household sanitary environment that appears to affect children's well-being. The present findings also illustrate that the most food-deprived population is not necessarily the least hygienic.

The environmental factors that affect childhood growth differ in importance from place to place. The underlying causes may be nationally or locally specific but the proximate causes, as illustrated by the NCRSP studies, are likely to be classifiable according to a typology of insufficient food, poor quality food and poor sanitation. A comparison of findings across the projects suggests that the contribution of each factor can be predicted provisionally by a few markers. At the community level, body mass index of women is an indicator of overall food availability; at the community and/or household level, the pattern of foods consumed is an indicator of dietary quality and nutrient adequacy; at the household level, a simple assessment of sanitary facilities and hygienic practices is an indicator of risk of infectious disease. Attention needs to be paid over the long term to addressing the root causes of malnutrition. But all governments should take such interim action as is within their capacity to improve the well-being of families and their children by paying attention to the triad of food sufficiency, food quality, and cleanliness.

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INTRODUCTION

BACKGROUND

The University of California at Berkeley served as the Management Entity (ME) for the Collaborative Research Support Program on Nutrition and Human Function (NCRSP) from December, 1981 through December, 1987. The ME facilitated and coordinated the scientific enterprise but had no direct role in the research *per se*. The NCRSP projects gathered data according to an agreed protocol at field locations in Egypt, Kenya, and Mexico. The common data were then sent to the ME and archived. A full description of ME activities and commentary on the projects' procedures and variables is included in the ME Final Report (1).

The Berkeley group was asked by USAID to prepare an interpretive summary of the findings reported by each project separately (2-4). The brief did not include extensive statistical analysis but the Final Summary Report identified important differences and commonalities between project findings that merited further investigation (5). Some of these topics and others have now been examined under the terms of a cooperative agreement in force from September, 1989 through January, 1992. The results of the across-project analyses are presented in this Final Report.

SCOPE OF WORK

The original objective of the NCRSP was to test hypotheses linking food energy intake of individuals and households to functional outcomes in several important domains -- childhood growth, morbidity, cognitive development, reproduction and work performance. Two of the three study sites proved, in retrospect, not to be suitable for investigation of the impact of chronic food energy deficit but there were marked differences across projects in dietary composition that could usefully be examined. In simplifying the original research plan (to reduce costs and research complexity), much of the focus on the household as a unit of study was lost. Nevertheless, household food intake data are available from two sites (and a partial set from the third) and certain characteristics of households (economic status, hygienic procedures, etc.) and parents (size, diet, education, etc.) could be tested in relation to outcomes in children.

The intent of the present research was to refine the three-country data archive, producing uniform variables, and to use these variables to look across projects for comparability of associations between diet and outcomes. Where findings are consistent, they should be generalizable. Where they are not consistent, comparisons across projects might yield clues as to the factors likely to affect outcomes in different environments.

RESEARCH PLAN

The present research has focused on four principal types of variables: a classification of foods and nutrients; comparative economic, social and hygienic factors; anthropometry; and morbidity. The classification of foods and nutrients can be viewed as a complement or an alternative to energy intake as the independent variable in hypothesis testing. Socioeconomic factors and household hygiene are examined as determinative or explanatory variables. Morbidity serves as either an intervening or outcome variable. Limitation of funds available for this research has limited our exploration of outcomes, other than toddler morbidity, to anthropometric characteristics of toddlers and school-age children. Throughout this work we have specifically sought to identify robust and reliable indicators (preferably at the household level) of child growth and health.

STUDY POPULATIONS

In each country, one community or a cluster of adjacent communities was selected for study. Each project gathered data from about 300 households. Household selection was based primarily on demographic characteristics (the presence of predefined target classes of individuals). There was no attempt to sample on a randomized or stratified random basis. Communities were selected where mild-moderate malnutrition was believed to exist and where the studies were logistically feasible but the study samples were not required to be representative of the populations of the three countries.

The research site in Egypt was the village of Kalama, located on the Nile delta about 25 km from Cairo. Kalama, a community with strong Islamic traditions, was in the process of economic transformation from a predominantly rural agricultural village to a periurban community with full electrification and other amenities. Locally produced foods included vegetable crops and fruits, wheat and goat-milk cheese. Prices of staples, sugar, oil and meat were subsidized by the Egypt government to stabilize prices and improve access by the poor.

The Kenya study included three sublocations in the Embu district on the southeastern slopes of Mt. Kenya at altitudes of 1000 to 1500 m. The population is predominantly Embu (part of the larger Bantu group) and about equally divided between Protestants and Catholics. The communities were without electricity and regular postal service and had no hard-surfaced roads beyond the main highway. The study communities normally grow cash crops (coffee and cotton) and food for their own subsistence, primarily maize, legumes and vegetables, but productivity depends on rainfall.

The Mexico project was based in six communities in the Solis Valley in the Central Highlands. The elevation of the valley floor is about 2500 m with the slopes rising to about 3000 m. The people are mainly Mestizo (mixed European and Indian) and usually Catholic. Communities generally have access to water and electricity but service is often interrupted. The population studied was still predominantly agricultural (producing maize and lesser amounts of wheat, rice, beans and squash) but about half the men commuted weekly to work outside the area (mainly in Mexico City, three hours distant by bus).

SUBJECTS

The target subjects are the lead male (LM) and lead female (LF) who are the conjugal heads of household and who are parents of toddlers (T) aged 18-30 months and/or schoolers (S) aged 7 to 9 years. The LF may be pregnant (P), lactating (L), or neither (NPNL). The archive includes target infants born to P LFs but they are omitted from the present study. Non-target subjects are all other members of the households of target subjects.

DEFINITION OF VARIABLES

Except as noted, the variables used to derive the present analytical files are the same as those archived by the projects and used in their own analyses. We have, however, applied inclusion / exclusion rules that were developed after considering the data available in all three projects and these rules may not be consistent with those of the individual projects. Thus, the numbers of subjects and means and standard deviations may differ from those reported by the projects even though both are drawn from the same archive.

HOUSEHOLD VARIABLES: SOCIOECONOMIC AND HYGIENIC

A wide variety of information on household social and economic characteristics and sanitation and hygienic factors was collected by each of the three projects. Each project reported data collected in household interviews and observations on assets, house construction, land ownership, source of water, type of sanitary facilities, cleanliness, education of lead adults, occupation and employment. Additionally, each project devised a household socioeconomic (SES) index, according to what was deemed to be culturally-appropriate to each particular site. While these SES indexes are useful for across-project analyses, it is important to recognize that they reflect different facets of household assets and wealth. Because no data were collected on current income or expenditures, the SES index provides an indicator of the relative position of the household in the community but may or may not accurately portray the household's current economic circumstances.

Out of the large data set collected by each project, we selected a subset of variables for across-project analysis according to the following criteria:

1. Relevancy to intake-function relationships
2. Availability of data for all three projects
3. Comparability of meaning across three projects

By examining the full set of SES variables collected by each project and looking at univariate distributions of key variables and bivariate relationships among them, we determined which variables would fulfill these criteria. Table 1 shows the sources of variables which were chosen for across-project investigations. For purposes of across-project analyses, further categorization of variables was sometimes necessary. Definitions of the chosen SES and sanitation variables are as follows:

House Quality

Information on house construction was reclassified to provide a measure of house quality for each project.

In Egypt, we classified houses according to type of construction and number of rooms (adobe as level 1; clay-based and at least three rooms as level 3; all others as level 2). In Kenya, houses were classified according to construction material, and whether there is a separate kitchen (thatched roof, unsmeared walls, no separate kitchen as level l; iron roof, smeared walls, separate kitchen as level 3; all others as level 2). In Mexico, we classified according to construction materials (earth floor as level l; constructed floor and tile or wooden roof as level 3; all others as level 2).

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TABLE 1: SOURCES OF ANALYTICAL SOCIOECONOMIC AND SANITATION AND HYGIENE VARIABLES USED IN ACROSS-PROJECT ANALYSIS

Variables	Egypt	Kenya	Mexico
House quality computed from materials and number of rooms	Materials used for house construction Number of rooms	Roof, walls, floor materials Type of kitchen	Roof, walls, floor materials Number of rooms
Sanitation	Type of latrine	Latrine in compound? shared?	Type of facility
Water source	In house, public tap, private or public pump, canal	Tap, stream, well, rainwater	Well, faucet, spring
Household size	Number of occupants	Number of occupants	Number of occupants
Occupation of lead male	Regrouped 36 occupational categories	Off-farm employment, size of farm	9 categories of occupation
Schooling/Highest grade attained for lead males and females	Type of schooling completed	Highest class attained	Number of years of schooling
Socio-economic Score* (SES)	Economic, educational, occupational factors combined to make a scale with four categories	Weighted total value of household assets	Material Style of Life (MSL) and quality of house (CASA) were combined into an SES score which was categorized by quartiles.
Sanitation Score*	A project-generated score for each HH visit was based on eight components: care and storage of cooking utensils, type and care of latrine, laundry practices, use of boiled water, mfr. of dung cakes, condition of house, location of animals, presence of pests.	A project-generated score for each HH visit was based on: interview of the lead female on hygienic practices, care of the house and compound, and observations of house construction, presence and use of latrine, and presence of flies.	From the means of the repeated observations of the household, five indexes were constructed on the internal environment, external environment, and observations of the mother, preschool child, and school-age child.

*The 1987 Final Report of each project provides details on the construction of their measures.

Water Source

Information on water source was reclassified according to whether water was available inside the house or compound (if present, Water = 1; if not present, Water = 0).

Latrine

Information on latrine was reclassified according to whether there was a latrine at the house or compound (if present, Latrine = 1; if not present, Latrine = 0).

Schooling

Information on the number of years of schooling of lead males and females was used as collected. However, some difficulty was encountered in achieving comparability across projects because of differences between countries in the organization of schooling and the reporting of grades completed. Because past educational opportunity varies considerably between countries, the number of years of schooling was categorized to create a set of indicators which would reflect relative levels of education within each community, For Egypt, where education of females has remained at relatively low levels, lead female schooling was categorized into three levels (none, 1-5 years, and 6 or more years), while lead male schooling was categorized into four levels (none, 1-5 years, 6-8 years, and 9 or more years). For Kenya, where schooling was reported according to type of education completed, education was grouped into four levels for both lead males and females (none, 1-4 years, 5-8 years and 9 or more years). In Mexico, four categories were created for lead males and females (none, 1-2 years, 3-5 years, and 6 or more years).

SES Index

An overall measure of household socio-economic status was computed for each project based on repeated observations of the household. For Egypt, we used the project's categorical variable, GROUP, (reordered from low to high) which was based on occupation and assets of the household. In Kenya and Mexico, project-generated scales were categorized by quartiles in order to create variables comparable to the Egypt project's score. For Kenya, we took the mean of repeated measures of the continuous variable TOTAL, a weighted scale of all household assets, and computed a categorical scale by quartiles. For Mexico, we used the mean of the repeated measures combining household assets and housing characteristics and created a categorical measure by quartiles.

Sanitation Score

A sanitation score was constructed by each project from the collection of its observational and interview data on the sanitary and hygienic conditions of the household. Scales were constructed from observations of the lead female's proficiency in performing care-giving and sanitary activities. For Egypt and Kenya we used the project-constructed continuous variables, taking the means of the repeated measures. For Mexico, where five indexes were provided by the project, we selected the Internal Environment Score for its comparability with the other projects' scales.

Child Appearance Variables, Mexico Project

Each time a nutritionist or other project personnel visited a study household in Solis, a child appearance rating was recorded (ranging from neat/clean to dirty/unkempt) for both a preschool child and a school age child (not necessarily the target children). High values are associated with greater cleanliness. An average appearance score was calculated as the mean of all ratings by all observers. Since previously reported analyses have found that the Mexico child appearance variable is strongly associated with child size and growth, this variable was included in selected analyses of the Mexico Project data. No comparable variable was examined for the Kenya or Egypt Projects.

ANTHROPOMETRIC MEASUREMENTS

For target subjects the across-project anthropometric measures are height, weight, mid-upper arm circumference, head circumference, and the thickness of biceps and triceps skinfolds; subscapular and suprailiac skinfold thicknesses were measured in some subjects in some locations.

According to the research plan, adult height and head circumference were to be measured at least once, mid-upper arm circumference and skinfold thicknesses every three months, and body weight monthly. Supine length of toddlers and standing heights of schoolers were to be measured at least every three months and all other parameters monthly.

Methods of measurements and selection of equipment were agreed upon collectively by the project investigators, one of whom provided the manual used by all. Project staff field-tested methods and trained observers on site during the year prior to longitudinal data collection. Each project used paired observers as a method of quality control and implemented controlled protocols to examine the reliability of selected measurements. For the present study, automated outlier range checks were performed on all height, weight, and head circumference parameters; mid-upper arm circumference and skinfold parameters were checked visually.

Individual subject characteristics have been represented as median values over all valid measurements; medians are a more robust measure of central tendency in that they are less influenced by the magnitude of outliers. A mean value for the day was precomputed if multiple measurements occurred within a single day for the same subject.

For adult female subjects, all weight, mid-upper arm and skinfold parameters determined to be measured during the second or third trimester of pregnancy or the first or second trimester of lactation were excluded. In the event that this restriction eliminated all observations for any subject, it was relaxed to include the last observation within the second trimester of lactation and, if required, relaxed again to include the second trimester of pregnancy. Due to a potential change in posture, height measurements taken during the third trimester of pregnancy were excluded for female subjects whenever other measurements were available. Head circumferences were computed from all observations, regardless of reproductive status. For the Kenya and Egypt projects pregnancy and lactation periods were determined by identifying all infant births and miscarriages. For the Mexico project, the determination was made by the staff at the University of Connecticut based upon females' physiological status data and records of weaning.

Derived Values

The Body mass index (BMI), also called Quetelet-Score, was calculated by dividing body weight by median height squared (kg/m^2).

Body fat of adults was estimated from skinfold thickness using formulas developed by Durnin and Womersley (6) to predict body density, and Siri's (7) formula to calculate fat from density. Density was calculated from median values for each of the three skinfold thicknesses separately and in all possible combinations, and using both age-specific and general equations for adult males (age 17-72 years) and females (age 16-68 years). No one formula appeared to produce consistently higher or lower values across locations or sex groups, nor was there appreciable difference between values calculated from age-specific or general adult formulas. Subsequent analyses were carried out using percentages of fat derived from a combination of triceps, biceps, and subscapular skinfold measures (where the N for Egypt is low) and from triceps values only, calculated according to the general adult equations.[1] Lean body mass was calculated as the difference between body weight and the weight of fat estimated from these percentages.

Arm muscle area was calculated from mid-upper arm circumference and triceps skinfold thickness according to Frisancho (8).[2] Values were not corrected for bone.

To assess size and growth of children, all valid data in an individual's file were included in regressions of height and weight on age (run for each individual) without controlling for autoregression effects. The weight and stature at 24 months or 8 years were predicted from these regressions. The slopes of the regression lines were used as indices of growth rates.

Z-scores for body weight, height and body mass index were calculated from U.S. norms developed by the National Center for Health Statistics (9) from the 1976-80 NHANES data.

Nontarget Household Members

The height and weight of all household members was to be measured annually, but many of these data are missing. To estimate the size of non-target subjects, two different procedures were followed. In Kenya where missing data are less frequent, the population with complete records was divided into various age and sex groups (0-3 yrs, 3-10, 10-18, 18-30, 30-60, over 60, for males and females) and the mean observed weight of the corresponding age and sex category was assigned to missing observations. In Egypt and Mexico where the extent of missing data is greater, mean weights were calculated for all adults and adolescents combined (over 10 years of age) and for all children. Then, two average household-specific Z-scores were computed from all available data for the household: one for persons less than 10 years old and one for the household members over 10 years of age. The appropriate Z-score, according to age, was assigned to missing data and the corresponding weight was then back-calculated.

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[1]

$$\%\ \text{Fat} = \frac{4.95}{\text{Density}} - 4.50 \times 100$$

Density = C - M x log skinfold, where

	Males	Females
Triceps:	C = 1.1143 M = 0.0618	C = 1.1278 M = 0.0775
Biceps, Triceps and Subscapular:	C = 1.1689 M = 0.0793	C = 1.1543 M = 0.0756

[2] $$\text{Arm Muscle Area} = \frac{[\text{MUAC} - \pi \times \text{triceps skinfold thickness})]^2}{4\pi}$$

FOOD INTAKE MEASUREMENTS

The NCRSP archive is unique in the extent of food intake information included. According to plan, food intake of all target subjects and of their households was to be measured for two consecutive days each month, including a random sample of holidays and all days of the week, for a full year. The intent was to generate reliable, representative food intake figures and from these, energy intake, the independent variable.

Although methods of measuring food intake varied somewhat among projects, quantitative data on food preparation and consumption by individual members for the 48 hour study period generally were obtained by questioning and observing the lead female. Observers were present in the household during the daytime for these two days. Information on foods prepared before or after the period of observation was reported to the observer by the lead female. Ingredients of mixed dishes were weighed at the time of preparation or as recalled. Portions consumed were directly measured (Kenya and Mexico) or were estimated as a proportion of the lead female's intake (Egypt). Intakes of foods not from a household common pot were measured by the observer when present or otherwise reported by the lead female. Lead males and schoolers were interviewed about foods consumed outside the household. If children were breastfed, the event was recorded but the amount of milk consumed was not measured.

A minimum of six days of valid intake data is required to estimate "usual" intake of energy and macronutrients (10). The three projects obtained sufficient data from all or subsets of the study populations to permit analysis but each project experienced problems that have affected the amount and quality of the data. Issues that affect comparability of data across projects are listed below and discussed in detail elsewhere (1,5):

	Egypt	**Kenya**	**Mexico**
Random sample days of observation	Adequate, including Ramadan	Weekends and holidays undersampled	Weekends and holidays undersampled
Interviewer issues	HHs assigned interviewers; Some known bias	None known	All records before January 1985 defaulted
Respondent issues	Low LM compliance; Observation rescheduled if LF ill or away	Low LM compliance; If LF ill or absent, respondent was alternate food preparer	Frequent LM absence; Observation rescheduled if LF ill or away

In Kenya the rains failed in 1984, the first year of the main study and harvests of the main subsistence crops were very poor. Despite relief efforts, food intakes were low from mid-year 1984 to early in 1985, and at expected levels thereafter. Seasonal fluctuations are not atypical for Africa, but the food intake figures for subjects studied mainly in 1984 are lower than those studied in 1985.

Nutrient Intake Variables

Development of an international food composition database (INT Minilist)

Each of the three projects developed a nutrient database corresponding to the food items reported in the study location, and calculated daily intakes of a variety of nutrients for each target subject. At the time of the initial analyses, focus was primarily on intakes of the macronutrients: energy, protein, fat, and carbohydrate, although each country project included additional nutrients on its database. Since preliminary results indicated potential relationships between dietary quality (as well as quantity) and functional outcomes in these countries, interest grew in obtaining information for a much wider variety of nutrients in the various diets. As a result, we developed a single nutrient database, with a large number of nutrients, which could be used in all three locations, with the potential to expand to other countries as the need arose.

The INT Minilist is an abbreviated table of food composition in which foods of like nutrient content are represented by a single entry (e.g. "apples" is used as a good approximation for pear, white cherries, etc.). Thus the number of entries is small (234) but more information on nutrients in the class-representative foods is included than in conventional food tables. The INT Minilist was developed from the UCB Minilist for the United States (11,12), modified to incorporate foods consumed in Egypt, Kenya and Mexico.

Considerable time was spent in determining the best estimate of nutrient content of the most frequently consumed items (e.g. maize in its many forms, chili peppers, leafy vegetables), methods of food preparation and extraction rate of grains. A cross-reference index, giving the INT Minilist entry equivalent for each reported project food was reviewed for acceptability by the three project groups and the index and/or INT Minilist modified as necessary. Nutrient content of a sample of individual diets was calculated for each project and compared with values generated by the projects from their individual data bases. The INT Minilist values were in substantial agreement with project values for the proximate components of the diets. More information on the development of the INT Minilist has been published (13).

The calculated values, for the full array of 48 nutrients contained in the INT Minilist, are judged to be acceptable for further analytical purposes. The nutrient intake figures must, however, be viewed as reasonable approximations. For many foods actually consumed there is no published information on the content of many vitamins and minerals. We regard values for animal-source foods as more reliable than those for plants in general, because composition of plants is more variably affected by soil composition, maturity and storage. The values for proximate constituents (protein, fat and carbohydrate) are probably the most reliable because these are more frequently analyzed. Least reliable are likely to be some of the trace minerals and vitamins. It is our belief that the nutrient values as presently estimated are the best that can be derived without a major investment in laboratory analysis of foods.

Calculation of average nutrient intake values

Using the INT Minilist and the country-specific cross-reference indexes, the nutrient content of foods consumed was calculated for each subject for each day of observation. Mean intakes of each of the 48 nutrients were computed over all days of observation for each subject, after excluding days with any of the following conditions:

(1) The day contained an unresolved food item (due to an invalid food code).

(2) Breastmilk was consumed on that day.

(3) The day's energy intake was unreasonably high. The exclusion limits (kcal/d), which were based approximately on country-specific means plus 3 SD, are as follows:

	Egypt	Kenya	Mexico
Mean Energy Intake (kcals/day)			
Men	5026	4934*	6466
Women	4345	4221	5197
Schoolers	3844	3343	3938
Toddlers	3100	2600†	3100
Total days of intake	11,877	22,557	10,694‡
Total days out of range	88	195	113

* If more than 20% of calories from alcohol, intakes up to 5500 kcal/d were accepted.
† If less than 20% of calories from fat, intakes above 2200 kcal/d were excluded.
‡ Excludes records collected prior to 1/1/85.

Calculation of derived nutrient intake variables

The ratio of mean nutrient intake to body size was calculated for children by dividing by the 24-month (toddlers) or 8-yr (schoolers) predicted weight.

Ratios of the intakes of two nutrients (e.g., vitamin B_6 [mg]/protein [g]) or percents (e.g., percent of energy from fat) were calculated from the mean intakes.

Protein requirement estimates are expressed in terms of protein of reference (egg or milk) quality, hereafter designated "utilizable" protein. Observed intakes were adjusted to take into account amino acid composition and digestibility of the mixed proteins in the diets as consumed. The approach proposed in the 1985 FAO/WHO/UNU report (14) was:

$$\text{Utilizable Protein Intake} = \text{Observed Intake} * \text{Amino Acid Score} * \text{Relative Digestibility}$$

where amino acid score (for amino acid AA1) is computed as follows:

$$\text{Amino Acid Score AA1} = \frac{\text{Estimated Intake AA1 / g dietary protein}}{\text{Reference Pattern AA1}}$$

The procedure was followed independently for lysine, tryptophan, threonine, methionine + cystine, phenylalanine + tyrosine, isoleucine, leucine, and valine. The reference amino acid patterns proposed (14) for toddlers and schoolers were used. The lowest amino acid score was then selected and applied in estimating utilizable protein intake. In effect, amino acid composition of dietary protein was the composite of all available intakes collected over periods up to a year.

The FAO/WHO/UNU report emphasized that digestibility is a feature of the individual protein source and recommended that digestibility of total protein intake be estimated by weighted summation of digestibility of individual sources. As the INT Minilist does not include protein-digestibilities of individual foods, many of which are unknown, a digestibility factor was imputed for the present analyses. An empirical association between dietary fiber (included in the INT Minilist) and protein digestibility was developed using regression models, based on reported data for maize, polished rice, whole wheat, refined wheat, oatmeal, millet, mature peas, peanut butter and soyflour (14) and for dry beans (Phaseolus spp.) as reported by Arzu (15). The prediction equation so derived was:

Digestibility = 1 - (0.1 * Dietary Fiber/Dietary Protein)

While it is known that characteristics other than dietary fiber affect protein digestibility, the above empirical relationship yielded estimates for toddler diets that fell within the reported range of estimated digestibilities of mixed food diets (14).

Available iron and available zinc intakes were calculated for each subject using the following algorithms (for details, see ref 16):

Available iron = Heme iron x 0.25 + (Non-heme iron x Iron availability factor x Tea factor)

Where: Heme iron = 40% of the iron in meat, fish or poultry.

Non-heme iron = all iron except heme iron.

Iron availability factor = 0.05 to 0.15 for non-heme iron depending on the average ascorbic acid and meat-fish-poultry protein density of the diet.[3] Availability = 0.25 for heme iron.

Tea factor = 0.4 to 1.0 depending on the average number of cups of tea in the diet.

Available zinc = Total zinc x Zinc availability factor

Where zinc availability factor = 0.10 - 0.35 depending on the phytate:zinc molar ratio of the diet.[4]

Household Energy Intake Variables

The HH energy intake was evaluated in two ways. A household energy adequacy ratio was computed as the ratio between energy consumed in the household and household energy need. The basal metabolic rate (BMR, kcal) of each household member was calculated according to the

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[3] Non-heme iron availability was set at 0.05 if ascorbic acid was less than 35 mg/1000 kcal and meat-fish-poultry (MFP) protein was less than 9 g/1000 kcal. Availability rose to 0.10 if ascorbic acid was 35 to 105 mg/1000 kcal or MFP protein was 9 to 27 g/1000 kcal. For all other diets, availability was set at 0.15.

[4] Zinc availability was set at 0.10 if phytate:zinc molar ratio was greater than 30. Availability rose to 0.15 if the ratio was between 15 and 30. For diets with ratios under 15, the availability factor for basal requirement was 0.35, and for normative requirement was 0.30.

FAO/WHO/UNU (14) equations[5] based on body weight plus 10% additional for the LF if she was P or L; total HH energy intake (kcal/d) was divided by total HH BMR. A second statistic was total HH energy intake divided by the number of persons in the HH, giving an average energy intake per capita for each HH.

Food Group Intake Variables

Twenty-six food group categories were chosen for the purpose of uniformly categorizing the foods consumed in all three country projects. All food items on the INT Minilist were assigned to one of these groups. Table 2 lists the group names and the types of foods included in each.

To examine the homogeneity of nutrients within each food group, the means and standard deviations of the nutrients per 100 kcal were calculated for the food items within each group (Table 3). The densities of protein, iron, zinc, calcium, vitamin A, vitamin C, and riboflavin were selected for detailed examination, as examples of nutrients of general interest in these populations. In general, the foods within groups are more homogeneous for the nutrients supplied in meaningful amounts than are the foods between groups. For example, the vitamin A density of three of the fruit and vegetable groups is very high (by design), while the vitamin A density of the remaining food groups is relatively low. Of these non-vitamin A groups, the SD is high for the meat/fish/poultry group due to the inclusion of beef liver, but SD's for the remaining groups are relatively small. Likewise, the milk, cheese, and leafy green vegetable groups are good sources of calcium, but the remaining groups are relatively low. Again, the meat/fish/poultry group is less homogeneous due to the inclusion of dried whole fish, which is very high in calcium because the bones are consumed. Vitamin C is found in large amounts only in three of the fruit/vegetable groups, while riboflavin is more generally distributed, but most concentrated in leafy green vegetables and milk. Once again, the meat group has a high SD for riboflavin. Iron and zinc are found in the meat group, although with high SD's, as well as in the fruit/vegetable and staple groups (however these non-heme iron sources would be in a less available form). Protein nutrient densities are fairly uniform within groups, with SD's usually well below the mean. For the NCRSP populations, with relatively low intakes of meat/fish/poultry, the food groups should serve as good proxies for intakes of these seven nutrients. However, for other populations, it might be desirable to subdivide the meat group further.

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[5] Equations for predicting metabolic rate (kcal/d) were taken from ref. 14 as follows (W = body weight in kg):

Age (yrs)	Males	Females
0 - 3	60.9 W - 54	61.0 W - 51
3 - 10	22.7 W + 495	22.5 W + 499
10 - 18	17.5 W + 651	12.2 W + 746
18 - 30	15.3 W + 679	14.7 W + 496
30 - 60	11.6 W + 879	8.7 W + 829
> 60	13.5 W + 487	10.5 W + 596

TABLE 2: FOOD GROUPS FOR THE INTERNATIONAL MINILIST

Staples
Plantain/bananas
Taro/cassava/white sweet potatoes
Maizemeal and maize (including tortillas, sorghum)
Wheat, whole (including bread)
Wheat, white, unenriched (including bread, crackers, pasta)
Rice
Other grains (oats, millet)
Potatoes, white (English)

Fruits/vegetables
Leafy green vegetables (leaves of spinach, sukuma, lettuce, etc.)
High vitamin A, low vitamin C (A greater than 300 RE/100 g; carrots, sweet potato)
High vit. C, low vitamin A (C greater or equal to 18 mg/100 g; oranges, guava, cabbage, green peppers, broccoli, tomatoes, papaya, unripe mango)
High vitamin A and C (ripe mango, cantaloupe, red chili peppers)
Low vitamin A and C (apples, watermelon, eggplant, onion, etc.)

Dairy
Milk
Cheese

Legumes/nuts
Nuts/seeds
Mature beans, peas, etc.

Meat/eggs
Meat/fish/poultry
Eggs

Fats
Vegetable fats (including olives, avocados, coconut)
Milk fat and lard (including cream)
Other animal fat (additional chicken fat and beef tallow used in combination with Int Minilist meats to match fatter country-specific meats)

Sweets
Sugar, candy, soda
Grain desserts (cookies, cake, donuts)

Beverages
Beer, wine, pulque
Coffee, tea

TABLE 3: FOOD GROUPS FOR THE INTERNATIONAL MINILIST, NUTRIENTS/100 kcal, MEAN (M) AND SD

	# foods*	Protein (g)		Iron (mg)		Zinc (mg)		Calcium (mg)		Vit A (RE)		Vit C (mg)		Ribo (mg)	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Staples															
Plantain/bananas	2	0.9	0.3	0.4	0.1	0.2	0.1	4	3	44	49	10	0	0.08	0.05
Cassava/white sweet pot.	2	2.1	0.7	1.7	1.7	0.3	0.0	49	31	0	1	20	8	0.10	0.04
Maizemeal and maize	10	2.4	0.9	0.8	0.4	0.4	0.2	14	29	37	107	2	5	0.07	0.11
Wheat, whole	1	4.0	-	1.2	-	0.9	-	10	-	0	-	0	-	0.06	-
Wheat, white, unenr	5	2.9	0.5	0.8	0.4	0.2	0.1	22	13	0	0	0	0	0.06	0.04
Other grains	2	3.6	0.9	0.8	0.4	0.8	0.0	8	7	2	2	0	0	0.05	0.02
Potatoes, white	3	1.8	0.5	0.3	0.1	0.3	0.1	7	2	0	0	8	5	0.02	0.01
Rice	2	1.8	0.0	0.7	0.7	0.3	0.0	2	0	0	0	0	0	0.02	0.00
Fruits/vegetables															
Leafy green vegetables	5	10.6	4.5	7.9	5.7	1.5	1.3	489	173	2740	607	120	46	0.58	0.36
High vit. A, low vit. C	4	2.8	1.4	1.1	0.4	0.6	0.2	50	19	3710	2739	11	8	0.15	0.04
High vit. C, low vit. A	16	3.3	2.4	1.4	1.0	0.5	0.4	68	60	156	137	160	94	0.14	0.10
High vit. A and C	4	2.7	1.4	1.3	1.1	0.6	0.4	31	13	1906	1924	115	113	0.16	0.11
Low vit. A and C	21	3.5	2.8	1.6	1.2	0.9	0.8	60	62	116	185	24	26	0.13	0.10
Dairy															
Milk	9	8.5	4.2	0.3	0.5	0.7	0.3	205	101	39	32	2	2	0.27	0.12
Cheese	3	8.0	1.7	0.2	0.1	0.9	0.2	210	39	76	6	0	0	0.12	0.02
Legumes/nuts															
Nuts/seeds	6	3.4	0.9	1.1	0.8	0.9	0.5	46	62	1	1	0	0	0.05	0.04
Mature beans, peas	6	7.3	0.8	2.2	0.6	0.9	0.2	43	34	3	4	2	5	0.07	0.03
Meat/eggs															
Meat/fish/poultry	21	11.9	4.4	2.7	6.0	5.6	24.3	66	225	191	915	3	7	0.16	0.34
Eggs	2	7.4	1.0	0.8	0.0	0.6	0.0	38	7	113	7	0	0	0.30	0.05

TABLE 3. CONT'D

	# foods*	Protein (g)		Iron (mg)		Zinc (mg)		Calcium (mg)		Vit A (RE)		Vit C (mg)		Ribo (mg)	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Fats															
Vegetable fat	10	0.4	0.5	0.5	0.9	0.1	0.1	10	24	22	43	1	3	0.01	0.02
Milk fat and lard	6	1.0	0.9	0.1	0.1	0.2	0.2	27	26	83	49	0	0	0.05	0.05
Other animal fat	2	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0.00	0.00
Sweets															
Sugar, candy, soda	12	0.3	0.5	0.7	0.7	0.3	0.6	24	35	3	6	1	3	0.02	0.02
Grain desserts	7	1.5	0.4	0.4	0.2	0.1	0.1	17	10	9	7	0	0	0.05	0.02
Beverages															
Beer, wine, pulque	5	0.4	0.3	0.4	0.6	0.1	0.1	11	11	0	0	1	3	0.03	0.03
Coffee, tea	2	2.5	3.5	2.5	3.5	0.0	0.0	175	35	0	0	0	0	0.00	0.00

*Includes only food items reported in one or more NCRSP locations.

MORBIDITY VARIABLES AND DERIVED VALUES

A comparison of the morbidity collection methodologies and tables of morbidity rates across projects have been presented previously (ref 1, pp 157-173).

Household Morbidity

We originally planned to develop a household morbidity index which would be tested in relation to household food intake and as a potential predictor of toddler morbidity. We began the analysis with the most complete file, from Kenya, but found that up to December 1984, all illness experienced by the non-target members was recorded under the ID#99 instead of being specifically assigned to the particular non-target ID#. This lack of specificity led to two overlapping biases. First, less per capita illness was recorded in larger households because the non-target siblings, which represented nearly half of the total population, reported a disproportionately low total number of illness episodes. The data are as follows:

Target type	% of total population	% of total diagnoses reported by the target type	
	(1984 - 1985 combined)	1984	1985
Lead males	11.5	15.9	12.9
Lead females	11.5	31.6	25.5
Male schoolers	4.5	5.8	3.6
Female schoolers	3.5	3.6	3.1
Male toddlers	2.5	7.7	5.9
Female toddlers	3.0	9.6	9.1
Male infants	3.5	3.4	9.5
Female infants	3.0	1.7	1.7
Non-target siblings			
males	24.0	1.0	10.8
females	25.5	1.0	11.0
Other relatives	7.5	0.7	0.7
Others (ID#99)	N/A	18.5	0.3

As the household size decreases, the percentage of target individuals increases, which leads to further negative correlations between household size and morbidity episodes. This problem may be illustrated by examining the percentage of individuals with at least one illness episode in relation to household size in Kenya as follows:

HH size	number of HH	% of total Population	% of total number of individuals with at least 1 illness record
< 8	101	34.6	42.2
8 - 10	60	30.4	30.0
> 10	53	35.0	27.9

Furthermore, even though the non-target siblings ranged in age from 6 months to 20 years, assignment of all illness episodes coded 99 could be done only globally as it was impossible to assign a particular illness to a particular ID. Because illness experience varies with age, we were unable to develop a reliable indicator of household morbidity.

For these reasons, we were forced to discard HH morbidity as an analytic variable for the Kenya data, and thus for any across-project comparisons.

Toddler Morbidity

For each project, analytical variables were derived to describe the extent of morbidity due to diarrhea and lower respiratory infections (LRI), and overall "severe" morbidity regardless of diagnosis. This last variable was based on severe illness and/or illness accompanied by decreased activity depending on the project-specific mode of recording. In Kenya, both severity and decrease in activity accompanying illness were independently recorded. In Mexico, only decrease in activity level is available. In Egypt, this variable is based on the diagnostic severity criteria, as a change in activity level was rarely recorded (out of 45,563 person days observed, 2,940 days were recorded with severe illness and only 79 with decreased activity).

The information we have used to characterize diarrhea is diagnostic code #702 for Egypt and Kenya and the symptom-based classification provided by the Mexico project which includes: nausea (#07), diarrhea (#17), vomiting (#20), dysentery (#62), tenesmus (#64), dehydration (#68) and hyperperistalsis (#90).

For lower respiratory illness (LRI), the codes for bronchitis and pneumonia were used in Egypt and Kenya (codes 505 and 507 in Egypt, and 504, 506 in Kenya). In Mexico, the project definition was also used and includes: cough (13), chest pain (47), bronchitis (57), ronchi (71), abnormal lung sounds (79), lung stertoris (80).

To calculate the denominator of the rates, the variable "observation period" was used in Kenya. This variable includes adjustment for missing days of observation. In Egypt, all days recorded in either the morbidity recall or illness episode files were included in the construction of the denominator. Exclusion criteria were applied to illness prior to age 16.5 months or after age 31.5 months, and toddlers with entering age greater than 19.5 months or exiting before 28.5 months were excluded from the analysis.

In Mexico, a crude adjustment was made to convert the data collected under the Mexico protocol (illness recorded only if present on the day of interview) to increase comparability with the CRSP protocol (all illness recorded). The adjustment factors were derived from the morbidity records of the 69 project-identified longitudinal toddlers with both Mexico and CRSP protocol records starting in September 1985. Morbidity collected under the Mexico protocol was multiplied by the following factors (ratios of Mexico Method/CRSP protocol):

Diarrhea:	incidence:	1.41
Diarrhea:	prevalence:	1.20
Diarrhea with accompanying decreased activity:	prevalence:	1.20
LRI:	incidence:	1.14
LRI:	prevalence:	1.16
All illness with accompanying decreased activity:	prevalence:	1.23

Note that, during the period with both methods of recording in effect, the weekly recall shows a 20% increase in diarrhea prevalence compared to the Mexico method. This increase in reporting was 86% for diarrhea marked by decreased activity but the same factor of 1.20 is used for both. Using a separate adjustment factor of 1.86 for diarrhea marked by decreased activity would have led, in some cases, to a number of days ill with decreased activity greater than the total number of days ill. In Mexico, exclusion criteria were applied to the month-based morbidity file: data prior to age 16 months or after age 32 months and children entering the study after age 20 months or exiting before age 28 months were excluded from the analyses.

All morbidity variables are expressed in person-years and include either the number of episodes (incidence) or the number of days ill (prevalence) for the numerator.

ALCOHOL CONSUMPTION VARIABLES

Alcohol consumption was measured in two separate ways in both Kenya and Mexico; alcohol use was not recorded in Egypt and is assumed not to have occurred. For Kenya and Mexico, in addition to the daily food intake measurements, a survey of alcohol use was administered (quarterly in Mexico, once in Kenya) where subjects were questioned regarding their use of specific alcoholic beverages. Responses to this survey can serve as a validation for the alcohol consumption as measured in the daily food intake survey.

In Mexico, subjects were asked to record their frequency of use and their frequency of intoxication of pulque, beer, brandy, tequila, liqueurs, and other alcoholic beverages. Response categories were recoded to reflect a monthly frequency: "Not ingested" recoded to 0, "Daily" recoded 30, "3 to 5 times a week" recoded to 15, "Twice a week" recoded to 10, "Once per week" recoded to 5, "Twice per month" recoded to 2, "Once per month" recoded to 1, and "Sporadic ingestion" recoded to 3. Results in this report regarding the alcohol use survey are based on individual means of this recoded variable.

In Kenya, subjects recorded their consumption of beer in the following categories: local beer consumed during the week (cups), local beer consumed during the weekend (cups), and commercial beer consumed during the entire month (bottles). A single measurement was created to reflect monthly beer consumption. This variable was further recoded as follows: no beer consumed, coded as 0; 1 to 30 cups per month, recoded as 1; 31 to 100 cups, recoded as 2; and more than 100 cups, recoded as 3. Cups and bottles are assumed to be approximately the same size. It is also assumed that beer accounts for almost all of the alcoholic beverages consumed. Results in this report regarding the alcohol use survey are based on this recoded variable.

CLINICAL AND LABORATORY VARIABLES FOR TODDLERS

Project protocols included physical examination of toddlers for signs of nutritional deficiency, hematologic studies and examination of stools for ova and parasites. Not all of these data sets are complete.

In the toddler samples, the frequency of stool parasites was computed from the archived files. The presence of clinical signs of vitamin deficiencies (eye and skin alterations), although not uniformly reported across projects, was assessed from the archived data.

Blood samples were collected for most of the targeted toddlers and analyzed for several hematologic parameters, including hemoglobin and ferritin levels. For toddlers with multiple measures, only the first was used in analyses reported here.

For the Egypt site, prevalence of anemia was calculated as the percent of toddlers with hemoglobin levels below 110 g/L (17). Since the elevation of the Solis Valley in Mexico is approximately 2300 meters and that of Embu District, Kenya, ranges from approximately 1000 to 1500 meters, an altitude adjustment for hemoglobin values of 4% per 1000 ml was used (18). The adjusted cut-points used for anemia were 120 g/L and 115 g/L for Mexico and Kenya, respectively. The prevalence of low iron stores was calculated as the percent of toddlers with serum ferritin values below 10 μg/L (17). Since infections can elevate serum ferritin (19), a ferritin value greater than 50 μg/L was excluded from these analyses. Low measures of both hemoglobin and ferritin were assumed to be indicative of anemia due to iron deficiency.

ANALYTICAL APPROACHES

SELECTION OF THE ANALYTIC SAMPLES

Toddlers and Schoolers

Only children meeting minimum criteria for food intake and anthropometry measures were included in analyses. For toddlers, the criteria were: at least three length and weight measures between 17 and 31 months of age spanning at least 6 months, with at least one before 23.5 months of age and one after 24.5 months of age; and at least 6 one-day food intake records between 17 and 31 months of age, with at least one prior to 23.5 months and one after 24.5 months. The criteria for schoolers were: at least two height and weight measures between 78 and 114 months of age, with the measurements separated by at least 5 months; and at least 6 food intake records between 78 and 114 months of age spanning at least 5 months.

Spousal Pairs

Only spousal couples whose members were both determined to have at least one valid height and weight measurement have been included in the analytic sample. Measures for the females taken during the second and third trimester of pregnancy and the first and second trimester of lactation were initially excluded from this sample. Subjects who were eliminated entirely due to this restriction were allowed back into the sample if they were determined to have at least one valid second trimester lactation measurement or, if they were still eliminated, if they showed a single valid second trimester pregnancy measurement.

PROBABILITY ASSESSMENT OF APPARENT ADEQUACY OF OBSERVED NUTRIENT INTAKE

Computations for Toddlers and Schoolers

As described by an NRC committee (20), a probability assessment was made for the adequacy of each individual's mean intake and then these were averaged to yield an estimate of the group prevalence of inadequacy. The probability assessment makes no assumption about the nature of the distribution of intakes, but does require that there be a quantitative description of the distribution of requirements.

The probability approach also requires the assumption that intakes and requirements are independent or nearly so. There is no reason, *a priori*, to believe that intakes and requirements of nutrients are correlated. Conversely, because there is a literature to suggest that energy intake may be regulated, in part at least, to match energy expenditure (14), correlation between energy intake and requirement is implicitly assumed and the probability approach is not applied to assessment of energy intakes.

No attempt was made to adjust the observed distribution of intakes for residual effects of day-to-day variation in intake. It was judged that the impact of such residual variance would be minor since intake estimates represented the pooling, on average, of more than 20 single days for each individual in Kenya and Mexico and 15 days in Egypt. Limitations attached to the assessment of intakes of individuals are greatly diminished when the approach is applied to assessment of distributions of intake in population groups (20,21). By the design of data collection and pooling, "usual" reflects the average intake over a period of 8-12 months.

Nutrient requirements figures used in this analysis are shown in Table 4. These estimates of mean requirement and variance generally were developed by international agencies (14,22-26). If the standard deviation of nutrient requirement was not stated, a CV of 15% was assumed. Canadian (27) and U.S. (28) recommendations were used for vitamins B_6 and E and magnesium, nutrients for which there are no international standards. Alternative approaches to estimating toddler requirements for some nutrients also were explored.

Alternative Protein Computations for Toddlers

The 1985 FAO/WHO/UNU report (14) recognizes two major components of protein requirement: the requirement for maintenance of existing tissue mass (presumably a function of existing body size) and the requirement for deposition of new tissues (presumably a function of growth rate). In its factorial model of requirements the FAO/WHO/UNU committee increased the estimated growth requirement by 50%. This was seen as adding a margin to allow for catch up growth. The published total requirement estimate at 24 months of age, 0.925 ± 0.111 g/kg/d, thus theoretically provides for growth rates that, on average, greatly exceed the observed growth rates in healthy population groups; thus the requirement overestimates the actual distribution of protein needs for healthy children (29).

The FAO/WHO/UNU requirement estimate was recomputed without inclusion of the 50% increment in growth requirement. This derivation accepted all other assumptions/component estimates included in the FAO/WHO/UNU factorial model.

Another alternative used age based on the child's height instead of chronological age in the selection of a requirement estimate from the FAO/WHO/UNU report. Since toddlers in all three locations were short for their age, this should yield a requirement/kg that is adequate to sustain the growth rate of a younger child growing at a greater rate and hence set on a path that would be expected to have achieved larger body size at the present chronological age. The protein requirement for this age was estimated as 0.97 ± 0.123 g/kg/d. Again this estimate includes the 50% inflation of the growth component of protein requirement.

To explore the potential benefit of adding sources of amino acids that would increase intakes of the limiting amino acid, specified amounts of lysine and/or tryptophan were added to estimated intakes before computation of amino acid scores and utilizable protein. Similarly, to explore the possible impact of differing bioavailability of lysine, specified availability factors (90%, 80%, 70%) were applied to estimated lysine intakes. The apparent adequacy of protein intake was then assessed using these adjusted data.

Alternative Vitamin Computations for Toddlers

Requirements for thiamin, riboflavin and niacin are related to energy. The 1967 FAO/WHO (25) recommendations for these nutrients, relative to energy intake, are uniform for all ages and both sexes. Both U.S. (28) and Canadian (27) nutrient recommendations specify a "floor", i.e. a minimum daily intake of thiamin, riboflavin and niacin, for adults who consume less than 8.4 MJ (2000 kcal)/d; no floor is stipulated for children. The figure 8.4 MJ is about 70% of the adult male energy requirement (14). For toddlers in this series, a figure of 3.3 MJ (800 kcal) is about 70% of the FAO/WHO/UNU (14) energy requirement and was used to create a floor requirement for those B vitamins. For children with energy intakes below 3.3 MJ/d the floor was set as if intake were 3.3 MJ, yielding values of 0.26 mg/d for thiamin, 0.35 mg/d for riboflavin, and 4.4 mg NE/d for niacin. For toddlers with energy intakes above 3.3 MJ the daily requirement was calculated as a ratio to actual energy intake, as specified in Table 4. The floor requirement is assumed to have the same variability as the FAO/WHO assigned to the energy-driven requirement (CV = 10%).

TABLE 4: ESTIMATED NUTRIENT REQUIREMENTS OF TODDLERS AND SCHOOLERS

Nutrient	Level	Unit	Toddler*	Schooler*	Ref
Protein		g/kg/d	0.925 ± 0.111	0.81 ± 0.097	A
Iron	Basal†	mg/d	0.525 ± 0.079	0.88 ± 0.132	B
Zinc	Normative	µg/kg/d	68.9 ± 8.61	44.8 ± 5.60	C
	Basal	µg/kg/d	49.2 ± 6.15	32.0 ± 4.00	C
Copper	Normative	mg/d	0.23 ± 0.0345	0.33 ± 0.050	C‡
	Basal	mg/d	0.2 ± 0.030	0.3 ± 0.045	C‡
Calcium		mg/d	346 ± 52	346 ± 52	D‡
Phosphorus		mg/d	346 ± 52	346 ± 52	D,E‡§
Magnesium		mg/kg	4.8 ± 0.6	4.8 ± 0.6	E‖
Thiamin		mg/1000 kcal	0.33 ± 0.033	0.33 ± 0.033	F
Riboflavin		mg/1000 kcal	0.44 ± 0.044	0.44 ± 0.044	F
Niacin		mg NE/1000 kcal	5.5 ± 0.55	5.5 ± 0.55	F
Folate		µg/kg/d	2.5 ± 0.38	2.5 ± 0.38	B
Vitamin B_{12}		µg/kg/d	0.03 ± 0.0045	0.03 ± 0.0045	B
Vitamin B_6		µg/g protein	11.5 ± 1.7	11.5 ± 1.7	G
Vitamin C		mg/d	15 ± 2.3	15 ± 2.3	H‡
Vitamin A	Normative	µg RE/kg/d	18.6 ± 3.7	11.4 ± 2.3	B
	Basal	µg RE/kg/d	9.3 ± 1.9	7.1 ± 1.4	B
Vitamin D		µg/d	7.7 ± 1.2	7.7 ± 1.2	H‡¶
Vitamin E		mgαTE/d	4.6 ± 0.7	5.4 ± 0.8	E‡

*Mean ± SD

†Requirement to prevent anemia is the same, but a 50% higher efficiency of absorption is assumed.

‡CV of 15% assumed.

§Phosphorus requirement assumed equal to calcium.

‖CV of 12.5% assumed, based on text in ref. 23.

¶Schooler requirement assumed equal to toddler requirement.

References

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Based on survey data from China and re-examination of the literature, Campbell *et al.* (30) have suggested that the riboflavin requirement is substantially less than the present recommended allowance but they do not offer an estimate of requirement. We devised two alternative values derived from studies used in setting Canadian, U.S. and international recommended intakes. Studies of adults, dating from the 1940's and 1950's (25) recorded the absence of clinical signs of deficiency with diets supplying 0.31 and 0.35 mg/1000 kcal and clear evidence of deficiency with a daily intake of 0.55 mg or less (~ 0.2 mg/1000 kcal), and deficiency symptoms in 1 of 22 men given 0.75 to 0.85 mg/d (≃ 0.3 mg/1000 kcal). We have used 0.34 ± 0.05 mg/1000 kcal as a mean "basal" requirement. Earlier committees, more contemporaneous with the original investigations, were not persuaded that riboflavin requirement is related to energy requirement and based their recommendation on body weight and/or protein requirement. We have used their recommendation of 0.025 mg/g protein requirement in devising a second alternative. As toddler mean protein requirement is about 1 g/kg, the riboflavin requirement becomes 0.025 mg/kg body weight. For both alternatives, we have assumed the CV to be 15%.

Total niacin equivalents in the diet is the sum of preformed niacin plus niacin derived from tryptophan (using a factor of 1:60). Toddler gain of protein in growth would remove a small amount of tryptophan (not more than 30 mg/d) from the pool available for conversion to niacin. The probability assessment was repeated based on the intake of preformed niacin only.

Values for preformed niacin in the food composition table do not take into account the known lower availability of niacin in mature cereal grains (25,28). Mature maize is the principal staple in Kenya and Mexico but in Mexico maize is lime-treated, which unbinds the niacin. Similarly, differences in protein (and thus amino acid) digestibility are not reflected in food tables. The analysis for Kenya was rerun with niacin content of maize reduced to 30%, the accepted availability figure for mature grains (28), and with dietary tryptophan corrected for protein digestibility.

It has been suggested that the requirement for vitamin E be viewed in relation to the content of polyunsaturated fatty acids (PUFA) in the diet, an acceptable ratio being 0.4 mg α TE/g PUFA (28). An assessment was made with all diets having less than the suggested ratio assigned a risk of 100.

Energy-Related Computations for Toddlers

Estimated energy intakes of Kenyan toddlers were very low in comparison to published estimates of mean energy requirement. It was of interest to pose the hypothetical question "What would be the expected situation of adequacy of protein intake if the same diets were consumed at levels that approximated currently estimated energy needs?" An empirical approach applied by Beaton and Chery (29) was followed. A protein:energy requirement distribution was based on a simulated bivariate distribution of protein and energy requirements at 24 months of age. The specific assumption of independence of protein requirements and energy requirements was accepted. A file was created with 20,000 simulated observations representing random members of a normal distribution with mean = Mean Requirement and standard deviation = SD Requirement. This was done for energy requirements and then, independently, for protein requirements (each observation then including a simulated energy requirement and simulated protein requirement). The protein requirement was then divided by the energy requirement yielding, for that simulated individual, a protein:energy ratio requirement. The simulated individuals were then rank-ordered and the 5th, 15th, 25th, 35th, 45th, 55th, 65th, 75th, 85th and 95th centiles of the protein:energy requirement distribution were estimated. These were taken as marking the likelihood that an observed actual protein:energy ratio falling in a defined interval would be adequate to meet protein needs if the individual's energy intake satiated energy needs (as estimated in the FAO/WHO/UNU report (14)).

The risk of inadequacy was taken as 100 - centile. Thus, 5% of children would be expected to have protein:energy requirements above the 95th centile of this distribution of simulated requirements. If the observed protein:energy ratio were at the 95th centile, the risk or probability of inadequacy would be 5%. For application, a mid-point risk was assigned to each of the intervals defined above. Thus an intake falling between the 75th and 85th centiles was assigned a risk assessment of 20%. This 'risk curve' was then applied to the computed utilizable protein:energy ratios of the observed intakes of the study toddlers. In this assessment, the protein requirement still provides for a growth rate 50% above the median rate of the CDC reference population.

This analysis was replicated for intakes of iron, zinc and vitamin B_{12}.

OTHER STATISTICS

All statistical results, except those otherwise noted, were produced using SAS Versions 5.18 and 6.06. For some analyses, partial correlations were produced using SPSSX Version 3.1. Z-scores for children's anthropometry measurements were computed from NCHS standards using the PCTL9Z Anthropometry Subroutine Program, distributed by the Centers for Disease Control, Atlanta, GA.

Unless otherwise noted, all correlation coefficients are Pearson product-moment correlations. Also, unless otherwise noted, all p-values reported or referred to in relation to tests of significance for regression parameters, mean comparisons, or correlation coefficients are based on two-tailed tests.

Principal component analysis was used to examine relationships among food group intakes of toddlers and schoolers and to produce new composite variables. This technique was useful in reducing the number of variables to be included in multivariate regression analyses. Each child was assigned a score for the first two principal components, and these scores were incorporated into further analyses.

Some of the multivariate analyses used the forward selection technique which allows exploratory analyses using a large number of possible independent variables. Using this procedure, all food group, nutrient, and principal component variables were allowed as potential variables, while the child's sex, child's energy intake, and household measures were forced into the model. A dietary variable was brought into the model only if the F statistic for the variable's contribution had a significance level ≤ 0.05.

FINDINGS: SOCIO-ECONOMIC VARIABLES AND SANITATION SCORES

DESCRIPTIVE STATISTICS

Three types of samples were available for analysis: the full set of households surveyed, the households with toddlers, and the households with schoolers. We compared these samples within and between projects. Table 5 shows the sample sizes, means, and standard deviations, by project and by sample type. Differences between samples within a country may affect results obtained in multivariate models.

Table 5 shows that in all three projects years of education for lead females is higher in households with toddlers than for other types of households; there is no such consistency in lead male education. This reflects the secular trend apparent in all three countries where education of girls has increased markedly in the last decade. Thus younger mothers, those with toddlers, will likely have benefitted from greater educational opportunities than mothers of schoolers. The number of years of education completed is consistently highest in Kenya across all samples for both males and females and consistently lowest for Egypt females.

It is difficult to make inter-country comparisons of socio-economic status (SES) as these scales were created by each project for purposes of internal ranking of households. Data on income and household expenditures were not collected by all three projects and therefore could not be used for analysis. It should be noted, however, that for the three countries of the study, the World Bank classifies Kenya as a "low-income economy" and Egypt and Mexico as "lower-middle income economies." While such classifications use measures of Gross National Product (GNP) aggregated over the whole population and do not take into account rural-urban differences, they do provide rough indications of comparative wealth and poverty in the countries studied.

Household size is consistently lower in households with toddlers than in households with schoolers for all three projects.

House quality and percentage of households with water are higher for schooler households than for those with toddlers. Other comparisons show that household latrines are most available in Egypt and least available in Mexico, while water in the household is most available in Mexico and least available in Egypt. These differences may explain variations in patterns of disease between locales.

Sanitation scores used in across-project analyses are seen to be higher for schooler households than for toddler households in Egypt and Kenya. Child appearance scores, which were utilized only for the Mexico project analytical sample of toddlers and schoolers, ranged from 109 to 267 (mean 187 ± 41).

INTERCORRELATIONS

Tables 6 and 7 show the intercorrelations of socio-economic and sanitation variables used in across-project analysis. These intercorrelations show that for Egypt, education of lead males and females is highly correlated with socio-economic level, reflecting the fact that Egypt's SES scale has occupational and educational components not included in the scales created by the Kenya and Mexico projects. Consistently strong and significant correlations can be noted between lead male and lead female education for all three projects. Age of the lead female is negatively correlated with

TABLE 5: COMPARISONS OF SAMPLES BY TARGET INDIVIDUALS FOR SOCIOECONOMIC AND SANITATION VARIABLES

Variables	All Households			Toddler households*			Schooler households*		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
EGYPT									
SES (1 to 4)†	311	2.15	0.97	94	2.17	1.00	61	2.34	1.06
Sanitation	280	3.43	0.43	94	3.43	0.38	61	3.51	0.36
Latrine, %HH	311	90		94	96		61	95	
Water, %HH	311	21		94	19		61	29	
HH size	312	7.01	2.74	94	7.62	2.78	61	7.79	2.57
LM educ, yrs	310	4.54	4.73	94	4.38	4.80	61	5.07	4.84
LF educ, yrs	311	1.16	2.69	94	1.53	2.88	61	1.44	2.71
House quality	310	2.06	0.41	94	2.05	0.82	61	2.23	0.84
LF age‡	269	29.07	6.45	91	30.34	5.91	60	32.08	4.76
KENYA									
SES (1 to 4)†	284	2.50	1.12	100	2.31	1.12	138	2.67	1.12
Sanitation	277	36	10	100	35	8	138	37	10
Latrine, %HH	277	68		100	62		138	73	
Water, %HH	277	49		100	41		138	49	
HH size	292	7.29	2.49	100	6.90	2.22	138	8.04	2.24
LM educ, yrs	291	7.04	3.50	99	6.88	3.16	138	6.96	3.78
LF educ, yrs	291	5.75	3.62	99	6.18	3.13	138	5.33	3.75
House quality	277	2.49	0.66	100	2.42	0.67	138	2.57	0.61
LF age‡	283	32.67	5.97	100	31.29	6.21	138	34.47	5.05
MEXICO									
SES (1 to 4)†	330	2.47	1.11	59	2.76	1.04	84	2.45	1.09
Sanitation	235	923	148	59	922	130	84	889	140
Latrine, %HH	235	12		59	14		84	13	
Water, %HH	234	79		59	73		84	77	
HH size	329	7.18	2.62	58	7.17	2.38	83	7.98	2.16
LM educ, yrs	198	2.98	3.11	43	3.19	2.10	71	2.72	2.57
LF educ, yrs	244	2.22	2.08	49	2.53	1.84	80	2.15	1.81
House quality	330	2.09	0.88	59	2.19	0.86	84	2.20	0.88
LF age‡	222	31.95	7.33	59	30.92	6.13	84	35.29	5.55

*In Egypt, 33 households have both toddlers and schoolers; in Kenya, 39; and in Mexico, 16.

†The Egypt project constructed a 4-category scale based on economic, educational, and occupational elements.

The Kenya project's total assets score was converted to a 4-quartile scale.

The Mexico project scale based on household assets and house quality was converted to a 4-quartile scale.

‡LF Age is included only for mothers with at least one day of food intake.

TABLE 6: CORRELATION MATRIX: SOCIO-ECONOMIC VARIABLES FOR TODDLER SAMPLE†

	SES	Sanitation	Latrine	Water	HH size	LM educ	LF educ	House qual
EGYPT (N=94)								
Sanitation	0.29**							
Latrine	0.19							
Water	0.19	0.23*						
HH size		-0.16						
LM educ (0-3)	0.77**	0.29**		0.18				
LF educ (0-2)	0.49**	0.27**		0.16		0.39**		
House quality	0.30**	0.33**		0.27**		0.29**		
LF age						-0.16		
KENYA (N=100)								
Sanitation	0.42**							
Latrine	0.31**	0.20*						
Water								
HH size	0.31**		0.32**					
LM educ (0-3)	0.19*	0.20*	-0.15		-0.18			
LF educ (0-3)		0.16			-0.31**	0.38**		
House quality	0.59**	0.31**		0.21*		0.18	0.18	
LF age	0.32**		0.36**		0.80**	-0.29**	-0.39**	
MEXICO (N=59)								
Sanitation	0.16							
Latrine	0.43**	0.24						
Water	0.19	0.19	0.24					
HH size				0.16				
LM educ (0-3)			0.28		-0.15			
LF educ (0-3)		0.22	0.29*	0.19	-0.17	0.37*		
House quality	0.53**	0.16	0.15		0.17	0.27		
LF age	0.26*			0.29*	0.55**	-0.15	-0.15	
Child appear.	0.15	0.78**	0.26		-0.33*	0.15	0.27	

† Correlation coefficients are shown if $|r| \geq 0.15$; significance levels $p \leq 0.05$*, $p \leq 0.01$**

TABLE 7: CORRELATION MATRIX: SOCIO-ECONOMIC VARIABLES FOR SCHOOLER SAMPLE†

	SES	Sanitation	Latrine	Water	HH size	LM educ	LF educ	House qual
EGYPT (N=61)								
Sanitation	0.38**							
Latrine	0.29*	0.29*						
Water	0.19	0.19						
HH size		-0.25						
LM educ (0-3)	0.81**	0.31*	0.27*					
LF educ (0-2)	0.42**	0.30*		0.19		0.30*		
House quality	0.34**	0.36**	0.24			0.35**	0.20	
LF age	-0.16		-0.24			-0.17		
KENYA (N=138)								
Sanitation	0.51**							
Latrine	0.32**							
Water	0.21**	0.34**						
HH size	0.34**							
LM educ (0-3)	0.37**	0.47**		0.24**				
LF educ (0-3)	0.23**	0.33**			-0.29**	0.46**		
House quality	0.44**	0.23**	0.17*	0.23**		0.20*		
LF age	0.23**				0.69**	-0.24**	-0.39	
MEXICO (N=84)								
Sanitation	0.34**							
Latrine	0.46**	0.38**						
Water	0.28**							
HH size								
LM educ (0-3)	0.30**		0.24*	0.21	-0.16			
LF educ (0-3)	0.18		0.18	0.27*		0.27*		
House quality	0.41**			0.22*	-0.15			
LF age			0.19		0.36**	-0.20	-0.31**	
Child appear.	0.42**	0.76**	0.34**				0.19	0.27*

† Correlation coefficients are shown if |r| ≥ 0.15; significance levels $p \leq 0.05$*, $p \leq 0.01$**

the lead female's educational level in Kenya and Mexico and with the lead male's educational level for all data sets.

Here we also see that the sanitation score is positively correlated with water for the samples of Egypt toddlers and schoolers, Kenya schoolers, and Mexico toddlers. Sanitation is positively and significantly correlated with latrine for the samples of Egypt schoolers, Kenya toddlers and Mexico toddlers and schoolers. We need to keep these correlations in mind as we examine the results of multivariate analysis where we utilize the sanitation score as an explanatory variable but do not enter the latrine and water variables explicitly.

We should also note that in Kenya, household size unexpectedly correlates positively with socioeconomic status; larger family groupings apparently contribute positively to family asset holdings, a result that should be further investigated.

Child appearance scores in Mexico, as expected, strongly correlate (r = 0.76 - 0.78) with the sanitation score (reflecting interior appearance of the house). In toddlers, appearance is negatively related to household size, and in schoolers, to the SES score, presence of an indoor latrine and house quality.

FINDINGS: HOUSEHOLD CONSUMPTION

FOOD INTAKE

Household intake records are available from almost all households in the Egypt (n = 235) and Kenya (n = 286) sample populations but for only one of the six communities in Mexico (n = 43) at the present time. Total energy from foods consumed within the household (HH) was calculated using the projects' specific nutrient databases. Foods obtained by HH members away from home is excluded.

For calculation of the HH basal metabolic rate (BMR), HH members were divided into appropriate sex and age categories. Missing body weights were estimated (see page 11 for the method used) for 38% of the HH members in Egypt, 26% in Kenya and 30% in Mexico (Tables 8-10). Missing data were not uniformly distributed across ages and sexes; the percentage of estimated values tends to be highest for adolescents and young adults, the groups most likely to be away from the house during working hours. BMR of other HH members was computed based on median observed weight.

Total HH energy intake was divided by total HH BMR, to yield an adequacy ratio (Table 11). FAO/WHO/UNU (14) estimates of the energy needs of adults in terms of multiples of BMR are as follows:

MULTIPLE OF BMR USED TO ESTIMATE ENERGY NEEDS

	Activity levels		
Sex of Adult	Light	Moderate	Heavy
Men	1.55	1.78	2.10
Women	1.56	1.64	1.82

Standards for young children have not been presented in these terms but for older children (10-18 yrs) the FAO/WHO/UNU average requirements range from 1.52 x BMR (oldest girls) to 1.76 x BMR (youngest boys). Thus, a moderately active HH would be expected to need about 1.7 x BMR. HH intake in one community in Mexico is 1.71 x BMR but in Egypt and Kenya, values are lower, 1.57 and 1.49 x BMR, respectively. The value for Mexico is consistent with energy needs for agricultural work and household labor in the absence of labor-saving appliances and that for Egypt also is consistent with the easier conditions in Kalama. The value for Kenya is low and suggests that energy availability may have limited HH activity.

Another way to look at HH intake is as energy available per capita. The HHs are about the same size in the three samples and close to the same mean age in Egypt and Mexico, but a little younger in Kenya. Energy intake per capita was about the same in Egypt and Mexico, 1838 and 1874 kcal/cap, respectively, but lower in Kenya, 1606 kcal/cap. The equivalence of per capita intakes in Egypt and Mexico, but difference in BMR-based adequacy ratio, is due to heavier body weights of the Egypt sample, as calculated BMR is weight-related (see "Variable Definitions").

We have reported previously (5) that the percentage of energy derived from fat (FCAL%) in the lead female's diet is a useful proxy for household diet quality. Further analysis of the diets of the LFs who were toddlers' mothers has shown that the FCAL% does not vary with reproductive status, even though total energy intakes are not the same. The LF FCAL% for the total sample is about 11% in Kenya and much higher in Mexico (20%) and Egypt (22%) (Table 11).

TABLE 8: MEAN WEIGHTS, AGES AND BASAL METABOLIC RATES (BMR), BY SEX AND AGE CATEGORIES USED IN THE CALCULATION OF HOUSEHOLD ENERGY REQUIREMENTS: EGYPT

		Recorded			Recorded and Estimated*				
Age grp (yrs)	Sex	Mean wt (SD) (kg)	Mean age (SD) (yrs)	n	Mean wt (SD) (kg)	Mean age (SD) (yrs)	n	% estimated	Average BMR (SD)† (kcal/pers/day)
0 - 3	M	8.9 (3.1)	1.4 (0.9)	144	9.1 (3.2)	1.4 (0.9)	169	14.8	498 (197)
	F	8.9 (3.3)	1.5 (0.9)	129	9.2 (3.4)	1.5 (0.9)	150	14.0	508 (206)
3 - 10	M	20.0 (4.7)	6.3 (2.1)	129	20.2 (6.0)	6.5 (1.9)	251	48.6	954 (135)
	F	20.4 (6.6)	6.6 (2.1)	146	19.6 (7.0)	6.5 (1.8)	280	47.9	941 (157)
10 - 18	M	42.7 (12.6)	13.7 (2.5)	39	47.4 (15.1)	13.7 (2.5)	88	55.7	1480 (264)
	F	41.1 (14.3)	13.0 (2.5)	67	42.8 (13.7)	13.1 (2.4)	88	23.9	1268 (167)
18 - 30	M	68.9 (10.5)	24.7 (3.6)	43	70.7 (8.3)	22.1 (4.0)	171	74.9	1760 (127)
	F	60.9 (10.4)	24.2 (3.5)	137	59.6 (20.2)	22.9 (3.6)	200	31.5	1371 (149)
30 - 60	M	69.2 (11.5)	38.4 (6.2)	138	72.0 (11.9)	38.6 (6.7)	192	28.1	1714 (138)
	F	66.9 (11.2)	38.2 (8.0)	136	66.0 (10.8)	42.0 (10.6)	169	19.5	1403 (94)
> 60	M	69.7 (15.3)	66.2 (5.9)	16	72.0 (9.8)	65.7 (6.2)	57	71.9	1459 (132)
	F	62.6 (13.8)	67.5 (6.7)	22	62.3 (12.3)	67.7 (6.8)	34	35.3	1251 (129)
Total number of individuals				1146			1849	38.0	
Total number of households				235			235		

*Recorded values are for records with complete weight, age and sex. Imputed values are based on the household average Z-score for weight in the 0 - 10 and over 10 years old age categories.

†FAO/WHO/UNU. Energy and protein requirements, 1985 [14].

TABLE 9: MEAN WEIGHTS, AGES AND BASAL METABOLIC RATES (BMR), BY SEX AND AGE CATEGORIES USED IN THE CALCULATION OF HOUSEHOLD ENERGY REQUIREMENTS: KENYA

		Recorded			Recorded and Estimated*				
Age grp (yrs)	Sex	Mean wt (SD) (kg)	Mean age (SD) (yrs)	n	Mean wt (SD) (kg)	Mean age (SD) (yrs)	n	% estimated	Average BMR (SD)† (kcal/pers/day)
0 - 3	M	8.4 (3.0)	1.3 (1.0)	151	8.5 (3.0)	1.3 (1.0)	170	11.2	461 (184)
	F	8.2 (2.8)	1.3 (1.0)	143	8.2 (2.8)	1.3 (1.0)	158	9.5	450 (171)
3 - 10	M	17.9 (3.8)	6.5 (1.8)	309	18.0 (3.1)	7.7 (2.1)	506	38.9	903 (70)
	F	17.3 (4.1)	6.2 (1.8)	283	17.4 (4.1)	6.3 (1.8)	286	1.0	890 (91)
10 - 18	M	33.1 (8.7)	13.4 (2.2)	136	33.1 (8.6)	13.4 (2.2)	138	1.4	1230 (151)
	F	33.7 (9.3)	13.3 (2.3)	157	33.4 (6.6)	11.6 (2.1)	383	59.0	1153 (81)
18 - 30	M	55.0 (6.9)	24.4 (4.0)	73	55.0 (4.9)	22.9 (3.2)	146	50.0	1521 (75)
	F	52.4 (7.2)	24.6 (3.3)	128	51.5 (7.8)	24.3 (3.1)	221	42.1	1253 (115)
30 - 60	M	55.1 (6.9)	38.7 (6.0)	232	55.1 (6.7)	38.6 (6.0)	242	4.1	1518 (78)
	F	51.5 (8.6)	35.5 (4.1)	184	51.6 (8.6)	35.5 (4.1)	185	0.5	1278 (75)
> 60	M	44.4 (12.7)	69.6 (8.3)	6	45.9 (12.2)	69.6 (7.6)	7	14.3	1107 (165)
	F	46.1 (10.5)	71.2 (7.2)	8	46.1 (10.5)	71.2 (7.2)	8	0	1080 (111)
Total number of individuals				1810			2450	26.1	
Total number of households				286			286		

*Recorded values are for records with complete weight, age and sex. Imputed values are based on the means by age groups and sex categories.

†FAO/WHO/UNU. Energy and protein requirements, 1985 [14].

TABLE 10: MEAN WEIGHTS, AGES AND BASAL METABOLIC RATES (BMR), BY SEX AND AGE CATEGORIES USED IN THE CALCULATION OF HOUSEHOLD ENERGY REQUIREMENTS: MEXICO

		Recorded							Recorded and Estimated*							
Age grp (yrs)	Sex	Mean wt (SD) (kg)		Mean age (SD) (yrs)		n	Mean wt (SD) (kg)		Mean age (SD) (yrs)		n	% estimated	Average BMR (SD)† (kcal/pers/day)	
0 - 3	M	8.7	(2.7)	1.3	(0.9)	156	8.4	(2.8)	1.2	(1.0)	190	17.9	457	(171)
	F	8.7	(2.9)	1.3	(0.9)	158	8.2	(3.0)	1.2	(1.0)	197	19.8	448	(180)
3 - 10	M	20.2	(4.1)	6.9	(1.6)	254	19.8	(4.1)	6.7	(1.6)	315	19.4	946	(94)
	F	19.1	(4.1)	6.8	(1.6)	238	18.6	(4.2)	6.6	(1.7)	300	20.7	917	(95)
10 - 18	M	36.2	(9.5)	13.0	(1.9)	122	42.0	(12.8)	13.6	(2.2)	245	50.2	1386	(224)
	F	38.4	(10.8)	13.3	(2.1)	135	40.9	(10.3)	13.8	(2.2)	256	47.3	1246	(126)
18 - 30	M	63.5	(12.4)	24.7	(3.7)	53	63.3	(9.5)	23.0	(3.6)	150	64.7	1648	(146)
	F	56.1	(7.8)	24.5	(3.7)	119	54.8	(7.9)	23.9	(3.7)	170	30.0	1368	(155)
30 - 60	M	66.0	(9.9)	40.0	(6.9)	177	67.2	(10.0)	40.3	(7.1)	227	22.0	1658	(116)
	F	60.5	(9.6)	37.9	(5.6)	168	60.2	(9.6)	38.4	(6.1)	175	4.0	1476	(102)
> 60	M	51.4	(16.9)	71.2	(6.1)	13	60.4	(13.1)	71.9	(7.6)	35	62.9	1302	(177)
	F	51.6	(16.6)	71.1	(8.5)	9	54.8	(10.0)	71.2	(8.0)	37	75.7	1233	(133)
Total number of individuals						1602					2297	30.3		
Total number of households						278					278			

*Recorded values are for records with complete weight, age and sex. Imputed values are based on the household average Z-score for weight in the 0 - 10 and over 10 years old age categories.

†FAO/WHO/UNU. Energy and protein requirements, 1985 [14].

TABLE 11: MEAN (SD) HOUSEHOLD ENERGY ADEQUACY RATIO, ENERGY INTAKE PER CAPITA, HOUSEHOLD SIZE AND PERCENTAGE OF ENERGY FROM FAT IN LEAD FEMALE DIETS IN EGYPT, KENYA AND MEXICO

	Egypt (n = 235)	Kenya (n = 286)	Mexico (n = 43)*
HH energy adequacy ratio†	1.57 (0.39)	1.49 (0.34)	1.71 (0.48)
HH energy intake per person (kcal/cap/day)	1838 (448)	1606 (391)	1874 (513)
HH size (pers.)‡	7.9 (2.7)	7.7 (2.5)	8.5 (3.2)
Average age of HH members (yrs)	18.4 (5.0)	15.4 (2.7)	17.3 (5.4)
% FAT in LF diet			
Toddler sample§	21.7 (3.5)	10.9 (1.7)	20.3 (4.3)
Schooler sample§	22.2 (3.2)	11.4 (2.5)	19.3 (4.2)

*Households from community #1 except for % fat LF diet, which is for the toddlers and schoolers included in food intake analyses.

†Mean over all days of food records of the total energy intake originated in the HH/sum of household members BMR. Basal Metabolic Rates were calculated from each person sex, age and weight given equations published in: Energy and Protein Requirements; Technical Report Series #724. WHO, Geneva. 1985.

‡HH size was adjusted in Kenya according to quarterly census updates. No such adjustment was done in Egypt and Mexico.

§N as in Table 5.

ALCOHOL CONSUMPTION

Alcohol consumption was reported in food intake records in Kenya and Mexico. In addition, a separate alcohol use survey was administered. This survey was conducted with an assurance of anonymity and the results can be used as an indication of both family and community alcohol use as well as a check on the accuracy and completeness of the alcohol consumption recorded as food intake. In Egypt, no alcohol intake was reported in the food intake records.

In order to detect all adult use of alcohol as reported in the food intake records, all observed intakes were used in the computation of each subject's mean alcoholic beverage consumption in kcals, regardless of the number of valid days of food intake.

Mexico

Both male (n=195) and female (n=177) adults in Mexico were given the alcohol use survey in which subjects were asked to categorize their frequency of use and frequency of intoxication of several alcoholic beverages (pulque, beer, tequila, brandy, liqueur, and others). Each subject's mean response was recoded to reflect an actual monthly frequency (see Methods Section).

As reported in the alcohol use survey, the mean frequency of consumption for all beverages was 27 per month for men and 14 per month for women. Among all of the beverages surveyed, only pulque and beer were consumed at a mean rate greater than once monthly. Males reported a mean pulque consumption rate of 21 times per week and a mean beer consumption rate of approximately twice per month; females reported average consumption rates of 14 and less than once per month for pulque and beer consumption respectively. Males reported intoxication rates of four times and once per month for pulque and beer; women's mean intoxication rate for pulque was nearly once per month and zero for beer.

Based on measurements from the food intake survey, 81 percent of men (n=210) and 74 percent of women (n=224) reported consuming alcoholic beverages. Among those reporting alcohol use, mean daily energy from alcoholic beverages for men was 510 kcal (sd=420, n=170) and for women was 201 kcal (sd=211, n=165).

Among the 195 men responding to the alcohol use survey, 28 did not participate in the food intake survey; 18 of the 177 women were not included in the food intake survey. Responses to the alcohol survey did not differ based upon participation in the food intake study. Men without food intake measurements reported a rate of consumption of pulque of 19 times/month and a rate of intoxication from pulque of 3 times/month, compared to rates of 22 and 4 times/month respectively for those participating in the food intake measurements (both differences not significant, based on 2 tailed t-test with pooled variance). Women who did not participate in the food intake study reported mean rates of pulque consumption of 13 times/month with a pulque intoxication rate of zero; women in the food intake group reported a pulque consumption rate of 14 times/month with a pulque intoxication rate of less than one (also, differences found to be not significant).

Among the adults participating in both surveys (males: n=167, females: n=159), some discrepancies in responses were noted. About 14 percent of males who indicated some use of alcohol on the alcohol use survey, showed no daily intake in the food intake records; about 1 percent showed actual, measured intake, but did not indicate alcohol use in the survey. For females, about 9 percent indicated alcohol use in the survey with no actual daily measured values and 7 percent indicated no alcohol use in the alcohol use survey yet were recorded to have consumed alcohol in the food intake study. Frequency of pulque use is highly correlated to total kcals of alcoholic beverages as measured in the food intake study (for men: r=0.51, n=164; for women: r=0.52, n=134).

Men's frequency of pulque use correlates significantly (p<0.05) and negatively to both their own weight (r=–0.16) and fatness measures (with BMI: r=–0.22; with mid-arm circumference: r=–0.20) as well as their spouses fatness measures (BMI: r=–0.15; mid-arm circumference: r=–0.19). The women's frequency of pulque use shows this same significant relationship to male weight (r=–0.18) and fatness measurements (BMI: r=–015; mid-arm circumference: r=–0.17) (n=145 in all measures), but not with her own anthropometry.

Male pulque consumption, but not female pulque consumption, was found to be negatively correlated to both SES (r=–0.20, n=181) and household sanitation (r=–0.27, n=172).

Both male and female frequency of pulque consumption was significantly and negatively correlated to male and female education (male pulque use x male educ.: r=–0.20, n=144; male pulque use x female educ.: r=–0.29, n=159; female pulque use x male educ.: r=–0.19, n=117; female pulque use x female educ.: r=–0.30, n=132).

Use of alcohol by toddlers and schoolers

Some use of pulque by toddlers was observed with 19 of the 59 toddlers in the toddler nutrient assessment group showing intakes of alcohol. These intakes were small (only six toddlers reported daily mean alcohol intakes greater than 10 kcals) and were not analyzed in relation to patterns or correlations. Thirty of the 84 children in the schooler nutrient assessment group reported some alcohol use; 19 reported daily intakes greater than 10 kcals.

Household consumption patterns

Intra-spousal alcohol consumption correlations were found to be significantly positive (p<0.05). The correlation between male and female frequency of pulque consumption is 0.40 (n=139); with alcoholic beverage consumption as measured in calories from the food intake survey it is 0.53 (n=210). Further, a strong pattern between schoolers' alcohol consumption and that of their parents was observed (fathers' versus schoolers' alcoholic beverage intake in kcals: r=0.31, n=81; mothers' versus schoolers': r=0.64, n=84).

Kenya

Adults in Kenya also responded to a confidential alcohol use survey (males, n=223; females, n=285) in which subjects were asked to quantify their use of both "local" beer and commercial beer. These responses were recoded into a four part variable representing "no alcohol use", "little use", "moderate use", and "heavy use". It is assumed that beer is the only alcoholic beverage consumed at the Kenya study site. Sixty two percent of men and three percent of women reported the consumption of any alcohol.

Based on the food intake records, however, only eleven percent of men (n=285) had recorded any alcohol use and only one woman in the sample (n=285) reported any alcohol consumption. This difference between the surveys is likely due to failure of men to report alcohol consumed outside of the house and hence not entered in the food intake records. Among the men whose food intake records include alcohol, daily intake from alcoholic beverages was 63 ± 71 kcal (n=32). Almost all subjects participating in the alcohol use survey were measured in the food intake survey.

Among the 222 men and 238 women participating in both surveys, very little discrepancy was found between their responses. Less than one percent of men and women showed actual intakes of alcohol based on the food intake survey, yet reported no alcohol use in the alcohol use survey. Five percent of men and two percent of women reported alcohol use on the alcohol use survey yet showed no alcohol consumption in the food intake records.

Using four categories for the alcohol use variable, no significant relationships were found between men's or women's alcohol use and (a) their own or spouse's anthropometric characteristics, (b) household SES, (c) sanitation score, or (d) their own or spouse's educational levels.

No use of alcohol was reported by either toddlers or schoolers. Since alcohol use by adult females and children was little or non-existent, no analysis of intra-family alcohol consumption patterns was conducted.

FINDINGS: ANTHROPOMETRIC CHARACTERISTICS OF SPOUSES

AGE

Mean ages of men and women were approximately 38 and 33 years, respectively, in both Kenya and Mexico; Egypt men and women were a bit younger, 36 and 30 years of age (Table 12). Most women in the sample populations were between 20 and 40 years of age. Male's ages centered between 25 and 50 years but there was a wider spread into older ages than for women. The age of spousal pairs was closely correlated ($r = 0.74$ to $.80$, $p < .0001$) and in almost all couples the male was older (mean differences in spousal age were 5.5 ± 5.2 years in Kenya, 4.6 ± 4.9 years in Mexico and 5.6 ± 4.7 years in Egypt).

HEIGHT AND WEIGHT

There was a small difference in stature between locations, and mean height was well below U.S. norms in all locations. The mean Z-scores for male heights are –1.26 in Egypt, –1.45 in Mexico and –1.55 in Kenya. The average height in Egypt was near the U.S. 10th centile and average height of Kenya and Mexico males was below the 10th centile. Mean height of women was also below the U.S. average. Z-scores indicate that height of women was less depressed, relative to U.S. norm, than that of men in Egypt and Kenya but the situation was reversed in Mexico.

The possibility that height and age were correlated, indicative of a secular trend in recent decades, was examined. A significant negative correlation between male height and age was found in the Mexico sample ($r = -0.19$, $p < 0.01$) and the association just missed statistical significance in Kenya males ($r = -0.11$, $p = 0.06$). There was no relationship between male height and age in Egypt, nor between female height and age in any location.

Mean body weights differed between locations much more than did heights, and weight was also more variable within groups. The Kenya population weighed the least; the Egypt sample was the heaviest; Mexico weights were intermediate. Group mean weights were below U.S. values but except for Kenya men, the Z-scores for weight were closer to U.S levels than were the scores for height. The Kenya male weight was notably low (Z-score –1.84, much below the U.S. 3rd centile) and negatively correlated with age, the older men being thinner than the younger men. Weight and age were not correlated in Kenya women nor in men in Egypt or Mexico, but these parameters were strongly correlated in Mexico and Egypt women ($p < 0.001$).

BODY MASS INDEX AND MID-UPPER ARM CIRCUMFERENCE

As expected, body weight and height were related in all three locations (Table 13). The correlation was slightly stronger in males than females; the correlation is highest in Kenya and lowest in Egypt for both males and females. A convenient way to look at these relationships is by the computed body mass index. BMI was strongly correlated with weight in the three locations but essentially was unrelated to height (correlated only in Kenya women, $r = 0.14$, $p = 0.03$).

BMI standards, for classification of under- and overweight in the U.S., are set at approximately the 15th and 85th centiles of persons aged 20 to 29 years in the U.S. population. The cut-off points increase slightly with age but for the project populations values of 20 through 26 would be appropriate.

TABLE 12: ANTHROPOMETRIC MEASUREMENTS* IN ADULTS AND Z-SCORES FOR WEIGHT, HEIGHT AND BODY MASS INDEX (MEAN ± SD)

Measurement	Units	EGYPT Men	EGYPT Women	KENYA Men	KENYA Women	MEXICO Men	MEXICO Women
(N)†		(195)	(195)	(276)	(276)	(199)	(199)
Age	yr.	35.5 ± 7.4	29.9 ± 6.4	38.2 ± 7.7	32.7 ± 6.0	37.4 ± 8.0	33.0 ± 7.1
Weight	kg.	71.3 ± 12.0	64.0 ± 11.6	55.2 ± 6.8	51.1 ± 8.1	66.1 ± 10.1	58.4 ± 9.5
Height	m.	1.67 ± 0.06	1.56 ± 0.05	1.65 ± 0.06	1.55 ± 0.06	1.66 ± 0.06	1.53 ± 0.05
Body Mass Index	kg/m2	25.4 ± 3.9	26.4 ± 4.7	20.2 ± 1.9	21.3 ± 2.7	23.9 ± 3.1	24.9 ± 3.8
Skinfold Thickness	mm.						
Triceps		11.1 ± 6.4	21.8 ± 8.5	6.2 ± 2.8	16.7 ± 6.8	7.6 ± 3.9	17.0 ± 5.1
Biceps		5.8 ± 3.1	11.3 ± 6.5	3.0 ± 0.8	6.1 ± 3.8	3.1 ± 2.2	7.5 ± 3.6
Subscapular		11.3 ± 6.2†	14.9 ± 7.0†	8.0 ± 2.8	13.6 ± 6.5	13.0 ± 6.6	26.5 ± 9.8
Suprailiac					8.4 ± 6.0	14.9 ± 7.6	26.6 ± 10.1
Circumference	cm						
Midupper Arm		27.0 ± 2.9	26.8 ± 3.5	25.7 ± 1.9	26.3 ± 2.9	28.2 ± 2.3	28.0 ± 2.9
Head		55.5 ± 2.2	53.6 ± 2.2	55.6 ± 1.5	53.8 ± 1.5	55.8 ± 1.5	53.3 ± 1.4
Z score‡							
Weight		-0.62 ± 0.90	-0.03 ± 0.77	-1.84 ± 0.52	-0.95 ± 0.55	-1.02 ± 0.77	-0.45 ± 0.63
Height		-1.26 ± 0.90	-1.17 ± 0.80	-1.55 ± 0.91	-1.33 ± 0.88	-1.45 ± 0.85	-1.54 ± 0.80
Body Mass Index		-0.05 ± 1.01	0.43 ± 0.83	-1.42 ± 0.51	-0.57 ± 0.50	-0.45 ± 0.80	0.08 ± 0.67
Body fat§	%						
3 skinfolds		18.1 ± 7.5†	31.2 ± 6.0†	11.6 ± 4.3	26.5 ± 6.1	15.5 ± 7.0	31.9 ± 5.7
triceps only		19.8 ± 6.7†	32.2 ± 6.2†	13.9 ± 4.2	28.0 ± 6.3	15.7 ± 5.6	28.8 ± 4.9
Lean mass§	kg						
3 skinfolds		57.2 ± 7.6†	43.6 ± 5.7†	48.6 ± 5.1	37.2 ± 3.9	55.3 ± 6.0	39.2 ± 4.3
triceps only		56.2 ± 7.5†	42.5 ± 5.2†	47.4 ± 5.1	36.4 ± 4.0	55.3 ± 6.5	41.1 ± 5.1
Arm muscle area‖	cm2	44.6 ± 9.7	32.1 ± 6.9	45.0 ± 6.3	35.3 ± 5.1	53.1 ± 7.7	41.1 ± 6.7

*For each adult, the median measure of anthropometry was used.

†N of parameters except head circ. (Egypt M 35, F 51; Kenya M 195, F 267; Mexico M 183, F 194) and skinfolds (Egypt M triceps & biceps 153, subscap 49 and F triceps & biceps 174, subsc 45; Kenya M 275; Mexico F 195)

‡Computed Z score based on U.S. reference data for height and weight from National Center for Health Statistics, 1987 (Ref. 9).

§Body fat calculated from Durnin and Womersley, 1974 (Ref. 6). Three skinfolds are triceps, biceps, and subscapular. Lean body mass = body weight - (body wt x [% body fat/100])

‖Calculated from Frisancho, 1981 (Ref. 8).

TABLE 13: CORRELATION BETWEEN ANTHROPOMETRIC PARAMETERS OF ADULTS IN EGYPT, KENYA AND MEXICO*

				SKINFOLDS						% BODY FAT	
	Country†	Height	Body Mass Index	Triceps	Biceps	Subsc.	Midarm Circum.	Head Circum.	Arm Muscle Area	Three Skinfolds	Triceps
Males											
Weight	E	0.39	0.90	0.57	0.55	0.61	0.82	0.42	0.50	0.63	0.58
	K	0.63	0.78	0.49	0.49	0.52	0.73	0.49	0.59	0.55	0.51
	M	0.53	0.88	0.66	0.60	0.68	0.83	0.52	0.62	0.68	0.64
Height	E								0.23		
	K				0.15		0.16	0.29	0.17		
	M			0.17			0.25	0.35	0.21		0.15
Body Mass Index	E			0.68	0.66	0.71	0.83	0.36	0.43	0.72	0.66
	K			0.60	0.52	0.61	0.81	0.38	0.62	0.64	0.60
	M			0.68	0.64	0.73	0.84	0.40	0.62	0.73	0.66
Triceps Skinfold	E				0.89	0.64	0.58			0.90	0.96
	K				0.82	0.85	0.52	0.32		0.94	0.96
	M				0.81	0.85	0.61	0.30		0.92	0.96
Females											
Weight	E	0.25	0.93	0.77	0.74	0.62	0.90		0.53	0.83	0.73
	K	0.58	0.88	0.74	0.68	0.73	0.85	0.52	0.56	0.74	0.69
	M	0.41	0.92	0.71	0.69	0.80	0.88	0.52	0.76	0.78	0.70
Height	E									0.30	
	K		0.14	0.18	0.12	0.16	0.26	0.46	0.23	0.18	0.18
	M						0.17	0.29	0.20		
Body Mass Index	E			0.78	0.76	0.68	0.89		0.50	0.82	0.74
	K			0.79	0.76	0.81	0.88	0.38	0.55	0.81	0.74
	M			0.75	0.73	0.83	0.89	0.44	0.75	0.81	0.73
Triceps Skinfold	E				0.83	0.48	0.80			0.89	0.97
	K				0.87	0.85	0.85	0.32	0.21	0.96	0.97
	M				0.87	0.79	0.81	0.31	0.41	0.91	0.98

*N's are as given in Table 12. All values shown are significant ($p \leq 0.05$).
†E=Egypt, K=Kenya, M=Mexico

In Kenya, BMI was below 20 in 32% of women and 52% of men; values were above 26 in only 7% of women and 1% of men. Mean Z-scores of BMI were −1.42 and −0.57 for men and women, respectively, and describe a generally thin population. At the other extreme, 2% of women in Egypt and 4% of men had a BMI below 20; BMIs of 35% of men and 45% of women were above 26. Although there is substantial variation within the populations, on average, men in Egypt would match the weight of the U.S. population of their height and women would be slightly heavier. Z-scores of BMI in the Mexico sample were intermediate between values for Kenya and Egypt.

Correlations between BMI and age reflect the relationship of weight and age (see Figure 1). In Kenya, BMI and age were not correlated in either sex. In Mexico and Egypt, male BMI did not vary with age, but BMI of women increased significantly with age. The change in female BMI with age was much greater in Egypt than in Mexico.

Differences in mean mid-upper arm circumference (MAC) between countries were small, but interesting in relation to body weight. MAC was closely correlated ($p < .0001$) with body weight and BMI in each country/sex group and the correlations were closer for women ($r = .85$ to .89) than for men (0.73 to 0.84). MAC was a more uniform characteristic than was body weight in each group (CVs in Mexico were, for example, 8 and 15% for male MAC and body weight and 10 and 16% for respective female values). Looking across countries, however, mean MAC did not follow the rank order of mean weight; MAC was greater in Mexico than in Kenya, as body weight would predict, but mean MAC in Mexico was greater than in Egypt where mean body weight was heavier.

PREDICTION OF BMI FROM MAC

Because it is easier to measure MAC than BMI under field conditions and the two measures are strongly related, we explored the possibility of using MAC to predict risk of underweight defined as BMI values below the minimum accepted value of 20 kg/m^2. Values from all spousal couples were used to construct a series of logistic models with the outcome measurement of "BMI Risk" or BMI below 20. Logistic models were created and BMI Risk was predicted using four sets of independent variables (1) MAC only, (2) MAC and biceps skinfold, (3) MAC, biceps skinfold, and triceps skinfold, (4) MAC, biceps skinfold, triceps skinfold, and height A model was also created using MAC (only) with the addition of a project site indicator (and a project site indicator x MAC interaction term), thereby producing three intra-country models.

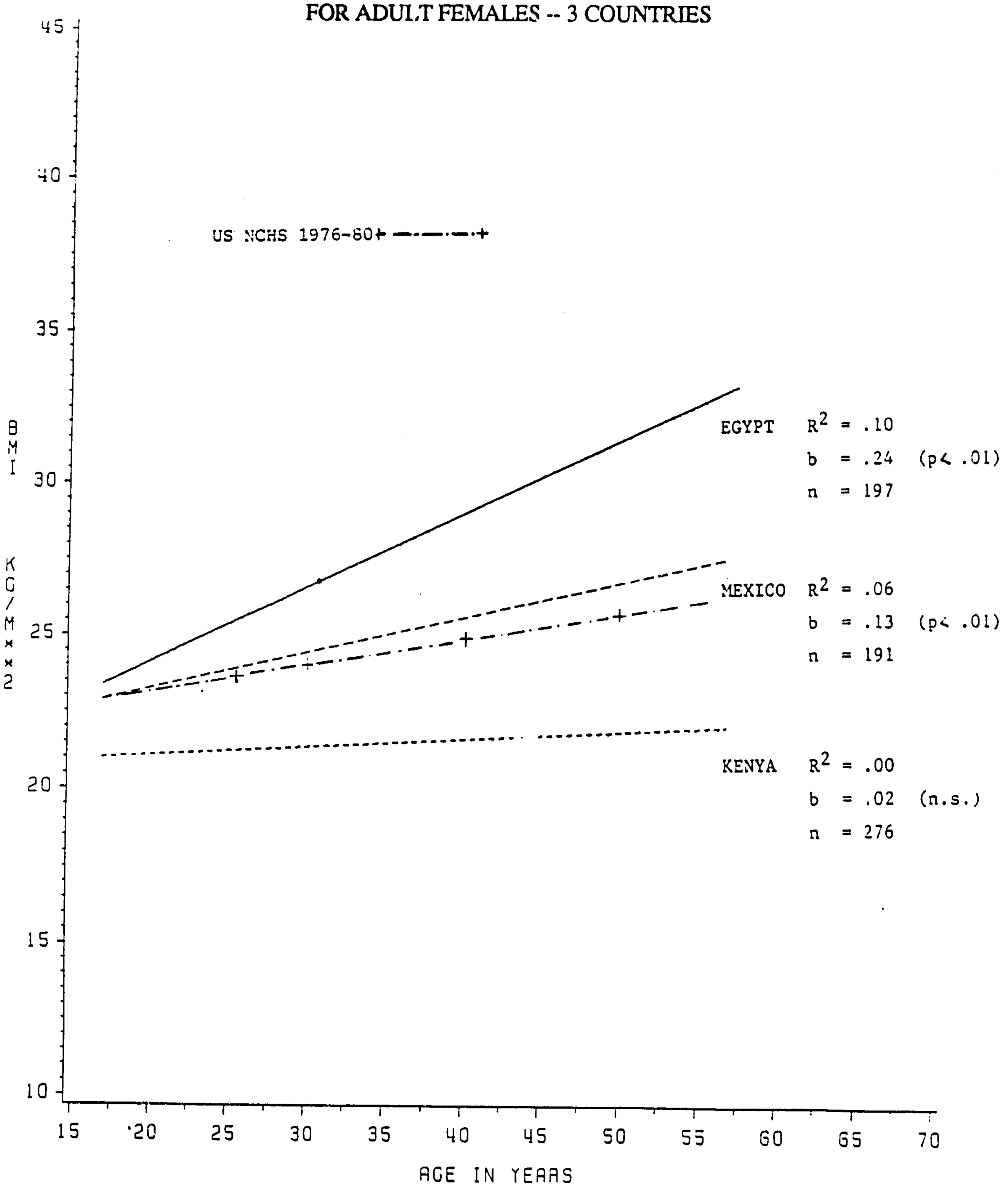
Percent of individuals with false negatives (those with true BMI less than 20 where the logistic model would predict BMI greater than 20) and corresponding false positives were computed and compared. The analysis was conducted separately for men and women.

Success in the prediction of low BMI differed by country. Where prevalence of risk is high (Kenya), the errors in classification using the MAC (only) model were found to be unacceptable, particularly in respect to the rate of false negatives (34.9% for men, 21.2% for women). The addition of other anthropometric measurements to MAC in the model did not significantly improve BMI prediction in any of the three countries.

In Kenya, the rate of false negatives was lower for women than for men in all models, though the rate of false positives was uniformly higher for women. In Mexico, the rate of false negatives was about the same for men and women, yet the rate of false positives was generally much higher for the men. In Egypt, there were virtually no false negative predictions for women; only 3 of 173 women had actual BMIs below 20.

FIGURE 1: BODY MASS INDEX BY AGE

FOR ADULT FEMALES -- 3 COUNTRIES



Better prediction results were generally obtained in each country when applying the individually constructed, intra-country models versus applying the single, inter-country model. For example, in Kenya the rate of false negatives for the MAC (only) model based on data contributed from all three countries is 34.9 for men and 21.2 for women; based on Kenya-specific data, the rate is 20.4 for men and 12.8 for women. This indicates that improved prediction results may be obtained by concentrating on individual populations within similar levels of risk and somatotype.

HEAD CIRCUMFERENCE

There was very little difference in head circumference between populations (maximum difference in means was 0.5 cm) and very little variability within groups (CVs of 2 - 4%). Nonetheless, head circumference correlated significantly with body weight in all groups, with BMI in all but Egypt women and with height in Kenya and Mexico populations. Correlations of weight and BMI with head circumference were lower than those with MAC but associations between height and head circumference, where they existed, were stronger than the correlations of height with MAC.

SKINFOLD THICKNESS AND BODY FAT

Measures of skinfold thickness at the different body sites were closely correlated. Skinfolds were consistently greater in women than in men. Biceps and triceps measures were similar in the Kenya and Mexico populations, both in men and women, but the subscapular skinfold was much thicker in Mexico. The difference in suprailiac skinfold thickness between women in Kenya and Mexico is particularly striking (8.4 and 26.6 mm) respectively. In Egypt, biceps and triceps skinfolds are thicker than in other countries. Subscapular skinfold measures, recorded for about 25% of the Egypt men and women, are inconsistent with expectations based on the comparison between Kenya and Mexico values, and the correlation between these and other skinfold measures within Egypt adults is much lower than in the other countries. This difference may be artifactual, due to methodology, or may indicate a valid difference in body fat patterning.

Percentage of body fat calculated from triceps skinfold measures was lowest in Kenya. Even in this generally lean population the body fat of women (28%) was twice that of men (14%). Comparable values for Mexico women and men were only slightly higher (29% and 16%) but figures for Egypt, especially the men (20%), were substantially higher.

Although skinfold thicknesses at various body sites are strongly correlated, the magnitude of change with increasing fatness is not uniform among sites. For the two populations where the subscapular data are complete (Kenya and Mexico), the difference in percentage body fat calculated from three skinfolds versus only triceps is predictable from the relative thickness of the subscapular skinfold. The differences, however, are not significant; the two estimates of percentage fat are very closely correlated (r > 0.9, p < .0001) in all three country locations.

A fourth skinfold measure, suprailiac, is available for women in Kenya and Mexico. Inclusion of this measure has no effect on the estimate of fat in Kenya women (mean 28%) but predicts a higher percentage in Mexico women (mean 36%).

The percentage of body fat is calculated from body density which is estimated from skinfold thickness using equations derived from a large series of European subjects (6). Any factor that causes density of the lean body compartment to differ from that on which the equations are based will introduce an unknown error. The factor that is most likely to affect density in the present populations is skeletal mass. There is no information at hand from which to estimate the probability of such differences. Differences in fat patterning, alluded to above, would also vitiate the validity of the predictive formulas.

LEAN BODY MASS AND ARM MUSCLE AREA

Lean body mass (LBM) is estimated by subtracting the amount of body fat, calculated as described above, from the median body weight. LBM of Kenya men and women was about 15% below that of the Mexico groups. Despite the difference in body weights between the Mexico and Egypt populations, there was relatively little difference (< 5%) in LBM, most of the weight differential being due to fat.

The only other indicator of LBM available is the computed arm muscle area. These estimates of leanness are not entirely independent because both utilize the triceps skinfold measure in the computation. The two measures are closely correlated in all groups ($r = 0.64$ to 0.75, $p < 0.0001$) but the rank order of arm muscle area among countries was not the same as for LBM. Although LBM was about the same in Mexico and Egypt, arm muscle area was much larger in Mexico. The differences in arm muscle area between Mexico and Kenya did, however, follow the pattern in LBM. These patterns suggest heavier upper-body work patterns in Mexico and Kenya than in Egypt, for both men and women.

SPOUSAL CORRELATIONS

Because height of Mexico males was negatively correlated with age, and weight of Mexico and Egypt females was positively correlated with age, relationships between spousal pairs were evaluated after removal of age. Correlations between spousal parameters (see Table 14) are not as strong as those within individuals but there is surprising consistency in the three very different populations. Height was not correlated between spouses in any country but spousal weights and MACs were significantly related. Correlations for BMIs and triceps skinfold thicknesses between spouses were more robust in Kenya and Mexico than the correlations for weight and MAC, but these parameters were not related in Egypt spouses. Male MAC is correlated with female BMI, as well as MAC, in all locations. Arm muscle area of spouses is correlated only in the Mexico populations.

SOCIOECONOMIC AND SANITATION SCORE: CORRELATES OF ADULT ANTHROPOMETRY

These findings suggested that fatness is a commonly shared characteristic, reflecting one or more household variables. (Arm muscle development may be a common characteristic as well, but the relationship was found only in Mexico.) Controlling for age, we examined the relationships between male and female anthropometric measures, and socioeconomic and sanitation scores, education, and percentage of fat in the lead female diet as a marker of household diet quality (see Table 15). In Egypt there were few significant associations; sanitation score is related to female weight and MAC, and LF diet fat is weakly associated with male MAC. Almost all of the variables tested are positively associated with adult weight, BMI and MAC in Kenya men and women; SES is the strongest correlate. Female height also is related to SES, education and LF diet fat in Kenya. In Mexico, weight, BMI and MAC of men and women are significantly related to SES score and the female height-SES relationship just misses significance; sanitation score, education and LF diet fat are positively associated with female weight and related parameters. As noted earlier, these non-dietary variables are related to one another but it is of interest that the sanitation score is the only factor consistently associated with female weight and MAC across all projects.

TABLE 14: CORRELATION BETWEEN ANTHROPOMETRIC PARAMETERS OF SPOUSAL PAIRS IN KENYA, MEXICO AND EGYPT*

		MALE				
FEMALE	Country†	Weight	Body Mass Index	Triceps Skinfold	Midarm Circum.	Arm Muscle Area
Weight	E	0.16	0.12		0.23	0.17
	K	0.17	0.23	0.34	0.23	
	M	0.13	0.16	0.17	0.20	0.15
Body Mass Index	E	0.15	0.12		0.22	0.15
	K	0.17	0.25	0.35	0.25	0.11
	M	0.17	0.22	0.22	0.24	0.16
Triceps Skinfold	E					
	K	0.15	0.24	0.34	0.25	0.11
	M	0.19	0.23	0.27	0.24	0.12
Mid-arm Circumference	E				0.14	
	K	0.15	0.25	0.35	0.23	
	M	0.15	0.18	0.17	0.22	0.17
Arm Muscle Area	E					
	K		0.13	0.18		
	M				0.14	0.16

*N as in Table 5. Correlation coefficients have been controlled for male and female age. All values shown are statistically significant ($p<0.05$); values of the order 0.2 and above are highly significant ($p<0.001$).

†E=Egypt, K=Kenya, M=Mexico

TABLE 15: CORRELATION BETWEEN ADULT ANTHROPOMETRIC MEASURES† AND AGE, AND AFTER CONTROLLING FOR AGE, WITH SOCIOECONOMIC AND SANITATION SCORES, EDUCATION AND PERCENTAGE OF ENERGY FROM FAT IN THE LEAD FEMALE DIET‡

		Controlled for Age				
	Age	Soc-econ Score	Sanit Score	Education, yrs LM	Education, yrs LF	% Fat kcal LF diet
Egypt Lead Male						
Mid-arm circumference, cm						0.16
Egypt Lead Female						
Weight, kg	0.31**		0.16*			
Body Mass Index, kg/m^2	0.35**					
Mid-arm circumference, cm	0.30**		0.18*			
Kenya Lead Male						
Weight, kg	-0.12*	0.28**	0.16**	0.15*	0.17**	0.19**
Body Mass Index, kg/m^2		0.29**	0.20**	0.19**	0.21**	0.16**
Mid-arm circumference, cm	-0.14*	0.22**	0.15*	0.13*		0.14*
Kenya Lead Female						
Height, m		0.18**		0.15*	0.17**	0.18**
Weight, kg		0.31**	0.19**	0.21**	0.21**	0.22**
Body Mass Index, kg/m^2		0.28**	0.19**	0.17**	0.15*	0.17**
Mid-arm circumference, cm	0.12*	0.33**	0.22**	0.20**	0.18**	0.24**
Mexico Lead Male						
Height, m	-0.19**					
Weight, kg		0.20**				
Body Mass Index, kg/m^2		0.20**				
Mid-arm circumference, cm		0.17*				
Mexico Lead Female						
Height, m		0.14				
Weight, kg	0.28**	0.24**	0.19*	0.20*	0.18*	0.15*
Body Mass Index, kg/m^2	0.27**	0.19**	0.19*			0.16*
Mid-arm circumference, cm	0.26**	0.28**	0.27**	0.18*	0.21**	0.20**

†N varies with measure but is 145 - 195 in Egypt, 270 - 276 in Kenya and 154 - 199 in Mexico.
‡Correlations shown if $p \leq 0.06$; *$p \leq 0.05$; **$p \leq 0.01$.

FINDINGS: ANTHROPOMETRIC CHARACTERISTICS OF CHILDREN

Measurements for toddlers (Table 16) and schoolers (Table 17) in the total anthropometry sample (those whose anthropometry records met the stated criteria) are almost identical with those of the subset who also met food intake criteria. In Kenya, all anthropometry-eligible schoolers met food-record criteria, as did most of the toddlers. Availability of food records reduced the toddler sample by almost half in Mexico and more than one-quarter in Egypt; the schooler sample was less affected in both cases. This has not resulted in any detected bias, but the reduced sample sizes make it more difficult to prove statistical significance of differences observed.

Correlations between anthropometric measurements are very strong and similar to those found in the adult samples (Table 18). In both toddlers and schoolers in all projects, the strongest relationship is between weight and stature (r = 0.74 to 0.85). As expected, BMI is correlated with weight (r = 0.55 to 0.73), but not height, and equally strongly with mid-arm circumference (MAC). In toddlers, skinfold thicknesses correlate more closely and consistently with weight than with BMI but the reverse is true in schoolers. For all children, skinfold thickness correlates best with MAC. Of the three skinfolds, the triceps measure is the most consistent correlate of other parameters. MAC is a consistent correlate of height, more strongly related in schoolers than toddlers but significant in all cases. Head circumference is related to all the other parameters shown, but most consistently with weight in all and BMI in schoolers.

Only in one instance was any significant relationship shown with rate of linear growth; MAC was a positive correlate for toddlers in Mexico (r = 0.26). Weight and/or BMI or MAC were related to rate of weight gain, but the correlations were neither strong nor consistent.

Among the parameters reported here, it appears that the MAC is the best single marker of differences in physical status in children, along with weight and height. No state measure was reliably associated with growth.

TODDLERS

Toddler weight and length are very similar in Egypt and Mexico samples. The Mexico toddlers are, however, thinner (as assessed by skinfold thickness) and probably more muscular, based on arm circumference. During the year of study, the rate of gain in length (predicted from the regression of length and age) is greater in Mexico than Egypt but the rate of gain in weight is much lower in Mexico than Egypt.

Kenya toddlers are shorter and weigh less than the other toddlers and their rates of gain also are less. Skinfold thicknesses would suggest that the Kenya toddlers are slightly fatter than the Mexico sample, despite a lower BMI, but the skinfolds may reflect only a difference in pattern of fat distribution as seen in the adults. Kenya toddlers are thinner than Egypt toddlers by both measures.

Girl toddlers are significantly shorter and lighter than boys in Egypt and Kenya (Table 19) as is the usual relationship. There were no significant differences in their Z-scores, however, which are based on sex-specific reference standards. In the Mexico sample, there is no sex difference in median height and weight though the Z-scores show that Mexico boys' size is relatively poorer than girls' compared to sex-specific standards.

TABLE 16: ANTHROPOMETRIC MEASUREMENTS IN TODDLERS FOR TOTAL SAMPLE AND GROUP AVAILABLE FOR NUTRIENT INTAKE ASSESSMENT (MEAN ± SD)

Measurement	Egypt		Kenya		Mexico	
	Total	FI Grp*	Total	FI Grp*	Total	FI Grp*
(N)	(132)	(96)	(110)	(100)	(108)	(59)
% boys	52.3	49.0	48.2	50.0	50.9	47.5
Median:						
Age, months	23.7 ± 1.7	23.6 ± 1.6	23.8 ± 0.9	23.8 ± 0.9	25.4 ± 1.2	24.8 ± 0.9
Length, cm.	79.9 ± 3.5	79.8 ± 3.5	79.2 ± 3.3	79.2 ± 3.4	79.8 ± 3.5	79.9 ± 3.3
Weight, kg	11.0 ± 1.3	10.9 ± 1.2	10.2 ± 1.2	10.2 ± 1.2	10.8 ± 1.1	10.8 ± 1.1
Body Mass Index, kg/m^2	17.1 ± 1.3	17.1 ± 1.3	16.3 ± 1.2	16.3 ± 1.2	17.0 ± 0.9	16.9 ± 0.9
Skinfold Thickness, mm.						
Biceps	6.2 ± 1.4	6.1 ± 1.3	5.8 ± 1.4	5.9 ± 1.4	4.4 ± 0.9	4.4 ± 1.0
Triceps	10.3 ± 2.0	10.3 ± 1.9	8.5 ± 1.7	8.6 ± 1.8	7.8 ± 1.4	7.9 ± 1.3
Subscapular	6.9 ± 1.8	6.9 ± 1.9	5.1 ± 1.0	5.1 ± 1.0	5.0 ± 1.3	5.3 ± 1.3
Arm Circumference, cm	13.9 ± 1.0	13.9 ± 1.0	14.4 ± 1.0	14.5 ± 1.0	14.8 ± 0.9	14.9 ± 0.9
Head Circumference, cm	46.4 ± 1.6	46.5 ± 1.6	47.4 ± 1.4	47.5 ± 1.4	46.9 ± 1.4	46.8 ± 1.2
Rate of Gain†						
Length, cm/mo	0.657 ± 0.298	0.699 ± 0.21	0.633 ± 0.156	0.635 ± 0.159	0.727 ± 0.198	0.749 ± 0.166
Weight, kg/mo	0.222 ± 0.116	0.227 ± 0.91	0.165 ± 0.058	0.164 ± 0.059	0.177 ± 0.085	0.164 ± 0.064
Predicted 24-month‡						
Length, cm	79.8 ± 3.6	80.1 ± 3.3	79.3 ± 3.1	79.4 ± 3.2	79.2 ± 3.4	79.1 ± 3.2
Weight, kg	11.0 ± 1.3	11.1 ± 1.2	10.3 ± 1.1	10.3 ± 1.2	10.6 ± 1.1	10.6 ± 1.0

*Subset of the total sample for whom food intake data are sufficient and who were not breast-fed beyond 23.5 months of age

†Slope of linear regression for weight, based on approximately 7 observations per subject in Egypt, 13 in Kenya, and 15 in Mexico

‡24-month intercept of linear regression of observed values

TABLE 17: ANTHROPOMETRIC MEASUREMENTS IN SCHOOLERS FOR TOTAL SAMPLE AND GROUP AVAILABLE FOR NUTRIENT INTAKE ASSESSMENT (MEAN ± SD)

Measurement	Egypt		Kenya	Mexico	
	Total	FI Grp*	Total/FI Grp†	Total	FI Grp*
(N)	(73)	(63)	(138)	(117)	(84)
% boys	46.6	44.4	55.1	50.4	50.0
Median:					
Age, yr	8.0 ± 0.6	8.1 ± 0.6	7.6 ± 0.3	8.1 ± 0.5	8.0 ± 0.4
Height, cm.	121.3 ± 4.9	121.2 ± 5.1	116.0 ± 5.8	119.2 ± 5.2	118.7 ± 4.8
Weight, kg	23.3 ± 2.7	23.2 ± 2.7	20.0 ± 2.5	21.6 ± 2.5	21.3 ± 2.4
Body Mass Index, kg/m^2	15.8 ± 1.0	15.7 ± 1.0	14.8 ± 1.0	15.1 ± 0.9	15.1 ± 0.9
Skinfold Thickness, mm.					
Biceps	4.5 ± 1.2	4.5 ± 1.2	3.2 ± 0.8	3.0 ± 0.9	2.9 ± 0.8
Triceps	8.4 ± 2.1	8.4 ± 2.1	6.1 ± 1.4	6.8 ± 2.0	6.7 ± 2.0
Subscapular	6.0 ± 1.8	6.0 ± 1.8	4.3 ± 0.7	4.3 ± 1.3	4.2 ± 1.3
Arm Circumference, cm	16.3 ± 1.2	16.2 ± 1.1	15.8 ± 1.1	16.9 ± 1.1	16.9 ± 1.0
Head Circumference, cm	50.5 ± 2.1	50.4 ± 2.2	50.8 ± 1.5	50.3 ± 1.5	50.1 ± 1.5
Rate of Gain‡					
Height, cm/mo	0.457 ± 0.114	0.458 ± 0.117	0.344 ± 0.099	0.437 ± 0.088	0.436 ± 0.088
Weight, kg/mo	0.191 ± 0.135	0.187 ± 0.119	0.118 ± 0.072	0.156 ± 0.074	0.157 ± 0.072
Predicted 8 year§					
Height, cm	121.2 ± 4.9	121.0 ± 5.0	117.8 ± 5.5	118.3 ± 4.9	118.1 ± 4.7
Weight, kg	23.1 ± 2.7	23.0 ± 2.7	20.7 ± 2.5	21.4 ± 2.4	21.2 ± 2.3

*Subset of the total sample for whom food intake data are sufficient.

†In Kenya, the total sample and the nutrient intake assessment group are the same.

‡Slope of linear regression for weight, based on approximately 5 observations per subject in Egypt, 14 in Kenya, and 7 in Mexico

§8-year intercept of linear regression of observed values

TABLE 18: CORRELATION BETWEEN ANTHROPOMETRIC PARAMETERS FOR TODDLERS AND SCHOOLERS IN EGYPT, KENYA AND MEXICO†

				SKINFOLDS					RATE OF GAIN	
	Country‡	Length/Ht	BMI	Biceps	Triceps	Subsc.	MAC	HC	Length/Ht	Weight
Toddlers										
Weight	E	0.74**	0.62**	0.21*	0.34**		0.67**	0.58**		
	K	0.77**	0.68**	0.30**	0.40**	0.45**	0.83**	0.67**		0.22*
	M	0.84**	0.55**	0.32**	0.33**	0.18	0.75**	0.47**	0.22	0.27*
Length	E						0.29**	0.44**		
	K						0.38**	0.50		0.17
	M			0.18	0.19		0.49**	0.39**	0.16	0.22
BMI	E			0.40**	0.48**	0.30**	0.65**	0.34**		0.20*
	K						0.38**	0.50**		0.17
	M			0.32**	0.32**	0.37**	0.64**	0.27*		0.16
MAC	E	0.29**	0.65**	0.50**	0.59**	0.29**		0.40		0.16
	K	0.38**	0.86**	0.56**	0.69**	0.66**		0.53**	0.18	0.20*
	M	0.49**	0.64**	0.54**	0.61**	0.38**		0.36**	0.26*	0.25
Schoolers										
Weight	E	0.83**	0.73**	0.34**	0.40**	0.22	0.82**	0.42**	-0.16	0.25*
	K	0.85**	0.61**		0.16	0.37**	0.76**	0.55**		
	M	0.84**	0.68**	0.23*	0.39**	0.45**	0.76**	0.61**		0.28**
Height	E		0.22	0.15	0.22		0.60**	0.21	-0.24	0.20
	K					0.19*	0.49**	0.39**		
	M		0.18		0.22*	0.28**	0.47**	0.45**		0.20
BMI	E	0.22		0.41**	0.44**	0.31*	0.69**	0.49**		0.17
	K			0.24**	0.30**	0.39**	0.71**	0.47**	0.15	0.19*
	M	0.18		0.27**	0.38**	0.42**	0.73**	0.49**		0.22**
MAC	E	0.60**	0.69**	0.50**	0.53**	0.41**		0.33*	-0.18	0.21
	K	0.49**	0.71**	0.32**	0.48**	0.47**		0.38		
	M	0.47**	0.73**	0.42**	0.64**	0.65**		0.39**		0.32**

†Correlation coefficients are shown if |r| ≥ 0.15; significance levels p ≤ 0.05*, p ≤ 0.01**

‡E = Egypt, K = Kenya, M = Mexico

TABLE 19: ANTHROPOMETRIC PARAMETERS AND Z-SCORES OF CHILDREN BY SEX (MEAN ± SD)

TODDLERS

	Egypt		Kenya		Mexico	
	Males	Females	Males	Females	Males	Females
(N)	(47)	(49)	(50)	(50)	(28)	(31)
Median†						
Length, cm	80.7 ± 3.7	78.9 ± 3.1*	79.9 ± 3.7	78.5 ± 2.9*	80.0 ± 2.7	79.8 ± 3.8
Weight, kg	11.2 ± 1.2	10.6 ± 1.1*	10.5 ± 1.1	10.0 ± 1.2*	10.7 ± 0.9	10.8 ± 1.2
Body Mass Index, kg/m^2	17.2 ± 1.3	17.0 ± 1.4	16.4 ± 1.1	16.2 ± 1.3	16.8 ± 0.8	16.9 ± 0.9
Triceps skinfold, mm	10.4 ± 1.9	10.1 ± 2.0	8.4 ± 1.7	8.8 ± 1.9	7.7 ± 1.3	8.1 ± 1.4
Mid-arm Circum., cm	14.1 ± 1.0	13.6 ± 1.0*	14.6 ± 0.9	14.4 ± 1.1	14.8 ± 0.9	15.0 ± 0.9
Z-score‡						
Length	-1.96 ± 0.93	-2.03 ± 1.78	-2.13 ± 1.03	-2.33 ± 0.87	-2.50 ± 0.72	-2.30 ± 1.14
Weight	-0.88 ± 0.87	-0.97 ± 0.93	-1.57 ± 0.79	-1.50 ± 0.97	-1.51 ± 0.64	-1.03 ± 0.95*
Weight-for-length	0.28 ± 0.84	0.51 ± 1.68	-0.45 ± 0.76	-0.36 ± 1.00	-0.21 ± 0.66	0.29 ± 0.77*

SCHOOLERS

	Egypt Males	Egypt Females	Kenya Males	Kenya Females	Mexico Males	Mexico Females
(N)	(28)	(35)	(76)	(62)	(42)	(42)
Median†						
Height, cm	121.2 ± 5.4	121.2 ± 4.8	116.2 ± 5.0	115.7 ± 6.7	119.6 ± 5.2	117.8 ± 4.4
Weight, kg	23.1 ± 2.5	23.2 ± 2.9	20.1 ± 2.1	19.8 ± 2.9	21.9 ± 2.7	20.6 ± 1.8*
Body Mass Index, kg/m^2	15.7 ± 0.7	15.8 ± 1.2	14.9 ± 0.9	14.7 ± 1.0	15.3 ± 0.9	14.9 ± 0.8*
Triceps skinfold, mm	7.7 ± 2.1	9.0 ± 1.9*	5.7 ± 1.2	6.6 ± 1.6	6.1 ± 1.8	7.3 ± 1.9*
Mid-arm Circum., cm	15.9 ± 1.0	16.4 ± 1.1	15.8 ± 1.0	15.8 ± 1.2	16.9 ± 1.1	16.9 ± 0.9
Z-score‡						
Height	-1.02 ± 0.90	-0.95 ± 0.87	-1.68 ± 0.92	-1.47 ± 1.03	-1.46 ± 0.91	-1.56 ± 0.71
Weight	-0.87 ± 0.67	-0.56 ± 0.76	-1.44 ± 0.71	-1.24 ± 0.78	-1.12 ± 0.77	-1.23 ± 0.54
Weight-for-height	-0.08 ± 0.56	0.23 ± 0.91	-0.42 ± 0.67	-0.32 ± 0.73	-0.14 ± 0.60	-0.13 ± 0.57

*Value for females significantly different from males, $p \leq 0.05$

†Median value; median ages are similar except for Kenya schoolers whose median age is ca. 6 mo. less than Egypt and Mexico schoolers.

‡Z-scores for toddlers are based on predicted 24 mo. size using the NCHS reference values for recumbent length at 23.99 mo.; Z-scores for schoolers use predicted 8-yr size for comparability.

SCHOOLERS

The between-country differences seen in length and weight of toddlers also are found in schoolers' height and weight, and the magnitude of the difference is larger. Egypt schoolers are taller and heavier than the other two groups; Kenya schooler size lags slightly behind Mexico values. The rate of weight gain of Kenya schoolers is lower than in Mexico and Egypt. Even when their smaller body weight is taken into account, the Kenya schoolers' rate of gain is lowest, at 5.9 g/d/kg versus 7.2 g in Mexico and 8.2 g in Egypt schoolers. Rate of height gain as well as weight gain is slightly greater in the Egypt schoolers than Mexico schoolers, and both exceed linear growth rate of Kenya schoolers.

Kenya and Mexico schoolers' BMI and skinfold thicknesses are less than in respective toddler samples. Egypt schoolers, like those in Kenya and Mexico, are thinner than the toddler sample but there is less difference in skinfold thickness than between ages elsewhere.

In the Mexico schooler sample, girls weigh significantly *less* than boys and have a significantly lower BMI but thicker triceps skinfolds. Girls skinfolds are thicker than boys in the other two samples as well, but the difference is not significant in Kenya. As shown in adults, fat deposition is a sexually dimorphic characteristic which is detectable even at this early age. There are no significant differences between sexes in Z-scores for weight, height or weight-for-height.

CATCH-UP GROWTH AND INTRAFAMILY CORRELATIONS

The Z-scores for recumbent length of toddlers are uniformly lower than the height Z-scores of schoolers of both sexes in all locations (Table 19). Toddler lengths are of the order of 2 SDs below the reference U.S. population; at age eight years, children in the same communities have attained heights that, on average, are 1.0 to 1.5 SD's below the norm. In Kenya, schooler height scores are somewhat lower than those of adults of both sexes (Table 12 and 19), suggesting that there may be further catch-up growth in adolescence. The Mexico schoolers' height scores are the same as the adults; the secular increase in height, suggested by the correlation of height and weight in male adults, may be continuing and for females as well as males. Egypt schoolers, even if they follow the normal growth trajectory (i.e. have normative rates of growth rather than accelerated or catch-up growth), will be taller as adults than adults presently in Kalama.

Z-scores for weight reveal a different picture. In all cases, the Z-score for weight is closer to the reference population than is height. For each age group, the weight Z of females is higher than that of males, with the single exception of female schoolers in Mexico. Weight Zs are higher with increasing age except for the Mexico female schoolers and Kenya male adults.

These relationships of weight and height result in weight-for-height Z-scores that are much closer to the reference population. The Kenya children would still appear thin (wt/ht Z-scores approximately 0.4 to 0.5 SD below the norms) but the other children would be perceived as about normal weight for height.

Correlations of adults' and children's anthropometric measures are displayed in Table 20. Note that the number of parent-child pairs in the various subgroups in this table range from 44 to 137 and that levels of significance for correlations are, in part, a function of these sample sizes.

TABLE 20: CORRELATION BETWEEN ANTHROPOMETRIC PARAMETERS OF PARENTS WITH THEIR TODDLERS AND SCHOOLERS IN EGYPT, KENYA AND MEXICO†

	TODDLER				SCHOOLER			
	Wt	Length	BMI	MAC	Wt	Ht	BMI	MAC
Egypt		(n = 78)‡				(n = 50)		
Lead Male:								
Weight	0.15				0.40**	0.36*	0.39**	0.35**
Height					0.30*	0.36**	0.17	0.33*
BMI					0.32*	0.26	0.36**	0.26*
MAC					0.38**	0.23	0.40**	0.42**
Lead Female:								
Weight	0.29*	0.19			0.17	0.20		0.15
Height	0.34**	0.37**			0.27	0.43**		0.18
BMI	0.17							
MAC	0.18							
Kenya		(n = 100)				(n = 137)		
Lead Male:								
Weight	0.29**	0.29**	0.16	0.22*	0.38**	0.28**	0.31**	0.38**
Height		0.21*			0.26**	0.27**		0.15
BMI	0.28**	0.21*	0.20*	0.21*	0.26**		0.31**	0.35**
MAC	0.20*		0.19	0.20*	0.26**		0.27**	0.39**
Lead Female:								
Weight	0.25*	0.25*	0.15	0.22*	0.46**	0.30**	0.42**	0.43**
Height	0.15	0.26**			0.37**	0.43**		0.25**
BMI	0.21*		0.19	0.22*	0.35**		0.46**	0.38**
MAC	0.26**	0.22*	0.17	0.27**	0.37**	0.19*	0.41**	0.38**
Mexico		(n = 44)				(n = 78)		
Lead Male:								
Weight					0.19	0.20		0.23*
Height						0.22*	-0.23*	
BMI		0.18			0.21		0.25*	0.31**
MAC		0.19			0.22*		0.20	0.31**
Lead Female:								
Weight	0.35*	0.25	0.24	0.23	0.38**	0.32**	0.27*	0.27*
Height	0.30*	0.40**			0.28**	0.39**		
BMI	0.29	0.16	0.24	0.23	0.31**	0.19	0.33**	0.27*
MAC	0.42**	0.28	0.32*	0.33*	0.38**	0.30**	0.33**	0.33**

†Shown if $|r| \geq 0.15$; *$p \leq 0.05$, **$p \leq 0.01$

‡All sample sizes as indicated except Egypt: lead male MAC x toddler, n = 70; Egypt lead male MAC x toddler, n = 41; Kenya: lead male MAC x schooler, n = 136

Across all projects, maternal height was found to be significantly ($p \leq 0.05$) and positively correlated with their toddlers' length; lead female weight was correspondingly correlated with toddler weight. In both Kenya and Mexico, mothers' mid-arm circumference, often interpreted as a measure of "fatness", was significantly correlated to those of their toddlers. Only in Kenya was maternal BMI, another "fatness" marker, significantly associated with toddler BMI. Also, only in Kenya were *any* of the adult males' anthropometric measurements significantly correlated with those of their toddlers. In fact, all four of the Kenyan parental anthropometric parameters were significantly correlated to the respective toddler measurements.

In general, the relationship between schoolers and their parents was stronger and more consistent across the anthropometric measurements. With the exception of lead females in Egypt, nearly every parental anthropometric parameter was found to be significantly and positively correlated with the corresponding parameter of the schooler. In Egypt, however, mothers' anthropometry was, for three of the four parameters, not found to be significantly correlated with the corresponding measure of their school-aged children (though maternal height was significantly ($p \leq 0.01$) correlated with schooler height at $r = 0.43$). The only other exception was for the association of father and schooler weight in Mexico; while the correlation was positive ($r = 0.19$), it was not significant at $p \leq 0.05$.

FINDINGS: CHILDREN'S INTAKE

EFFECT OF WEANING AND AGE ON TODDLER'S ENERGY INTAKE

Analysis of food intakes of toddlers is more complicated than is the case with schoolers. Toddlers were weaned at different ages which might reflect differences in culture, economics, health or the like. Also, because toddler potential growth rate is higher in the first half than the second half of the study year, there might be a systematic difference in intake across the year. Several procedures were carried out to explore these questions.

As expected, toddlers' caloric intakes from food varied with breast-feeding status. When average intakes over the 18 to 24 month age period were examined for all toddlers, those who were still being breastfed at 24 months of age consumed significantly less energy from food than toddlers who had been weaned by 18 months of age: 915 vs. 1202 kcal/d in Egypt, 694 vs. 817 kcal/d in Kenya, and 596 vs. 918 kcal/d in Mexico.[6] Thus it appears that breastfeeding at this age replaced an average of 287 kcal/d in Egypt, 123 kcal/d in Kenya, and 393 kcal/d in Mexico toddlers.

Toddlers in the analytic sample were divided into three subsamples: weaned before 18 mo., between 18 and 24 mo. and after 24 mo. The number in the last category proved too small for statistical analysis (N's were 4 in Egypt and 3 in Kenya) and in Mexico almost all toddlers (53 out of 59) were weaned before 18 mo. When averaged across the year (18 to 30 months of age), differences in energy intake from food, categorized by time of weaning (before 18 months vs. between 18 and 24 months), were relatively small: 46 more kcal/d in Egypt, 28 kcal/d in Kenya, and 100 kcal/d in Mexico. Other variables examined for the early-weaned (< 18 mo.) and late-weaned (18 to 24 mo.) groups were: SES and sanitation scores, parental education, toddler weight and length at 24 mo., toddler energy intake and energy intake from animal sources. The only consistent, but small, difference was fewer years of parental education (both LM and LF) in all three locations for the late-weaned group. The late-weaned toddlers were larger at 24 mo. age in Egypt (11.2 vs. 10.9 kg; 80.3 vs. 79.8 cm) and Kenya (10.6 vs. 10.2 kg; 80.2 vs. 79.1 cm). The six late-weaned Mexico toddlers were smaller than the other 53 (10.3 vs. 10.6 kg and 76.8 vs. 79.3 cm).

Using only the subset of toddlers who were not breastfed past 18 months of age, we examined changes in average intakes of energy between 18 to 24 months of age and 24 to 30 months of age. Mean intakes were virtually identical at the two ages in Egypt (1202 kcal/d at 18 to 24 months and 1207 kcal/d at 24 to 30 months), but significantly lower (using paired t-tests) at the younger age in Kenya (817 vs. 870 kcal/d) and Mexico (989 vs. 1095 kcal/d).

MACRONUTRIENT INTAKE

Energy intake of both toddlers and schoolers was much lower in Kenya than the other two sites (Table 21). In Egypt and Mexico, energy intakes of both age groups are above the FAO/WHO/UNU (14) average requirements figures of 103.6 and 76.2 kcal/kg for toddlers and schoolers, respectively. The intake of Kenya toddlers (83 kcal/kg) is approximately 80% of the standard and that of schoolers, while still low (70 kcal/kg), is above 90% of the standard.

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[6] To increase the sample size for these comparisons, all toddlers with one or more days of food intake were included. However, sample sizes were still small for toddlers not weaned at 24 months: 8 in Egypt, 10 in Kenya, and 6 in Mexico.

TABLE 21: ENERGY, MACRONUTRIENT AND RELATED INTAKES OF TODDLERS AND SCHOOLERS (MEAN ± SD)

Nutrient Variable	Toddlers			Schoolers		
	Egypt (N=96)	Kenya (N=100)	Mexico (N=59)	Egypt (N=63)	Kenya (N=138)	Mexico (N=84)
Energy, kcal/d	1204 ± 295	847 ± 149	1110 ± 262	1759 ± 346	1434 ± 242	1849 ± 445
kcal/kg/d	109 ± 27	83 ± 17	106 ± 27	78 ± 20	70 ± 10	88 ± 21
Protein, total, g/d	35.8 ± 10.2	23.1 ± 5.5	33.1 ± 7.6	54.3 ± 11.1	42.5 ± 8.3	53.2 ± 12.6
g/kg/d	3.2 ± 0.9	2.3 ± 0.5	3.2 ± 0.8	2.4 ± 0.6	2.1 ± 0.4	2.5 ± 0.6
Animal protein, g/d	13.5 ± 5.9	3.8 ± 2.8	9.6 ± 5.3	17.5 ± 6.0	2.9 ± 2.3	10.1 ± 6.4
g/1000 kcal	11.1 ± 3.1	4.4 ± 3.0	8.8 ± 5.0	9.9 ± 2.6	2.0 ± 1.5	5.6 ± 3.6
Meat, fish, poultry protein, g/d	6.6 ± 3.9	0.4 ± 0.8	3.6 ± 2.2	9.0 ± 4.4	0.9 ± 1.4	5.1 ± 3.7
g/1000 kcal	5.4 ± 2.5	0.5 ± 0.9	3.2 ± 1.9	5.1 ± 2.1	0.6 ± 0.9	2.9 ± 2.3
Amino acid score, %*						
Toddler pattern	94.8 ± 5.8	85.9 ± 7.8	87.6 ± 8.9	90.9 ± 5.9	81.4 ± 7.2	78.1 ± 9.0
Schooler pattern	NA	NA	NA	100 ± 0.0	98.9 ± 2.9	96.5 ± 5.2
Protein digestibility, %†	95.1 ± 0.8	90.5 ± 1.5	95.4 ± 1.1	94.7 ± 0.7	89.9 ± 1.1	94.6 ± 0.9
Fat, total, g/d	32.7 ± 9.6	11.5 ± 4.1	28.9 ± 9.0	43.4 ± 10.0	17.8 ± 4.9	41.9 ± 12.3
Polyunsaturated fatty acids, g/d	5.9 ± 1.4	3.4 ± 0.6	7.0 ± 2.2	11.0 ± 2.6	6.7 ± 1.3	13.5 ± 4.7
Saturated fatty acids, g/d	12.0 ± 1.4	3.7 ± 1.9	8.3 ± 3.1	15.9 ± 4.7	4.7 ± 1.7	11.3 ± 3.7
Cholesterol, mg/d	96 ± 60	19 ± 15	114 ± 64	105 ± 60	12 ± 10	126 ± 76
Carbohydrate, total, g/d	196 ± 50	171 ± 36	186 ± 48	294 ± 60	291 ± 48	326 ± 83
Dietary fiber, g/d	17 ± 6	22 ± 6	15 ± 5	29 ± 6	43 ± 8	29 ± 8
Sucrose, g/d	38 ± 13	19 ± 8	24 ± 12	36 ± 12	21 ± 8	29 ± 15
Phytic acid, g/d	0.80 ± 0.25	1.07 ± 0.32	1.67 ± 0.65	1.27 ± 0.28	2.39 ± 0.48	3.38 ± 1.07
Phytate:zinc molar ratio	15.5 ± 3.0	28.3 ± 4.5	30.1 ± 7.4	15.8 ± 2.3	33.1 ± 2.9	35.1 ± 5.1

* Final composite scores based on the most limiting amino acid in each diet with scores above 100 set to 100%. Toddler pattern = FAO/WHO/UNU recommended preschool child pattern; schooler pattern = recommended school child pattern.

† Estimated digestibility of protein relative to milk/egg

NA = not applicable

The percentage of energy derived from protein is quite similar across locations and ages (11-12% of kcal) but in Egypt 37% of protein in toddler diets was from animal products, compared to values of 16% in Kenya and 29% in Mexico. Schooler diets in Egypt were like those of toddlers (32% animal protein) but Mexico schoolers had proportionately less animal protein (19%) and Kenya schooler diets were very low in animal protein (7%).

Calculated protein digestibility was approximately 95% for Egypt and Mexico diets of both age groups, and 90% for the Kenya diet. Amino acid score of the toddler diets calculated using the FAO/WHO/UNU (14) toddler requirement pattern, was highest in Egypt (95%), as expected from the greater proportion of animal products, and lower in Mexico (88%) and Kenya (86%). The most limiting amino acid (the one in lowest concentration relative to the pattern) is almost always lysine; the second most limiting (and in a very few cases the first) is tryptophan. Scores for the schooler diets were calculated according to both the toddler and schooler requirement patterns (FAO/WHO/UNU (14)). Using the toddler pattern, in all locations the schooler diets rate lower than the toddler diets owing to the lesser proportion of animal protein; the difference is smallest in Egypt (95 vs. 91%), as expected, and surprisingly large in Mexico (88 vs. 78%). However, for purposes of calculating the amount of "utilizable protein", the amino acid pattern appropriate to the age group is to be used. These schooler scores are much higher, reflecting the lower amino acid requirements (relative to total protein requirements) of schoolers: Egypt, 100%; Kenya, 99%; and Mexico, 96%. In practical terms, this implies that protein quality, short of markedly low digestibility, is unlikely to be a limiting nutritional factor beyond about 6 years of age.

In Kenya toddler diets 12% of energy is from fat, compared with 23% in Mexico and 24% in Egypt diets; values for schooler diets in each site are about one percentage point below the respective toddler value. Dietary lipid patterns reflect a variation in use of animal products. Intakes of both PUFA and SFA were low in Kenya and the P/S ratio of 0.9 reflects a predominance of plant sources. The P/S ratio of the Mexico diet was 0.8 and that of the Egypt diet was 0.5. Cholesterol intakes were extremely low in Kenya and low, by Western standards, in Mexico and Egypt as well.

Carbohydrates are the principal energy source in all diets. Intake of sucrose was highest in Egypt and lowest in Kenya; all intakes are much lower than U.S. consumption levels. Intakes of fiber were highest in Kenya and much higher in schooler than toddler diets in all sites.

MICRONUTRIENT INTAKE

Despite the low energy intake of Kenya toddlers, the intake of most vitamins (per day or per unit of energy) was higher than in the other groups (Table 22). Kenya ranked lowest only in intakes of nutrients specific to animal products: vitamins B_{12} and D and retinol (but not total vitamin A). Intakes of almost all vitamins, except vitamin D, were lowest in Mexico.

Intakes of total and available zinc and of copper, calcium and phosphorus were lowest in Kenya but intakes of total and available iron, magnesium and potassium were highest. Calcium is exceptionally high in the Mexico diets due to addition of lime in preparation of maize tortillas. Total zinc does not differ markedly between Egypt and Mexico but available zinc is much reduced in the latter (as well as in Kenya) because of the high phytate content of the diet. In Egypt the practice of yeast-leavening bread reduces dietary phytate appreciably. Factors that contribute to reduced availability of iron are low proportions of meat-fish-poultry iron (Kenya especially but also Mexico), low vitamin C intake (Mexico) and consumption of tea (Egypt and Kenya).

CORRELATIONS OF NUTRIENT INTAKES WITH EACH OTHER AND WITH SES

Since associations between intakes of animal-source foods and functional outcomes have previously been reported (5), it is of interest to examine nutrients that co-occur in diets that are high in animal-source foods. Table 23 shows correlations of animal-source energy and animal-source protein with several other macro- and micronutrients. Total energy and animal-source energy are highly correlated in toddler and schooler diets in Egypt, moderately associated in Kenya diets, and non-significantly associated in Mexico diets. Fat strongly correlates with animal-source energy in diets in all locations, while vitamin A, riboflavin, and vitamin B_{12} co-occur with both animal-source energy and animal-source protein. Vitamins C and E are correlated with animal-source foods for Egypt and Mexico toddlers and Mexico schoolers, while calcium is found with animal-source protein in Egypt and Kenya (since milk is a major source of both nutrients) but not in Mexico (where much of the calcium comes from a plant source: maize tortillas).

To investigate associations between socioeconomic level and child nutrient intakes, correlations with SES score were examined for toddlers and schoolers (Table 24). Only for Kenya schoolers were energy intakes associated with SES, but animal protein intakes were strongly associated with SES in all locations and for both age groups. Other nutrients that tended to be associated with SES across sites and ages were fat, riboflavin, and vitamin B_{12}. Calcium intakes and SES were positively associated in Egypt and Kenya, but negatively associated in Mexico (due to a negative association of high-calcium maize tortilla intake and SES). Several other negative associations with SES are of interest for Kenya and/or Mexico: fiber, iron, thiamin, niacin, and folate. As will be discussed later, these are nutrients commonly found in less expensive foods (maize and indigenous fruits/vegetables).

PREDICTED PREVALENCE OF INADEQUATE NUTRIENT INTAKES

The estimated prevalences of inadequate nutrient intakes, as predicted by the probability approach, described in the earlier section, "Analytical Approaches," are listed for toddlers and schoolers in Table 25. These are mean probabilities of inadequacy across all children in each sample.

Protein does not appear to be at risk except for Kenya toddlers and even there the risk is low. We investigated the characteristics of the three Kenya toddlers with the lowest mean protein intakes (10.7, 12.4, and 13.8 grams per day). Based on their body weights, intakes were approximately at the FAO/WHO/UNU safe level of protein intake, after adjustment for the digestibility and amino acid score of the dietary protein. One child (intake of 12.4 g/d) was growing at a rate well below the Kenya average and was sicker than the average, but the other two were growing normally. The child with 13.8 g/d was probably meeting her requirements. The child with 10.7 g/d appears to be an anomaly; the household was among those seriously affected by the drought and it is possible that intake was recorded incorrectly or that breastfeeding was unreported.

The predicted prevalence of inadequate iron intakes is sufficiently high (27 to 88%) to suggest serious problems in all three communities but particularly in Egypt and Mexico. The mean total iron intakes were generally similar in the three groups of toddlers and schoolers (although somewhat higher for Kenya schoolers) but intakes of enhancing and inhibiting factors varied: Kenya toddlers and schoolers reported the most ascorbic acid per 1000 kcal, but the least meat/fish/poultry protein (Table 22). Although Egypt children had the highest heme iron intakes, the estimated intakes of available iron were reduced by the high levels of tea in the diet (176 g/d for toddlers and 155 g/d for schoolers).

TABLE 22: ESTIMATED VITAMIN AND MINERAL INTAKES OF TODDLERS AND SCHOOLERS (MEAN ± SD)

	Toddlers			Schoolers		
	Egypt (N=96)	Kenya (N=100)	Mexico (N=59)	Egypt (N=63)	Kenya (N=138)	Mexico (N=84)
Vitamin intakes						
Vitamin A, µg RE/d	305 ± 192	370 ± 228	203 ± 181	336 ± 135	495 ± 185	255 ± 163
µg RE/kg/d	28 ± 16	36 ± 20	19 ± 16	15 ± 6	24 ± 9	12 ± 7
animal source, µg RE/d	174 ± 179	50 ± 154	119 ± 162	155 ± 106	21 ± 43	106 ± 142
Vitamin D, µg/d	0.31 ± 0.33	0.06 ± 0.05	0.44 ± 0.29	0.33 ± 0.29	0.03 ± 0.03	0.52 ± 0.44
Vitamin E, mg α TE/d	6.0 ± 1.7	3.3 ± 1.1	2.6 ± 1.1	8.3 ± 1.9	5.8 ± 1.5	3.5 ± 1.5
mg α TE/g PUFA	0.8 ± 0.1	1.1 ± 0.3	0.3 ± 0.04	0.8 ± 0.1	0.9 ± 0.2	0.25 ± 0.04
Ascorbic acid, mg/d	42 ± 21	46 ± 19	14 ± 7	57 ± 27	62 ± 23	20 ± 10
mg/1000 kcal	35 ± 16	54 ± 20	13 ± 6	33 ± 16	44 ± 17	11 ± 6
Thiamin, mg/d	0.59 ± 0.20	0.67 ± 0.16	0.46 ± 0.10	0.95 ± 0.20	1.32 ± 0.24	0.73 ± 0.18
mg/1000 kcal	0.48 ± 0.07	0.79 ± 0.11	0.42 ± 0.06	0.52 ± 0.05	0.92 ± 0.08	0.40 ± 0.03
Riboflavin, mg/d	0.62 ± 0.22	0.55 ± 0.16	0.54 ± 0.23	0.90 ± 0.20	0.81 ± 0.14	0.65 ± 0.25
mg /1000 kcal	0.51 ± 0.08	0.65 ± 0.12	0.49 ± 0.22	0.51 ± 0.06	0.57 ± 0.05	0.35 ± 0.12
Niacin, total*, mg NE/d	15 ± 5	10 ± 2	12 ± 3	23 ± 5	18 ± 3	21 ± 5
mg NE/1000 kcal	12 ± 1	12 ± 1	11 ± 1	13 ± 1	13 ± 1	11 ± 1
Pantothenic acid, mg/d	2.4 ± 0.7	2.0 ± 0.5	1.9 ± 0.5	3.7 ± 0.7	3.0 ± 0.7	2.7 ± 0.7
Vitamin B_6, mg/d	0.75 ± 0.24	0.91 ± 0.22	0.64 ± 0.16	1.15 ± 0.23	1.34 ± 0.27	1.09 ± 0.29
µg/g protein	21 ± 3	40 ± 9	19 ± 2	21 ± 2	32 ± 5	21 ± 2
Folate, mg/d	0.19 ± 0.06	0.19 ± 0.06	0.16 ± 0.05	0.30 ± 0.06	0.37 ± 0.09	0.25 ± 0.08
µg/kg/d	17 ± 5	18 ± 6	15 ± 5	13 ± 3	18 ± 4	12 ± 4
Vitamin B_{12}, µg/d	1.4 ± 1.4	0.61 ± 1.62	1.4 ± 1.7	1.1 ± 0.8	0.34 ± 0.49	1.5 ± 2.1
µg/kg/d	0.13 ± 0.14	0.06 ± 0.14	0.13 ± 0.16	0.05 ± 0.04	0.02 ± 0.02	0.07 ± 0.10
Mineral intakes, mg/d						
Iron	6.8 ± 2.2	7.0 ± 1.8	6.8 ± 1.9	10.9 ± 2.4	14.5 ± 2.7	11.9 ± 3.2
Iron from meat, fish, poultry	0.64 ± 0.48	0.05 ± 0.12	0.37 ± 0.36	0.86 ± 0.63	0.09 ± 0.14	0.51 ± 0.53
Zinc	5.2 ± 1.6	3.7 ± 0.9	5.4 ± 1.3	8.0 ± 1.8	7.2 ± 1.4	9.4 ± 2.4
Zinc (µg/kg/d)	473 ± 143	363 ± 86	509 ± 134	355 ± 100	347 ± 58	449 ± 117
Copper	0.85 ± 0.22	0.73 ± 0.18	0.85 ± 0.21	1.29 ± 0.23	1.22 ± 0.25	1.49 ± 0.38
Calcium	218 ± 89	210 ± 99	735 ± 199	301 ± 79	228 ± 65	1311 ± 367
Phosphorus	624 ± 190	556 ± 130	956 ± 246	953 ± 196	1011 ± 177	1711 ± 464
Magnesium	203 ± 68	241 ± 54	236 ± 67	324 ± 69	451 ± 77	439 ± 120
Potassium	1166 ± 317	1582 ± 399	1138 ± 259	1736 ± 287	2354 ± 501	1746 ± 434
Sodium†	1839 ± 940	1383 ± 459	1405 ± 874	2465 ± 959	2124 ± 579	1762 ± 980

TABLE 22. CONT'D

	Toddlers			Schoolers		
	Egypt (N=96)	Kenya (N=100)	Mexico (N=59)	Egypt (N=63)	Kenya (N=138)	Mexico (N=84)
Mineral availability estimates						
Estimated iron availability (at level of basal requirement), %	7.1 ± 2.8	8.7 ± 1.9	5.5 ± 0.8	6.7 ± 2.7	8.1 ± 2.6	5.5 ± 0.9
Available iron, mg/d	0.49 ± 0.27	0.61 ± 0.21	0.37 ± 0.10	0.74 ± 0.35	1.16 ± 0.42	0.64 ± 0.17
Estimated zinc availability (at level of basal requirement), %	23.1 ± 9.9	13.1 ± 2.4	13.2 ± 6.3	21.7 ± 9.5	10.9 ± 1.9	10.9 ± 3.1
Available zinc (at level of basal requirement), µg/kg/d	112 ± 64	47.3 ± 13.4	64.0 ± 24.5	80.7 ± 53.2	37.7 ± 9.4	47.6 ± 11.5

*Preformed niacin + 1/60 tryptophan.
†Sodium estimates do not include salt added to foods after preparation.

TABLE 23: ACROSS-PROJECT CORRELATIONS BETWEEN INTAKES OF NUTRIENTS: TODDLERS AND SCHOOLERS

	TODDLERS			SCHOOLERS		
	Egypt (N=96)	Kenya (N=100)	Mexico (N=59)	Egypt (N=63)	Kenya (N=138)	Mexico (N=84)
Energy: animal -source energy	0.69**	0.39**	0.19	0.69**	0.32**	0.20
Animal-source energy:						
fat	0.87**	0.81**	0.61**	0.83**	0.75**	0.63**
vitamin A	0.67**	0.27**	0.64**	0.60**	0.16	0.43**
riboflavin	0.76**	0.75**	0.93**	0.79**	0.38**	0.84**
vitamin B_{12}	0.48**	0.36**	0.62**	0.31*	0.49**	0.33**
vitamin C	0.34**		0.61**	0.20		0.45**
vitamin E	0.31**		0.24			0.36**
Animal-source protein:						
vitamin A	0.65**	0.33**	0.59**	0.44**	0.19*	0.43**
riboflavin	0.80**	0.78**	0.94**	0.78**	0.40**	0.81**
vitamin B_{12}	0.53**	0.44**	0.59**	0.30*	0.51**	0.36**
vitamin C	0.34**		0.61**			0.46**
vitamin E	0.35**		0.37**		0.18*	0.46**
calcium	0.79**	0.93**		0.60**	0.73**	

Shown if $|r| \geq 0.15$; * $p \leq 0.05$; ** $p \leq 0.01$

TABLE 24: ACROSS-PROJECT NUTRIENT CORRELATIONS WITH SES: TODDLERS AND SCHOOLERS

	Toddlers			Schoolers		
	Egypt (N=96)	Kenya (N=100)	Mexico (N=59)	Egypt (N=63)	Kenya (N=138)	Mexico (N=84)
Nutrients						
Energy	0.15			0.21	0.27**	-0.15
Animal protein	0.44**	0.37**	0.37**	0.31*	0.46**	0.43**
Fat	0.44**	0.32**	0.23	0.36**	0.41**	0.22*
Dietary fiber		-0.31**	-0.18			-0.44**
Iron		-0.27**				-0.38**
Zinc	0.23*				0.25**	-0.29**
Calcium	0.44**	0.29**		0.30*	0.30**	-0.31**
Vitamin A	0.47**		0.31*	0.41**		0.21
Vitamin C	0.18		0.22			
Thiamin		-0.18				-0.17
Riboflavin	0.27**	0.18	0.36**	0.30*	0.23**	0.29**
Niacin		-0.17				-0.30**
Folate		-0.25**			0.15	-0.34**
Vitamin B_{12}	0.43**		0.31*	0.30*	0.31**	0.24*
Vitamin B_6				0.19	0.20*	-0.26*

Shown if $|r| \geq 0.15$. * $p<0.05$; ** $p<0.01$

TABLE 25: PREDICTED PREVALENCE OF INADEQUATE NUTRIENT INTAKES (PERCENT)

	Toddlers			Schoolers		
	Egypt (N=96)	Kenya (N=100)	Mexico (N=59)	Egypt (N=63)	Kenya (N=138)	Mexico (N=84)
Protein	0.0	2.2	0.0	0.0	0.0	0.0
Iron, basal	65.3	36.2	88.5	70.4	31.4	87.3
Iron, prevent anemia	36.1	12.6	43.1	43.1	7.7	40.6
Zinc, normative	35.6	90.2	67.7	23.6	78.6	42.8
Zinc, basal	9.8	57.0	25.2	3.5	29.5	9.2
Copper, normative	0.0	0.0	0.0	0.0	0.0	0.0
Copper, basal	0.0	0.0	0.0	0.0	0.0	0.0
Calcium	89.6	87.9	1.7	69.3	91.2	0.0
Phosphorus	1.8	6.5	0.1	0.0	0.0	0.0
Magnesium	0.0	0.0	0.0	0.0	0.0	0.0
Thiamin	1.4	0.0	5.9	0.0	0.0	7.4
Riboflavin	20.4	1.9	51.7	16.3	1.6	83.4
Niacin	0.0	0.0	0.0	0.0	0.0	0.0
Folate	0.0	0.0	0.0	0.0	0.0	0.0
Vitamin B_{12}	3.2	44.2	8.0	23.6	86.9	38.3
Vitamin B_6	0.0	0.0	0.5	0.0	0.0	0.0
Vitamin C	3.1	1.2	62.7	1.6	0.0	34.6
Vitamin A, normative	32.5	12.3	67.6	34.2	6.2	61.5
Vitamin A, basal	2.2	0.4	19.5	9.2	0.6	24.4
Vitamin D	100.0	100.0	100.0	100.0	100.0	100.0
Vitamin E	21.5	85.1	91.8	4.5	43.5	86.0

Mexico and Kenya toddlers, particularly the latter, appear to have potentially serious problems of inadequacy of zinc intake if current estimates of basal requirements are correct. Kenya schoolers also are at high risk of low normative intakes. Again the impact of other dietary factors is apparent. Mean daily zinc intakes are similar in Egypt and Mexico children. However, the diets in Mexico provide almost double the intake of phytic acid, an antagonist of zinc utilization, which accounts for the low level of utilizable zinc in Mexico. In Kenya the estimated absolute levels of zinc ingested are low as is the estimated availability of dietary zinc.

The vitamins at highest risk (> 10% prevalence) are riboflavin and vitamin A (except in Kenya), vitamin B_{12} (except in Egypt and Mexico toddlers) and vitamin C (in Mexico, especially toddlers). It is of concern that inadequacy of several nutrients not only persists between toddler and schooler ages, but in some cases it worsens: predicted riboflavin inadequacy is 52% in Mexico toddlers' diets and 83% in the schoolers'; estimates for vitamin B_{12} are 44% in Kenya toddlers and 87% in schoolers, and 3% and 24% in the respective Egypt diets. Vitamin C is the only vitamin that seems to be better supplied, relative to requirement, in the schooler diet.

Vitamin D is inadequate in all diets but may be clinically sufficient with exposure to sunlight. The vitamin E risk is estimated to be high but the requirements figures are not established with reliability. When the adequacy of vitamin E was evaluated as a ratio of 0.4 mg α TE/g PUFA, predicted inadequacy of toddler diets fell to 0 in Egypt and Kenya, but remained high in Mexico. Only one diet of the 59 Mexico toddlers met this requirement.

ALTERNATIVE CALCULATIONS, TODDLER DIETS

Protein

When toddler protein requirement was increased to the level set by FAO/WHO/UNU (14) for children of the *height-age* (rather than chronological age) of our sample populations (16 mo.), the predicted prevalence of inadequacy increased very little -- to 0.01% in Egypt, to 2.8% in Kenya, and to 0.06% in Mexico.

Because energy intake is low in Kenya, we examined the question of whether or not the risk of protein inadequacy would exist if the toddlers ate enough of the same diet to meet the FAO/WHO/UNU guidelines; the predicted prevalence of inadequacy fell to 0.5%. Another alternative would be to raise the level of the limiting amino acid, increasing the estimated utilizable protein. Simulated supplementation of 20 mg lysine and 2 mg tryptophan/kg body weight reduced the apparent prevalence of inadequate intakes to 0.75%.

Minerals

The iron:energy ratios of Kenya toddler diets were examined to determine if the predicted prevalence of low iron intakes would change if energy intakes satisfied estimates of energy needs. The prevalence of Kenya toddler intakes likely to be inadequate to prevent anemia, fell to about 5% and the prevalence of intakes judged too low to meet basal requirements, fell to about 19%. When a comparable exercise was undertaken for zinc, the expected prevalence was 30% for basal requirements and 71% for normative needs. The quality of the diet would remain critical for zinc but much less so for iron if energy intake from the same mixture of foods were increased.

Vitamins

Of the three B vitamins for which requirement is stipulated in relation to energy intake, only riboflavin is estimated to be at some risk of inadequacy in all three sites. Toddler intakes were re-evaluated with a floor of 0.35 mg/d applied to all diets with energy intake below 800 kcal/d. Introduction of the floor has almost no effect in Egypt and Mexico because relatively few diets fall below the energy cut-point, but the predicted prevalence of inadequate intake of riboflavin increased to 9% in Kenya.

The analysis was repeated using alternative requirements for riboflavin. Lowering the requirement per unit of energy to a "basal" level (0.34 mg/1000 kcal) decreased predicted inadequacy from 52% to 22% in Mexico, from 20% to 1.5% in Egypt and from 2% to 0.1% in Kenya. When requirement was related to body weight (and not to energy intake), the predicted prevalence of inadequate diets is 6% in Mexico and about 1% in Egypt and Kenya.

Thiamin intakes appear to be adequate in Kenya and at low risk in Egypt irrespective of the basis of calculation. The predicted prevalence of inadequacy rose slightly from 6% to 8% with a floor requirement in Mexico.

With the niacin equivalents derived from tryptophan included in the calculation, the predicted prevalence of niacin inadequacy is essentially zero in all three groups, with or without a floor allowance. Adjustment of dietary preformed niacin intake to reflect its 30% availability in mature maize reduces the estimated niacin intake in Kenya from 7.2 ± 4.6 mg/1000 kcal to 4.8 ± 3.3 mg/1000 kcal; the predicted prevalence of inadequate intakes, based on preformed niacin only, increases to 78%. With available tryptophan equivalents added, the effective intake is 9.1 ± 6.8 mg NE/1000 kcal and the predicted prevalence of inadequacy remains low, 0.05% without and 2.6% with a floor.

The predicted prevalence of inadequacy of vitamin B_{12} intake is high (44%) in Kenya toddler diets. If energy intakes from existing diets were increased to meet suggested requirements, predicted prevalence of inadequacy is reduced but still substantial, 33%. Given the even higher estimate of inadequacy in schooler diets, where energy intakes are closer to standard, simply adding more of the same food would not be sufficient.

The Kenya toddler food intake data set includes 49 children whose records include at least six days (mean 11.5 ± 3.8 d) when no animal-source food was consumed and at least six days (mean 13.0 ± 4.4 d) when it was (irrespective of amount consumed). The nutrient content of the diets with and without animal products was computed. Energy intake did not differ significantly, being 826 ± 185 kcal/d without and 839 ± 182 kcal/d with animal foods. On days with animal food, the energy from animal sources averaged 80 ± 40 kcal/d and the animal protein averaged 4.9 ± 3.0 g/d, 20% of total protein. Nutrients that differed significantly with inclusion of animal products are as follows:

Increased: riboflavin, vitamin B_{12}, vitamin D, calcium, phosphorus, fat, protein and the essential amino acids.
Decreased: total iron, magnesium, fiber and phytic acid

The difference in lysine intake is approximately 35 mg/kg toddler body weight and that of tryptophan is 5 mg/kg, amounts that significantly increase the amino acid score and raise the utilizable protein level. The increase in heme iron, and animal protein, together with a reduction of fiber and phytic acid would improve iron and zinc utilizability as well. These observations show that the answer to nutrient adequacy issues is likely to be found in analysis of food intake patterns.

COMPARISON OF IRON INTAKES AND BLOOD MEASURES OF IRON STATUS FOR TODDLERS

Anemia, as defined by low blood hemoglobin (< 100 g/L in Egypt, < 115 g/L in Kenya and < 120 g/L in Mexico), was prevalent in all three locations: 73.5% of toddlers in Egypt, 74.3% in Kenya, and 62.1% in Mexico. Low iron stores, as defined by low serum ferritin values (< 10 µg/L) was less prevalent: 38.2%, 40.0%, and 44.8% in Egypt, Kenya, and Mexico respectively. The prevalence of iron deficiency anemia (presence of anemia as well as low iron stores) was 29.4%, 30.0% and 31.0%.[7] The predicted prevalence of iron intakes inadequate to prevent anemia (Table 25) is similar to the prevalence of iron deficiency anemia in Egypt (35.3% vs. 29.4%) and Mexico (43.1% vs. 31.0%) but less so in Kenya (12.5% vs. 30.0%); it seems likely that the role of ascorbic acid in enhancing non-heme iron absorption in the Kenya diet is over-estimated in the iron bioavailability algorithm.

Correlations of iron intakes (total iron, meat/fish/poultry iron, and available iron calculated using the previously described bioavailability algorithm) with iron status measures (hemoglobin, hematocrit, and ferritin) were examined. In general, the correlation coefficients were low, but several relationships are noteworthy. Total iron intake and available iron intake were significantly correlated with serum ferritin for Kenya toddlers ($r = 0.32$ to 0.34, $p < 0.01$). Total iron intake was negatively correlated with hemoglobin in Mexico ($r = -0.31$, $p = 0.07$) and with hematocrit in Egypt ($r = -0.32$, $p = 0.004$) while available iron was not significantly associated with any measures in Egypt or Mexico. Meat/fish/poultry iron was significantly associated with iron status measures only in Egypt ($r = 0.26$ with hemoglobin, $p = 0.01$).

FOOD GROUP INTAKE

Mean intakes from each of the 26 food groups by toddlers and schoolers in each country are shown in Table 26. Intakes are expressed as calories per day to adjust for differences in energy density among food items within each group; thus, for example, 100 g of powdered milk will contribute more calories to the group than 100 g of fresh milk. Consumption of foods of low calorie density (fruits, vegetables, coffee and tea) is expressed as grams per day. Maize was the primary staple in both Kenya and Mexico, while wheat, maize, and rice were all frequently consumed in Egypt. Intakes of most foods were highest in Egypt, with the exception of mature beans and milk. Food group consumption was remarkably similar in Kenya and Mexico, although fat intakes were higher in Mexico, while fruit/vegetable intakes were higher in Kenya. Consumption of most foods was greater for schoolers than for toddlers within a country, although important differences were seen: less milk in Kenya and Mexico, less plantain and rice in Kenya, less grain desserts and tea in Egypt. The distribution of calories among the groups can be seen more easily in Table 27, where calorie contributions are expressed as percent of total intake. In Kenya and Mexico, almost half the toddlers' calories were from maize and over 60% of the schoolers' calories. The percent of calories from sweets tended to be equal to or greater than calories from fats, except for Egypt schoolers. Only a small proportion of calorie intake was from animal-source foods, with Egypt reporting the highest intakes (17.9% for toddlers) and Kenya the lowest (3.2% for schoolers). In all three countries, schoolers obtained a lower percent of energy from animal foods than did toddlers.

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[7] Prevalence of low iron measures was estimated for toddlers in the analytic sample who had at least one hemoglobin measure and one ferritin measure (N = 34 in Egypt, 70 in Kenya, and 29 in Mexico).

TABLE 26: ACROSS-PROJECT FOOD GROUP INTAKES*: TODDLERS AND SCHOOLERS (MEAN ± SD)

	Toddlers			Schoolers		
	Egypt (N=96)	Kenya (N=100)	Mexico (N=59)	Egypt (N=63)	Kenya (N=138)	Mexico (N=84)
Staples						
Plantain/bananas	1 ± 3	89 ± 52	7 ± 13	0 ± 2	53 ± 44	4 ± 11
Cassava/white sweet pot.	4 ± 6	26 ± 33	NC	2 ± 5	28 ± 42	NC
Maizemeal and maize	169 ± 105	369 ± 138	551 ± 244	291 ± 127	877 ± 196	1185 ± 394
Wheat, whole	99 ± 47	NC	NC	180 ±57	NC	NC
Wheat, white, unenr	193 ± 68	24 ± 31	75 ± 55	358 ± 104	26 ± 31	97 ± 83
Rice	126 ± 55	41 ± 52	26 ± 20	187 ± 87	29 ± 47	28 ± 26
Other grains	NC	11 ± 20	1 ± 3	NC	8 ± 14	1 ± 3
Potatoes, white	34 ± 20	34 ± 31	14 ± 9	50 ± 26	32 ± 32	17 ± 13
Fruits/vegetables						
Leafy green vegetables	9 ± 7	41 ± 24	4 ± 5	16 ± 12	73 ± 32	10 ± 11
High vit. A, low vit. C	0 ± 1	0 ± 2	0 ± 1	0 ± 1	0 ± 2	0 ± 2
High vit. C, low vit. A	79 ± 41	17 ± 15	21 ± 13	109 ± 43	27 ± 24	25 ± 17
High vit. A and C	1 ± 3	13 ± 17	1 ± 13	1 ± 2	21 ± 22	2 ± 5
Low vit. A and C	50 ± 26	4 ± 6	23 ± 13	80 ± 35	6 ± 8	38 ± 25
Dairy						
Milk	24 ± 17	59 ± 49	64 ± 70	25 ± 18	35 ± 26	37 ± 60
Cheese	35 ± 29	NC	2 ± 3	47 ± 31	0 ± 1	3 ± 7
Legumes/nuts						
Nuts/seeds	6 ± 11	0 ± 1	0 ± 1	7 ± 9	0 ± 1	1 ± 2
Mature beans, peas	43 ± 21	83 ± 42	80 ± 50	62 ± 29	201 ± 85	121 ± 63
Meat/eggs						
Meat/fish/poultry	71 ± 38	5 ± 9	31 ± 20	98 ± 45	11 ± 17	42 ± 29
Eggs	14 ± 15	1 ± 2	29 ± 21	13 ± 14	0 ± 1	34 ± 24
Fats						
Vegetable fat	87 ± 39	28 ± 20	82 ± 51	125 ± 50	40 ± 26	104 ± 66
Milk fat and lard	51 ± 36	1 ± 3	13 ± 20	65 ± 41	1 ± 4	16 ± 26
Other animal fat	24 ± 14	0 ± 1	3 ± 4	36 ± 22	0 ± 1	6 ± 9

TABLE 26. CONT'D

	Toddlers			Schoolers		
	Egypt (N=96)	**Kenya (N=100)**	**Mexico (N=59)**	**Egypt (N=63)**	**Kenya (N=138)**	**Mexico (N=84)**
Sweets						
Sugar, candy, soda	123 ± 47	50 ± 30	75 ± 44	125 ± 42	51 ± 28	85 ± 53
Grain desserts	51 ± 46	NC	36 ± 68	14 ± 21	NC	27 ± 62
Beverages						
Beer, wine, pulque	NC	NC	6 ± 22	NC	NC	17 ± 58
Coffee, tea	176 ± 169	70 ± 125	61 ± 57	155 ± 83	68 ± 67	123 ± 166

*Mean kcal/d except mean g/d for fruit/vegetable groups and for coffee/tea.
NC = not consumed

TABLE 27: PERCENT OF ENERGY INTAKE FROM EACH FOOD GROUP: TODDLERS AND SCHOOLERS

	Toddlers			Schoolers		
	Egypt (N=96)	**Kenya** (N=100)	**Mexico** (N=59)	**Egypt** (N=63)	**Kenya** (N=138)	**Mexico** (N=84)
Staples						
Plantain/bananas	0.0	10.6	0.7	0.0	3.7	0.3
Cassava/white sweet pot.	0.3	3.2	NC	0.1	2.0	NC
Maizemeal and maize	13.5	43.7	48.9	16.3	61.5	63.6
Wheat, whole	8.0	NC	NC	10.2	NC	NC
Wheat, white, unenr	16.0	2.7	6.7	20.3	1.8	5.4
Rice	10.7	4.8	2.3	10.6	1.9	1.5
Other grains	NC	1.3	0.1	NC	0.6	0.1
Potatoes, white	2.9	4.1	1.3	2.9	2.1	0.9
Fruits/vegetables	4.3	3.1	1.3	4.5	3.3	1.4
Dairy						
Milk	2.0	6.8	6.1	1.5	2.4	2.0
Cheese	2.8	NC	0.2	2.6	NC	0.1
Legumes/nuts						
Nuts/seeds	0.5	0.0	0.0	0.4	0.0	0.0
Mature beans, peas	3.7	9.9	7.4	3.6	13.8	6.5
Meat/eggs						
Meat/fish/poultry	5.8	0.5	2.8	5.5	0.7	2.3
Eggs	1.1	0.2	2.5	0.7	0.0	1.9
Fats						
Vegetable fats	7.4	3.2	7.3	7.3	2.7	5.7
Milk fat and lard	4.2	0.1	1.2	3.6	0.1	0.9
Other animal fat	2.0	0.0	0.3	2.0	0.0	0.4
Sweets						
Sugar, candy, soda	10.4	5.8	6.8	7.1	3.6	4.7
Grain desserts	4.4	NC	3.5	0.8	NC	1.5
Pulque	NC	NC	0.6	NC	NC	0.8

NC = not consumed

Tables 28 to 30 show partial correlations between nutrient intakes and food group intakes for each project, after adjusting for energy intakes. Correlations would be expected to be high if a food group is a good source of a nutrient (e.g., milk and calcium), and also if a food frequently consumed in the same diet is a good source of a nutrient (e.g., tea and calcium for Kenya schoolers because tea is often consumed with milk). Negative correlations would be expected when one food displaces another that is a good source of a nutrient (e.g., maize is negatively associated with animal protein in all three countries, because children who consume more maize consume less animal-source foods).

Table 31 gives the associations between the project-specific measures of SES and food group intakes of toddlers and schoolers. As would be expected, children from families in higher SES categories generally consumed more foods which were costly to produce or purchase, including animal-source foods (milk, cheese, meats, eggs, and animal fats), sugar and sweets, rice, potatoes, and wheat. Children in these families were generally less likely to consume inexpensive food items such as maize, legumes, and leafy green vegetables.

Principal component analyses of the foods in children's diets can give insight into dietary patterns. The first two patterns (components) for toddlers and schoolers in each country are shown in Tables 32 to 34. Since 26 food groups are being used in the analysis, any pattern that explains more than 4% of the variance in consumption can be considered as having some useful explanatory power. In these analyses, dietary pattern 1 explained 16 to 20% of the variance while pattern 2 explained 10 to 13% of the variance; thus, both may be considered as useful composite variables. The loadings (coefficients, as shown in parentheses) for the food groups indicate which contributes the most to each pattern (i.e., which are relatively consumed the most or, in the case of negative loadings, which are relatively consumed the least). There is remarkable consistency between patterns for toddlers and schoolers within a country, and to some extent, across countries as well. Pattern 1 has positive loadings for milk and meat/fish/poultry, and a negative loading for maize in both Kenya and Mexico for both age groups. In Egypt, pattern 1 also shows positive loading for meat/fish/poultry, and dairy products (cheese). Pattern 2 tends to have high loadings for locally produced foods such as maize, leafy green vegetables, and fruits and vegetables high in vitamin C (e.g., mangos in Kenya), and negative loadings for dairy products.

For each child, a score can be obtained which is a function of the child's mean intake from each food group and the loading for that food group, summed across all food groups. These scores (one for each pattern) can then be examined in relation to other variables of interest. Scores on pattern 1 are very significantly positively correlated with SES in all locations (r = 0.31 to 0.54). By comparison, scores on pattern 2 are negatively correlated with SES for all but Egypt schoolers, but the association is significant only for Egypt toddlers (r = -0.36).

Scores on the dietary patterns also are associated with energy intake but the relationship varies among the countries. Pattern 1 is highly correlated with energy intake in Egypt toddlers and schoolers (r = 0.87 to 0.90), to a lesser degree in Kenya toddlers and schoolers (r = 0.37 to 0.41), and not at all in Mexico (r = 0.09 to 0.20). However, pattern 2 is highly correlated with energy intake in Mexico toddlers and schoolers (r = 0.65 to 0.66), somewhat in Kenya toddlers (r = 0.46), and not at all for Egypt (r = 0.12 to 0.14) or for Kenya schoolers (r = -0.15).

TABLE 28: PARTIAL CORRELATIONS BETWEEN NUTRIENT INTAKES AND FOOD GROUP INTAKES (ENERGY CONTROLLED): EGYPT TODDLERS AND SCHOOLERS†

	Plantain/ Banana	Cassava	Maize	Wheat, Whole	Wheat, White	Rice	Other Grains	Potatoes	Leafy Veg	High A F/V	High C F/V	High A &C F/V	Low A &C F/V
Toddlers													
Animal protein			-0.41	-0.31	-0.24			-0.41					
Fat			-0.64	-0.63	-0.27	0.21		-0.28					0.22
Dietary fiber	0.34		0.84	0.76		-0.30		0.32			0.33		-0.25
Iron	0.32		0.67	0.58		-0.22					0.29		-0.25
Zinc			0.20	0.34	-0.24			-0.20					
Calcium			-0.39	-0.45				-0.38					0.24
Vitamin A			-0.35	-0.41				-0.26				0.22	0.23
Vitamin C	0.43										0.76	0.26	0.37
Thiamin	0.40		0.84	0.76		-0.41		0.38			0.36		
Riboflavin	0.25		0.21			-0.28		-0.21					
Niacin	0.38		0.61	0.68		-0.28		0.22			0.38		
Folate	0.36		0.55	0.49					0.23		0.37		-0.24
Vitamin B_{12}			-0.33	-0.35				-0.20					
Vitamin B_6	0.60		0.54	0.55		-0.24		0.48			0.59		
Schoolers													
Animal protein					-0.25			-0.30					
Fat			-0.36	-0.49									
Dietary fiber			0.61	0.62	-0.29								
Iron			0.26	0.49									
Zinc			0.36	0.39	-0.28			-0.38					-0.26
Calcium		0.31	-0.25										
Vitamin A				-0.26					0.46	0.26	0.50		
Vitamin C			-0.29								0.85		
Thiamin			0.60	0.74		-0.39							
Riboflavin			0.50	0.46	-0.45	-0.36							
Niacin			0.48	0.63									-0.26
Folate				0.35							0.29		
Vitamin B_{12}											0.41		
Vitamin B_6			0.39	0.41	-0.40			0.55					

†Correlations are shown if $p \leq 0.05$.

TABLE 28, CONT'D†

	Milk	Cheese	Nuts Seeds	Beans	Meat/ Poult	Eggs	Veg Fat	Milk fat/lard	Other fat	Sugar	Grain desserts	Pulque	Coffee Tea
Toddlers													
Animal protein	0.29	0.51	0.26	-0.35	0.74	0.36		0.55	0.24	0.37		NC	
Fat		0.53	0.25	-0.27	0.54		0.38	0.64					
Dietary fiber		-0.44	-0.24	0.40	-0.50			-0.46		-0.40	-0.20		
Iron		-0.34		0.39	-0.21		-0.27	-0.26		-0.34	-0.25		
Zinc					0.54		-0.31			-0.29	-0.21		
Calcium	0.49	0.86		-0.21			-0.20	0.73		0.20			
Vitamin A		0.37			0.37	0.32		0.42		0.22			
Vitamin C													
Thiamin		-0.35		0.27	-0.43		-0.24	-0.38		-0.40	-0.26		
Riboflavin	0.43	0.32				0.49	-0.39	0.32			-0.29		
Niacin	-0.27	-0.35					-0.23	-0.37		-0.39	-0.25		
Folate		-0.36		0.71	-0.35		-0.23	-0.31		-0.31			
Vitamin B_{12}	0.20				0.39	0.28		0.23		0.28			
Vitamin B_6		-0.33	-0.22					-0.35		-0.36	-0.33		
Schoolers													
Animal protein	0.29	0.29		-0.43	0.70	0.45	-0.39	0.45					
Fat		0.32		-0.29	0.39	0.44	0.33	0.42	0.32				
Dietary fiber				0.32	-0.28		-0.32		-0.34		-0.28		
Iron							-0.40				-0.26		
Zinc					0.58		-0.58						
Calcium		0.79						0.38		0.32			
Vitamin A		0.29				0.38		0.49					
Vitamin C													
Thiamin							-0.39		-0.36		-0.34		
Riboflavin	0.41	0.27				0.41	-0.56	0.50			-0.26		
Niacin							-0.42				-0.35		
Folate			0.30	0.76									
Vitamin B_{12}	0.32	0.27			0.26	0.27		0.38			-0.39		
Vitamin B_6													

†Correlations are shown if $p \leq 0.05$.

TABLE 29: PARTIAL CORRELATIONS BETWEEN NUTRIENT INTAKES AND FOOD GROUP INTAKES (ENERGY CONTROLLED): KENYA TODDLERS AND SCHOOLERS†

	Plantain/ Banana	Cassava	Maize	Wheat, Whole	Wheat, White	Rice	Other Grains	Potatoes	Leafy Veg	High A F/V	High C F/V	High A &C F/V	Low A &C F/V
Toddlers													
Animal protein			-0.52		0.20	0.26			-0.20	0.36		-0.23	
Fat		-0.27	-0.50		0.20	0.34			-0.21	0.45		-0.23	
Dietary fiber	-0.26		0.79		-0.34	-0.63		-0.48	0.58	-0.21			
Iron	-0.37		0.78		-0.29	-0.62		-0.54	0.44	-0.20			
Zinc	-0.65		0.68		-0.32	-0.37	0.27	-0.59	0.25				
Calcium			-0.50										
Vitamin A					0.23				0.48		0.31	0.25	
Vitamin C	0.41	0.41	-0.20			-0.24	-0.22		0.53		0.67	0.38	
Thiamin	-0.34		0.73		-0.40	-0.64		-0.36	0.35	-0.25			
Riboflavin		0.23	-0.21										
Niacin			0.75		-0.38	-0.65		-0.23	0.41	-0.23			
Folate			0.22			-0.41		-0.23	0.44				
Vitamin B_{12}			-0.23		0.31								
Vitamin B_6	0.72	0.46	-0.35			-0.20		0.52					
Schoolers													
Animal protein			-0.71		0.36	0.44		0.37	-0.21	0.42	0.19		
Fat		-0.29	-0.64		0.44	0.45		0.39		0.46			
Dietary fiber	-0.16		0.63		-0.57	-0.64		-0.30	0.44	-0.35	-0.22		
Iron			0.37		-0.59	-0.65		-0.21		-0.26	-0.38		
Zinc	-0.40	-0.24	0.26		-0.44	-0.34	0.18		-0.18		-0.42	-0.23	
Calcium	0.27	0.22	-0.66		0.22	0.28		0.29	0.22	0.38	0.38		
Vitamin A	0.34		-0.23				-0.19		0.68		0.25	0.48	
Vitamin C	0.43	0.55	-0.17						0.64		0.62	0.32	
Thiamin			0.56		-0.55	-0.65		-0.27		-0.33	-0.28		0.21
Riboflavin		0.63			-0.21	-0.20		-0.18	0.35		0.28		0.31
Niacin		0.26	0.77		-0.51	-0.60		-0.30	0.30	-0.44			0.26
Folate	0.32		-0.26		-0.26	-0.35					-0.19	0.20	
Vitamin B_{12}			-0.26										0.28
Vitamin B_6	0.60	0.57	-0.26		-0.24	-0.27		0.39	0.41				

†Correlations are shown if $p \leq 0.05$

TABLE 29. CONT'D†

	Milk	Cheese	Nuts Seeds	Beans	Meat/ Poult	Eggs	Veg Fat	Milk fat/lard	Other fat	Sugar	Grain desserts	Pulque	Coffee Tea
Toddlers													
Animal protein	0.95			-0.30	0.21		0.31			0.36			0.23
Fat	0.77			-0.29	0.27		0.71			0.23			
Dietary fiber	-0.61			0.54			-0.55			-0.57			
Iron	-0.57			0.69			-0.52			-0.53			
Zinc				0.59			-0.38			-0.54			
Calcium	0.96			-0.20									
Vitamin A					0.42								0.70
Vitamin C													0.25
Thiamin	-0.47			0.60	-0.21		-0.62			-0.51			
Riboflavin	0.71												0.47
Niacin	-0.66			0.27			-0.54			-0.45			
Folate	-0.33			0.86			-0.29			-0.38			
Vitamin B_{12}	0.20				0.50		0.24		0.25				0.86
Vitamin B_6													
Schoolers													
Animal protein	0.81				0.75	0.18	0.55	0.27	0.32	0.43			0.25
Fat	0.60				0.70	0.22	0.87	0.34	0.41	0.41			0.24
Dietary fiber	-0.58				-0.38	-0.24	-0.62			-0.58			-0.20
Iron	-0.37			0.58	-0.29	-0.37	-0.54			-0.44			-0.19
Zinc				0.52	0.24	-0.36	-0.31	0.17	0.19	-0.27			
Calcium	0.81				0.23	0.21	0.38			0.27			0.33
Vitamin A					0.17		0.24						
Vitamin C				-0.29									
Thiamin	-0.44				-0.40	-0.30	-0.66			-0.52			
Riboflavin	0.32			-0.21			-0.25			-0.23			
Niacin	-0.65			-0.34	-0.32	-0.25	-0.68			-0.60			-0.18
Folate				0.82									
Vitamin B_{12}	0.34				0.44		0.20			0.17			
Vitamin B_6										-0.24			

†Correlations are shown if $p \leq 0.05$.

TABLE 30: PARTIAL CORRELATIONS BETWEEN NUTRIENT INTAKES AND FOOD GROUP INTAKES (ENERGY CONTROLLED): MEXICO TODDLERS AND SCHOOLERS†

	Plantain/ Banana	Cassava	Maize	Wheat, Whole	Wheat, White	Rice	Other Grains	Potatoes	Leafy Veg	High A F/V	High C F/V	High A &C F/V	Low A &C F/V
Toddlers													
Animal protein	0.55		-0.77		0.31				-0.35	0.31	0.47	0.43	
Fat	0.44		-0.66							0.26	0.55	0.30	
Dietary fiber	-0.51		0.71		-0.41	-0.30			0.31		-0.39	-0.27	
Iron	-0.41		0.41		-0.34								
Zinc	-0.38		0.70		-0.51	-0.36					-0.33		
Calcium			0.49		-0.34	-0.33					-0.37		
Vitamin A	0.58		-0.47							0.32	0.39	0.61	
Vitamin C	0.77		-0.55							0.39	0.82	0.65	0.29
Thiamin			-0.26								0.27	0.33	0.26
Riboflavin	0.60		-0.77		0.31				-0.39	0.34	0.44	0.50	
Niacin	-0.33		0.75		-0.51	-0.40			0.30		-0.37		
Folate													
Vitamin B_{12}	0.50		-0.45						-0.26		0.35	0.48	
Vitamin B_6			0.30		-0.47	-0.26						0.31	0.32
Schoolers													
Animal protein	0.48		-0.70		0.25						0.48	0.35	
Fat	0.32		-0.69			0.25			-0.25		0.50	0.26	
Dietary fiber	-0.39		0.67		-0.39	-0.34			0.35		-0.38	-0.35	
Iron	-0.25		0.43		-0.36	-0.36			0.36		-0.33	-0.28	
Zinc	-0.27		0.70		-0.54	-0.30			0.32		-0.28	-0.39	
Calcium	-0.27		0.68		-0.44	-0.35			0.35		-0.32	-0.28	
Vitamin A	0.44		-0.37							0.25	0.29	0.33	0.23
Vitamin C	0.68		-0.40						0.24		0.66	0.69	0.47
Thiamin			-0.23			-0.23							0.23
Riboflavin	0.49		-0.77		0.32				-0.22		0.41	0.33	
Niacin			0.61		-0.39	-0.37			0.32		-0.28		
Folate						-0.23			0.36				
Vitamin B_{12}	0.35		-0.27								0.21		0.29
Vitamin B_6			0.40		-0.43	-0.30			0.49				0.31

†Correlations are shown if $p \leq 0.05$.

TABLE 30. CONT'D†

	Milk	Cheese	Nuts Seeds	Beans	Meat/ Poult	Eggs	Veg Fat	Milk fat/lard	Other fat	Sugar	Grain desserts	Pulque	Coffee Tea
Toddlers													
Animal protein	0.87	0.42		-0.39	0.64	0.34		0.27	0.43	0.38	0.32		
Fat	0.55			-0.37	0.52	0.41	0.68	0.28	0.36				
Dietary fiber	-0.71	-0.26		0.75	-0.45			-0.30	-0.41	-0.48	-0.47		
Iron	-0.59			0.87	-0.29				-0.32	-0.38	-0.29	0.27	
Zinc	-0.43			0.52			-0.37			-0.59	-0.48		
Calcium							-0.39	-0.31	-0.35	-0.45			
Vitamin A	0.50	0.27		-0.26	0.61			0.42	0.38				
Vitamin C	0.49				0.49			0.32	0.29				
Thiamin	0.26			0.58						-0.30	0.30		
Riboflavin	0.92	0.36		-0.33	0.46	0.28			0.30	0.28	0.46		
Niacin	-0.54					-0.36	-0.34			-0.60	-0.36	0.39	
Folate	-0.29			0.95									
Vitamin B_{12}	0.46			-0.27	0.63			0.42	0.41				
Vitamin B_6				0.36						-0.43	-0.42		-0.34
Schoolers													
Animal protein	0.78	0.50		-0.31	0.72	0.42	0.32	0.33	0.36	0.24	0.39		
Fat	0.51	0.40		-0.22	0.54	0.54	0.79	0.23	0.38	0.24	0.34	-0.23	
Dietary fiber	-0.60	-0.27		0.74	-0.54		-0.23	0.40	-0.37	-0.34	-0.58		
Iron	-0.45	-0.22		0.71	-0.26	-0.28	-0.23			-0.49	-0.40	0.38	
Zinc	-0.35			0.44			-0.29	-0.32		-0.55	-0.51		
Calcium						-0.27	-0.47	-0.32		-0.59	-0.32		
Vitamin A	0.33	0.25			0.38		0.23		0.23		0.27		
Vitamin C	0.29				0.44			0.31				0.34	
Thiamin	0.30			0.59						-0.24			
Riboflavin	0.92	0.58			0.37	0.42	0.22	0.25		0.23	0.57		
Niacin	-0.48	-0.28				-0.44	-0.35			-0.54	-0.34	0.43	
Folate				0.93	-0.36				-0.32		-0.29		
Vitamin B_{12}	0.28				0.32		0.23						
Vitamin B_6	-0.30					-0.27				-0.62	-0.41	0.48	

†Correlations are shown if $p \leq 0.05$.

TABLE 31: ACROSS-PROJECT FOOD GROUP CORRELATIONS WITH SES: TODDLERS AND SCHOOLERS†

		Toddlers			Schoolers	
	Egypt (N=96)	Kenya (N=100)	Mexico (N=59)	Egypt (N=63)	Kenya (N=138)	Mexico (N=84)
Staples						
Plantain/bananas			0.18	-0.18		0.27*
Cassava/white sweet pot.						
Maizemeal and maize		-0.27**	-0.17			-0.43**
Wheat, whole						
Wheat, white, unenr		0.21*	0.37**			0.30**
Other grains						
Potatoes, white		0.18		0.17	0.35**	
Rice		0.29**		0.20	0.34**	0.22*
Fruits/vegetables						
Leafy green vegetables		-0.27**	-0.20		-0.23**	-0.25*
High vit. A, low vit. C					0.25**	0.20
High vit. C, low vit. A			0.29*	0.21		0.33**
High vit. A and C	0.18		0.20			0.26*
Low vit. A and C	0.25*		0.17	0.29*		
Dairy						
Milk		0.37**	0.34**		0.43**	0.42**
Cheese	0.48**		0.15	0.28*		
Legumes/nuts						
Nuts/seeds		0.15				
Mature beans, peas	-0.25*	-0.22*	-0.23	-0.33**	0.25**	-0.35**
Meat/eggs						
Meat/fish/poultry	0.38**		0.37**	0.18	0.32**	0.32**
Eggs	0.32**	0.23*		0.51**		
Fats						
Vegetable fat		0.24*			0.35**	0.20
Milk fat and lard	0.49**		0.18	0.40**		0.24*
Other animal fat			0.31*			0.25*
Sweets						
Sugar, candy, soda		0.33**	0.31*		0.32**	0.31**
Grain desserts			0.18			0.34**
Beverages						
Beer, wine, pulque						-0.20
Coffee, tea		0.23*	0.17	-0.18		-0.16

†Correlation coefficients are shown if $|r| \geq 0.15$; significance levels are for $p<0.05$*, $p \leq 0.01$**

TABLE 32: DIETARY PATTERNS FOR EGYPT CHILDREN; RESULTS FROM PRINCIPAL COMPONENT ANALYSES OF FOOD GROUP INTAKES (LOADINGS > 0.20 SHOWN)

	Toddlers	**Schoolers**
Pattern 1	Milk fat (0.33) Wheat, whole (0.32) Cheese (0.32) Maize (0.30) Wheat, white (0.30) Meat/fish/poultry (0.30) Eggs (0.28) High C F/V (0.26) Low A & C F/V (0.24) Other animal fat (0.21) Sugar (0.20)	Milk fat (0.39) Maize (0.34) Meat/fish/poultry (0.33) Wheat, whole (0.32) Cheese (0.31) Eggs (0.29) Sugar (0.29) Wheat, white (0.23) Other animal fat (0.21)
Percent of variance explained:	16.9%	16.6%
Pattern 2	Potatoes (0.40) Maize (0.33) Wheat, whole (0.33) Milk fat (-0.33) Cheese (-0.27) Nuts/seeds (-0.26) Bananas (0.25) High C F/V (0.21) Beans (0.21) Meat/fish/poultry (-0.21)	Rice (0.43) High C F/V (0.36) High A F/V (0.27) Milk (-0.27) Nuts/seeds (0.25) Maize (-0.24) Tea (-0.24)
Percent of variance explained:	9.7%	10.7%

TABLE 33: DIETARY PATTERNS FOR KENYA CHILDREN: RESULTS FROM PRINCIPAL COMPONENT ANALYSES OF FOOD GROUP INTAKES (LOADINGS > 0.20 SHOWN)

	Toddlers	Schoolers
Pattern 1	Vegetable fat (0.42)	Vegetable fat (0.41)
	Sugar (0.36)	Milk (0.33)
	Potatoes (0.32)	Rice (0.32)
	Wheat (0.29)	High A F/V (0.30)
	Rice (0.29)	Sugar (0.29)
	Milk (0.28)	Wheat (0.29)
	Meat/poultry (0.25)	Potatoes (0.28)
	Maize (-0.24)	Meat/poultry (0.27)
	Bananas (0.23)	Maize (-0.20)
	High A F/V (0.23)	
	Tea (0.21)	
Percent of variance explained:	16.1%	20.2%
Pattern 2	Leafy green veg (0.47)	High C F/V (0.50)
	Maize (0.36)	Beans (-0.42)
	High C F/V (0.36)	Eggs (0.39)
	Meat/poultry (0.36)	Leafy green veg (0.31)
	Tea (0.34)	Cassava (0.29)
	Rice (-0.23)	Other animal fat (-0.20)
	Beans (0.23)	
Percent of variance explained:	10.3%	9.9%

TABLE 34: DIETARY PATTERNS FOR MEXICO CHILDREN: RESULTS FROM PRINCIPAL COMPONENT ANALYSES OF FOOD GROUP INTAKES (LOADINGS > 0.20 SHOWN)

	Toddlers	Schoolers
Pattern 1	Bananas (0.33)	Milk (0.35)
	High C F/V (0.32)	Bananas (0.32)
	Milk (0.30)	High C F/V (0.32)
	Meat/fish/poultry (0.30)	High A & C F/V (0.31)
	Other animal fat (0.30)	Meat/fish/poultry (0.29)
	High A F/V (0.27)	Grain desserts (0.26)
	Sugar (0.26)	Wheat (0.25)
	Wheat (0.24)	Cheese (0.24)
	Milk fat and lard (0.24)	Maize (-0.21)
	Maize (-0.22)	Sugar (0.21)
	Leafy green veg (-0.20)	Milk fat and lard (0.20)
Percent of variance explained:	20.0%	17.6%
Pattern 2	Vegetable fat (0.43)	Eggs (0.41)
	Potatoes (0.41)	Vegetable fat (0.38)
	Eggs (0.35)	Potatoes (0.36)
	Maize (0.30)	Maize (0.30)
	Low A & C F/V (0.25)	Beans (0.30)
	Grain desserts (-0.25)	Low A & C F/V (0.29)
	Milk (-0.23)	Rice (0.22)
	Tea/coffee (-0.23)	Sugar (0.20)
Percent of variance explained:	12.9%	12.4%

MULTIVARIATE ANALYSES OF CHILD ANTHROPOMETRY

RELATIONSHIPS WITH DIETARY AND OTHER PREDICTOR VARIABLES

Relationships between child anthropometry, child energy intake, and several non-dietary variables are shown in Table 35. Toddler girls are significantly smaller than toddler boys in Egypt and somewhat (but non-significantly) smaller in Kenya as well. Schooler girls are smaller than schooler boys in Mexico. The household sanitation score is positively related to toddler anthropometry in all locations and to schooler anthropometry in Kenya and Mexico. Likewise, household SES is positively associated with most measures of toddler and schooler anthropometry in Kenya and Mexico, but unexpectedly is negatively associated with schooler weight in Egypt. Child appearance, a proxy for child sanitation in Mexico, is strongly associated with toddler and schooler weight. Maternal size (either height or BMI) is positively correlated with attained size for toddlers and schoolers in all three locales, although associations for schoolers are stronger in Kenya and Mexico than in Egypt. Energy intake is not as consistently related to child size as might be expected; associations are strongly positive only for Kenya children and are significantly negative for Egypt schoolers.

Table 36 presents partial correlations between nutrient intakes, adjusted for energy intake, and child anthropometry. Kenya toddlers' length and/or length gain are positively related to intakes of animal protein, fat, and vitamins A and B_{12} and negatively related to intakes of dietary fiber, iron, zinc, thiamin, niacin, and folate. Kenya toddlers' weight is not correlated with any of the nutrient intake variables, and weight gain is correlated only with animal protein, vitamin B_6 (both positive), and zinc (negative). Many of the associations for Mexico toddlers are similar to those seen for Kenya: positive associations with animal protein, and vitamins A and B_{12}, and negative associations with dietary fiber, iron, zinc, niacin, and folate (associations of the same magnitude are less significant in Mexico than in Kenya due to the smaller sample size). For Egypt toddlers there are relatively few significant correlates of nutrients with anthropometric measures; weight gain is positively related to intakes of fiber, thiamin and niacin and negatively to fat intake.

Associations for schoolers are generally similar to those for toddlers, but correlations ≥ 0.15 are less numerous in Egypt and Kenya, while more numerous and often stronger in Mexico. All but one nutrient (thiamin) has a correlation coefficient of 0.15 or greater with Mexico schooler weight, which is particularly surprising since energy intake is, in effect, held constant for these partial correlations. As for toddlers, many associations are negative (particularly for nutrients present in tortillas). Associations in Kenya schoolers were strongest for height gain. For Egypt schoolers, no correlation of nutrient intake and anthropometry reaches significance.

Partial correlations (adjusted for energy intake) between food group intakes and child anthropometry are shown in Tables 37 (toddlers) and 38 (schoolers). As was the case for nutrients, there were far fewer correlations of 0.15 or higher in Egypt than in Kenya and Mexico. Negative correlations with maize intake were seen in Kenya and Mexico for toddlers and in all locations for schoolers (although maize intake was positively associated with weight gain for Mexico schoolers). Associations with intakes of animal foods (milk, cheese, eggs, and meat) were consistently positive for all locations and both ages except for Egypt toddlers (where associations with dairy product intake were non-significantly negative). Intakes of legumes were negatively associated with toddler size and with schooler growth in Mexico, but positively with schooler

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TABLE 35: CORRELATIONS BETWEEN NON-DIETARY VARIABLES, ENERGY INTAKE, AND ANTHROPOMETRY MEASURES FOR TODDLERS AND SCHOOLERS

	Egypt				Kenya				Mexico			
	Wt	Wt Gain	Length†	Length Gain	Wt	Wt Gain	Length	Length Gain	Wt	Wt Gain	Length	Length Gain
Toddlers	(n=94)				(n=100)				(n=59)			
Sex (F=2, M=1)	-0.30**		-0.29**		-0.20		-0.17	0.16				
Household SES					0.19	0.16	0.24*	0.19	0.42**	0.22	0.34**	
Household sanitation	0.23*		0.31**		0.20		0.15	0.29**	0.35**	0.24	0.29*	
LF height	0.29**		0.40**		0.16	0.17	0.26**		0.33*	0.17	0.38**	
LF BMI	0.21*		0.23*		0.21*				0.36**		0.21	0.25
Child's energy intake			0.15		0.32**		0.35**					0.15
Child appearance	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.48**	0.23	0.41**	
Schoolers	(n=61)				(n=138)				(n=84)			
Sex (F=2, M=1)									-0.28**		-0.24*	
Household SES	-0.25*				0.26**		0.32**	0.23**	0.35**		0.24*	0.15
Household sanitation					0.27**	0.16	0.28**	0.29**	0.24*		0.16	
LF height	0.19		0.32*		0.38**		0.44**		0.33**		0.43**	0.18
LF BMI					0.35**	0.17*		0.24**	0.35*		0.23*	
Child's energy intake	-0.27*		-0.27*	0.16	0.50**		0.31**		0.21*		0.19	
Child appearance	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.29**		0.18	

Shown if |r| ≥ 0.15
*p ≤ 0.05
**p ≤ 0.01
N.A. = not available
†Length = height for schoolers

TABLE 36: PARTIAL CORRELATIONS BETWEEN NUTRIENT INTAKES AND ANTHROPOMETRY MEASURES FOR TODDLERS AND SCHOOLERS, ADJUSTED FOR ENERGY INTAKE†

	Egypt (N=94)				Kenya (N=100)				Mexico (N=59)			
	Wt	Wt Gain	Length‡	Length Gain	Wt	Wt Gain	Length	Length Gain	Wt	Wt Gain	Length	Length Gain
Toddlers												
Animal protein						0.21*	0.16	0.22*	0.28*	0.26*	0.25	0.26*
Fat		-0.22*					0.24*	0.30**				
Dietary fiber		0.20*					-0.30**	-0.34**	-0.18	-0.18		-0.37**
Iron	-0.17	0.16					-0.30**	-0.30**				-0.32*
Zinc						-0.25*	-0.23*	-0.22*				-0.22
Calcium	0.18	-0.18	0.16									
Vitamin A	0.16		0.18				0.17		0.26*		0.23	
Vitamin C								-0.16	0.23		0.26*	0.19
Thiamin		0.23*					-0.26**	-0.31**			0.20	
Riboflavin									0.25	0.16	0.16	0.26
Niacin		0.30**					-0.18	-0.27**				-0.21
Folate								-0.24*				-0.22
Vitamin B_{12}							0.21*		0.23		0.21	
Vitamin B_6		0.19				0.23*						
Schoolers	Egypt (N=61)				Kenya (N=138)				Mexico (N=84)			
Animal protein								0.18*	0.28**		0.19	
Fat						0.17		0.30**	0.28**		0.16	
Dietary fiber									-0.40**		-0.22*	
Iron	0.25		0.17						-0.40**		-0.21	
Zinc		-0.16		0.21		0.22**		0.18*	-0.35**		-0.23*	
Calcium							0.22	0.28**	-0.25*		-0.23*	
Vitamin A									0.23*		0.19	-0.29**
Vitamin C				0.20					0.27*	0.35**	0.21	
Thiamin				-0.16				-0.18*				0.19
Riboflavin					0.16		0.20		0.33**		0.25*	
Niacin								-0.37**	-0.16			
Folate								0.16	-0.31**			
Vitamin B_{12}									0.15			-0.23*
Vitamin B_6									-0.21			

†Shown if $|r| \geq 0.15$; *$p \leq 0.05$, **$p \leq 0.01$. ‡Length = height for schoolers

TABLE 37: PARTIAL CORRELATIONS BETWEEN FOOD GROUP INTAKES AND ANTHROPOMETRY MEASURES FOR TODDLERS, ADJUSTED FOR ENERGY INTAKE†

	Egypt (N=94)				Kenya (N=100)				Mexico (N=59)			
	Wt	Wt Gain	Length	Length Gain	Wt	Wt Gain	Length	Length Gain	Wt	Wt Gain	Length	Length Gain
Bananas						0.18	0.20*		0.22		0.19	0.21
Cassava									N.C.	N.C.	N.C.	N.C.
Maize		0.19				-0.22*	-0.27**	-0.29**	-0.21			-0.23
Wheat, whole		0.18			N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Wheat, white									0.23			0.16
Rice								0.22*				0.31*
Other grains	N.C.	N.C.	N.C.	N.C.						0.17		
Potatoes		0.15				0.28**	0.17	0.17	-0.22		-0.24	
Leafy veg								-0.21*				
High A F/V		-0.15		-0.20			0.19	0.19	0.16		0.16	
High C F/V								-0.24*	0.18		0.21	
High A&C F/V									0.17		0.21	
Low A&C F/V		-0.23*										-0.19
Milk				-0.17				0.19	0.23	0.20		0.33*
Cheese	0.16	-0.17			N.C.	N.C.	N.C.	N.C.	0.23	0.25		0.26*
Nuts/seeds				0.21*						-0.21		-0.21
Beans										-0.15		-0.29*
Meat					0.17		0.23*		0.22		0.23	
Eggs												
Veg fat				-0.28**			0.29**	0.36**	-0.21	-0.21	-0.26*	-0.15
Milk fat & lard												
Other animal fat		0.21*			0.15		0.30**		0.25		0.30*	0.18
Sugar							0.36**		0.19			0.26
Grain desserts					N.C.	N.C.	N.C.	N.C.		0.21		
Pulque	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.				
Coffee, tea							0.17					
Diet pattern 1					0.16	0.17	0.41**	0.29**	0.29*		0.23	0.28*
Diet pattern 2		0.21*						-0.28**	-0.22	-0.21	-0.21	-0.26*

†Shown if $|r| \geq 0.15$; *$p \leq 0.05$, **$p \leq 0.01$, N.C. = not consumed

TABLE 38: PARTIAL CORRELATIONS BETWEEN FOOD GROUP INTAKES AND ANTHROPOMETRY MEASURES FOR SCHOOLERS, ADJUSTED FOR ENERGY INTAKE†

	Egypt (N=61)				Kenya (N=138)				Mexico (N=84)			
	Wt	Wt Gain	Ht	Ht Gain	Wt	Wt Gain	Ht	Ht Gain	Wt	Wt Gain	Ht	Ht Gain
Bananas				-0.23		-0.21*		-0.16	0.27*	0.21	0.16	
Cassava						-0.23**	0.13		N.C.	N.C.	N.C.	N.C.
Maize				-0.27*				-0.30**	-0.32**	0.21	-0.25*	
Wheat, whole					N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Wheat, white				0.15					0.22*		0.25*	
Rice	0.21						0.17		0.17			
Other grains	N.C.	N.C.	N.C.	N.C.		-0.19*		-0.30**				
Potatoes	-0.19							0.25**				
Leafy veg		-0.18		0.25								
High A F/V												
High C F/V				0.16					0.41**	0.36**	0.26*	
High A&C F/V				-0.16					0.18	0.31**		
Low A&C F/V			0.20	0.19	0.16		0.17*		0.16	0.21	0.15	
Milk							0.19*	0.30**	0.27*		0.16	
Cheese					N.C.	N.C.	N.C.	N.C.				
Nuts/seeds				0.27*								-0.17
Beans						0.17*		0.36**	-0.35**		-0.21	
Meat				0.26*				0.17*	0.16			
Eggs									0.16		0.16	
Veg fat		-0.22						0.28**				-0.16
Milk fat & lard										0.20		0.15
Other animal fat				0.18								
Sugar	-0.17							0.20*	0.18			
Grain desserts	-0.18	0.20		-0.22	N.C.	N.C.	N.C.	N.C.	0.38**		0.33**	
Pulque	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.				
Coffee, tea											0.17	-0.20
Diet pattern 1								0.29**	0.41**	0.22*	0.26*	
Diet pattern 2				0.33*			0.19*	-0.16				

†Shown if $|r| \geq 0.15$; *$p \leq 0.05$, **$p \leq 0.01$, N.C. = not consumed

growth in Kenya. Inconsistencies also were seen in associations with fat and sugar intakes: intakes of both were positively correlated with measures of child size or growth in Kenya; however, in Egypt and Mexico, sugar intake was not significantly correlated with child anthropometry, and associations varied by type of fat intake: associations with vegetable fat were negative, while those with animal fat were positive.

MODELS WITH SEX, SES, SANITATION SCORE, MATERNAL ANTHROPOMETRY, AND CHILD'S MACRONUTRIENT INTAKE AS INDEPENDENT VARIABLES

We created a series of multiple regression models to estimate the effect of sex, SES, sanitation score, maternal anthropometry, and macronutrient intake (energy, animal protein, fat, and dietary fiber) on toddler length and weight and schooler height and weight. Table 39 shows the results for toddler length; Table 40 for toddler weight; Table 41 for schooler height; and Table 42 for schooler weight. Each table also presents four successive models: Model 1 shows the results with energy intake plus all non-dietary variables, Model 2 has animal protein added to Model 1, Model 3 has fat added to Model 1, and Model 4 has dietary fiber added to Model 1.

Although other non-dietary variables besides SES and sanitation score were considered as candidates for inclusion in the multiple regression models (female schooling, house quality, household crowding, presence of latrine, source of water), they were ruled out because: (a) associations were not strong enough to warrant further restricting the degrees of freedom; (b) there was insufficient variance of the variables considered and/or data were missing for many subjects; or (c) high levels of intercorrelation existed with the already included variables. We investigated a much wider range of multiple regression models than are shown here in Tables 39 to 42, but for the sake of brevity include the results, when relevant, only in the text.

Macronutrient Intake and Child Size

Results differ by projects. For Kenya, energy intake appears consistently as a highly significant determinant of child anthropometry when controlling for maternal anthropometry, sex, and SES and sanitation. When energy is entered as the sole intake variable, it is always positive and highly significant. For example, an increase of 100 kcal/d is associated with an increase in 24-month weight of about 0.15 kg. When energy intake is entered with the other macronutrients, it generally continues to be a highly significant determinant for toddler and schooler size.

For Egypt, energy intake is a statistically significant determinant of toddler length only when energy and animal protein intakes are included; it does not reach statistical significance for any models of toddler weight. Energy intake is a significant negative determinant of schooler height; the significance is dependent upon a single potential outlier.

For Mexico, energy intake does not appear to be a significant determinant of toddler anthropometry, although for schoolers, energy intake is a significant and positive determinant of weight (except when entered with fat intake, where the significant effect disappears). In models, not presented here, in which SES and sanitation are omitted, energy intake appears to reach statistical significance for schooler anthropometry.

When animal protein, fat, and fiber are entered in combination with energy intake in Models 2 to 4 respectively, we note the following results:

For Egypt, none of the nutrients entered are statistically significant for any of the models.

TABLE 39: TODDLER LENGTH (cm AT 24 mo) AS A FUNCTION OF SEX, SOCIOECONOMIC SCALE, SANITATION SCALE, MOTHER'S HEIGHT AND CHILD'S INTAKE OF ENERGY, ANIMAL PROTEIN, FAT AND FIBER†

Independent Variable	Model 1	Model 2	Model 3	Model 4
EGYPT (N=94)				
Intercept	39.07	37.86	38.94	38.82
Sex (F=2, M=1)	-1.79**	-1.75**	-1.77**	-1.79**
SES	0.33	0.43	0.40	0.38
Sanitation	2.23**	2.38**	2.33**	2.33**
LF height (cm)	0.22**	0.22**	0.21**	0.22**
Child intake				
Energy (100 kcal)	0.14	0.22*	0.20	0.04
Animal protein (g)		-0.06		
Fat (g)			-0.02	
Fiber (g)				0.05
R^2	0.33**	0.33**	0.33**	0.33**
KENYA (N=100)				
Intercept	55.56	57.63	58.16	58.79
Sex (F=2, M=1)	-1.07	-1.19*	-1.23*	-1.21*
SES	0.61*	0.51	0.47	0.31
Sanitation	0.02	0.01	-0.01	-0.01
LF height (cm)	0.12*	0.11*	0.12*	0.12*
Child intake				
Energy (100 kcal)	0.53**	0.44*	0.18	1.06**
Animal protein (g)		0.16		
Fat (g)			0.22*	
Fiber (g)				-0.22*
R^2	0.25**	0.26**	0.28**	0.29**
MEXICO (N=59)				
Intercept	44.41	39.44	39.79	37.05
Sex (F=2, M=1)	-0.54	-0.50	-0.47	-0.54
SES	0.68	0.78	0.77*	0.90*
Sanitation	0.005	0.005	0.004	0.004
LF height (cm)	0.19*	0.22**	0.22**	0.24**
Child intake				
Energy (100 kcal)	0.03	0.07	0.26	-0.25
Animal protein (g)		0.07		
Fat (g)			-0.09	
Fiber (g)				0.21
R^2	0.25**	0.26**	0.28**	0.29**

†Regression coefficients and levels of significance: $p \leq 0.05$*, $p \leq 0.01$**

TABLE 40: TODDLER WEIGHT (kg AT 24 mo) AS A FUNCTION OF SEX, SOCIOECONOMIC SCALE, SANITATION SCALE, MOTHER'S BODY MASS INDEX AND CHILD'S INTAKE OF ENERGY, ANIMAL PROTEIN, FAT AND FIBER†

Independent Variable	Model 1	Model 2	Model 3	Model 4
EGYPT (N=94)				
Intercept	7.41	7.45	7.40	7.44
Sex (F=2, M=1)	-0.80**	-0.80**	-0.80**	-0.80**
SES	0.08	0.08	0.08	0.08
Sanitation	0.72*	0.71*	0.72*	0.70*
LF BMI (kg/m^2)	0.06**	0.06**	0.06**	0.06**
Child intake				
Energy (100 kcal)	0.05	0.05	0.06	0.07
Animal protein (g)		0.002		
Fat (g)			-0.001	
Fiber (g)				-0.01
R^2	0.23**	0.23**	0.23**	0.23**
KENYA (N=100)				
Intercept	7.24	7.09	7.12	7.16
Sex (F=2, M=1)	-0.52*	-0.50*	-0.51*	-0.52*
SES	0.18	0.20	0.19	0.18
Sanitation	0.01	0.02	0.02	0.01
LF BMI (kg/m^2)	0.08	0.08	0.08	0.08
Child intake				
Energy (100 kcal)	0.15*	0.17**	0.18*	0.14*
Animal protein (g)		-0.04		
Fat (g)			-0.02	
Fiber (g)				0.01
R^2	0.21**	0.21**	0.21**	0.21**
MEXICO (N=59)				
Intercept	5.80	5.84	5.77	5.78
Sex (F=2, M=1)	0.07	0.06	0.08	0.07
SES	0.31**	0.30*	0.32**	0.31*
Sanitation	0.002*	0.002*	0.002*	0.002*
LF BMI (kg/m^2)	0.06*	0.06*	0.07*	0.06*
Child intake				
Energy (100 kcal)	0.01	0.01	0.04	0.01
Animal protein (g)		0.01		
Fat (g)			-0.01	
Fiber (g)				0.002
R^2	0.33**	0.33**	0.34**	0.33**

†Regression coefficients and levels of significance: $p \leq 0.05$*, $p \leq 0.01$**

TABLE 41: SCHOOLER HEIGHT (cm AT 8 yrs) AS A FUNCTION OF SEX, SOCIOECONOMIC SCALE, SANITATION SCALE, MOTHER'S HEIGHT AND CHILD'S INTAKE OF ENERGY, ANIMAL PROTEIN, FAT AND FIBER†

Independent Variable	Model 1	Model 2	Model 3	Model 4
	EGYPT (N=61)			
Intercept	74.60	69.09	73.67	74.80
Sex (F=2, M=1)	-0.73	-0.34	-0.67	-0.73
SES	0.15	0.27	0.22	0.14
Sanitation	0.29	0.91	0.46	0.26
LF height (cm)	0.35*	0.36**	0.35*	0.35*
Child intake				
Energy (100 kcal)	-0.44*	-0.27	-0.34	-0.42
Animal protein (g)		0.15		
Fat (g)			-0.04	
Fiber (g)				-0.01
R^2	0.19*	0.21*	0.20	0.19
	KENYA (N=138)			
Intercept	56.93	56.98	55.35	56.09
Sex (F=2, M=1)	0.03	0.03	0.04	-0.11
SES	0.78	0.78	0.85*	0.86*
Sanitation	0.06	0.06	0.08	0.08
LF height (cm)	0.33**	0.33**	0.33**	0.33**
Child intake				
Energy (100 kcal)	0.38*	0.38*	0.56*	0.03
Animal protein (g)		0.01		
Fat (g)			-0.14	
Fiber (g)				0.11
R^2	0.29**	0.29**	0.30**	0.30**
	MEXICO (N=84)			
Intercept	57.13	56.93	57.04	57.95
Sex (F=2, M=1)	-0.74	-0.76	-0.72	-0.74
SES	0.68	0.71	0.61	0.57
Sanitation	0.001	0.001	0.001	0.001
LF height (cm)	0.36**	0.36**	0.36**	0.36**
Child intake				
Energy (100 kcal)	0.22	0.22	0.18	0.30
Animal protein (g)		-0.01		
Fat (g)			0.02	
Fiber (g)				-0.05
R^2	0.27**	0.27**	0.27**	0.27**

†Regression coefficients and levels of significance: $p \leq 0.05$*, $p \leq 0.01$**

TABLE 42: SCHOOLER WEIGHT (kg AT 8 yrs) AS A FUNCTION OF SEX, SOCIOECONOMIC SCALE, SANITATION SCALE, MOTHER'S BODY MASS INDEX AND CHILD'S INTAKE OF ENERGY, ANIMAL PROTEIN, FAT AND FIBER†

Independent Variable	Model 1	Model 2	Model 3	Model 4
	EGYPT (N=61)			
Intercept	26.03	26.14	25.90	26.55
Sex (F=2, M=1)	-0.35	-0.36	-0.33	-0.35
SES	-0.62	-0.62	-0.60	-0.67
Sanitation	0.57	0.54	0.63	0.44
LF BMI (kg/m^2)	0.02	0.02	0.02	0.02
Child intake				
Energy (100 kcal)	-0.21*	-0.22	-0.18	-0.10
Animal protein (g)		0.01		
Fat (g)			-0.01	
Fiber (g)				-0.07
R^2	0.13	0.13	0.13	0.14
	KENYA (N=138)			
Intercept	9.47	9.18	8.88	8.57
Sex (F=2, M=1)	0.44	0.43	0.44	0.27
SES	0.16	0.19	0.19	0.24
Sanitation	0.02	0.02	0.03	0.04
LF BMI (kg/m^2)	0.15*	0.16*	0.15*	0.18**
Child intake				
Energy (100 kcal)	0.44**	0.45**	0.54**	0.01
Animal protein (g)		-0.06		
Fat (g)			-0.07	
Fiber (g)				0.13*
R^2	0.31**	0.31**	0.32**	0.34**
	MEXICO (N=84)			
Intercept	12.66	12.73	12.90	13.82
Sex (F=2, M=1)	-0.66	-0.62	-0.64	-0.64
SES	0.60**	0.51*	0.52*	0.34
Sanitation	0.001	0.001	0.001	0.0004
LF BMI (kg/m^2)	0.20**	0.21**	0.20**	0.20**
Child intake				
Energy (100 kcal)	0.13*	0.12*	0.08	0.30**
Animal protein (g)		0.03		
Fat (g)			0.02	
Fiber (g)				-0.12
R^2	0.31**	0.32**	0.32**	0.34**

†Regression coefficients and levels of significance: $p \leq 0.05$*, $p \leq 0.01$**

For Kenya, animal protein is positively related to toddler length and schooler height only when SES is omitted, but disappears when SES is included in the regression. For Kenya, fat is a positive and significant determinant and fiber a significant negative determinant for toddler length and fiber a significant positive determinant for schooler weight in the full models reported here.

For Mexico, in simple models without SES and sanitation, fiber is significantly negatively related to schooler height and weight when controlling for energy intake. When SES and sanitation are entered this effect disappears. Neither animal protein nor fat is significantly related to anthropometric measures of toddlers or schoolers.

SES and Child Size

For Kenya, SES significantly relates to toddler length and schooler height, and in Mexico, SES significantly influences toddler length and weight and schooler weight but not height, controlling for the other factors. For Egypt, none of the measures was related to SES.

Sanitation Score and Child Size

For Egypt, a better sanitation score is highly significantly associated with increased weight and length for toddlers; for Mexico, better sanitation is associated with increased toddler weight. No associations with sanitation were found for Kenya toddlers, or for schoolers in any country.

In other regression models which are not reported here, we replaced the sanitation score (which represents household sanitary practice) with the variables "water" and "latrine" (which represent household facilities). From these analyses we found that: a water tap in the household in Egypt is positively associated with the height gain for schoolers and a latrine in the household in Mexico is positively associated with toddler and schooler weights and toddler length gain.

Maternal Anthropometry and Child Size

As expected, for most models maternal size significantly influences child size, independently of intake and SES, and associations are particularly strong for maternal and child stature. Each cm increase in the mother's height is associated with increases of 0.11 to 0.24 cm in toddler length and 0.33 to 0.36 cm in schooler height. Associations of child weight and maternal BMI are somewhat more variable, ranging from increases of 0.06 to 0.08 kg for toddlers and 0.02 to 0.21 kg for schoolers with each unit (kg/m^2) increase in maternal BMI; this association is non-significant for Kenya toddlers and Egypt schoolers.

Child Height and Weight Gain

In most cases, the multivariate models of height or weight gain were statistically nonsignificant. The only models that reached significance were those for height gain among Kenya toddlers and schoolers (Table 43). Schooler height gain is significantly correlated with sanitation score and animal protein and fat; the models account for 10 to 13% of the variance in rate of linear growth. In toddlers, models including fat (positive) or dietary fiber (negative) are significant but account for only 14 to 15% of the variance; sanitation is a significant coefficient in models 1 and 2, but the models are not significant. In Mexican toddlers, dietary fiber was negatively related to length gain adjusting for toddlers sex, energy intake, household SES and sanitation ($R^2 = 0.19^*$ and fiber coefficient = -0.02^{**}). However, adding LF height to the model leads to non-significance of the model even though the coefficient for dietary fiber remains significant.

TABLE 43: HEIGHT GAIN AS A FUNCTION OF HOUSEHOLD SOCIOECONOMIC AND SANITATION SCALES, MOTHER'S ANTHROPOMETRY AND CHILD'S INTAKE OF ENERGY, ANIMAL PROTEIN, FAT AND FIBER FOR KENYAN TODDLERS AND SCHOOLERS[†]

	Model 1	Model 2	Model 3	Model 4
	KENYA SCHOOLERS (N=138)			
Intercept	0.25	0.28	0.32	0.24
Sex (2=F, M=1)	0.01	0.01	0.01	0.01
SES	0.01	0.1	0.01	0.01
Sanitation scale	0.002*	0.001	0.001	0.002*
LF height (cm)	-0.0004	-0.0004	-0.001	-0.0004
Child intake				
Energy (100 kcal)	0.002	0.001	0.006	0.001
Animal protein (g)		0.01*		
Fat (g)			0.01*	
Dietary fiber (g)				0.0003
R^2	0.10**	0.13**	0.13**	0.10*
	KENYA TODDLERS (N=100)			
Intercept	0.27	0.35	0.40	0.43
Sex (2=F, 1=M)	0.04	0.04	0.03	0.03
SES	0.01	0.004	0.001	-0.01
Sanitation scale	0.005*	0.004*	0.004	0.003
LF height (cm)	0.001	0.0005	0.001	0.005
Child intake				
Energy (100 kcal)	0.0001	0.004	0.02	0.03
Animal protein (g)		0.01		
Fat (g)			0.01	
Dietary fiber (g)				-0.01*
R^2	0.11	0.11	0.14*	0.15*

[†] Regression coefficients and levels of significance: $p \leq 0.05$*, $p \leq 0.01$**

STEPWISE MODELS WITH CHILD MICRONUTRIENT AND FOOD GROUP INTAKE AS INDEPENDENT VARIABLES

The multivariate models of child size and gain were extended to include the child's micronutrient and food group intakes as potential explanatory variables. Due to the large number of variables, a stepwise procedure was employed to bring only significant variables into the model. The results are shown in Tables 44 (toddlers) and 45 (schoolers). The variables in the base model are the same as those in Model 1 in Tables 39 to 42.

Toddler Models

For several of the toddler models, none of the additional dietary variables was statistically significant at $p \leq 0.05$. In all three countries, where weight was the dependent variable, no new dietary variable was added to the model. This was also the case for length in Egypt. Although some dietary variables entered the weight gain models (niacin in Egypt, vitamin B_6 in Kenya, and nuts/seeds (negatively) in Mexico), none of these model R-square values was statistically significant. The addition of a single dietary variable substantially increased the R-square values for toddler length in Kenya and Mexico (dietary pattern #1 in Kenya, and zinc intake in Mexico). It is likely that the dietary pattern score summarizes the positive effects of energy and fat intakes and the negative effect of fiber intake shown in Table 39 for Kenya toddler length. For Mexico toddlers, zinc intake is strongly associated with child length at 24 months (adding zinc to the model increases the R-square value from 0.33 to 0.45). Significant dietary variables were identified for length gain models in all three countries, although the R-square values were only moderately high (0.14 to 0.29). Intake of the high vitamin A fruit and vegetable food group was a negative predictor of length gain in Egypt. Kenya toddlers receiving more vegetable fat and less high vitamin C fruits and vegetables (mostly mangoes) were gaining length faster, while Mexico toddlers with a greater energy intake, but less fat and fiber in their diets were gaining length faster.

An additional non-dietary variable was optionally included as a potential predictor in the Mexico models: preschool child appearance. This variable entered both the weight and length models, but neither of the gain models.

Schooler Models

Additional significant dietary variables were identified in all the stepwise models of schooler size and gain except height and weight models for Egypt schoolers. Increased weight gain in Egypt was associated with higher intakes of animal fat other than milk fat and grain desserts. The score on dietary pattern 1 was a strong predictor of height gain in Egypt (this pattern had high loadings for milk fat, maize, meats, wheat, and cheese), but when these pattern scores were in the model, intakes of maize and grain desserts were negatively associated with height gain. A variety of dietary variables were strong positive predictors ($p < 0.01$) of schooler anthropometry in Kenya: zinc for weight gain, riboflavin for height, and calcium and legumes for height gain. Important negative dietary predictors, after adjustment for the positive predictors, were cassava and grains other than maize/wheat/rice (primarily millet) for weight gain, vitamin B_6 for height and plantain/bananas and other grains such as millet. For schoolers in Mexico, intake of fruits and vegetables high in vitamin C was a strong positive predictor of 8-year weight and of weight gain over the year of observation. Thiamin intake was strongly associated with height gain over the year, while vitamin A and energy intakes were negative predictors (after adjusting for the positive effect of thiamin). The schooler appearance variable, available only for the Mexico models, was significant only for the height gain model.

TABLE 44: STEPWISE REGRESSION MODELS OF TODDLER ANTHROPOMETRY† USING ALL DIETARY VARIABLES AS POTENTIAL INDEPENDENT VARIABLES

	EGYPT				KENYA				MEXICO			
Independent Variables‡	Wt	Wt Gain	Length	Length Gain	Wt	Wt Gain	Length	Length Gain	Wt	Wt Gain	Length	Length Gain
Intercept	7.41	0.38	39.07	-0.35	7.24	0.05	63.9	0.24	6.71	-0.04	45.4	0.83
Sex (F=2, M=1)	-0.80**	0.01	-1.79**	0.08	-0.52*	-0.01	-1.29*	0.02	-0.06	-0.01	-1.19	0.03
SES	0.08	0.01	0.33	0.03	0.18	0.01	0.38	0.01	0.31**	0.01	0.90*	-0.03
Sanitation	0.72*	-0.03	2.23**	-0.03	0.01	0.001	-0.03	0.003	-0.00	0.0001	-0.01*	-0.00
LF height (cm)	N.I.	N.I.	0.22**	0.006	N.I.	N.I.	0.10	0.002	N.I.	N.I.	0.20**	0.001
LF BMI (kg/m^2)	0.06*	0.00	N.I.	N.I.	0.08	0.003	N.I.	N.I.	0.05	0.002	N.I.	N.I.
Child appearance	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.01*		0.06**	
Child's nutrient intake:												
Energy (100 kcal)	0.05	-0.02**	0.14	-0.001	0.15*	-0.01	0.28	-0.01	0.01	0.003	-1.00**	0.07**
Fat (g)												-0.01*
Dietary fiber (g)												-0.04**
Zinc (mg)											2.25**	
Niacin (mg)		0.02**										
Vitamin B$_6$ (mg)						0.11*						
Child's food intake:§												
High vit A F/V				-3.31*								
High vit C F/V								-0.25*				
Nuts/seeds										-1.4*		
Vegetable fat								0.25**				
Child's dietary pattern 1							0.71**					
R^2	0.23**	0.11	0.33**	0.14*	0.21**	0.11	0.36**	0.22**	0.40**	0.19	0.45**	0.29*

* $p \leq 0.05$, ** $p \leq 0.01$, N.A. = not available, N.I. = not included; coefficients less than 0.0005 are shown as 0.00 if $p \geq 0.50$.
†Weight (kg), weight gain (kg/month), length (cm), length gain (cm/month)
‡Sex, SES, Sanitation, LF height and weight, and child's energy intake included in all models. Other variables included only if $p \leq 0.05$.
§Units are 100 g for fruit/vegetable food groups and 100 kcal for the remaining food groups.

TABLE 45: STEPWISE REGRESSION MODELS OF SCHOOLER ANTHROPOMETRY† USING ALL DIETARY VARIABLES AS POTENTIAL INDEPENDENT VARIABLES

	Egypt				Kenya				Mexico			
Independent Variables‡	**Wt**	**Wt Gain**	**Ht**	**Ht Gain**	**Wt**	**Wt Gain**	**Ht**	**Ht Gain**	**Wt**	**Wt Gain**	**Ht**	**Ht Gain**
Intercept	26.0	-0.27	74.6	1.50	9.39	-0.01	52.3	0.18	15.12	0.17	59.7	0.35
Sex (F=2, M=1)	-0.35	0.09**	-0.73	-0.06	0.34	0.01	0.03	0.01	-0.71	0.01	-0.67	-0.03
SES	-0.62	0.03*	0.15	-0.03*	0.25	-0.01	0.91*	0.01	0.26	-0.02*	0.41	0.01
Sanitation	0.57	0.09	0.29	-0.10*	0.02	0.001*	0.08	0.002**	-0.001	-0.0001	-0.001	-0.0002*
LF height (cm)	N.I.	N.I.	0.35*	-0.002	N.I.	N.I.	0.34**	0.00	N.I.	N.I.	0.31**	0.00
LF BMI (kg/m^2)	0.02	0.002	N.I.	N.I.	0.17**	0.003	N.I.	N.I.	0.18**	0.004	N.I.	N.I.
Child appearance,	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.				0.001*
Child's nutrient intake:												
Energy (100 kcal)	-0.21	0.01	-0.44*	0.001	0.46**	-0.03**	-0.25	-0.01*	0.06	-0.004*	0.12	-0.02**
Fat (g)		-0.01**										
Zinc (mg)						0.06**						
Calcium (100 mg)								0.04**				
Thiamin (mg)												0.42**
Riboflavin (mg)							27.9**					
Vitamin B_{12} (μg)							-1.85*					
Vitamin B_6 (mg)							-8.17**					
Vitamin A (100 RE)												-0.03**
Child's food intake:§												
Plantain/bananas								-0.08**				
Cassava						-0.04**						
Maize				-0.06**								
Wheat, white										0.02*		
Other grains						-0.13**		-0.20**				
High vit C F/V									4.17**	0.21**		
Low vit A & vit C F/V											4.16*	
Mature beans								0.05**				
Other animal fat		0.16*										
Sugar					-1.72*							

TABLE 45, CONT'D

Independent Variables‡	Egypt Wt	Egypt Wt Gain	Egypt Ht	Egypt Ht Gain	Kenya Wt	Kenya Wt Gain	Kenya Ht	Kenya Ht Gain	Mexico Wt	Mexico Wt Gain	Mexico Ht	Mexico Ht Gain
Grain desserts		0.19*		-0.21**					0.79*		1.71*	
Coffee/tea								-0.02*				-0.01*
Child's dietary pattern:												
Pattern 1				0.05**								
Pattern 2						0.01*						
R^2	0.13	0.29*	0.19*	0.37**	0.34**	0.24**	0.37**	0.43**	0.42**	0.26**	0.34**	0.32**

* $p < 0.05$, ** $p < 0.01$, N.A. = not available, N.I. = not included; coefficients less than 0.0005 are shown as 0.00 if $p \geq 0.50$.
†Weight (kg), weight gain (kg/month), height (cm), height gain (cm/month)
‡Sex, SES, Sanitation, LF height and weight, and child's energy intake included in all models. Other variables included only if $p \leq 0.05$.
§Units are 100 g for fruit/vegetable and coffee/tea food groups and 100 kcal for all other food groups.

MULTIVARIATE ANALYSIS OF TODDLER MORBIDITY

FOOD INTAKE AND MORBIDITY

Two questions partially addressed previously (1) were investigated further. The first question is whether or not food intake was lower during illness. If intake differed on ill-days, the second issue is whether or not days of illness are fairly represented in the food records -- a question of bias.

Differences in energy intake for days with food records, with or without overlapping severe illness are shown in Table 46. Although there is a trend toward diminished energy intake, the difference is highly significant only among Kenyan toddlers. In Kenya, if the severity code is ignored, and the energy intake during days ill with decreased activity compared to all other days, the same highly significant decrease is observed (860 ± 435 and 717 ± 412 kcal respectively). This difference is important to the interpretation of the results of multivariate analyses.

To examine the question of bias, the analysis presented for the Egypt project (ref 1, p 175) was extended to the three projects. Results are presented in Table 47. All chi-square statistics were nonsignificant and very similar across projects ($p > 0.80$). It can therefore be concluded that, as a group, food records are not biased by illness. (We are aware that the days of observation are not statistically independent. Any adjustment for this non-independence, however, would be in the direction of the null hypothesis. Thus none of the above conclusions would change.)

Table 48 reports summary statistics for the whole toddler sample with a minimum of 9 months of morbidity data; Table 49 shows the selected analytical variable descriptions for the sample used in cross sectional analysis. The analytical samples used in the present analyses do not differ generally from the total survey population. Tables 50 to 52 report bivariate correlations among the main variables considered in these analyses. The correlations between morbidity and the other variables are weak, although consistent relationships are seen between the prevalence of severe illness and some form of sanitation indicators in all three projects. These tables provide background for interpretation of the multiple regression analyses using morbidity as either an intervening or an outcome variable.

MORBIDITY, SIZE AND GROWTH

In these analyses, morbidity is considered successively as an intervening and outcome variable. To test the role of morbidity as an intervening variable for the relationship of attained size and growth (outcomes), with toddlers' energy intake, mothers' anthropometry and household environment (independent variables), both cross-sectional and longitudinal models were analyzed.

In the cross-sectional analyses the various morbidity variables were added one at a time to the regression model described in the previous section (model 1, Tables 39 - 40) using predicted length and weight at 24 months and length and weight gain between 18 and 30 months as dependent variables, and toddlers' sex, energy intake, household SES and sanitation, and maternal anthropometry as independent variables (models A). These models can identify significant morbidity variables but do not allow for interpretation as to the causal direction of effects (i.e. the models cannot discriminate if small size is a risk factor for morbidity or if morbidity leads to impaired physical growth).

TABLE 46: ENERGY INTAKES DURING DAYS WITH OR WITHOUT SEVERE ILLNESS AMONG TODDLERS IN EGYPT, KENYA AND MEXICO*

	Egypt	Kenya	Mexico
Days without severe illness			
mean (kcal) ± SD	1150 ± 550	862 ± 435	1116 ± 668
number of days	1848	2227	1689
Days with severe illness			
mean (kcal) ± SD	1077 ± 576	730 ± 420	884 ± 448
number of days	130	270	17
(P value for one-tail T test)	0.07	0.0001	0.08

*Kenya and Egypt include days coded as severely ill or ill with some impaired activity. Mexico recorded decreased activity but not severity.

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TABLE 47: TEST OF INDEPENDENCE BETWEEN MORBIDITY AND FOOD RECORDS FOR TODDLERS FROM EGYPT, KENYA AND MEXICO

	Days without severe illness	Days with severe illness*	χ^2
Egypt			
Food recorded (days)	1848	130	
Food not recorded (days)	40775	2810	N/S
Kenya			
Food recorded (days)	2227	270	
Food not recorded (days)	33731	4032	N/S
Mexico			
Food recorded (days)	1589	17	
Food not recorded (days)	26605	254	N/S

*Kenya and Egypt include days coded as severely ill or ill with some impaired activity. Mexico recorded decreased activity but not severity.

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TABLE 48: CROSS-PROJECT SUMMARY STATISTICS OF TODDLER MORBIDITY

A: Sample description and overall morbidity

Variable	Summary statistic	Egypt*	Kenya†	Mexico (adjusted)‡
	N	123	110	101
Days observed/pers.	mean (sd) [range]	330 (47) [160-417]	335 (16) [283-359]	350 (43) [219-430]
Age at entry (mo.)	"	17.7 (0.7) [16.5-19.5]	17.9 (0.2) [17.9-19.0]	17.6 (0.9) [17.0-20.0]
Age at exit (mo.)	"	30.8 (0.8) [28.5-31.5]	29.9 (0.2) [29.9-30.9]	30.7 (0.7) [28.0-31.0]
Illdays/pers.yr	"	41.6 (28.9) [0-127.0]	144.5 (80.2) [3.4-365.3]	22.4 (20.0) [0-93.8]
Illdays w/decreased activity/pers.yr	"	0.7 (2.8) [0-18.9]	**38.3** (40.6) [0-199.3]	**5.8** (8.6) [0-36.7]
Severe illdays/ pers.yr	"	**22.6** (21.8) [0-105.5]	**12.8** (21.1) [0-148.0]	n/a
% of toddlers w/illness marked by decreased activity	% (n)	6.5 (8)	88.2 (97)	44.6 (45)
% of toddlers w/ severe illness	"	87.8 (108)	52.7 (58)	n/a

*Maximum age at entry is 16.5 months and minimum age at exit is 28.5 months. No records before 16.5 and after 31.5 months are included.

†All observations are included.

‡Maximum age at entry is 20 months and minimum age at exit is 28 months. Records before 16 months and after 32 months of age are excluded. The raw morbidity file was modified to adjust the incidence and prevalence of illness by the average ratio of observed illness during weekly recalls/observed illness during days of visit calculated for the 69 toddlers with both data.

Note: Selected analytical variables are in bold.

TABLE 48. CONT'D

B: Morbidity from lower respiratory infection

Variable	Summary statistic	Egypt	Kenya	Mexico (adjusted)
Average/pers.yr:				
episodes	mean (sd) [range]	**1.2** (1.7) [0-8.1]	**0.3** (1.6) [0-4.6]	**1.0** (1.4) [0-5.8]
illdays	"	**7.8** (13.2) [0-80.0]	**3.5** (8.7) [0-44.2]	**6.2** (9.6) [0-60.5]
illdays with decreased activity	"	0.2 (1.4) [0-12.4]	1.8 (5.4) [0-30.4]	1.7 (4.8) [0-31.2]
severe illdays	"	7.8 (13.2) [0-80.0]	2.6 (7.2) [0-44.2]	n/a
% of cases	**% (n)**	55.3 (68)	19.1 (21)	49.5 (50)
% of cases with decreased activity	"	2.4 (3)	14.5 (16)	14.9 (15)
% of severe cases	"	55.3 (68)	14.5 (16)	n/a
Average/case:				
duration of episode (days)	mean (sd) [range]	6.8 (8.0) [2.0-66.0]	11.9 (6.6) [5.0-29.0]	6.1 (3.0) [1.4-13.2]
% of illdays with decreased activity	"	2.1 (10.6) [0-71.0]	58.0 (42.5) [0-100]	25.4 (40.9) [0-100]
% of severe illdays	"	100 (0)	70.4 (38.0) [0-100]	n/a

TABLE 48. CONT'D

C: Morbidity from diarrhea

Variable	Summary statistic	Egypt	Kenya	Mexico (adjusted)
Average/pers.yr:				
episodes	mean (sd) [range]	**2.8** (2.5) [0-9.6]	**1.2** (1.6) [0-9.5]	**1.3** (1.8) [0-7.8]
illdays	"	**12.7** (14.5) [0-65.3]	**7.6** (11.4) [0-49.6]	**5.6** (8.5) [0-46.5]
illdays with decreased activity	"	0.1 (0.5) [0-4.4]	**4.1** (8.4) [0-40.7]	**1.4** (3.2) [0-14.4]
severe illdays	"	**8.4** (10.4) [0-53.5]	**1.2** (5.5) [0-40.7]	n/a
% of cases	% (n)	80.5 (99)	60.0 (66)	48.5 (49)
% of cases with decreased activity	"	2.4 (3)	38.2 (42)	18.8 (19)
% of severe cases	"	67.5 (83)	7.3 (8)	n/a
Average/case:				
duration of episode (days)	mean (sd) [range]	4.3 (2.2) [1.0-13.8]	5.8 (5.0) [1.0-24.0]	4.6 (2.7) [0.6-13.6]
% of illdays with decreased activity	"	0.1 (1.0) [0-9.0]	44.0 (44.4) [0-100]	29.7 (41.8) [0-100]
% of severe illdays	"	64.1 (36.5) [0-100]	10.1 (27.9) [0-100]	n/a

TABLE 49: DESCRIPTIVE STATISTICS (MEAN ± SD) OF THE MORBIDITY VARIABLES IN TODDLER SAMPLES FROM EGYPT, KENYA AND MEXICO

	Egypt (n=82)	Kenya (n=99)	Mexico (n=59)
Overall morbidity			
w/ decreased activity (days/pers.yr)	N.A.	36.1 ± 39.9	5.5 ± 7.5
w/ severe illness (days/pers.yr)	23.1 ± 19.9	11.4 ± 20.0	N.A.
Diarrhea			
Incidence (episodes/pers.yr)	3.1 ± 2.7	1.1 ± 1.2	1.4 ± 2.0
Prevalence (days/pers.yr)			
- all episodes	14.2 ± 15.6	7.1 ± 10.3	6.7 ± 9.1
- illness w/ decreased activity	N.A.	3.6 ± 7.6	1.6 ± 3.5
- severe illness	9.1 ± 11.1	1.0 ± 5.0	N.A.
Lower respiratory infections			
Incidence (episodes/pers.yr)	1.3 ± 1.8	0.3 ± 0.7	1.3 ± 1.6
Prevalence (days/pers.yr)	7.8 ± 2.9	3.0 ± 7.6	8.0 ± 11.6

TABLE 50: SPEARMAN CORRELATIONS ($|R| \geq 0.15$) FOR MAIN VARIABLES CONSIDERED IN THE ANALYSIS OF TODDLER MORBIDITY BETWEEN 18 AND 30 MONTHS OF AGE (± 6 WEEKS): EGYPT (N=82)

	Overall morbidity		Diarrhea				LRI	
	w/decreased activity (days/ pers.yr)	w/severe illness (days/ pers.yr)	# episodes (epi./ pers.yr)	# days (days/ pers.yr)	# days w/ decreased activity (days/pers.yr)	# days w/ severe illness (days/pers.yr)	# episodes (epi./ pers.yr)	#days (days/ pers.yr)
Child:								
Length at 24 mo (cm)	N/A				N/A	-0.19		
Length gain (cm/mo)	N/A		-0.20	-0.18	N/A	-0.18		
Weight at 24 mo (kg)	N/A				N/A	-0.16		
Weight gain (kg/mo)	N/A				N/A			
Energy intake (kcal)	N/A				N/A			
Sex (1=M, 2=F)	N/A		-0.23*	-0.20	N/A	-0.17	0.20	0.23*
Mother:								
Height (cm)	N/A	0.20		0.16	N/A			
BMI (kg/m^2)	N/A		0.19	0.25*	N/A			
Age (yrs)	N/A			0.21	N/A	0.20		
Fat intake (% of energy)	N/A				N/A	-0.16		
Education (0-3)	N/A				N/A			
Household:								
SES (1-4)	N/A				N/A			
Sanitation scale	N/A	-0.27**	-0.20		N/A	-0.21		
Latrine (1=yes, 0=no)	N/A				N/A			
Water (1=in house, 0=no)	N/A				N/A			
HH size	N/A				N/A			

* $p \leq 0.05$
** $p \leq 0.01$

TABLE 51: SPEARMAN CORRELATIONS ($|R| \geq 0.15$) FOR MAIN VARIABLES CONSIDERED IN THE ANALYSIS OF TODDLER MORBIDITY BETWEEN 18 AND 30 MONTHS OF AGE (± 6 WEEKS): KENYA (N=100)

	Overall morbidity		Diarrhea				LRI	
	w/decreased activity (days/ pers.yr)	w/severe illness (days/ pers.yr)	# episodes (epi./ pers.yr)	# days (days/ pers.yr)	# days w/ decreased activity (days/pers.yr)	# days w/ severe illness (days/pers.yr)	# episodes (epi./ pers.yr)	#days (days/ pers.yr)
Child:								
Length at 24 mo (cm)	-0.15	-0.19					-0.21*	-0.20
Length gain (cm/mo)								
Weight at 24 mo (kg)	-0.29**	-0.22*						
Weight gain (kg/mo)	-0.18				0.17			
Energy intake (kcal)		-0.17						
Sex (1=M, 2=F)		0.15				-0.25**		0.15
Mother:								
Height (cm)								
BMI (kg/m^2)			0.15					
Age (yrs)		0.22*			0.17		0.24*	0.25*
Fat intake (% of energy)								
Education (0-3) (n=99)								
Household:								
SES (1-4)								
Sanitation scale	-0.17						0.15	0.15
Latrine (1=yes, 0=no)								
Water (1=in house, 0=no)	-0.41**							
HH size		0.18			0.15		0.21*	0.22*

* $p \leq 0.05$
** $p \leq 0.01$

TABLE 52: SPEARMAN CORRELATIONS ($|R| > 0.15$) FOR MAIN VARIABLES CONSIDERED IN THE ANALYSIS OF TODDLER MORBIDITY BETWEEN 18 AND 30 MONTHS OF AGE (± 6 WEEKS): MEXICO (N=59)

	Overall morbidity		Diarrhea				LRI	
	w/decreased activity (days/ pers.yr)	w/severe illness (days/ pers.yr)	# episodes (epi./ pers.yr)	# days (days/ pers.yr)	# days w/ decreased activity (days/pers.yr)	# days w/ severe illness (days/pers.yr)	# episodes (epi./ pers.yr)	#days (days/ pers.yr)
Child:								
Length at 24 mo (cm)	0.19	N/A				N/A		
Length gain (cm/mo)		N/A				N/A	0.21	0.20
Weight at 24 mo (kg)	0.19	N/A		0.17		N/A		
Weight gain (kg/mo)		N/A	-0.20	-0.15		N/A		
Energy intake (kcal)	0.17	N/A				N/A	-0.16	
Sex (1=M, 2=F)		N/A	0.16			N/A	-0.16	-0.15
Mother:								
Height (cm)		N/A	-0.28*	-0.26*	-0.15	N/A		
BMI (kg/m^2)		N/A				N/A		
Age (yrs)		N/A				N/A		
Fat intake (% of energy)		N/A	0.20	0.18		N/A	-0.15	
Education (0-3)	-0.15	N/A				N/A		
Household:								
SES (1-4)		N/A				N/A		
Sanitation scale		N/A			0.22	N/A	-0.22	-0.19
Latrine (1=yes, 0=no)		N/A				N/A		
Water (1=in house, 0=no)	-0.20	N/A	-0.18	-0.23		N/A		
HH size		N/A				N/A		

* $p \leq 0.05$
** $p \leq 0.01$

Two longitudinal models were used to investigate the direction of effect. In the first, the same independent variables including morbidity were used with attained size at 30 months (± 6 weeks) as the outcome (models B). The anthropometric measures closest to 30 months were transformed to Z-scores for length, weight and weight for length and used as dependent variables. The second model analyzes morbidity as an outcome variable using recorded size at 18 months (± 6 weeks) as the main predictor together with sex of toddler, household SES and sanitation and household size (models C). For this analysis, dichotomous variables were created for each anthropometric measure. The cut-off points were chosen as the closest whole Z-score which would maximize the number of observations in each category across projects (Table 53). Although no findings were significantly modified by this transformation, it offers the advantage of easier and, possibly, more practical characterization of the groups at risk, and represents an attempt at generalization.

The samples used for models B and C were identical whether the outcome was attained size at 30 months or morbidity between 18 and 30 months. These samples are limited by the availability of a weight and length measurement at 18 and 30 months (within a six weeks' window) and a minimum of six food records to calculate the average energy intake in the toddler's diet. These samples further exclude the few toddlers (6 cases in Kenya, 2 in Egypt and none in Mexico) whose weight-for-age was below 60% of the reference median (Z score –3.6 or less), in order to limit inference to the domain of mild to moderate malnutrition. Using identical samples for these two sets of longitudinal models, with either morbidity or attained size as outcomes, allows for interpretation of the relative roles of morbidity on growth and attained size on illness.

All longitudinal models were reexamined for consistency using the following two procedures:

(1) All morbidity variables were converted to ordinal variables (ranks).

(2) Anthropometry inclusion criteria were relaxed to include all toddlers with 18 month anthropometry measures in the morbidity outcome model (N = 101 for Egypt, 93 for Kenya, 57 for Mexico), or to include all toddlers with 30 month anthropometry in the models with morbidity as an intervening variable (N = 76 for Egypt, 107 for Kenya, 86 for Mexico).

The first procedure did not alter the significance of any model. Only these longitudinal models that remained statistically significant following the second procedure are presented in the tables. For comparability, data are shown for the samples that met both 18- and 30-month inclusion criteria (N = 62, 90 and 50 for Egypt, Kenya and Mexico, respectively).

Morbidity as an Intervening Variable

Cross sectional analysis

The morbidity variables which were statistically significant when added to Model 1 are presented in Table 54. The samples are identical to the ones previously used for Kenya (n = 100) and Mexico (n = 59) but limited in Egypt (n = 82) where fewer toddlers had the minimum of nine months of morbidity records. (For this reason, the basic model for Egypt is reported again, as Model A1 in Table 54, using only 82 cases).

In Egypt, incidence and prevalence of diarrhea are negatively related to body weight at 24 months of age. The prevalence of severe diarrhea shows the strongest negative association with weight and with this variable in the model, the household sanitation score loses statistical significance.

TABLE 53: FREQUENCY DISTRIBUTION (%) OF ANTHROPOMETRIC MEASUREMENTS AT 18 MONTHS ± 6 WEEKS (Z-SCORES) IN RELATION TO CUT-OFF POINTS USED IN REGRESSION MODELS FOR MORBIDITY

Anthropometric Indicator	Egypt (n=62)	Kenya (n=100)	Mexico (n=59)
Length for age			
< -2.0	41.9	55.6	52.0
≥ -2.0	58.1	44.4	48.0
Weight for age			
< - 1.0	43.6	76.7	68.0
≥ - 1.0	56.4	23.3	32.0
Weight for length			
< 0	50.0	72.2	66.0
≥ 0	50.0	27.8	34.0

TABLE 54: CROSS SECTIONAL REGRESSION MODELS IDENTIFYING MORBIDITY AS AN INTERVENING VARIABLE IN THE RELATIONSHIP BETWEEN TODDLER'S ENERGY INTAKE, HOUSEHOLD SOCIOECONOMIC AND SANITATION SCORES, MOTHER'S ANTHROPOMETRY AND TODDLER'S SIZE OR GROWTH RATE

EGYPT (n = 82)

	Dependent Variable = Weight at 24 mo (kg)			
	Model A1	Model A2	Model A3	Model A4
Intercept	7.40	8.02	7.84	8.07
Sex (1=M, 2=F)	-0.84**	-0.94**	-0.9**	-0.86**
SES	0.03	0.05	0.06	0.07
Sanitation	0.80*	0.66*	0.65*	0.56
LF BMI (kg/m^2)	0.05*	0.07**	0.07**	0.07**
Child energy intake (100 kcal)	0.10	0.10	0.10	0.10
Diarrhea incidence (episode/pers.yr)		-0.11*		
Diarrhea prevalence (days/pers.yr)			-0.02**	
Severe diarrhea prevalence (days/pers.yr)				-0.03**
R^2	0.24**	0.29**	0.25**	0.33**

KENYA (n = 100)

Dependent variable:	Weight at 24 mo (kg)		Length gain (cm/mo)	
	Model A5	Model A6	Model A7	Model A8
Intercept	7.69	7.29	0.27	0.31
Sex (M=1, F=2)	-0.48*	-0.42*	0.04	0.05
SES	0.19	0.17	0.001	0.002
Sanitation	0.09	0.01	0.005*	0.004*
LF BMI (kg/m^2)	0.08	0.10*		
LF height (cm)			0.001	0.001
Child energy intake (100 kcal)	0.10*	0.12*	0.0004	0.0004
Prevalence of illness w/ decreased activity (days/pers.yr)	-0.01*			
Prevalence of severe illness (days/pers.yr)		-0.02**		
Prevalence of diarrhea w/ decreased activities (days/pers.yr)				-0.004*
R^2	0.25**	0.27**	0.11	0.14*

*$p \le 0.05$, **$p \le 0.01$

In Kenya, toddler energy intake is positively related to weight, independent of morbidity. The prevalence of severe illness (by clinical criteria or as shown by the variable signifying decreased activity) is negatively related to weight. The model assessing rate of gain in length (slope) becomes significant only after addition of the variable, prevalence of diarrhea with decreased activity.

In Mexico, no model was statistically significant, so none is shown in Table 54.

Longitudinal analysis

The same basic models including morbidity variables were tested with Z-scores for attained size at 30 months (±6 weeks) as the outcome. Results are shown in Table 55 for the overall significant models showing an effect of morbidity.

These models identify a negative effect of the prevalence of severe diarrhea on attained stature in Egypt.

In Kenya, toddler energy intake is positively related to attained weight independent of morbidity. The prevalence of illness with decreased activity is negatively associated with weight.

Anomalously, illness with associated decreased activity is positively related to attained stature in Mexico. However, using only the 53 toddlers with a minimum of 3 months of weekly morbidity recalls implemented according to the CRSP protocol (September 1985 - April 1986) a strong effect of diarrhea on attained length is detected (Table 56), an effect comparable to the one observed in Egypt toddlers. Investigations of sources of bias in the morbidity data sets will be reported elsewhere (31).

Morbidity as an Outcome

The main predictor variable in this analysis is anthropometry at 18 months (± 6 weeks) treated as a dichotomous variable. In this analysis, household size is included as a potential confounding variable. Toddlers' energy intake is excluded from these models because it would not be possible to distinguish between energy intake as cause or effect of morbidity.

Results are presented in Table 57. In Egypt, weight at 18 months of age is negatively related to the subsequent prevalence of severe diarrhea. Similarly, in Kenya, weight is negatively related to the subsequent prevalence of lower respiratory infections, and weight for length, together with household sanitation score, are significant negative indicators of the subsequent prevalence of illnesses characterized by decreased activity. Again, counter-intuitively in Mexico, length at 18 months is positively associated with prevalence of illnesses with decreased activity.

Ideally, the household energy adequacy ratio might have been included as a predictor but it was not yet available for a sufficient number of households in Mexico. As an alternative the percent of energy derived from fat in the mother's diet was used as an indicator of household diet quality. With this variable included, Models C2 to C4 were statistically non-significant in Kenya and Mexico. In Egypt, the R^2 for Model C1 was increased to 0.23 and LF percent fat intake was negatively but not significantly ($p < 0.07$) related to prevalence of severe diarrhea.

TABLE 55: SIGNIFICANT LONGITUDINAL REGRESSION MODELS SHOWING THE EFFECT OF MORBIDITY, SEX, SES, SANITATION AND MOTHERS' ANTHROPOMETRY ON ATTAINED SIZE AT 30 MONTHS

	EGYPT (n=62)		KENYA (n=90)		MEXICO (n=50)	
	Length/age Zscore		Weight/age Zscore		Length/age Zscore	
	Model B1	Model B2	Model B3	Model B4	Model B5	Model B6
Intercept	-17.68	-18.94	-4.28	-3.86	-12.1	-11.7
Sex (1=M, 2=F)	-0.02	-0.04	0.01	0.02	0.11	0.05
SES	-0.05	-0.01	0.10	0.12	0.06	0.06
Sanitation	0.49	0.35	0.01	0.004	0.002	0.001
LF height (cm)	0.09**	0.10**			0.06	0.06*
LF BMI (kg/m^2)			0.06	0.06		
Child energy intake (100 kcal)	0.07	0.06	0.12*	0.11*	0.04	0.04
Prevalence of severe diarrhea (days/pers.yr)		-0.03**				
Prevalence of illness w/ decreased activity (days/pers.yr)				-0.01*		0.04**
R^2	**0.28****	**0.35****	**0.13***	**0.19***	**0.19**	**0.35****

*$p \leq 0.05$, **$p \leq 0.01$

TABLE 56: SIGNIFICANT LONGITUDINAL REGRESSION MODELS SHOWING THE EFFECT OF DIARRHEA, SEX, SES, SANITATION, AND MATERNAL HEIGHT ON ATTAINED STATURE AT THE END OF STUDY AMONG MEXICO TODDLERS WITH WEEKLY MORBIDITY RECALLS (N=53)†

	Length/age Zscore	
Intercept	-12.27	-12.95
Sex (1=M, 2=F)	0.16	0.09
SES	0.24*	0.22
Sanitation	0.002	0.002
LF height (cm)	0.05*	0.06*
Child energy intake (100 kcal)	0.02	0.03
Incidence of diarrhea (episodes/pers.yr)	-0.25*	
Prevalence of diarrhea (days/pers.yr)		-0.05*
R^2	0.38**	0.34**

†The average length of observation was 144 days starting at 26.1 months of age (sd=2.3 months). The mean age at length measurement was 31.1 months (sd=1.0 month).

TABLE 57: SIGNIFICANT MODELS SHOWING THE EFFECT OF ANTHROPOMETRY AT 18 MONTHS, SEX, HOUSEHOLD SOCIOECONOMIC AND SANITATION SCORES AND HOUSEHOLD SIZE ON SUBSEQUENT MORBIDITY (DAYS PER PERSON YEAR) BETWEEN 18 AND 30 MONTHS[†]

	Egypt (n=62)	Kenya (n=90)		Mexico (n=50)
	Model C1	Model C2	Model C3	Model C4
Dependent variable	Prev. severe diarrhea	Prev. illness w/decr. act.	Prev. lower resp. inf.	Prev. ill w/ decr. act.
Independent variables:				
Intercept	34.7	73.6	0.82	-24.9
Sex (1=M, 2=F)	-1.53	1.95	5.15**	-0.55
SES	0.92	0.38	-0.09	-0.45
Sanitation	-5.23	-1.05*	0.03	0.02*
HH size (n)	-0.72	-4.06*	0.40	1.52*
Weight for age[‡]	-5.81*		-4.91*	
Weight for length[§]		-23.0**		
Length for age[‖]				5.65*
R^2	0.18*	0.14*	0.12*	0.27*

[†] Significance levels are *p≤0.05, **p≤0.01

[‡] 0 if Z-score < –1.0; 1 if Z-score ≥ –1.0

[§] 0 if Z-score < 0.0; 1 if Z-score ≥ 0.0

[‖] 0 if Z-score < –2.0; 1 if Z-score ≥ –2.0

FINDINGS IN PERSPECTIVE

This report marks the formal ending of the Nutrition CRSP. Thus it seems appropriate to review the original goals of the program and to examine from that perspective the present findings on growth of children.

The NCRSP was developed to "examine in some detail the nature of the processes by which food-experiences - especially the experience of episodic or chronic deficiencies of intake - affect the lives of individuals, social groups and communities" (Final Report, planning contract, ref. 32, p. 37). The NCRSP projects were not intended to be fact finding surveys of the general nutrition situation in different Third World settings but, rather, to test specific hypotheses. As described in the planning document (p. 77), "The CRSP is designed as a series of research projects, each attempting to answer the same critical questions regarding the relationship between levels of food energy intake and functions of physiological, social and societal importance." It was envisioned that data would be obtained by the same methods and frequencies in several locations, all with prevalent mild-to-moderate energy restriction. The technique of meta-analysis then would allow assessment across the projects, strengthening the assurance of generalizability of the findings.

While the planners' emphasis was on *food* intake as represented by energy intake rather than on specific nutrients, it was recognized "that when food/energy intake is low, specific nutrient intake may also be low and that functional effects attributed to low food intake may not be consequences of inadequate energy intake per se. Also, levels of food intake that satisfy total energy needs may still be deficient in specific nutrients. These possibilities warrant consideration in experimental design and data interpretation.... Any research dealing with food energy deficits will necessarily entail consideration of nutrient content and bioavailability, but the intent is to focus on the more general problem of food energy intake as the primary independent variable." (p. 17). It was not, however, envisioned that projects might be sited in locations where food energy was not in short supply. The research design did include assessment of anemia because it is an almost universal associate of insufficient diets, but the overall plan did not encompass the range of micronutrient parameters appropriate to research designed to test hypotheses about vitamin and mineral deficits.

In choosing study locations, the principal investigators relied heavily on a traditional anthropometric measure, the prevalence of stunting, as the indicator of chronic food and food energy deprivation. Only in Kenya, however, does the evidence indicate that overall food availability, and hence energy intake, actually was low.

THE ROLE OF ENERGY INTAKE

A judgment as to whether or not food intake was quantitatively limited - and, hence, whether or not the original hypotheses were tested by the three projects - rests on the evidence of household energy intakes, body mass index of adults, and the relationships between energy intake and children's size and growth, and morbidity.

Household Energy Intake

Evaluation of the adequacy of household energy intakes is meaningful only in relation to energy requirements. Energy requirement is the total of the basal or resting metabolism (BMR, the maintenance energy cost which varies with size, sex and age), energy cost of activity (which varies with intensity and duration of effort) and, in children and pregnant women, a small energy cost for tissue gained, and for secretion of milk during lactation. Energy intake in excess of requirement results in accumulation of fat. To survive at low levels of intake a person or household must use up body reserves of fat and lean tissue or accommodate by reduction in expenditure. NCRSP data (3,5) have shown that there is no adaptive fall in BMR so accommodation must take the form of reduced activity, reduced growth, and/or reduced breast milk production. If energy intake is chronically limited, body fat reserves would likely be low because there is a limit to how far activity can be restricted - some productive activities are critical.

Activity was not measured in the NCRSP in ways that permit estimation of individual daily energy expenditures. International agencies (14) have, however, estimated that the total energy required for a heavy activity pattern is about two times the BMR, for moderate activity about 1.7 x BMR, and for light activity about 1.6 x BMR.

The household energy intake was over 1800 kcal/d/capita in Egypt and Mexico but only 1600 kcal/d/capita in Kenya (Table 11). Although per capita intakes are the same in Egypt and Mexico, owing to the heavier body weights and, hence, greater BMR of the Egypt household, the household energy adequacy ratio (household intake ÷ summed BMR of all members) is only 1.57 in Egypt but 1.71 in Mexico (Table 11). These ratios are consistent with probable expenditure requirements in the two locations due to differences in their occupations, terrain and amenities. Percentage of body fat (based on triceps skinfold measures) is somewhat higher in Egypt than Mexico and arm muscle area is lower in Egypt, indicating less upper body exercise in the latter (Table 12).

Based on body fatness, if there is an error in our assessment, it may be that consumption in Egypt is underestimated because habitual energy expenditure cannot have been appreciably lower than 1.5 to 1.6 x BMR. The population in Kalama appears well along on the transformation to a pattern of prevalent obesity (BMI of men is the same as the U.S. and women are one-half SD above the U.S. reference) and sedentary lifestyle typical of more affluent countries.

In Kenya, the household energy adequacy ratio was 1.49, sufficient only for a sedentary-to-light activity pattern. This does not coincide with expected requirements of a rural agricultural community lacking modern conveniences. Household food availability was especially low for about six months due to drought during year one of the main study. Adults lost weight during that period and regained it later. Still, Kenya adults were leaner than those in Mexico and the body mass index of Kenya women did not vary with age as it did in Mexico and Egypt (and as it does in the U.S.). BMI of Kenya men is far below the U.S. reference (Z score –1.4) and that of women is less constrained but still low (Z score –0.6).

Based on these observations, we suggest that:

- In Egypt, on average, household energy intake met or exceeded the energy requirements of adults; customary activity levels must be light for body fat to be accumulated, especially by women, at reported levels of intake.
- In Mexico, average energy intake met the average energy requirements of moderately active adults; energy intake probably is regulated by work demand; in women, but not men, fatness increases with age.
- In Kenya, average energy intake was insufficient to support the moderate activity level associated with typical occupational categories; on average, adults were thin and fatness did not vary with age; the energy supply probably regulates activity levels.

Body Mass Index of Adults

Energy adequacy appears to be a household attribute. Despite the differences between study populations in fatness and in trends of BMI with age in men and women, body weight, BMIs and mid-arm circumferences (MAC) of spouses are correlated significantly in all three locations (Table 14). Toddler weights and heights are correlated with their mothers' weights and heights, respectively, in all locations and also with their fathers' weight and height in Kenya (Table 20). Schooler weights and heights are correlated with paternal weights and heights in Egypt and Kenya and with maternal weights and heights in Kenya and Mexico. Mother-schooler heights are associated in Egypt and father-schooler heights in Mexico. Generally speaking, anthropometric characteristics of parents and children are more closely associated in Kenya than elsewhere and those of toddlers are more closely associated with mothers than with fathers. Paternal correlations are negligible in the toddler data set except in Kenya but associations between characteristics of fathers and schoolers are significant in Mexico and in Egypt where they are stronger than associations with maternal measurements (except for height which is approximately equal).

The strong intrafamilial similarities of height may have a significant genetic component, but weight or, more especially, fatness (as measured by BMI and/or MAC) is likely to reflect other shared household characteristics. Fatness indicators are closely associated with household socioeconomic score (SES) for both men and women in Kenya and Mexico, and with the household sanitation score for women in both locations and men in Kenya (Table 15). Socioeconomic and sanitation scores are, of course, intercorrelated in all locations (Tables 6 and 7), but for Egypt women only the sanitation score, not SES, is related to body weight and MAC.

SES scores reflect each project's composite measure of assets, occupation, and education. Higher SES could promote attainment of adequate to excessive body mass of adults by permitting higher energy intake through better access to food, by reducing expenditure due to less strenuous occupations or more labor-saving equipment and facilities, or both. The effect of socio-economic status on weight could be mediated through better sanitation (more money for soap, more energy available for cleaning activities) but only if improved sanitation led to decreased illness. This question has not been examined in the NCRSP adults.

The fact that SES was not correlated with fatness in Egypt, but that sanitation was, indicates to us that governmental subsidization of food staples, sugar, meat and cooking fuel effectively removed the economic barrier to adequate, even excessive, consumption of energy in Kalama. Other factors included in the aggregate socioeconomic status assessment - educational attainment, housing etc. - may exert their biological effects at least in part through improved sanitation.

It would be of interest to examine associations of adult anthropometric features with the household energy adequacy ratios and with adults' own energy intakes. It is not now possible for us to do so. Only a sample of Mexico household intakes has been prepared for analysis, lead female intakes are complicated by differing reproductive status and lead male intakes are often invalidated by inadequate recording of food consumed away from home. We have, however, looked at two potentially relevant adult dietary components, percent of calories from fat and consumption of alcohol.

Consumption of energy-dense, high-fat diets has been linked to obesity in some developed-country studies (33). None of the diets in the present studies is high in fat by Western standards (about 22% of energy is from fat in Egypt, 21% in Mexico and 11% in Kenya, Table 11). In Kenya, percent calories from fat in the lead female diet is strongly correlated with body weight, BMI and MAC of both men and women. In Mexico these relationships hold for women but not men, and in Egypt not for either sex.

The beverage pulque (fermented agave juice with about 2 to 3% alcohol) is a regular component of the diet in the Solis Valley. According to food records, 81% of men drink it (averaging about 500 kcal/d) and 74% of women, but in lesser amounts (200 kcal/d). In Kenya, 62% of men and 3% of women said that they drink beer, but only 11% of male food records include beer (63 kcal/d) and only one record of one woman listed beer. No consumption of alcoholic beverages is reported in Egypt.

Mexico men's frequency of pulque consumption was negatively correlated with their own and their spouses body weight and fatness measures and SES and sanitation scores. Consumption by spouses was strongly intercorrelated and pulque intake of schoolers (30% of the sample drank pulque) correlated with that of their parents. Linkages between SES and alcohol use are complex but in the Mexico study group it is the minority who do not drink. Fermentation of agave sap allows utilization of what would otherwise be an unexploitable resource. It may once have been an effective survival strategy in a subsistence culture and it may still be, a question worthy of further pursuit. In Kenya, self-reported frequency of beer consumption (survey data) is not correlated with anthropometric measures, SES or sanitation score.

Energy Intake, Child Size and Growth

Before turning to childhood growth relationships, we should comment on the anthropometric measurements *per se*. Size at birth was close to U.S. norms in all projects and deceleration in growth rate was apparent by 3 to 4 months of age (1-5). At age 24 months, toddler stature in all three locations was about 2 SD below the U.S. reference value for recumbent length, slightly more in Mexico boys (Z score of –2.50) and slightly less in Egypt boys (Z score of –1.96). Weight also was low but not as much as length, and weight-for-length was within one SD of the reference (Table 19). The 8-year old children were less stunted, relative to reference values, than the 2-year olds. In Egypt, the schoolers' height was a full Z score above that of toddlers, and better than the score of their parents. The increase in height Z score between toddler and schooler ages was about 0.7 in Kenya and 0.9 in Mexico, with girls showing more improvement than boys in Kenya and boys more than girls in Mexico. Kenya heights at age 8 yr were close to but slightly below adult heights (difference of 0.13 to 0.14 in Z score). Mexico schoolers' Z scores were almost identical with adults' (difference of 0.01 to 0.02 in Z score). As in the adults, Kenya children were the thinnest at both ages. Schoolers were thinner than toddlers in all locations.

These data are cross-sectional but if we assume that these points reflect longitudinal trends, then rates of growth must exceed those of the reference population at some period between ages 2 and 8 years. This led us to look for factors related to rates of change in stature and weight between 18 and 30 months of age and between 7$^1/_2$ and 8$^1/_2$ years. This was not a particularly promising avenue of inquiry because of the nature of the parameters: there is substantial variability in toddler weight increments that is not reflected in regression calculated from widely-spaced measures (one month or more); schooler growth rates are relatively low and to maximize the number available for study, slopes in some cases are estimated from a small number of measures. Attained height and weight are very closely correlated ($r \cong 0.8$, Table 18). Weight and rate of weight gain are significantly positively related in Kenya and Mexico toddlers and in Egypt and Mexico schoolers; height and rate of linear growth are not significantly related except in Egypt schoolers where the correlation is negative. In general, heavier children are continuing to gain the most weight during the study periods. The rate at which height is changing is not related to tallness except in Egypt schoolers where the taller ones are gaining at a lower rate. Furthermore height gain and weight gain are negatively correlated only in Egypt schoolers - those gaining in height are gaining less weight and vice versa. Because the improvement in height Z score between ages 2 and 8 in Egypt

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is so large, this may indicate that the period of "catching up" in height may be ending at about age 8 in Egypt.

Child's energy intake is related to both attained weight and height in Kenya toddlers and schoolers (Table 35). Attained size of Mexico schoolers, but not toddlers, also is related to energy intake. There is a negative association of energy intake and schooler height and weight in Egypt. Mothers' BMI, an indicator of household energy adequacy, is positively related to toddler sizes in all locations and to schooler sizes in both Kenya and Mexico. Bivariate correlations also point to SES and sanitation scores as related factors, so multivariate analyses were carried out to test the independent effects of the several factors.

Among toddlers, only in Kenya was attained height and weight significantly related to energy intake in models that adjusted for SES and sanitation scores and maternal height or BMI (Tables 39-40). SES was not a significant factor in weight and SES dropped from significance for height if dietary quality factors were included. Toddler weight, but not height, was significantly related to SES and sanitation scores in Mexico. Sanitation score but not SES was significant in both weight and height of Egypt toddlers.

The findings for Kenya schoolers were quite similar to those for Kenya toddlers (Tables 41-42). The only variable of significance for schooler height in Egypt and Mexico is mothers' height; maternal height is also significant in Kenya. SES and maternal BMI, as well as child's energy intake, are significant for Mexico schooler weight. Maternal BMI is also related to schooler weight in Kenya, but it is less significant than the schooler's energy intake, whereas the reverse is true in Mexico. The sanitation score is not related to these schooler parameters anywhere.

Stepwise regression analyses are generally consistent with the multivariate models just discussed. There are, however, some interesting differences in schooler findings. The positive relationship of Kenya schooler energy intake to attained height and weight is confirmed. Rates of gain in height and weight, however, become negatively related to energy intake in both Kenya and Mexico. In these two countries, growth rate is positively predicted by nutritional factors in stepwise analyses, implying that dietary quality is a key factor; when quality is held constant, diets with higher energy intake, and thus lower nutrient density (e.g., those high in unrefined cereal grains) are associated with poorer growth. In Egypt, attained size but *not* growth rate is negatively related to energy intake. In Egypt, larger school children may have lower energy intakes because they are less active and/or because their phase of catch-up growth has ended.

We conclude that:

- Energy intake is a first limiting factor in attained size of Kenya children. Under the prevailing conditions in Embu, food energy deficit is a more powerful correlate of growth failure than the aggregate factors of the socioeconomic status and sanitation scores. In Kenya, food scarcity at the household level is reflected in intergenerational stunting and overall thinness. Deprivation is shared.
- In Mexico, enough food energy appears to be available, although there is a hint of marginality in that maternal BMI, and in some analyses energy intake, is related to schooler size. *More* food is not the principal factor explaining the reason that SES is of some importance, but *what* food might be.
- In Egypt, SES was divorced from food energy intake by government intervention. Still, children are stunted.

WHERE ENERGY INTAKE IS ADEQUATE, WHY ARE CHILDREN SMALL?

Poor Dietary Quality

Since children are stunted in all three locations while energy intakes appear generally adequate in two of the locations, the possibility that the quality of the diet could be limiting child growth, even in the presence of adequate quantity, was considered.

Effects of nutrient intakes

Until the mid-1970s, the view was widely held that protein deficiency was responsible for the symptomatology of chronic malnutrition. The possibility that protein intakes were too low or that the profile of essential amino acids was limiting the utilization of protein was examined and effectively eliminated by a careful analysis of the diets in each location. Even in Kenya, where protein intakes were relatively low, there is little evidence that intakes are inadequate. It is unlikely that strategies which increase either the quantity or mixture of amino acids, *per se*, in children's diets will be effective in alleviating functional deficits. Addition of protein-rich foods would, of course, increase energy intake - a consideration in Kenya where energy intake limited growth - and might change the spectrum of other essential nutrients in the diet.

Although no evidence of an independent effect of animal-source protein on child growth was identified, there is considerable support for the likelihood of both vitamin and mineral deficiencies in the local diets. Co-occurrence of many of these nutrients in animal-source foods (Table 23) may explain the projects' previously reported associations of animal food intakes and functional outcomes. The children's dietary data (Table 25) would predict numerous inadequacies in Kenya (prevalences over 30% for iron, zinc, calcium, and vitamins B_{12}, D, and E) and Mexico (iron, riboflavin, and vitamins C, A, D, and E, plus zinc in toddlers and vitamin B_{12} in schoolers), and several in Egypt as well (iron, calcium, and vitamins A and D). Deficiencies of these nutrients, either singly or in combination, have known deleterious effects on functional outcomes (28):

- iron deficiency anemia is associated with poor growth and cognitive performance;
- low serum zinc levels are associated with poor growth and decreased immune system function;
- low vitamin B_{12} is associated with neurological problems and with macrocytic anemia and thus with poor outcomes due to anemia;
- vitamin A deficiency is known to lead to eye disorders (including blindness), changes in the skin and the lining of the lungs, and increased susceptibility to infections, and in the form of carotene, increased risk of certain cancers;
- low intakes of vitamin C can affect function of white blood cells, impair wound healing, and ultimately cause scurvy, and also contribute to poor absorption of dietary iron and increased risk of certain cancers;
- riboflavin deficiency is associated with various skin and mouth lesions and with anemia;
- low calcium intakes can lead to poor bone formation and growth in young animals and presumably in humans as well;

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- although vitamin D deficiencies are associated with poor calcium absorption, and thus with poor skeletal development, actual deficiencies in the NCRSP populations are unlikely due to production of this vitamin after exposure to sunlight;

- chronic vitamin E deficiency is associated with a spectrum of poor growth and maturation outcomes.

Biochemical measurements that have been reported generally support the conclusions from the dietary data as to what nutrients may be low:

- High prevalence of anemia is seen in all three countries; almost three-fourths of the toddlers in Egypt and Kenya have low hemoglobin values, as do over 60% of those in Mexico. Almost half of this anemia is also associated with low iron stores, but it is likely that multiple nutritional causes of anemia may be present (such as low intakes of vitamin B_{12}, zinc, riboflavin) in addition to non-nutritional causes (such as parasitic infections, sickle-cell anemia, and thalassemia).

- Although the analyses for serum zinc are limited, those which exist indicate levels to be low in Egypt (about one-third of the toddlers (2)), and Kenya (a small sample of adults (Charlotte Neumann, UC Los Angeles, personal communication)). Although a cause and effect association cannot be drawn from these data, the ranking of the degree of stunting observed in the three countries matches the magnitude of the prevalence of zinc deficiency (greatest in Kenya, and least in Egypt).

- Since folate intakes appear adequate in all locations, vitamin B_{12} deficiencies in both Kenya and Mexico are likely to be the cause of the macrocytic anemia observed in these locations (approximately 18% of toddlers in Kenya and 3% in Mexico). Vitamin B_{12} also is low in breast milk in Mexico (approximately 65% of samples are below levels which would prevent declines in biochemical measures in the infant (Lindsay Allen, U Connecticut, personal communication)); and Kenya (almost all samples collected after the first two months of lactation are very low (Susan Oace, UC Berkeley, personal communication)).

Finally, many significant associations of nutrient intake variables with child size and growth were observed (Table 36). These associations remained significant even after adjustment for energy intake, so the possibility that larger children are simply eating more food, and therefore more of all nutrients, is considered. In effect, if a nutrient remains a significant predictor of child size even after this adjustment, it is probable that the dietary density of the nutrient is important. As predicted by both the prevalence estimates and the clinical measures, nutrients with significant associations in one or more countries included vitamins A, C, B_{12}, and riboflavin. Associations with iron and zinc intakes can be interpreted only if the biological availability (absorbability) of these two minerals is taken into account. Negative associations are sometimes seen if the total intakes in considered (Table 36) because much of the iron and zinc in the diet is found in foods high in fiber and phytate which diminish the mineral absorption. When the intake of *available* mineral is calculated, the negative associations disappear, and significant positive associations appear for available zinc intake and child size among Mexico toddlers and Kenya schoolers. It is also notable that dietary fiber intakes were generally *negatively* associated with the child anthropometry measures, possibly reflecting the negative influence of fiber on mineral availability.

When all the nutrients are included in multivariate analyses, along with the non-dietary variables, many of the above associations remain significant. (In a total of 24 models examined (4 outcome measures for each age group and each country) one or more nutrients remained significant in 13 models). In fact, a number of the non-dietary variables which showed significant bivariate correlations with size and growth became non-significant when adjusted for nutrient variables. Thus, the question of whether the apparent associations of nutrients and child anthropometry are usually explained by associations of SES (or other non-dietary factors) and size/growth is answered in the negative by these analyses. The nutrients that were brought into these models contributed independent information about child size and growth in addition to the explanatory power of variables such as socioeconomic status, mother's size, and the types of food in the usual diet.

Effects of foods consumed

Although examination of associations between nutrient intakes and child anthropometry is the proper approach for elucidating possible biologic mechanisms, examination of food intakes and growth or size is useful for the purpose of guiding food policy and planning decisions, as well as for designing nutrition education programs. Furthermore, the potential limitations of the food composition data (which form an integral link in the calculation of the nutrient content of diets) are bypassed by considering consumption at the food rather than at the nutrient level.

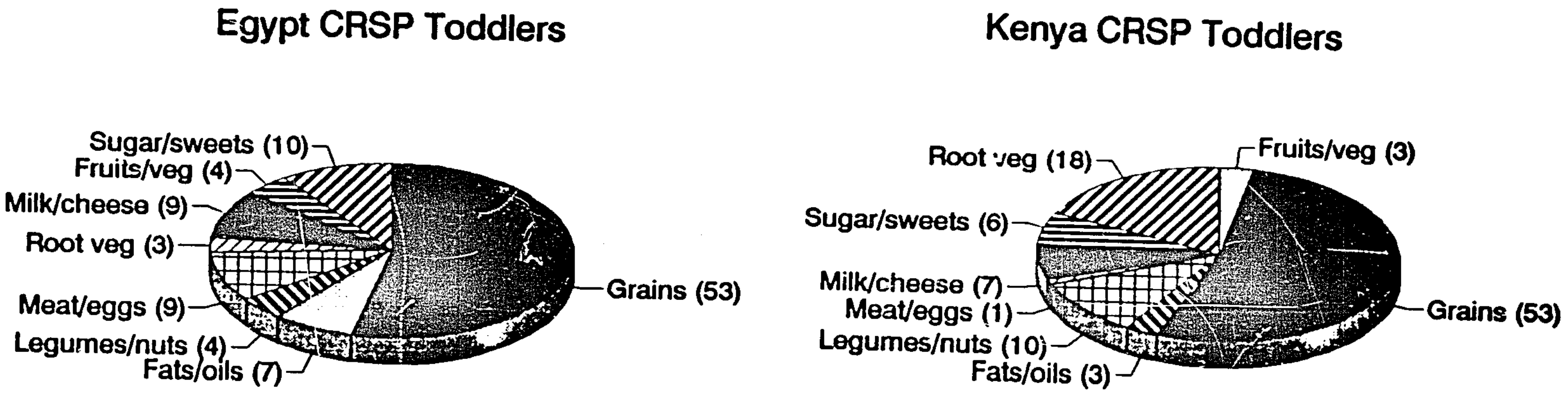
Differences among the countries in the percent of energy from each of eight food groups consumed by toddlers, along with comparable figures for U.S. preschoolers (34), are shown in the pie charts in Figure 2. It is obvious that grains form a much greater portion of the diets of young children in the CRSP countries than in the U.S.--almost twice the proportion in Mexico (62% of calories) than in the U.S. (32% of calories). On the other hand, the proportion of the U.S. children's diets from milk and cheese is two to three times the proportion in the CRSP countries. Although the Egypt children's diets have lower proportions of grains and higher proportions of dairy products than those for Kenya and Mexico, they are still much closer in composition to the diets of these two countries than to the U.S. diets. Thus, if dietary levels of dairy products and of unrefined grains are associated with the growth of children, it should be possible to see these effects in the CRSP countries where intakes are often at the extremes.

In general, food intake was as strongly correlated with child size and growth as was nutrient intake (Tables 36-38). As seen for nutrients, associations were stronger and more often significant in Kenya and Mexico than in Egypt, providing more evidence for the importance of diet in predicting child size in these two countries. Maize intake was uniformly associated with poorer growth and size in Mexico and Kenya toddlers (where intakes of maize were very high), and usually for schoolers as well. In contrast, milk and cheese intakes were positive predictors of child size in these two countries. As with the nutrient analyses, these associations are adjusted for energy intake, so the effect of larger children eating more of all foods is considered.

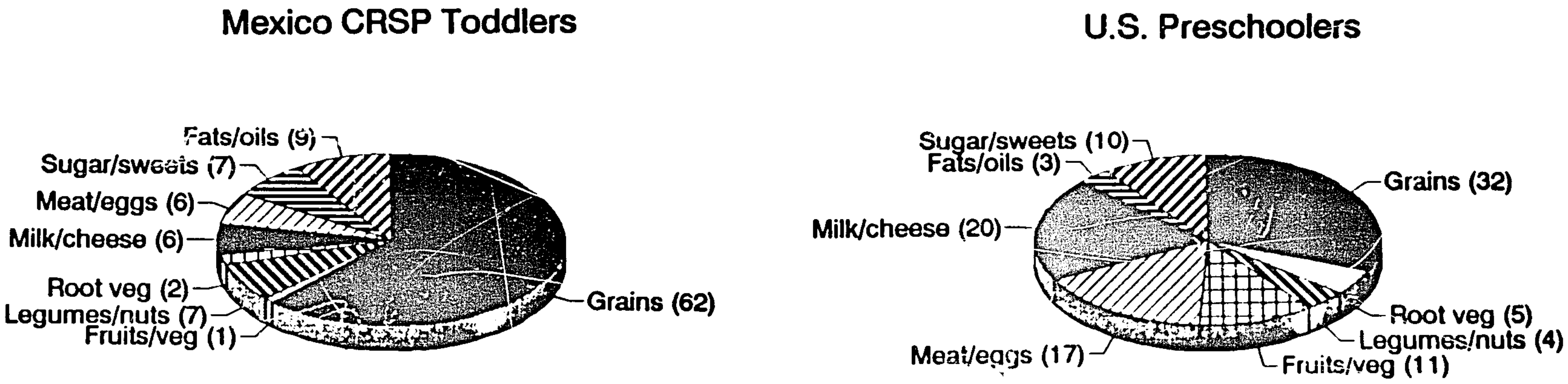
The question then arises of the importance of non-dietary variables, such as SES, sanitation, and mother's size, in these associations. Multivariate analyses of child anthropometry, including the non-dietary variables, showed that while some of the food intake associations were attenuated, many remained and were in fact stronger than the non-dietary associations.

The combination of positive and negative associations of foods and nutrients with child anthropometry led us to consider characterizing *patterns* of intake, i.e., some measures of the combinations of foods that were typically consumed. Principal component analyses identified two patterns for each country and each age of child (toddlers and schoolers); these patterns tended to describe a "positive" diet (positively associated with both SES and child size) and a "negative" diet

FIGURE 2: SOURCES OF ENERGY FOR CRSP TODDLERS: PERCENT OF CALORIES FROM EACH OF 8 FOOD GROUPS


Egypt CRSP Toddlers

Kenya CRSP Toddlers


Mexico CRSP Toddlers

U.S. Preschoolers

(negatively associated with SES and child size). As would be expected, the patterns were best correlated with child size and growth in Kenya and Mexico, and often predicted these outcomes nearly as well as any specific nutrient or food group. These analyses further support the concept that a dietary mix of foods (higher in dairy/meat and lower in maize) is predictive of better child growth and attained size.

Combined effects of foods and nutrients

Finally, we addressed the issue of the relative importance of the many dietary and non-dietary variables in predicting child anthropometry outcomes using multivariate analyses (Tables 45 and 46). Since nutrient intakes, food group intakes, and dietary pattern scores were allowed into the models, it is possible to evaluate the independent effects of each. As would be expected, there are fewer nutrients that are significant under these stringent conditions, but the ones that do remain (e.g., zinc and toddler length in Mexico, zinc and schooler weight gain in Kenya, calcium and schooler height gain in Kenya) are likely to be worthy of further investigation, and possibly intervention trials, especially when conclusions from the prevalence of inadequacy analyses and the clinical observations are congruent.

Several of the schooler multivariate models suggested that both nutrients and foods were important in predicting child anthropometry (e.g., zinc as a positive predictor and cassava as a negative predictor of weight gain in Kenya). In other models, foods were more important than nutrients as size or growth predictors (e.g., high vitamin C fruits/vegetables and attained weight and weight gain for Mexico schoolers). The first dietary pattern remained a highly significant predictors of toddler length in Kenya and schooler height gain in Egypt, implying that these variables can describe diets that are important in predicting child anthropometry independently of energy intake and of the household non-dietary variables. In cases where foods and/or patterns appear more important than nutrients, attention should be paid to possible effects of dietary density and consistency. Especially for toddlers, it may be that diets which require a large volume of consumption in order to satisfy energy needs may not be easily accommodated. The interactions of high fiber and phytate, low digestibility, and low nutrient density may combine to contribute to nutrient deficiencies in young children.

There is the possibility of nutrient interactions that have not been considered. In these analyses, calculated intakes of *available* iron and zinc have shown more logical correlations with serum measures of iron status. However, it is possible that the calculations could be improved by more research into the factors affecting trace element bioavailability. Furthermore, other interactions (for example, between fiber and the absorption of other minerals or vitamins) have not been considered and may be of importance for diets very high in unrefined grains. These interactions, and their effects on outcome measures, may be better captured by examining associations at the food and dietary pattern level than at the nutrient level.

It is important not to limit further investigations to only those variables present in the final multivariate models. Even variables which are not brought into these final models may share information with those that are. Furthermore, since effects of deficient intakes on functional outcomes are often difficult to determine with cross-sectional analyses, associations of importance may be overlooked. Foods which consistently predict outcome measures might be candidates for further studies of nutrient composition and availability. All nutrients for which there are either clinical signs of deficiency in the population, or for which a high prevalence of inadequate intakes is predicted, are candidates for further attention by policy analysts and program planners.

High Incidence of Morbidity

The incidence of morbidity, particularly that due to diarrheal and respiratory illnesses, is highest in the youngest age groups, the time when growth rate shows marked deceleration in these studies (5). We have, therefore, examined morbidity of toddlers both as a causal factor in attained size, and as an outcome.

Illness affects intake

In Kenya, energy intake is consistently related to children's anthropometry. In toddlers, part of the energy deficit, beyond the usually low intake of the community, is due to illness (Table 46). The average energy deficit on days of severe illness (132 kcal/d) and illness with accompanying decreased activity (143 kcal/d) is sizeable and very similar to the value reported by Martorell et al. (35) for a group of Guatemala toddlers with a comparable usual energy intake. The difference in intake on days with and without severe illness in Mexico also is substantial (232 kcal/d) but not significant because of the small number of illness-day records. The difference is much smaller in Egypt (73 kcal/d) and not significant.

In Egypt and Mexico usual energy intakes appear adequate to support growth. Compared to Kenya, the relationships between energy intake and anthropometry among toddlers in Egypt and Mexico are weak and inconsistent. This suggests that diminished energy intake on days of illness is relatively unimportant when enough food energy is available for consumption on days of wellness. Nevertheless, attained size is impaired in all three projects, with Kenya toddlers being the most affected and Egypt the least.

Growth deficits are already present by 18 months of age and, although persisting thereafter, they have been accumulated during the birth-to-18 months age window. Since no data on food intake are available before 18 months of age, the possibility of an inadequate energy intake due to illness during the early growth period cannot be excluded. Such energy deficit could be secondary to inappropriate consumption of solid or liquid foods of low nutritional value in addition to appetite-suppression accompanying the expected higher prevalence of infections in that vulnerable age group.

By 18 months of age, partial immunity to common infectious agents, as well as greater tolerance to a wider array of foods, may contribute to the overall adequate energy intake in communities where food is available in sufficient quantity (Egypt and Mexico). Even so, growth deficit persists into the second year of life.

Illness, size and growth

After adjusting for energy intake, the prevalence of diarrhea associated with decreased activity (an indicator of severity) still is negatively related to linear growth (i.e. more illness with poorer growth) in Kenyan toddlers (Table 54). Illness associated with decreased activity irrespective of diagnosis is also, together with energy intake, negatively related to attained weight at 30 months (Table 55).

The role of morbidity as a determinant of growth, independent of energy intake, is suggested in Egypt by the negative relationship of prevalence of severe diarrhea with attained height at 30 months (Table 55). Although causality is not necessarily implied by this model, it is suggested by 1) the time relationship between morbidity and attained size, and 2) the absence of increased risk of subsequent morbidity associated with height at age 18 months. Weight for age, however, which is related to diarrhea in the cross-sectional model (Table 54), appears as a predictor of subsequent severe diarrhea in the longitudinal model (Table 56). These observations are consistent with a negative but transitory effect of diarrhea on weight in situations where energy intake is sufficient during recovery. It also confirms the particularly negative effect of frequent and/or severe episodes of diarrhea on linear growth, independent of energy intake, a phenomenon attributed by Lunn et al. (36) largely to long-term intestinal lesions with reduction in absorptive surface area. Other potential mechanisms, although not specific to diarrhea, may include changes in the hormones that regulate growth (growth hormone/somatomedin axis (37)) and increased adrenal hormone (cortisol) production associated with stress (38).

In Mexico, the analysis so far does not support a role of morbidity as a determinant of physical growth. In this project, in addition to a different recall method used for most of the study duration, the diagnose for diarrhea and LRI are less specific and include milder symptoms are compared to the other two projects (see p. 17). However, additional analysis based on only the 53 toddlers for whom a minimum of 3 months of weekly morbidity recalls were administered according to the NCRSP common protocol suggests that diarrhea may have indeed a negative effect comparable to that observed in Egypt (Table 56).

Morbidity as an outcome

The question of whether a decrease in energy intake is a predictor of subsequent morbidity was not addressed directly. At the community level, it is clear that the highest morbidity burden will not always be found in the communities with the lowest food intake (within the limits investigated in this study). Our earlier report (5) noted that infant mortality was high in Egypt and quite low in Kenya. The present analysis shows that the Egypt toddlers were the most affected by diarrhea and lower respiratory infections in spite of their adequate energy intake (Table 48). The precarious sanitary conditions in that periurban community may be responsible for the high prevalence of infections. Irrespective of the causal factors, in these populations that exhibit linear growth retardation, unsatisfactory weight parameters appear to be indicators of subsequent morbidity. Within communities in both Egypt and Kenya, a decreased weight for age or weight for height at 18 months are predictive indicators of an ongoing increased risk of severe illness (Table 57). The mechanisms by which severity of illness, rather than incidence or prevalence, may be increased in mild to moderate malnutrition needs further investigation.

IMPLICATIONS FOR PROGRAMS AND POLICIES

The history of interventions intended to address malnutrition is marked by many more failures than successes. Some have failed because the nutrition problem was misidentified, others because the continuing cost was insupportable owing to inadequacies of targeting, high cost of delivery systems or requirement for infrastructure beyond the capacity of poor countries to provide. We recognize that failures are often due to reasons beyond the scope of the present study (conflicting national priorities, political instability, poor planning capacity, etc.).

Many of the failures appear, in retrospect, to be due to reductionist analyses, to a narrow definition of "the nutrition problem". In any case, an accurate diagnosis of the problem -- one that asks who the malnourished are, what they lack and why they lack it -- should greatly improve the probability of successful intervention. The present NCRSP research suggests ways in which the diagnosis necessary for planning can be improved and offers some new tools to aid the work.

Diagnosing the Problem

The NCRSP projects selected their populations according to the criterion on which the judgment of malnutrition historically rests, stunting of children. What the NCRSP has shown clearly is that stunting has multiple but identifiable etiologies. It has shown equally clearly that to define the nutrition problem in policy-relevant terms, information on food consumption is critical.

Indicators of energy deficit

The projects intended to study energy deprivation. Fortuitously, the fact that only in Kenya was there an energy deficit led to a new potentially useful marker of energy supply, the BMI of women. Where food energy was sufficient for needs, the BMI of women varied with age; in Kenya BMI of female adults was unrelated to age. Maternal BMI was a fairly consistent, positive correlate of children's size or growth. The simple indicator needs to be tested in other situations (particularly in urban populations with reduced energy requirements for activity) but it has desired attributes of simplicity and low cost.

The Household Energy Adequacy Ratio is a marker of another kind. The extent to which the household food energy consumption exceeds the total maintenance energy requirement (the resting or basal metabolism) is a measure of the amount of energy available for activity and tissue gain. A value that is less than 50% above the maintenance need (1.5 x BMR) is a strong indicator that the energy supply is insufficient for a productive, healthy lifestyle.

Food patterns as an indicator

These analyses have identified patterns of food intake as an important indicator of child size and growth. Estimates of the proportions of the energy in children's diets from specific food groups may be used to target individuals and communities likely to be at risk of poor anthropometric outcomes. In two of the NCRSP sites, lower intakes of dairy products coupled with higher intakes of unrefined grains were consistently associated with smaller size and slower rates of growth. Thus it appears that an evaluation of the usual sources of energy in children's diets might precede more expensive assessments of nutrient intakes or evaluations of biochemical markers of malnutrition. After a dietary pattern analysis, populations at risk of malnutrition could then be efficiently targeted for further evaluation and possible intervention. Further development and refinement of such a dietary pattern screening tool is seen as a research priority.

The food composition data base developed for this research (INT Minilist) allows translation of foods consumed into a first approximation of nutrient intakes. From this it proved possible to predict what nutrients are likely to be at risk in a population. This information can be used to narrow the range of costly, difficult and often invasive biochemical or clinical measures needed for more certain identification, or it can be used to design food- or nutrient-based intervention trials.

Anthropometric markers

This research has focused on anthropometric measurements as outcome variables, but the findings do offer some insights relevant to intervention.

Firstly, most of the deceleration in growth occurred before age 2. Some of the reasons for this may be found in NCRSP data on pregnancy, lactation and early infancy (which we have not yet been able to explore) but this period is consistently the high risk period across the projects and a target for further study and subsequent intervention.

In contrast to the commonly held view - based mainly on developed-country data - children in the CRSP communities did not follow a growth trajectory established by the age of 2 years. The schoolers were in better status relative to the reference population than were the toddlers. A more focused study might better identify the factors conducive to catch-up growth, taking advantage of the plasticity that clearly remains.

Finally, weight-for-age or for-height at 18 months differentiated these toddlers who experienced more severe illnesses in the following year. Programs with very limited resources may find such an assessment of value in more precisely targeting a spectrum of health-related activities, including nutrition.

Inferences About Root Causes of Inadequate Diets

Household choices concerning food consumption are affected by food availability, food prices, and the knowledge, attitudes, and preferences of household decision makers. For households involved in farming, whether for home production exclusively or for market exchange, decisions about what is grown and what is consumed are likely to be affected by the experience and knowledge of lead adults. Decisions about which foods are to be purchased in the market, and how they are to be shared within the household are likely to be affected by the education and knowledge of lead females. Thus the acquisition and sharing of foods is affected by household economics (availability of money and time) and the awareness of key decision makers concerning appropriate diets. The NCRSP was not designed to unravel this web of factors, to treat food intake as a dependent variable, but the findings allow reasonable inferences to be drawn about some of these factors.

Before turning to the household factors, the NCRSP shows clearly that government policies can affect the availability of food. In Egypt, basic levels of food consumption were supported through three types of subsidies: a monthly quota of rice, oil, sugar, tea, and soap was guaranteed for all households; state-owned cooperatives distributed certain foods at lower-than-market prices, such as macaroni, eggs, oil, cheese, sugar, tea, and frozen chickens; and bread and wheat flour were subsidized for all consumers regardless of income (39). These programs appear to have met their goal -- food was not a significant factor in the Egypt outcomes reported here. The effectiveness of governmental programs in the other countries is less obvious. In Kenya, staple commodities such as maize, milk, and sugar have been subsidized principally to benefit the urban poor. In Kenya, variability in rainfall is a recurrent problem leading to poor production and lack of available food: a family's ability to sustain itself through periods of want is a product of its economic reserves and strategic planning ability unless there is effective external intervention. Emergency food relief was provided in Embu at the time of the drought by order of the President, and was implemented through the local community famine relief committee. In Mexico, rural food stores provide basic goods to low-income populations at regulated prices. Additionally, food assistance has been provided through the National System for Integrated Development of the Family, offering direct assistance to low-income households, school-feeding programs, and the promotion of small-scale food production in some rural areas. Enough food appeared to be available in Solis but the extent to which that was owing to these programs is undocumented.

The measure of socio-economic status (SES score) created by each project allowed us to examine bivariate relationships between intakes and SES score (Table 24). SES score was positively associated with energy intake of Kenya schoolers and with toddlers' and schoolers' animal protein (a marker for several nutrients at risk of inadequacy) and fat intakes in all locations. Bivariate relationships between food patterns and SES (Table 31) in Kenya and Mexico show that generally, children's intakes of staple foods which were grown on local farms (maize, leafy vegetables, legumes and, in Mexico, pulque) are negatively correlated with SES while foods which were procured in the market (dairy products, meat, eggs, sugar, separated fats) are positively correlated with SES. In Egypt, subsidization attenuated these relationships.

The logical inference from these findings is that the relationship between SES and energy intake in Kenya is due at least in part to economic limitations on the capacity to produce and/or to purchase sufficient food; and, that the relationships between SES and intake of foods of high nutrient quality and density in both Kenya and Mexico are due in part to a combination of higher price and lower disposable income.

Knowledge about the need for specific foods in children's diets and who controls expenditures also may be important variables. Bivariate relationships between education of lead males and lead females with nutrient intakes were explored but are not presented in the text. Intercorrelation of SES and education present an obvious analytical problem. The findings, however, suggest that a pattern of parental education, more often for maternal than paternal education in the youngest age groups, is correlated with nutrient intake. In some instances, these relationships are stronger than the bivariate correlations of SES with nutrient intakes. While we have not been able during the course of [illegible] present study to carry out further investigations using multivariate analysis, there are some indications that education plays a role in determining food consumption decisions, independently of household SES level.

We have made the case, above, that higher SES allows consumption of more food where availability is low for all - the Kenya situation - and of better food where income is what limits access, as in Kenya and Mexico. In Egypt, the consumption constraint is essentially removed by government intervention, at least for those who eat from the household supply (excluding infants). Other facets of socio-economic conditions of the household provide clues as to other mediators of outcomes. For example, the sanitary environment of the household as reflected in the sanitation score, the quality of housing, the availability of potable water and latrines, and crowding (related to household size) all contribute to household health/morbidity, which in turn affects the relationships between intake and outcomes.

We have shown that mothers' height and BMI are consistently related to the size of their children. Maternal BMI is a marker of the present household environment. Maternal height can be interpreted as a genetic factor, but height is also an indicator of previous nutritional or infectious stresses carrying over generations. Because the early development of the child affects the productivity of the adult, each generation's intake and health will have echoes into the next generation.

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