PN-ABH-606

PEW/CORNELL LECTURE SERIES ON FOOD AND NUTRITION POLICY

THE FUNCTIONAL CONSEQUENCES OF MALNUTRITION AND IMPLICATIONS FOR GOVERNMENT POLICY

by

Doris Calloway
Professor, Department of Nutrition
University of California, Berkeley

November 21, 1989

Cornell Food and Nutrition Policy Program
Division of Nutritional Sciences
Savage Hall, Cornell University
Ithaca, New York 14853

The Cornell Food and Nutrition Policy Program (CFNPP) was created in 1988 within the Division of Nutritional Sciences to undertake research, training, and technical assistance in food and nutrition policy with emphasis on developing countries. The Nutritional Surveillance Program (CNSP), which was formed in 1980 with support from the Agency for International Development, is part of the CFNPP.

CFNPP is funded by several donors including the Africa Bureau, the Nutrition Office and several country missions of the agency for International Development, UNICEF, the Pew Memorial Trust, the Rockefeller and Ford Foundations, the Government of Indonesia, the Carnegie Corporation, and the World Bank.

CFNPP is served by an advisory committee of faculty from the Division of Nutritional Sciences, the departments of Agricultural Economics, City and Regional Planning, Rural Sociology, and Government, and the Program of International Agriculture. Several faculty members and graduate students collaborate with CFNPP on specific projects. The CFNPP professional staff includes nutritionists, economists, and anthropologists.

The Pew/Cornell Lecture Series on Food and Nutrition Policy, which was initiated in 1988, is sponsored by the Pew Memorial Trusts of Philadelphia and the Cornell Food and Nutrition Policy Program to generate and exchange knowledge about how government policies affect the welfare of the poor including their food security and nutritional status. A list of all Pew/Cornell lectures is shown in the back of this publication.

FOREWORD

Decisions about the allocation of scarce private and public resources are made at least in part on the basis of perceived relative economic returns. Therefore, although most of us probably feel that efforts to alleviate malnutrition can be justified on their own merit, such efforts must compete with other demands for resources, and more very likely would be done to improve nutrition if better knowledge of the associated economic gains were available. The result would be not only less malnutrition but also higher rates of economic growth. In order to estimate the economic gains, we need to understand the functional consequences of malnutrition at the individual and household levels.

In this lecture, Doris Calloway presents the results from the largest multi-country study ever undertaken to gain such understanding. Based on a comprehensive conceptual framework and field surveys in three countries, Professor Calloway discusses and analyzes the most critical relationships and findings and concludes that where total food intake is low, important functions are affected. However, even in cases where sufficient food is available, malnutrition and associated functional consequences can be found. The relationships between malnutrition and functional outcomes are complex and the interaction among food, infectious diseases, and behavior must be understood not only to determine the functional consequences but also to design effective solutions to nutrition problems. Findings from the work reported by Professor Calloway clearly illustrate these complexities and suggest that appropriate solutions to existing nutrition problems are likely to have functional consequences with economic implications.

Per Pinstrup-Andersen
Director, CFNPP

The Functional Consequences of Malnutrition and Implications for Policy: Case Studies in Egypt, Kenya and Mexico[1]

by

Doris Howes Calloway
University of California, Berkeley

BACKGROUND

The Nutrition CRSP, the Collaborative Research Support Program on Nutrition and Human Function that was responsible for the research to be presented here, was a more-or-less direct outcome of the unsatisfying argument about the place of nutrition in national planning in the late 1960s and '70s. Agencies convened multidisciplinary groups of experts to advise on the incor-

---

1 Research supported in part by the United States Agency for International Development under grants DAN-1309-G-SS-1070-00 and DAN-0262-G-SS-7079-00 and by the University of Arizona, University of California (Berkeley and Los Angeles), University of Connecticut, University of Kansas, Purdue University, and the University of Toronto. Findings presented in this paper are taken from the Final Reports of the Egypt Project (Galal et al., 1987), the Kenya Project (Bwibo et al., 1987), and the Mexico Project (Chavez et al., 1987) and the Management Entity (Calloway, Murphy, and Beaton, 1988). These are available from USAID or through interlibrary arrangements with the University of California at Berkeley (call no. TX 360 C84 1987).

poration of nutrition objectives for national development strategies in the reasoned belief that improvement in the nutritional state of the poor is necessary for sustained economic development. Not only was that premise rejected by some persons, then and subsequently, as being unproved, but other issues were raised.

Two principal points challenge the concept of a primary role for nutrition. The most consequential is that, barring actual famine, malnutrition results not from lack of food but from the disease experienced by young children in unclean environments. The logical conclusion is, therefore, that nutrition interventions are futile unless health conditions are improved first. There is, indeed, ample evidence that diseased children, like other diseased animals, fail to thrive; but there is also substantial evidence that good nutrition very significantly reduces the impact of infectious disease. Nutrition and disease are, however, so interactive and so difficult to investigate that it is hard to establish the independent contribution of either in natural situations.

The second point challenges the significance of the indicator most often used to demonstrate the existence of malnutrition, i.e., size of children. Almost all studies have relied on height and weight measurements to assess nutritional state and changes in state due to intervention. This practice persists, despite the knowledge that size is not a specific nutrition indicator, because it is costly and difficult to assess food intake and the biochemical markers of nutritional status. The challenge, however, has not been to the validity of the indicator, but to the significance of size, the argument being that there is nothing inherently bad about smallness per se. It is now, however, quite generally agreed that smallness caused by an adverse environment carries lasting prejudicial concomitants. The Nutrition CRSP has produced additional evidence on this point: cognitive development of infants at birth, of toddlers, and of school children is positively correlated with size, and infant birth weight is correlated with maternal size. The real problem is to know the extent to which achieved size is dependent on nutrition.

For nutrition concerns to be reflected in development planning, more, better, and different information is wanted. The incorporation of social/welfare objectives, including nutrition, has some perceived cost to the pace of economic development. The persuasive counter-argument would involve assessment of benefits in terms of people's ability to function capably in socially relevant domains. This means not just a demonstration that good nutrition makes a filthy environment more bearable or that bigger is better, but being able to document the functional improvements that can be expected from incremental inputs over what range of intakes for which groups of individuals.

The Nutrition CRSP was planned to address such policy-oriented questions.[2] Funding was provided by USAID to carry out binational projects in three USAID geographic regions. A research design was developed by the collaborating US and host country principal investigators in 1979. The program was funded in September, 1981, with the University of California at Berkeley serving as the Management Entity but not a direct participant in the research. As might be expected, the CRSP funding ended before the analytical work was complete. Funding has recently been obtained for the investigators to continue this task. Today's presentation, however, is based mostly on the principal investigators' reports of 1987 and our own brief review of their findings in 1988.

THE CRSP RESEARCH DESIGN

The grand research plan of 1979 was scaled down by the collaborating investigators in consideration of 1979 dollar-based budgets and in light of field experience with test methods. It was much further simplified on the advice of an External Evaluation Panel. The initial plan was to focus on households as the unit of study with assessment of five functional domains across two years. As

---

2 The history of the development of the Nutrition CRSP is too involved for this discussion. For a description of planning and implementation, see Calloway, Wood, Beall, and Cattle, 1980. The conceptualization of the research topic is described in National Academy of Sciences, 1977.

finally implemented, data were gathered over one year for each of four or five target individuals within a household, emphasizing disease experience, cognitive development, and aspects of reproduction. The unique design features of this research were that food intake would be measured in such a way that hypotheses linking intake to function could be tested; several members of a household (including fathers as well as mothers) would be studied simultaneously, allowing analysis of interactions through which the deprivation of one individual may impair the function of others; and potentially important intervening variables would be recorded. A common design would permit comparison across sites, each of which was to include a suitable population of food energy-deficient and -sufficient households.

The final research plan was designed to test six main sets of hypotheses:

1. Food intake of lead adults affects their morbidity, their care of and attention to children, and their performance of usual tasks; and these, in turn, affect the morbidity and cognitive and behavioral performance of other household members.

2. Maternal intake during pregnancy and lactation influences the infant's endowment at birth and development during the first six months of breast-feeding. Thus, infant body size, psychological development, and morbidity are affected by maternal food intake.

3. Food intake of the toddler between 18 and 30 months affects his/her body size, morbidity, and psychological development.

4. Food intake of the schooler between seven and nine years affects his/her body weight, morbidity, and behavioral and cognitive performance.

5. A reduction of the resting metabolic rate in adults provides a major path of adaptation to restore energy equilibrium.

6. Household food intake affects household morbidity.

A very large array of variables had to be measured to test these hypotheses. In brief, the regular cycle of principal measurements included the following:

1. weekly morbidity of all household members;

2. monthly food intake of all target individuals and households measured two days per month;

3. monthly anthropometry for target individuals and annual anthropometry for non-target household members;

4. monthly observations of selected activities of the lead female;
5. quarterly metabolic rate of a subsample of lead males and lead females;
6. semi-annual cognitive tests of children and once only of adults;
7. semi-annual clinical examinations and demographic updates; and
8. socioeconomic and sanitation indicators.

The investigators agreed on methods to measure and record these variables. Recognizing that adjustments appropriate to field conditions would be necessary, they also agreed nevertheless that measurement schedules would be constant and the contents of the variables uniform. Perfect concordance was not achieved, but, in many important respects, the three data sets can fairly be compared.

The investigators were free to add other variables appropriate to the site locations and their own interests. These project-specific variables add much richness to the data set.

RESEARCH SITES

The projects sites selected for the CRSP were in Egypt, Mexico, and Kenya. Population in all three countries increased by about 30 percent between 1969-71 and 1979-81, but the national food situations were quite different (FAO, 1987). In Egypt, the dietary energy supply (DES) rose by 24 percent, from 2561 to 3178 kcal/capita, a figure almost as high as the DES of developed countries. Food availability in Mexico also improved, despite population growth, though less dramatically: DES increased by nine percent, from 2641 to 2891 kcal/capita. Kenya lost ground: the low DES of 1969-71, 2260 kcal/capita, fell to 2012 kcal by 1979-81.

The research design did not require that the study populations be representative of the host countries. It only required that the sample include the range of energy intakes needed to test the hypotheses. Undernourished groups can be found in even the most prosperous countries, as studies in this country demonstrate, so there was no suggestion that the locations were unsuitable. The

research site within a country was chosen by the host country investigator in collaboration with the US partner. Criteria for selection of the study community were agreed upon in advance. But, in the end, selection appears to have been heavily weighted by practical factors, and two indicators, relative poverty and size of children, were used implicitly as a proxy for estimating the range of energy intake.

Site selection has directly affected comparability, but, fortuitously, has led to fruitful speculation across the projects. The three communities proved to be lacking in different areas, but they experienced some very similar outcomes. Similar outcomes will be seen to have different proximate causes. The implication is that attempts at problem-solving—the selection of an effective strategy for remediation—must be preceded by better problem definition.[3]

Egypt Project.

The project was a partnership of the Ministry of Health Nutrition Institute in Cairo and three US institutions: Purdue University and the Universities of Arizona and Kansas. The respective principal investigators were Dr. Osman Galal, the Director of the Institute, and Professors Avanelle Kirskey, Gail Harrison, and Norge Jerome.

Kalama, the site of the Egypt project, a town of about 1500 households, is in the Nile Delta, about 25 km. from Cairo, and just off the main Cairo-Alexandria highway. Because Kalama is close to Cairo, trained Institute personnel were used for field staffing, and senior investigators at the Nutrition Institute and in Cairo academic community were at hand. Field staff commuted daily by van from the Institute on a normal work schedule.

---

3 The ability to diagnose a problem is, in turn, dependent upon the national capacity for applied, problem-solving research. It is worth noting that a second major goal of a CRSP is to strengthen the research capacity of the overseas partners. The CRSP project contributed to such strengthening.

The village itself seems to escape the fast pace of the highway setting, yet it is experiencing a socioeconomic transformation. Kalama is fully electrified, although there are both traditional and modern homes in the village. Most families own electric appliances: two-thirds own television sets and half have washing machines. Only about 10 percent of the homes have an indoor water supply; another 10 percent have water pumps near their houses. The irrigation canal that makes its way through the village is important to community social life. It serves as a gathering place primarily for the women and girls as they do laundry and wash dishes at the waterside.

Fewer than one-half of the families in the study were farming families: 21 percent of the study households were employed only in agriculture, and 23 percent earned income in both the agricultural and non-agricultural sectors. A number of entrepreneurial enterprises, such as street food stands, television and bicycle repair shops, and haberdashery, weaving, and photography services, can be found there. Many Kalamans commute daily to work in Cairo.

Still, agricultural production remains a strong economic force. Most farming is done on small holdings (average 1.56 acres). The principal food crops are maize, beans, parsnips, carrots, leaf crops and other vegetables, and seasonal fruits. Kalama also produces and markets goat-milk cheese.

The Egyptian government subsidizes key staples—sugar, rice, flour, bread, lentils or fava beans, cooking oil, and tea—and cooking fuel, which stabilizes their price and availability. A rationing and price-support system for frozen meat and some canned goods is in place. The project's findings indicate that, with these policies and at the present stage of economic development, food supply is not a general problem in Kalama.

Kalama's political and social organization reflects the community's gradual modernization. The primary political body, the Village Council, was founded within the past twenty-five years. It is responsible for all public sector and commercial activities: schools, mosques, health centers, poultry farms, and bakeries.

Despite the apparent transition in Kalama, social and cultural traditions remain intact. Kalama is a strong Moslem community. Religious traditionalism is most obvious in the division of labor, and the different educational levels, between men and women. Kalama's religious preparatory school enrolls only males. The four other schools allow females to attend, but they are enrolled in significantly smaller numbers than male students. Almost half of the adult males are literate, but few of the women could read and write at the time of study.

Mexico Project

The Mexico project was a collaboration between Dr. Adolfo Chavez of the National Institute of Nutrition and Professors Lindsay Allen and Gretel Pelto of the University of Connecticut.

The project site was in the Solis Valley, approximately 2500 meters at the valley floor and 3000 meters in the surrounding hills, about three hours northwest of Mexico City in the central highlands. Temascalcingo is the principal town of the district. Paved roads run between Temascalcingo and some of the six villages from which the study population was drawn. Increasing numbers of private automobiles are joining commuter buses on the road.

Most households, except those on the poorer, upper slopes, have a faucet outside the house through which water from a community well is pumped. The pump breaks down frequently and then water must be carried from the well. Most of the homes have electricity and more than one-half have television sets.

Maize is the primary subsistence crop; wheat, rice, beans, and squash also are produced. The federal government, through its Systeme Alimentaire de Mexico, is involved in the marketing of maize, wheat, and beans; during the CRSP, the financial condition worsened in Mexico and the subsidy was directed principally to the lowest income, primarily urban, consumers. In the Solis Valley, families consume their own crops to a large extent but must rely on purchased staples for several months each year. Households both produce and

purchase pulque, which is a "beer" made from agave juice and a significant source of calories for most adults and some older children.

As the yield from farming is low, about half of the adult men in the communities work outside of the area, primarily in Mexico City. Because of the long bus trip, most of the men are absent for the week, usually returning on the weekend. Many remain in Solis during the peak periods of agricultural work demand, but their tasks generally fall to other members of the household or to hired labor.

In the past decade, each town in the Temascalcingo region has established a community primary school; the town of Solis also built a secondary school. This recent expansion of educational resources in the valley reflects a relatively new attitude toward literacy and education. Only six percent of the men and three percent of the women in the study had more than six years of schooling, and about a quarter of the women had little or no ability to read or write. Most children of school age were enrolled in school.

The Solis Valley is too far from Mexico City to allow daily commuting of field staff. The project was generously given use of governmental facilities in the central Solis location. The project developed and staffed small office and primary health care centers in some of the villages. Most of the research staff were mid- or upper-level professionals, mainly Mexican, recruited by the Institute for this project. A number of field staff initially were from the Temascalcingo region, but the work increasingly was carried out by the more advanced staff.

Kenya Project

Principal investigators were Professor Nimrod Bwibo, Principal of the Health Sciences at the University of Nairobi, and Professor Charlotte Neumann of the University of California, Los Angeles. The heavy local responsibilities of Dr. Bwibo and other Kenyan colleagues, as well as distance from the research site, made frequent commuting impractical. The project set up a field operation

center where a cadre of young foreign professionals led the field research effort. All other field supervisory staff were Kenyan mid-level professionals from the local area or the University of Nairobi. The approximately 150 field staff were local high-school graduates. The field staff, both expatriate and Kenyan, were resident in the study communities.

The communities selected for the Kenya project were in three sublocations of the Kyeni South Location in the Embu district, 160 kilometers northeast of Nairobi on the southeastern slopes of Mt. Kenya at an altitude ranging from 900 to 1500 meters. Coffee, tobacco, and cotton are the cash crops of the area. The principal subsistence crops are maize, beans, millet, sorghum, arrowroot, bananas, potatoes, and cassava. Governmental boards regulate the marketing of all major crops with a goal of stabilization of both returns to agriculture and consumer prices.

The Kyeni South Location community has government-sponsored school systems, health care provided by government and local health services, and maintains a system of feeder and access roads with the help of the Ministry of Transportation. Kyeni South Location is, however, by no means thoroughly modernized. The community is still without electricity, telephone, or postal service; away from the main Nairobi-Embu route are no hard-surfaced roads. In 1972, a major community water project servicing 15,000 households was completed, but water supply is severely limited and not available inside the houses.

Most adult males have had some education; about half had competency at elementary school level, and about one-fourth met high school standards. Adult women were less educated. About half of the sample could not read or write, although only about one-fourth had never attended school.

DROUGHT IN KENYA

Embu has two rainy seasons: the "short rains," which occur from the start of the agricultural season in October to December, and the "long rains," which

occur from March to May. Some crops are not harvested until the long rainy season. The short rains failed in 1983 and the long rains in 1984, the first year of the CRSP main study. Harvests of the main subsistence crops—maize, millet, and beans—were extremely poor. As the Kenya project report notes, "Drought does not necessarily translate into famine. Agricultural and economic systems (sharing food supplies within family networks, drought resistant crops, off-farm employment as well as production of cash crops) have been developed, which enable families to overcome the effects of reduced rainfall. The problem occurs when these survival strategies cannot cope with the scale or duration of the food shortages. This was the situation in Embu during the 1984 drought. For various reasons families were not able to offset the impact of food shortages, so adverse effects on health and nutritional status resulted, and external assistance became necessary." (Bwibo et al., 1987) Project personnel intervened by conducting a survey of the entire population in the project area that demonstrated an increased prevalence of severe wasting in children, identifying high-risk households, and helping to secure and distribute relief food supplies. They also bought seed, at the project's expense, for planting the next season. Although the project has had to cope with a formidable, confounding variable in its research, it now has a unique data set of inestimable value to Kenya government planners.

Seasonal want is common in sub-Saharan Africa. The relief efforts—which did prevent famine but fell short of the hoped-for 1500 kcal/day ration—may have increased the food supply to the level frequently experienced by this population. Based on 76 years' worth of records and the assumption that the minimum rainfall required is 300 mm per season, the probability of drought in Embu is estimated as follows (Downing et al., 1985):

	Level of Drought		
	Mild	Moderate	Severe
Long rains	.36	.22	.08
Short rains	.41	.29	.18

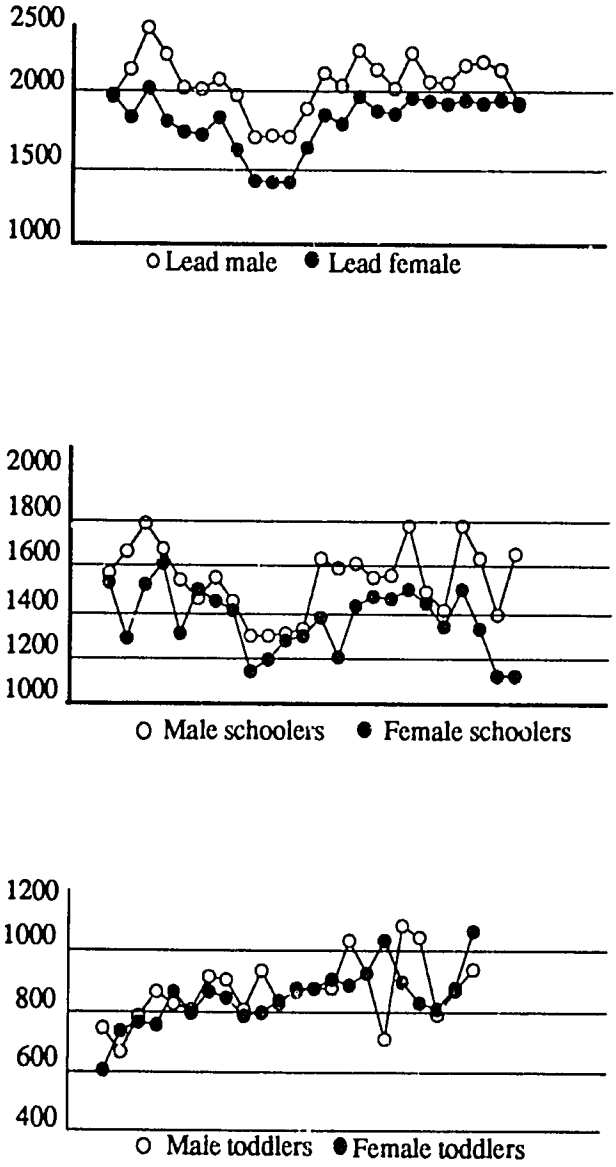
Source: Downing, Mungai, and Muturi, 1985:

These figures predict a mild deficit of long or short rains about every 2-1/2 years and a moderate failure about every 3-1/2 years. Severe drought frequency for the long rains is predicted to be once every 12-1/2 years and for the short rains, about every 5-1/2 years. The 1984-85 picture may be a fair representation of a commonly experienced food situation. Household food intake in Embu was sustained through April, 1984; it declined over the next several months, was very low from September through November, and returned to stable higher values by March, 1985. As shown in Figure 1, intakes of men and women were equally depressed, by about 400-500 kcal/day, but the impact on women would have been greater because many were pregnant. School girls' and boys' intakes were reduced by about 200-300 kcal/day, and the temporal pattern was similar to that of adults. Contrary to common expectation, the diet of toddlers was least affected in the household. Children did not gain weight at their expected rates, but they did not lose weight on the average as adults did.

ABSENCE OF METABOLIC ADAPTATION

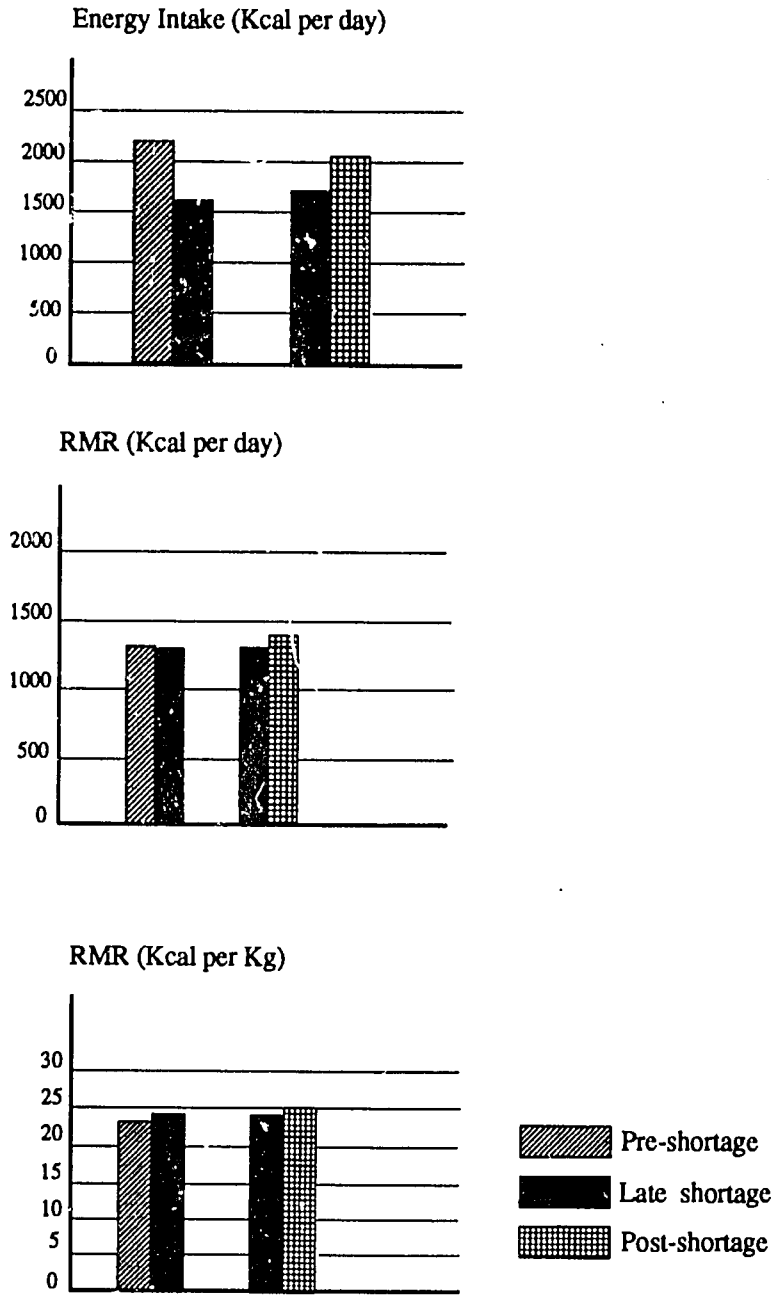
This "natural" event provided an opportunity to look for forced adaptation. If the processes of energy metabolism are capable of homeostatic responses to maintain energy balance in the face of energy deficit, one might expect an effect of restricted intake on resting metabolic rate (RMR): a fall during the food shortage and a rise during the recovery period. This hypothesis was examined through a series of paired analyses (comparing RMR estimated for the same subject in two phases of the food shortage/recovery period). Comparing body weights before and late into the period of food scarcity, men had lost 1.7+/-4.3 kg; six months after the period of critical shortage, men's weight had increased by 2.5+/-4.5 kg. Small differences were observed in the total RMR of men, but this was explained by the changes in body weight. As shown in Figure 2, RMR per kg body weight was the same in all periods. Furthermore, the observed RMR agrees reasonably well with expected values. From these and other observations, we conclude that no significant metabolic adjustment occurs to offset low

Figure 1 - Mean Daily Food Intake by Month for 1984-1985, Embu District, Kenya.



SOURCE: Bwibo et al. Kenya CRSP Project Final Report, 1987.

Figure 2 - Comparison of Energy Intakes and Resting Metabolic Rates for Adult Males Before, During and After Food Shortage in Kenya (paired data).



SOURCE: Calloway et al. CRSP Cross-project Report, 1988.

energy intakes. Energy-deprived individuals in a poor agricultural population adapt to such deprivation by using up body tissues (if they have reached adulthood) or foregoing growth (if they are children)—a limited strategy—and restricting physical activity. There is no evidence of a cost-free adaptation.

The policy implication is obvious. Measures should be taken to stabilize the food supply. Such measures might include irrigation schemes, buffer stocks, and non-agricultural employment generation. Improvement in drought tolerance of crops would help, but this strategy by itself would not eliminate the problem.

ENERGY INTAKE AND BALANCE IN THREE LOCATIONS

Food energy intake, the intended independent variable, was a critical measure. That a multiplicity of problems besets the investigator exploring intake is well known. Preliminary estimates of variance indicated that data would be needed on about 100 individuals in each target category to test hypotheses. It was necessary to enroll two to three-times as many households to secure this number (Table 1). A minimum of six days of food intake data is needed to

Table 1—Number and Composition of Households Enrolled and Number of Subjects in Longitudinal Samples.[a]

	Egypt	Kenya	Mexico
No. of households	312	292	320
No. of persons per household, mean[b]	7.5	7.28	10
TARGET SUBJECTS, LONGITUDINAL[c]			
Lead males	153	214	155
Lead females	153	214	158
Preg/Lact females/infants	62	93	69
Schoolers	42	129	109
Toddlers	88	91	55

[a]Total enrolled; number useful for analysis is less depending on variable of interest. See text.

[b]Mode

[c]Longitudinal sample is defined by the following criteria: toddler, at least 1 food intake record prior to 19 months and after 29 months; schooler, at least one food intake record between the ages of seven years and eight years, one month, and 10 months later; pregnancy/lactation, lead female with at least one food record prior to her infant's birthdate minus five months, and at least one food intake record after her infant's birthdate plus five months. The cross sectional sample, useful for analysis not dependent on food intake, is much larger.

provide reasonable assurance that the figure is representative of "usual" intake. Accordingly, household food consumption was recorded for two consecutive days each month, along with the total food intake (household and other) of each target subject, to be aggregated by 3-month intervals.

In comparing intake data from the three country projects, the most striking observation is the low energy intakes reported for all age groups in Kenya, whether expressed as absolute intake or intake per kg body weight (Table 2). Mean intakes per kg body weight for the Egyptian and Mexican children are generally similar, but Egyptian adult intakes are less than in Mexico and close to Kenya values when adjusted for body weight.

Most Kenyan toddlers consume less than the average requirement of about 104 kcal/kg as estimated by international bodies,[4] whereas Mexican and Egyptian toddlers' consumption is more evenly distributed and, on average, approximate the estimated average requirement. Intake of Kenyan schoolers is close to the estimated average requirement of 76 kcal/kg; in Mexico and Egypt, intakes of schoolers, particularly that of the girls, are above estimated average requirements.

For adults, a judgment must be made about activity level to derive an estimate of average requirement. The requirement estimates portrayed in Figure 3 reflect the international standard for "moderate activity." The adults' body weight remained stable during the study. If the reported energy intakes are correct, the observed intake is the same as the requirement. That is, enough

---

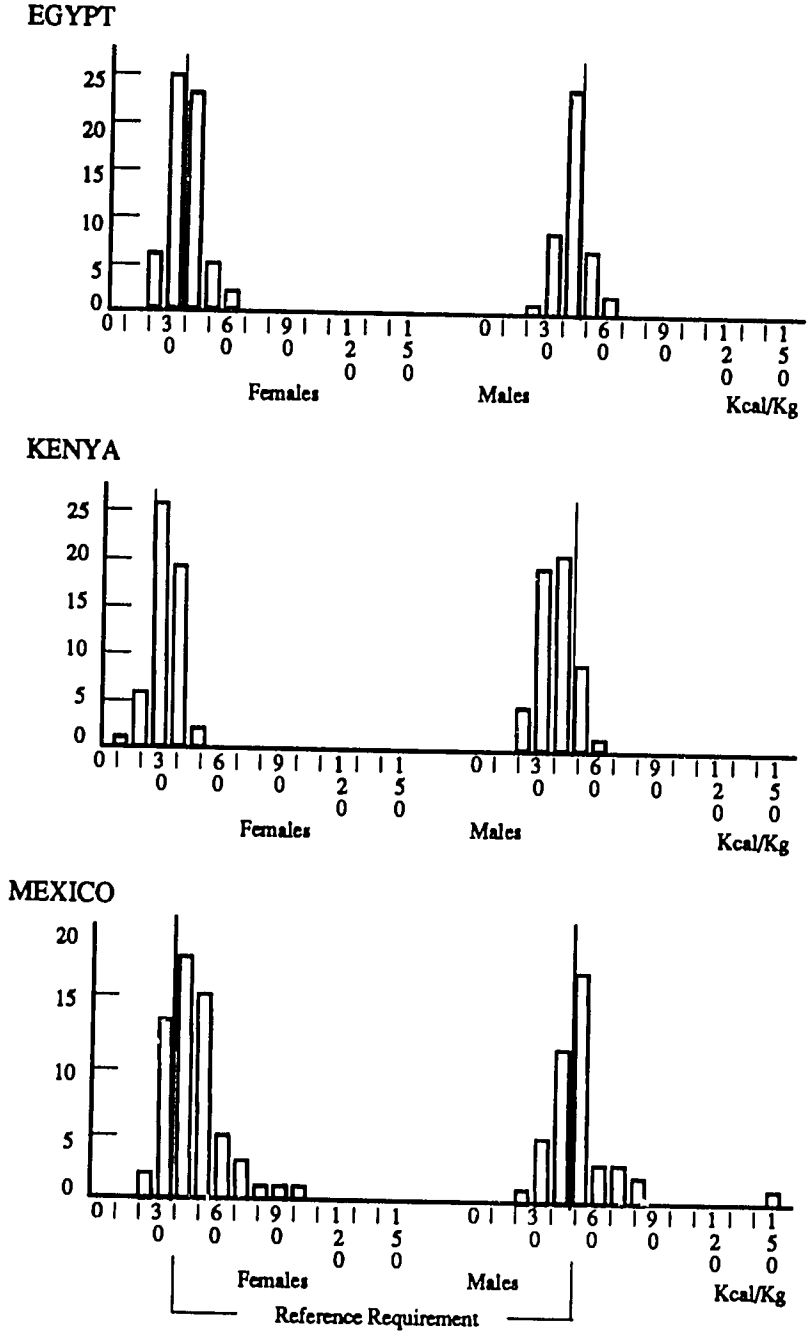
[4] These requirements for children assume normative activity. Adult energy requirements are expressed as multiples of BMR and are, for activity patterns, classed as "light," "moderate," and "heavy," respectively: for men, 1.55, 1.78, and 2.10; for women, 1.56, 1.64, and 1.82. (FAO/WHO/UNU, 1985).

Table 2 - Energy and Nutrient Intakes (mean +/- standard deviation)[a]

Group	Energy Kcal	Protein g.	Animal Protein g.	Fat g.	Iron mg.
			INTAKE PER DAY		
KENYA PROJECT, 1984-1985					
Toddlers	844+/-184	23+/-5	3.2+/-2.5	13+/-4.7	6+/-5
Schoolers	1447+/-266	43+/-9	2.5+/-2.0	21+/-5.7	13+/-7
Men	1954+/-439	58+/-13	5.2+/-4.0	30+/-8.6	18+/-11
Women	1672+/-339	49+/-11	4.1+/-3.2	25+/-8.0	15+/-9
MEXICO PROJECT, 1985					
Toddlers	1119+/-285	33.8+/-8.52	9.6+/-5.5	23.1+/-8.37	11+/-6
Schoolers	1828+/-462	54.1+/-13.4	10.2+/-6.5	29.5+/-10.2	21+/-8
Men	3070+/-747	84.3+/-20.6	14.9+/-10.3	41.2+/-15.2	36+/-17
Women	2572+/-643	73.1+/-17.9	12.5+/-8.6	38.1+/-13.9	28+/-13
EGYPT PROJECT, 1984-1985					
Toddlers	1173+/-316	36.1+/-10.7	13.8+/-5.3	31.3+/-9.7	7+/-6
Schoolers	1798+/-407	56.5+/-14.5	19.0+/-7.1	44.4+/-12.0	13+/-9
Men	2710+/-403	87.9+/-14.0	29.7+/-11.2	69.3+/-16.5	18+/-7
Women	2201+/-318	70.2+/-11.0	22.6+/-7.0	55.7+/-11.0	16+/-9
			INTAKE PER KG PER DAY		
KENYA PROJECT, 1984-1985					
Toddlers	84+/-18	2.3+/-0.6	0.34+/-0.24	1.3+/-0.5	
Schoolers	72+/-12	2.1+/-0.4	0.12+/-0.09	1.1+/-0.3	
Men	36+/-8	1.1+/-0.3	0.09+/-0.07	0.6+/-0.2	
Women	33+/-7	1.0+/-0.2	0.08+/-0.06	0.5+/-0.2	
MEXICO PROJECT, 1985					
Toddlers	102+/-32.8	3.10+/-0.96	0.87+/-0.48	2.08+/-0.84	
Schoolers	86+/-21.2	2.55+/-0.65	0.47+/-0.29	1.37+/-0.45	
Men	47+/-12.2	1.30+/-0.33	0.23+/-0.15	0.64+/-0.24	
Women	44+/-13.0	1.26+/-0.36	0.21+/-0.14	0.5+/-0.2	
EGYPT PROJECT, 1984-1985					
Toddlers	108+/-31	3.3+/-1.0	1.26+/-0.48	2.9+/-0.9	
Schoolers	81+/-22	2.5+/-0.8	0.86+/-0.35	2.0+/-0.6	
Men	39+/-7	1.3+/-0.2	0.44+/-0.15	1.0+/-0.2	
Women	35+/-8	1.1+/-0.3	0.35+/-0.11	0.9+/-0.2	

[a]Data for the longitudinal sample excluded information from toddlers who are still being breast fed, from Egypt project records missing meals, and from Kenya project records with missing nutrient values. For each subject, the mean intake across all observations has been computed. For the expression of intakes per Kg, all body weight data for the individual were averaged to yield a single estimate of the individual's weight. In toddlers and schoolers, neither the intakes nor the weights used in calculations are age-adjusted.

Figure 3 - Histogram of Distribution of Energy Intakes of Adults Compared with Reference Requirement for Moderate Activity (Kcal/Kg/d)



SOURCE: Calloway et al. CRSP Cross-project Report, 1988

energy is consumed to match the energy expended.[5] Based on reported intake, Egyptian adults engage in "light" activity; intake of Mexican women suggests a "heavy" work pattern, and that of men suggests a work pattern that is slightly greater than "moderate"; intake of Kenyan women and men is insufficient to support a light activity pattern and they would be rated as "sedentary." Considering the occupational, technological, and climatical characteristics of the three sites, the predicted activity patterns of Egypt and Mexico are within credible limits. The sedentary expenditure pattern predicted from the intake figures for Kenya does not, however, fit the profile of an agricultural community lacking modern conveniences.

The direct evidence one would wish to have on activity patterns was not obtained. Each project, however, made some observations from which inferences can be drawn. Between March, 1985 and February, 1986, the Kenya project studied time allocation of adults, making intermittent observation of activities during the daylight hours. An "average" activity pattern can be constructed from these observations. The Kenya project also measured the energy cost of typical household and agricultural tasks; the values found agree closely with published values. By assigning energy costs to the time spent at activities and counting unobserved time as "rest," a rough estimate of energy expenditure can be made. The "average" Embu man's daily energy expenditure during a normal year was about 1.77 times RMR, and that of women was 1.55 times RMR. These levels are classed as "moderately active." Activity patterns probably were less energy-intensive during the drought; the amount of heavy planting, tilling, and harvesting work was reduced, and few opportunities for physically demanding

---

5 Changes in body weight and/or composition do not enter into the balance equation because there is no evidence of net changes in these compartments in adults over the period of study (although temporary changes due to pregnancy, lactation, and food scarcity were observed). One year is insufficient to detect the very gradual change in body weight that occurs in mature adults in Egypt and Mexico.

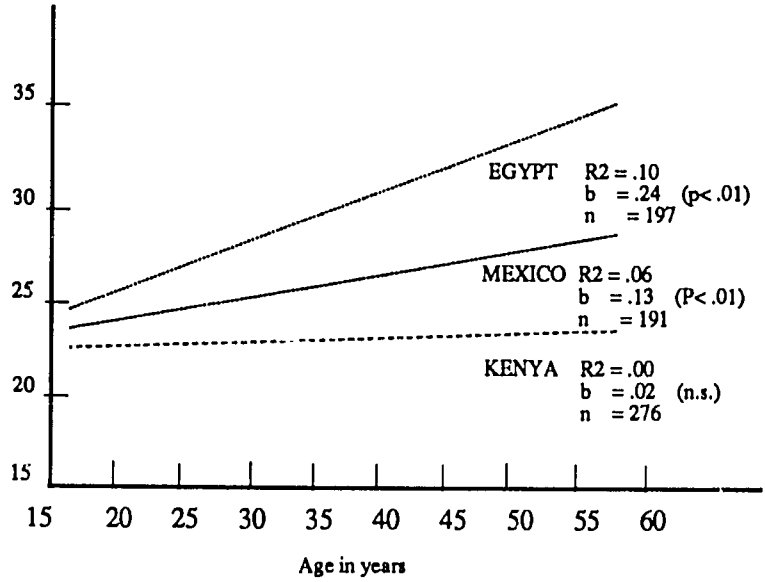
employment arose. Assuming a maintenance activity level during the drought period (1.4 x RMR for six months) and the factors calculated above for the remainder of the study, the average expenditure pattern across two years would be 1.51 x RMR for women and 1.68 x RMR for men. These figures predict an energy need about 10 percent above observed intake (36 vs. 33 kcal per kg for women and 40 vs. 36 kcal per kg for men).

Pregnant women reduce their activity levels, if they can, to compensate for the added burden of reproduction. The Kenya project reported that pregnant women increased "inactive" time by 70 minutes a day (a 140 percent increase) and similarly decreased time spent in food preparation and care of self and others. Depending on the energy cost of work foregone, this change would net about 100 kcal per day. The activities that were decreased are likely to be those that involve nurturing and personal hygiene, and their reduction will adversely affect those areas. The sanitation score of Kenya households was, in fact, found to be significantly positively correlated with the lead female's energy intake.

Women in the Mexico study appear to have heavy energy expenditure patterns, based on the observed intake. A pilot study of women's activities found a strong positive correlation between energy intake and the energy cost of recalled 24-hour activity in the sample population. In the longitudinal study, activity of mothers and toddlers was observed for 110 minutes over a period of 10 hours. There was a negative correlation between maternal energy intake and the amount of time she was observed "doing nothing."

The findings in the Mexico population suggest that the amount of energy consumed was determined by energy demand. This contrasts to the situation in Kenya, where the activity level is likely to have been lowered in the face of low energy supply and intake. Although some exceptions may be found within the sample, at the time of the study people in the Solis Valley appeared to have enough food available to sustain their necessary and expected work patterns. Under these conditions, variation in the functions of interest, the outcome variables, are unlikely to be related to energy intake *per se*. A similar conclusion

Figure 4 - Body Mass Index (BMI) by Age for Adult Females in Egypt, Mexico and Kenya



can be inferred for the Egypt population, where intake was sufficient to support light activity.

Examination of the body weight of adults generally supports these conclusions. Body mass index (weight, kg/height,m^2), a marker of fatness, does not change with age in Kenyan women but increases significantly with age in Mexico and more so in Egypt (Figure 4).[6] Kenyan women of all ages are leaner (BMI 21.7+/-2.5) than Mexican (24.8+/-3.7) and Egyptian (26.6+/-4.8) women. Kenyan women live in a marginal, adapted state throughout their adult lives. In the other countries, women's energy intake slightly exceeds expenditure, sufficient for the accumulation of body stores.

---

6 Values presented here differ from those in the 1988 cross-project report. The archive has been rechecked and weights recorded in the last six months of pregnancy deleted.

Kenyan men also are leaner than Mexican and Egyptian men (BMIs are 20.3+/-2.2, 23.9+/-3.2, and 25.7+/-4.1, respectively). The men, as expected, have lower BMIs than women in the same country, and the male BMI does not change significantly with age in any country ($p = .23 - .55$).

These findings suggest that the BMI of women could be used as an indicator of the food situation in developing country rural settings. If the average BMI of female adults is low and does not vary with age, household food availability is probably marginal and the community is at risk. BMI of women would seem to be an easy and efficient diagnostic tool.[7]

Energy Intake: Validity, Source, Covariance, and Variance

All analyses undertaken to assess the importance of energy and of all other nutrient intakes are flawed if the food intake information is invalid or if the nutrient composition assigned to the foods is wrong. The CRSP developed food composition data bases to calculate nutrient intakes and made a few analyses of diets and foods, and measured digestibility in the laboratory. Projects validated their intake methods initially; the Mexico project made a significant change at the midpoint after reassessment. In all projects, the usual respondent was the lead female. School children and men reported on food eaten away from home. The men were often unwilling or unable to respond, so records for them are less complete.

Under-reporting of alcohol consumption is a known problem in Kenya and is suspected in Mexico. Pulque, a mildly alcoholic (2 percent) brew made from agave juice, is a normal component of the Mexican adult diet. Men drink from one-half to one liter on weekdays (up to three-five liters), deriving 12 percent

---

7 This should be valid at least until Western elite notions of desirable body conformation are more widely adopted. In the U.S., where effective social welfare programs are in place, fatness is negatively correlated with income.

of their energy intake from pulque. Women drink less, but derive 6 percent of their energy intake from pulque. Weekend consumption is thought to be higher. Beer appears on the food intake records of 17 percent of the Kenyan men; the average intake was about 1000 kcal/day when consumed. A separate inquiry indicated that 53 percent of men drink beer with an average consumption of 600 kcal/day. Very few Kenyan women and no Egyptians reported intake of alcoholic beverages.

The sources of dietary energy were quite different in the three locations (Table 2). Total protein contributed about 12 percent of energy in all, slightly more in Egypt (13 percent) and slightly less in Mexico (11 percent). The Egyptian diet contained much more animal food than did the Mexican diet, which, in turn, contained much more than the diet in Kenya. Animal protein comprised 32-38 percent of total protein in Egypt, 17-28 percent in Mexico, and 6-14 percent in Kenya. Toddlers appeared to be a protected class: the toddler diet had proportionately more animal protein than that of other target subjects. Schoolers clearly were not favored; they consumed no more animal protein than adults. Compared to the U.S., fat intake was low in all areas; it contributed 23 percent of energy in Egypt, 19 percent in Mexico and 14 percent in Kenya.

In the CRSP data sets, total protein intake covaries with energy intake (r=0.85-0.86). Broadly speaking, the lower the energy intake, the lower the total protein intake, so the effects of low energy intake and low protein intake are confounded. Fat intake also covaries with energy intake (.62-.63 in Kenya and Mexico, .80 in Egypt) and is correlated with intakes of total and animal protein (.57-.65), which are correlated with each other (.54-.75) as well.

In Kenya, it is to be expected that relationships between energy intake and various outcomes can also be found with protein and, perhaps, fat. Because energy intake is unlikely to be limiting for the majority of people studied in Egypt and Mexico, associations between either energy or total protein and outcomes are unlikely as well.

The statistical power to detect associations between outcomes and dietary factors depends on the relationship between the variance within an individual's intake pattern and the variance among individuals in the population. At the time of CRSP's inception, published reports suggests that variability within individuals would be less than was observed. Variance was, in all cases, higher within than among individuals of the same age and sex. Variance both within and among persons was lowest for energy and almost as low for total protein. The coefficients of variation (percent) in energy intake within and among lead females were, respectively: Kenya, 46 and 18; Mexico, 25 and 21; and Egypt, 28 and 13. The most variable component was animal protein intake (CVs within 83-204 percent, between 23-68 percent). Variance within individuals was highest in Kenya for all nutrients examined. Although it would seem likely that this large variance was due to the drought period, preliminary examination suggested that it was not. The ratio of variances within and among individuals, the indicator of statistical power, was best in Mexico and poorest in Kenya.

The variance ratios carry the great risk of false negative interpretation of analyses. A relationship may not exist, or it may be invisible due to the great attenuation due to variance. The different variance ratios for various nutrient factors also have clear implications. If the real biological relationships between several nutrients and an outcome variable were comparable, statistical relationships would differ because of different degrees of attenuation.

Body Size of Adults

The height of mature adults was very similar in the three places, means varying by only about 2 cm. Men were about 166 cm tall and women about 155 cm (slightly shorter in Mexico). These heights are about 1.5 standard deviations (Z score-1.5) below U.S. norms (Table 3). Mean Z scores for weight are closer to U.S. norms except for the Kenyan men, whose mean weight score is lower than their height score, i.e., they are thinner than U.S. norms. The Egyptian women are shorter, but weigh as much as women in the U.S. (Z score 0+/-0.8).

Mean weight score of Mexican women is -0.4+/-0.6 and of Kenyan women, -0.9+/-0.5. The substantial interindividual variance, particularly in Mexico and Egypt, offers scope for analysis.

Women in Kenya entered pregnancy with low body weight (51 kg in contrast to 55 kg in Mexico and 62 kg in Egypt). They gained only 6.4 kg during pregnancy, about 15 percent less than the 7.4 kg gained by women in Egypt and Mexico. These gains are small compared with the internationally recommended gain of 12-13 kg. Kenyan women's weight had returned to prepregnancy weight within one to two months of delivery; they had no additional fat stores. Weight of Mexican women fell steadily during lactation but was still slightly above the non-pregnant mean at the sixth month postpartum. Egyptian women gained a small amount of weight during lactation. Because weight varies with age in Egypt and Mexico, parity and body weight relationships are confounded; but hypotheses about these relationships can be tested in Kenya.

Table 3—Mean Z Scores for Weight and Stature[a]

AGE		KENYA	MEXICO	EGYPT
STATURE				
Birth		-	-0.3	-
6 Months		-1.8	-1.3	-0.9
30 Months		-1.7	-1.9	-1.8
8 Years		-1.6	-1.6	-1.0
Adult[b]	Male	-1.5	-1.4	-1.3
	Female	-1.3	-1.6	-1.1
WEIGHT				
Birth		-0.2	-0.4	-0.1
6 Months		-0.7	-0.6	-1.1
30 Months		-1.4	-1.3	-0.7
8 Years		-1.3	-1.2	-0.6
Adult[b]	Male	-1.8	-1.0	-0.6
	Female	-0.9	-0.4	0

[a]Z score equals observed weight less reference mean weight divided by standard deviation in reference population. Reference population is the United States (see Dibley et al., 1987 and Abraham et al., 1979).

[b]Values differ slightly from The Cross-Project Report; data bases have been screened for outliers. Weights of women in the 2nd and 3rd trimesters of pregnancy have been excluded.

Similarity of Growth Patterns

Birth weight in all three countries was not far below the U.S. norm. Mean Z score was -0.1 in Egypt (about the 47th percentile), -0.2 in Kenya, and -0.4 in Mexico. Low birth weight is 2500 g or less, a level that indicates high risk of mortality or impairment. Four percent of the newborns in Egypt, 7 percent in Mexico, and 11 percent in Kenya were in that category. Ten of the target infants in Egypt died. In Kenya five infants died during the perinatal period and none during the first six months. No target infants died in the Mexico project, but several infants not in the longitudinal data set died. Perinatal deaths in all areas were mainly among those of low birth weight, some of whom were twins. The smallest individuals, therefore, are missing from the longitudinal data base.

Infant growth began to falter in stature by the third month and in weight shortly thereafter. At six months of age, mean Z scores for length were -0.9 in Egypt, -1.3 in Mexico, and -1.8 in Kenya. In Egypt, the mean Z score for weight was -1.1; weight Z scores were less depressed in Mexico (-0.6), and Kenya (-0.7).

At 30 months, mean height Z scores were similar in all three sites, -1.7 to -1.9. At eight years, mean height Z score was -1.6 to -1.7 in both Kenya and Mexico but less depressed in Egypt, at -1.0. Height Z scores at age eight years are quite close to adult values. At 30 months and eight years, mean weight Z scores were less depressed than height scores. Weight-for-height was within one SD of the norm; Kenya children are a bit lean and Egypt children a bit plump.

The consistency of Z scores beyond infancy indicates a fairly normal growth rate after 18-24 months. In fact, these data coincide with the long-standing belief that adult height is about twice the height achieved by age two years, slightly more for boys and slightly less for girls. In these populations, adult male height was 2.07-2.08 times the 24-month height of boys; women's heights were 1.95 and 1.97 times that of girls in Egypt and Kenya, and 1.91 times two-year-old height in Mexico.

These data and anthropometric characteristics of non-target siblings show that early life events—in utero and in the first 18 months —have profound and lasting effects. No significant catch-up growth was evident in Kenya or Mexico. Only modest improvement was seen in Egypt and, because the age samples are cross-sectional, it is not possible to know if catch-up growth occurs or if the smaller children have died in later childhood.

Because body size is correlated with certain important performance capacities, it is important to identify the concomitants of growth failure.

MORBIDITY: METHODOLOGY AND OBSERVATIONS

Quantification of "health" is a daunting task and at least as difficult as food intake evaluation, although it is not widely recognized to be as problematic. Most analyses have relied on episodes of illness, duration of episodes, proportion of total days ill, severity (itself judged by duration as well as other factors), and type of illness. Few studies have included an ongoing assessment of parasite burden, chronic diseases, accidents, and injuries, or have accounted for such health-related behaviors as smoking and alcohol consumption. The CRSP projects attempted to fill in some of these gaps with varying degrees of completeness, but analyses so far have concentrated on weekly observations of morbidity, principally from the infectious diseases.

In order to record episodes of illness, the lead female was interviewed weekly. Memory of anything but very important events is not reliable over longer periods. In Kenya and Egypt (and for a short period of time late in the Mexico project) structured questions about the health of all household members during the preceding week were asked, including a systematic probe to determine whether illness was present even if unreported. Interviewers for the Mexico project inquired if anyone was sick on the day of interview and followed up only on illness existing on that day. Interviewers were physicians in both Egypt and Mexico; in Kenya, the trained interviewers had no previous health

sector experience but were supervised by a public health nurse under direction of a physician. Diagnosis of illness was done by physicians in all countries according to categories of disease and severity. If illness was severe, primary care was given and the patient was referred to a health center for treatment.

At least three methodological problems must be confronted in inter-project comparisons of morbidity. The first is the difference in the field procedures, and hence the nature of data collected, between Mexico and the other two projects. The Mexico procedure of recording only illnesses observed on the day of interview resulted in underestimation of incidence and prevalence of short-term illness. Direct comparison of the two methods was made by the Mexico project and data have been adjusted accordingly to improve cross-project comparability.

The second problem is more fundamental. There may be a real difference in the judgments about the presence of symptoms and what constitutes a symptom. The cross-project report presents the issue as follows: "Such differences could result from the background training of the interviewers, from community perceptions of illness and hence subject responses to the interviewers, or from the operational criteria developed and standardized within an individual project. The prior training of the interviewer can affect the data recorded, and a physician examining a patient may render a different judgment than if he/she were examining only recorded symptoms. Regardless of who actually conducts the field interview, the recording of an 'illness' is contextual. That is, 'ill health' may be marked as a departure from 'normal health' (the background picture of the community) rather than from 'good health' (a conceptually diagnosed situation based on objective criteria). This distinction is implicit in the approach taken in the interviewing. The spontaneous answers to the questions, 'Has anyone been ill?' or, 'Is anyone ill today?' will be influenced by perceptions of illness in the community. These perceptions and the degree to which an interviewer probes a negative answer will influence reported morbidity. [The Mexico project notes that women are more likely than men to report symptoms

and to seek medical advice. Women also are the reporters of family illness, introducing their own biases about illness of others.] These factors apparently operated across projects to give differences in the meanings of the morbidity variables, particularly between Egypt and Mexico, on the one hand, and Kenya on the other. It has not been possible to develop objective procedures by which 'reporting bias' can be assessed across projects ."

A third concern is intervention. It is unethical to withhold treatment if the field team has the necessary skills and resources. On the other hand, where treatment is not ordinarily available to the community, intervention may distort the picture of morbidity. Projects made independent decisions but offered palliative treatment and referred serious illnesses to local health-care providers. These procedures may differentially have affected detection, duration, and severity of illness.

Nevertheless, crude comparisons of the incidence of selected diseases common to children are of interest (Table 4). The incidence of diarrhea and upper and lower respiratory infection decreased with age in all three countries. Infant boys were reported to experience more illness than girls. Incidence of diarrhea was two-to three-times higher in Egypt than elsewhere and was higher in Mexico than in Kenya. The positions are reversed for upper respiratory infection. Lower respiratory infection was strikingly common in Egypt infants; in older age groups, Egypt and Mexico report the same incidence and Kenya less.

Duration of illness episodes is longer in Kenya than elsewhere (Table 5). The incidence of lower respiratory illness is eight-fold higher in Egyptian infants than in Kenyan infants, but an episode lasts 2.5 times as long in Kenya. Both incidence and duration of upper respiratory illness are high in Kenya, and most children are affected, so the prevalence is very high. On any given day, 18 percent of all Kenyan toddlers were found to have an upper respiratory complaint. In Egypt and Mexico, only 2 percent were reported to have such an illness.

Table 4—Average Incidence of Specified Disease Categories Among Longitudinal Infants and Children in Egypt, Kenya, and Mexico (Episodes per 1000 person days)

Target Type	Sex	EGYPT PROJECT N	EGYPT PROJECT Average Incidence	KENYA PROJECT N	KENYA PROJECT Average Incidence	MEXICO PROJECT N	MEXICO PROJECT Average Incidence	MEXICO PROJECT Adjusted[a]
A. Diarrhea								
Infants	M	30	9.9	50	2.6	34	3.6	4.5
	F	24	7.4	43	1.5	35	4.0	5.1
Toddlers	M	41	9.4	42	2.9	29	1.8	2.9
	F	42	8.1	49	4.4	26	3.0	4.9
Schoolers	M	22	0.68	72	0.27	55	0.11	0.15
	F	19	0.99	57	0.14	54	0.19	0.27
B. Upper Respiratory Tract Illness								
Infants	M	30	5.7	50	15.4	34	6.0	8.1
	F	24	4.6	43	16.9	35	4.8	6.5
Toddlers	M	41	3.8	42	16.1	29	4.3	6.0
	F	42	3.8	49	16.7	26	3.7	5.2
Schoolers	M	22	2.2	72	6.6	55	1.1	1.9
	F	19	0.71	57	4.6	54	1.6	2.6
C. Lower Respiratory Tract Illness								
Infants	M	30	8.8	50	1.0	34	4.0	4.5
	F	24	8.3	43	0.49	35	2.7	3.0
Toddlers	M	41	3.4	42	0.58	29	3.1	3.6
	F	42	3.8	49	1.1	26	2.4	2.7
Schoolers	M	22	0.96	72	0.61	55	0.47	0.60
	F	19	0.16	57	0.43	54	0.93	1.2

[a]Adjusted to take into consideration the under-reporting of short term ilnesses in Mexico; see text.
SOURCE: Calloway et al. CRSP Cross-projectReport, 1988.

Severity classifications as reported by the projects are given in Table 6. Kenya and Mexico reported a much smaller proportion of severe illnesses than did Egypt. In Egypt about half of all illnesses in target individuals are coded as severe, except infants, where 71 percent are severe.

The following conclusions seem warranted. First, the remarkably low prevalence of upper respiratory illness in Egypt and Mexico suggests a substantial proportion of unreported minor complaints. Second, people in Egypt are not likely to be reported ill unless the illness is, or is perceived to be, severe.

Considering the high incidence of diarrhea and respiratory illness in Egyptian infants and the ranking of disease severity, these children appear to be an especially high risk group; Egyptian toddlers are at somewhat lower, but still high, risk. Finally, whatever problems are attached to chronic low-grade illness must be confronted in Kenya.

MORBIDITY AND INTAKE

The methodological differences and inherent problems in quantification of both food intake and morbidity make analyses complex. So far, projects have found little direct evidence that toddler and infant morbidity, as defined by

Table 5—Mean Duration of Illness Episodes, Days

	EGYPT	KENYA	MEXICO A[a]	MEXICO B[a]
Diarrhea				
Infants	5.5	7.0	6.4	5.6
Toddlers	4.4	6.1	5.4	4.1
Schoolers	7.0	4.8	6.6	4.0
Upper Respiratory				
Infants	5.2	18.9	4.9	5.1
Toddlers	5.9	16.1	6.2	4.0
Schoolers	4.4	14.2	5.4	4.0
Lower Respiratory				
Infants	6.2	15.2	6.5	6.3
Toddlers	6.4	11.2	6.2	6.1
Schoolers	5.7	7.1	5.9	5.2

[a]Mexico A = Project Methodology; Mexico B = CRSP methodology
SOURCE: Calloway et al. CRSP Cross-projectReport, 1988.

Table 6 —Comparison of Frequencies of Application of Severity Codes by Target Type (Percent of reported morbidity episodes)

	EGYPT		KENYA		MEXICO	
Target Type	mild	severe	mild	severe	mild	severe
Lead Males	46	54	94	6	96	4
Lead Females	52	48	96	4	95	5
Schoolers	54	46	95	5	91	9
Toddlers	42	58	94	6	97	3
Infants	29	71	96	4	100	0

SOURCE: Calloway et al. CRSP Cross-projectReport, 1988.

weekly reporting of illness, is dependent upon intake. Neither lead male nor schooler data have been examined, and much remains to be analyzed in all sets.

The Kenya project found weak positive correlations between morbidity and all food intake variables at some periods in toddlers; the investigators suggest that the better-fed toddlers were more active and mobile and therefore more frequently exposed to communicable disease.

In Mexico, infant morbidity in the first three months was negatively related to maternal intake of energy and protein during pregnancy. During three to six months, infant morbidity was positively correlated with maternal intake during lactation; the investigators suggest that better-fed mothers are more likely to notice and report symptoms of illness in their infants.

Food intake also can be treated as the dependent variable in studying effects of morbidity. The Kenya project confirmed a reduction of intake in toddlers with febrile illnesses (719+/-440 kcal/day) or gastrointestinal complaints (699+/-407 kcal/day) compared with intake on days not reported ill (861+/-465 kcal/day). The Mexico project has reported that appetite is reduced in about one-third of illness episodes in infants and in about 50-60 percent of episodes in all other age groups, but intake was not reported.

SIZE, INTAKE AND MORBIDITY

Newborn

No evidence was found that pregnant women eat more than non-pregnant women.[8] The amount of weight gained during the third trimester of pregnancy was positively related to energy intake and negatively related to maternal morbidity in Kenya and Mexico.

---

[8] Data are somewhat limited on nonpregnant, nonlactating women matched in age to the pregnancy series. A short time span, or none at all, elapses between successive reproductive cycles. The nonpregnant, nonlactating women tend to be older.

Multiple regression models account for 20-28 percent of the variance in infant birth weight. Only in Kenya did maternal diet correlate with birth weight; protein, energy, and fat intake in the second trimester were positive factors, but only protein intake was significant. All projects found a positive association between maternal weight and infant weight. Maternal BMI at term was equally strongly correlated with birth weight in Kenya and Mexico but not in Egypt. Serious maternal illness was negatively associated with birth weight in Kenya but not in Egypt or Mexico.

Infants

Pregnancy factors, including birth weight, continued to be associated with infant size at three and six months in Kenya and Mexico but not Egypt. Maternal prepregnancy weight, weight at delivery, height, and BMI were correlated with both weight and length of infants at three and six months. In Kenya, weight gained in pregnancy also correlated with infant weight at three months, but the effect dropped off by six months.

Among intake factors, maternal protein and fat intake in the second trimester were related in Egypt to infant length, but not weight, at three months. In Mexico, second trimester intake of animal protein correlated with infant weight at both three and six months. Energy, fat, and protein intake during the second and third trimesters related to both length and weight of Kenyan infants at both three and six months.

Maternal intake during lactation and maternal body energy stores were expected to influence growth. No such relationship was seen in Mexico. Maternal intakes of energy, fat, and animal protein during the first three months of lactation did relate to weight and even more strongly to length of infants at three months of age in Kenya and correlated with BMI of Egypt infants at three months of age. No maternal lactational dietary factors were associated with infant size at six months in any project.

A strong correlation between maternal energy intakes during pregnancy and lactation was found: women who had the more generous intakes during pregnancy also ate better during lactation. Energy intake during the first six months of lactation increased by about 170 kcal/day in Egypt, 200 kcal/day in Mexico, and 400 kcal/day in Kenya. These increases were not sufficient to meet the energy requirements of reference infants. The implication is that either infant demand for milk was reduced, or the milk supply was not sufficient to support reference growth. Illness and supplementary feeding might have reduced infant demand.

In Egypt, the percentage of time an infant was ill with diarrhea was negatively associated with infant weight at six months. All infants in Egypt received sugar-water of unknown sanitary quality virtually from birth, and the second most common infant food was a boiled mixture of starch, sugar, and water. Feeds of low nutritional quality that supply energy would displace breast milk, perhaps reducing intake of essential nutrients below requirement levels. Weights of Egyptian infants who were given feeds in addition to sugar-water during the first three months were significantly lower than those who were not supplemented.

Good quality food was given early to infants in Kenya. Ten percent of energy was from protein and 40 percent of the protein came from animal sources, mainly cow's milk. The supplement amounted to an average of 100 kcal/day. Supplemental feeding was positively correlated with infant weight during the first six months. Correlations between various aspects of morbidity and growth rate or size were weak; malaria and fever were associated with poor linear growth and fever with weight deficit.

Mothers in Mexico introduced supplemental foods at about three months. Supplements were sweetened products, usually including milk. The strongest and most consistent correlates of infant weight in Mexico were internal and external sanitation of the household. Infant illness was not, however, associated with infant body size, nor was illness correlated with the sanitation indexes.

Toddlers

CRSP investigators have given first attention to the search for determinants of toddler size and growth. Several small but significant associations were found between mean intake of toddlers between 18 and 30 months of age and size or growth. For the Kenyan toddlers, 26 percent of the variance in attained height at 30 months could be predicted by animal protein as a percent of total protein, total calories and protein as a percent of calories. Thirty-four percent of the variance in Mexico toddler heights was predicted by animal protein calories as a percent of total calories, average protein, and average fat intakes. Animal protein intakes were also predictors of the rate of gain in height for Mexican and Kenyan toddlers. Average fat intake was associated with height gain of Egyptian toddlers, but a regression model with eight dietary variables did not significantly predict height slope.

Dietary variables were not significantly associated with weight or weight gain in either Egypt or Kenya. In Mexico, weight at 30 months was predicted by protein calories as a percent of total calories, animal protein, and fat calories as a percent of total calories. With three diet variables (animal percent protein, total protein, and animal protein) in a regression model, 39 percent of the variance in 30 month weight could be predicted. Animal protein and animal protein as percent of calories also predicted the rate of weight gain in Mexico toddlers.

Weight gain was linear for most toddlers, but not all. Growth was not linear in 16 percent of Egyptian toddlers, 12 percent of Kenyan and 3 percent of Mexican toddlers. An examination of morbidity rates of Egyptian toddlers did not show increased illness days or episodes in those with non-linear growth. Diarrheal disease was negatively associated with weight in Mexico toddlers but not with height.

The strongest predictors of children's size at all ages are the height and weight of parents, especially the mother. Parental size accounted for about 20 percent of the variance in toddler size at 30 months. Two measures of maternal

diet quality—percent of energy from fat and percent from animal-source proteins—explained 10-20 percent of the variance in Mexico toddler and schooler sizes. These factors had small but consistent effects on children's height in Kenya but did not explain additional variance in Egypt.

Characteristics of the parents may reflect characteristics of the constraining environment in which parents and their children have developed. Improvement in growth and its concomitants may require improvement of diet and other factors over generations.

POLICY IMPLICATIONS

The need for intervention in the study communities is evident. Each project has reported its findings to government officials in the country at a conference specifically arranged for this purpose. It would, of course, be best if there could be broadly based development with the various relevant sectors (agriculture, health, finance) involved in a coherent strategic plan. But it is also possible to set priorities among competing demands. My own ordering of those dealing with food are as follows:

Kenya

Improvement and stabilization of the food supply is the most fundamental need. Some suggestions were offered in the discussion of the drought experience. Of concern is the households' need to purchase water for cooking and consumption, a serious problem that deserves attention.

Second-order attention should be given to diet quality, specifically, to the augmentation of animal-source foods (especially dairy products and eggs) that supply fat and an array of essential nutrients at risk (iron, calcium, B-vitamins). Tenuous evidence is in hand that toddlers fared better in households that held small livestock (in contrast to cattle-holders). Groundnuts might also be featured if protection from molds can be assured.

Mexico

The first need is for augmentation of animal-source foods in the diet. Because roads are well-developed, poultry production and marketing schemes might be feasible, and a local industry would allow male adults to remain in the home communities and, by doing so, perhaps reduce some evident social pathology.

Second, consumption of pulque should be reduced. But as this is a significant source of energy and dietary energy is not in excess, an acceptable alternative source of energy is needed. It is also possible to reduce energy requirement by providing more mechanical aids to men's and women's labor and improvement in water and fuel systems, etc. An education program would be essential.

Egypt

Government food policies appear effective; neither the food supply nor its quality seem generally to be limiting. The household water situation needs early attention. The most critical problem is the education, modernization, and empowerment of women. This must occur if they are to make more informed decisions about their own well-being, the feeding of infants, and hygienic conditions of their households. Television and radio can be used.

IMPLICATIONS FOR RESEARCH

Some conclusions and their implications have been stated throughout this paper. Some explore the relationships among food intake, morbidity, and function, and draw inferences for interpretation of existing evidence and for research design. These should affect decisions about investment in problem-defining research. Two methodological suggestions are quite straightforward: the body mass index of women may be a good indicator of over-all food availability in poor communities; and effects of change in environmental factors should be most readily detected in growth of children below age 12 or 18

months. Other periods of life are important, but rate of change is greatest very early in life, an experimental and analytical advantage.

Two other conclusions indicate a need for creative new approaches. The difficulties of measuring food intake were known before the CRSP research was designed, and intake measurements have allowed us to reach important conclusions not otherwise possible. But the results show that variance is an even more formidable problem than had been appreciated and that failure to detect real food-effects is a likely outcome. Therefore, and because present methodoiogies are so costly, other markers must be sought. Much can be done using the existing CRSP data. The difficulties with morbidity measures are widely under-appreciated. Not only are the recognized problems of scaling and quantification of disease yet to be resolved, but the potential for bias due to both informant and questioner perceptions is significant and difficult to detect. Again, much more can be gleaned from the CRSP data base. An important difference in the CRSP that has allowed us to learn much more is the multi-disciplinary nature of research teams. Nutritionists, physicians, anthropologists, statisticians, physiologists, and biochemists all brought their special skills and conceptualizations to work.

CONCLUSION

Because we have been able to look across three projects, the Nutrition CRSP has provided evidence that where total food intake is low (i.e., the Kenya case) important functions are affected. Evidence from both Kenya and Mexico indicates that some essential nutrients are at risk, and that foods of animal origin are a marker of adequacy. Even when the food situation is reasonably satisfactory (i.e., the Egypt case) infants may fail to thrive because women lack the information to make and authority to implement better decisions. Common methodologies have revealed these different proximate causes of growth and development failure. The implications for government policies are different and may be location specific. However, the three patterns of deprivation may be

widely replicated, and future analysis may identify efficient ways of determining the factor(s) that account for growth failure elsewhere.

REFERENCES

Abraham S., C.L. Johnson and M.F. Najjar. 1979. "Weight and height of adults 18-74 years of age, United States, 1971-1974." *Vital Health Statistics* Series 11, No. 211. Washington, D.C.: U.S. Government Printing Office.

Bwibo, N., and C.G. Neumann. 1987. *Final report of the Kenya Project.* Los Angeles: University of California.

Calloway, D.H., S.P. Murphy, and G.H. Beaton. 1988. *Food intake and human function: A cross-project perspective of the collaborative research suport program in Egypt, Kenya and Mexico, Final Report.* Berkely,CA: University of California.

Calloway, D.H., C. Wood, R.D. Beall, and D.J. Cattle. 1980. *Final report to United States Agency for International Development contract no. AID/DSAN-C-002: Collaborative Research Support Program on intake and function.* Berkely: University of California.

Chavez, A., L.H. Allen and G.H. Pelto. 1987. *Final report of the Mexico Project.* Storrs, CN: University of Connecticut.

Dibley, M.J., J.B. Goldsby, N.W. Staehling and F.L. Trowbridge. 1987. Development of normalized curves for the international growth reference: historical and technical considerations. *American Journal of Clinical Nutrition.* Vol. 46: 736-748.

Dibley, M.J., N. Staehling, P. Nieburg and F.L. Trowbridge. 1987. Interpretation of Z-score anthropometric indicators derived from the international growth reference. *American Journal of Clinical Nutrition.* Vol. 46: 749-762

Downing, T.E., D.N. Mungai, and H.R. Muturi. 1985. Drought climatology of Central and Eastern Kenya. In *Climatic variability and agricultural production in Central and Eastern Kenya.* Nairobi: National Environment Secretariat, Ministry of Environment and Natural Resources.

Food and Agriculture Organization. 1987. *Fifth world food survey.* Rome: Food and Agriculture Organization.

Food and Agriculture Organization/World Health Organization/United Nations University. 1985. *Energy and protein requirements*. Techn. Rept. Ser. 724. Geneva: World Health Organization.

Galal, O., G. Harrison, N. Jerome, and A. Kirksey. 1987. *Final report of the Egypt Project*. West Lafayette, IN: Purdue University.

National Academy of Sciences. 1977. *World food and nutrition study, the potential contributions of research*. Vol. 14 (and supporting papers). Washington, D.C.: National Academy of Sciences.

LECTURES IN THIS SERIES:

1988:

Jere Behrman: "Nutrition and Incomes: Tightly Wedded or Loosely Meshed?"

Michael Lipton: "Attacking Undernutrition and Poverty: Some Issues of Adaptation and Sustainability"

Laura Sims: "Nutrition Policy through the Reagan Era: Feast or Famine?"

Daniel Sisler: "The Income, Employment, and Nutritional Implications of Nepal's Agricultural Policy"

Erik Thorbecke: "The Impact of the International Economic System on Nutrition and Health"

C. Peter Timmer: "Food Price Stability and Welfare of the Poor"

1989:

Doris Calloway: "The Functional Consequences of Malnutrition and Implications for Policy: Case Studies in Egypt, Kenya, and Mexico"

Godfrey Gunatilleke: "Government Policies and Nutrition in Sri Lanka: Changes During the Last Ten Years and Lessons Learned"

Per Pinstrup-Andersen: "Government Policy, Food Security, and Nutrition in Sub-Saharan Africa"

David Sahn: "Seasonal Fluctuations in Factor and Products Markets: Is There a Nutritional Risk?"

Joachim Von Braun: "Income Sources of the Malnourished Rural Poor in Africa: Implications for Food and Nutrition Policy"

Olivia Yambi: "The Role of Government in Promoting Community-Based Nutrition Programs: Experience from Tanzania and Lessons for Africa"