Managing Interactions between Household Food Security and Preschooler Health

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Foreword

Food security does not assure good nutrition. The nutritional status of an individual is influenced not only by food but also by nonfood factors, such as clean water, sanitation, and health care. The effect of all of these factors must be considered in efforts to rid the world of malnutrition. Food security will result in good nutrition only if nonfood factors are effectively dealt with. In this paper, Lawrence Haddad, Saroj Bhattarai, Maarten Immink, and Shubh Kumar show how malnutrition among preschool children is determined by a complex interaction of illness and lack of food.

The authors look at three countries—Ethiopia, Pakistan, and the Philippines— to study how food availability and diarrhea interact and what this interaction means for preschooler malnutrition. Their results show that the links between food consumption, diarrhea, and malnutrition are stronger than most economic studies have assumed. When diarrhea is prevalent, the effects of food shortages on child malnutrition are worse, and when food is scarce, the effects of diarrhea on child malnutrition are worse.

These findings have important implications for policy and programs. If factors other than food are critical elements in turning food consumption into good nutrition, then policymakers will need to ensure that the poor do not have to choose between, for example, food and health care.

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Current theory holds that good nutrition for preschoolers depends on household food security, an adequate health environment, and adequate maternal and child care (UN ACC/SCN 1991).[1] It is increasingly clear, however, that nutrition status is a product not only of the levels of these three factors, but also of the interactions between them. For example, von Braun and Kennedy find little evidence to support the hypothesis that the improved income and food availability from agricultural commercialization translate into improved child nutrition.[2] They state,

> Increased income and increased food availability contribute to solving the hunger problem but not the problem of preschool children's malnutrition, which results from a complex interaction of lack of food and morbidity (von Braun and Kennedy 1994, 374–375).

To date, there has been little empirical research examining the magnitude and policy relevance of the interactions between food insecurity and morbidity—especially in a multicountry comparison. This paper argues that (1) a better understanding of the magnitude of the interactions will lead to more cost-effective policies and programs for the improvement of child nutrition today, and (2) as 2020 approaches, the need to appreciate these interactions will become even greater.

First, a brief review of the literature reveals that nutritionists have carefully studied these interactions, but economists have not. Second, the paper uses household data from eight countries to examine the relative importance of household food security and self-reported diarrhea prevalence and interactions between them for the production of child nutrition. Third, it traces the implications of these results for research and policy in light of some current global trends. Finally, it discusses a wider concept of food security that is consistent with the results here and that could lead to improved research and programming for the good nutrition of children.

Recent Literature on the Interaction of Diet and Infection

This brief literature review is intended to be representative of the wider literature on the interactions between food and nonfood inputs into nutrition, but is by no means a comprehensive treatment of it. The literature review is divided along disciplinary lines to give a flavor of the different debates within the nutrition and economics communities.

1 The generally accepted definition of household food security says that "a household is food secure when it has access to the food needed for a healthy life for all its members (adequate in terms of quality, quantity, safety, and culturally acceptable), and when it is not at undue risk of losing such access" (UN ACC/SCN 1991, 6).

2 A case from the Philippines provides an interesting exception. Here, the adoption of sugarcane production reduced the demand for female labor in heavy activities, led to improved maternal nutrition, allowed increased child care time, and improved anthropometry for children under age one. As these preschoolers got older, however, their anthropometric status slipped back to match that of other preschoolers as a result of a poor community health and sanitation infrastructure (Bouis and Haddad 1990).

The Nutrition Literature

It is well-known that current diet and nutrient availability influence the body's immune response capacity in later time periods. This body of work was summarized by R. K. Chandra in his 1990 McCollum Award Lecture (Chandra 1991). This literature shows that general protein energy malnutrition—as measured by child growth—and specific nutrient deficiencies diminish the body's ability to resist infection, leading to a higher incidence, longer duration, and greater severity of illness. Malnutrition induced by dietary and related factors contributes to the breakdown of a wide range of human defense mechanisms that protect against infections. Mechanisms include physical barriers (skin and mucous membranes), nonspecific mechanisms (interferon, lysozyme, and phagocytes), and antigen-specific processes (antibodies and cell-mediated immunity).

This literature suggests that an initial nutritional deficiency may contribute to an increased risk of infections, which leads to a downward spiral of malnutrition (increased loss, reduced intake) and infection. Studies have consistently shown that primary or secondary malnutrition and cell-mediated immune deficiency are important independent risk factors in the prevalence of common diseases, such as diarrhea. Relatively few studies have measured immunocompetence with nutrient interventions in order to assess the time frame for the buildup and reduction in human immunocompetence. One recent example, involving beta-carotene administration, found that it took nine months of dietary supplementation in healthy adults for a significant increase in immunocompetence against viral infections to occur (Murata et al. 1994). Some recent zinc supplementation trials on young preschool zinc-deficient children have, however, shown a quicker response in diarrhea reduction as a result of supplementation (Sazawal et al., forthcoming).

Just as diet affects infection, infection affects food intake and the utilization of foods. Infection (1) increases nutrient requirements because of increased nutrient loss during illness, (2) reduces dietary intake through appetite suppression, and (3) creates a metabolic response that both stimulates the immune response and suppresses body growth. On the first point, for instance, during the acute-phase response to infection, the metabolism of many nutrients is altered and the requirements for some nutrients are increased (Beisel 1984). During acute respiratory infections, for example, vitamin A requirements increase substantially because of the excretion of retinol in the urine (Stephensen et al. 1994). Measles and diarrhea have also been associated with an increased vitamin A deficiency (Bhaskaram et al. 1984) that contributes to the depletion of body stores (Campos, Flores, and Underwood 1987) and the emergence of severe deficiency symptoms such as xerophthalmia (Mahalanabis 1991).

The Economics Literature

Economists tend to represent the production of nutrition as analogous to the production of any other commodity, in that inputs are transformed, at a given level of technology, into output. The major inputs into child nutrition are food intake, health levels, and care[3] (UN ACC/SCN 1991; Strauss and Thomas 1994).

The economics literature has not, however, taken as balanced a view as the previous sentence implies. First, a relatively large amount of time has been spent on the measurement of food consumption and relatively little on the validity, reliability, and usefulness of measures of morbidity that rely on self-reported information (Strauss and Thomas 1994). Second, food intake is more likely to be handled properly from an econometric viewpoint (that is, treated endogenously) than is illness (in that illness, diet, and weight are, to some extent, simultaneously determined). Third, very few studies control for unobserved heterogeneity (such as the often

[3] Care is defined as "the provision in the household and in the community of time, attention, and support to meet the physical, mental, and social needs of the growing child and other household members" (ICN 1992, 1). Care is thought to affect nutrition in two broad ways: through dietary intake and through health and hygiene practices.

unobserved individual and household characteristics of feeding and hygiene caring behaviors).[4]

These shortcomings aside, most of the studies find that preschooler diarrhea has a significantly negative impact on preschooler anthropometry, controlling for either preschooler or household calorie consumption. Calorie consumption at the household and preschooler level is positively and significantly associated with preschooler anthropometry, controlling for preschooler diarrhea. Rarely, however, does one get a sense of the relative magnitude of the impact of these two inputs on nutrition. Moreover, even in the more sophisticated treatments (for example, Bhargava 1994), interaction terms are not used; therefore it is impossible to assess the impact of disease, such as diarrhea, on preschooler anthropometry at different levels of household calorie consumption. Nor is it possible to assess the impact of household calorie consumption on preschooler anthropometry at different probabilities of diarrhea episodes.

New Evidence on the Synergism between Household Food Insecurity and Morbidity for Preschooler Nutrition

This section attempts to fill some of the gaps identified in the previous sections. Specifically, new evidence is presented on the trade-offs between food security (measured by household food availability) and preschooler morbidity in the generation of preschooler nutrition as measured by anthropometric measures. A descriptive analysis of data sets from eight countries—Ethiopia, Ghana, Guatemala, Kenya, Nicaragua, Pakistan, the Philippines, and Zambia—is undertaken to examine the associations between household food security and access to health inputs, self-reported morbidity, and nutrition outcomes.

In addition, a multivariate regression analysis is undertaken on data from Ethiopia, Pakistan, and the Philippines. The regression analysis involves the estimation of a system of three equations explaining (1) household calorie availability, (2) preschooler diarrhea outcomes, and (3) the standardized weight-for-age of preschoolers. In the third regression, special emphasis is placed on the relative contributions of diarrhea and household calorie availability to improvements in nutrition outcomes. Specifically, interaction terms are used to explore the impacts of nutrition inputs at different levels of other inputs.

Descriptive Data from Eight Countries

Table 1 describes a wide range of total expenditure, food availability, morbidity, and nutrition data from the eight countries. Table 1 presents the sample of preschoolers from each country, divided into preschoolers from food-secure and from food-insecure households.[5] The data and the individuals they represent are briefly described in Appendix Table 4.

In four out of eight data sets—Ghana, Kenya, Pakistan, and Zambia—preschooler Z-score weight-for-age is actually worse in households that are classified as food secure, compared with preschoolers in households classified as food insecure, although only in Pakistan is the difference statistically significant. The results for preschooler Z-score weight-for-height are less striking but show some similarities. Compared with preschoolers from households that are food insecure, preschoolers from households that are food secure are worse off in terms of Z-score weight-for-height in two out of seven countries—Ghana and Pakistan; again, only in Pakistan is the result statistically significant.[6]

[4] The largest number of similar case studies has probably been generated by IFPRI. Appendix Table 3 summarizes the significant explanatory variables from Z-score regressions from these studies, together with their limitations.

[5] A household is operationally defined as food secure if calorie intake per adult equivalent is above 2,200, except for Guatemala, where the top three quartiles of food expenditure per capita is used as a cutoff.

[6] When the preschoolers in Table 1 are disaggregated into two groups, zero to less than two years old and two to less than five years old, there is no appreciable strengthening of the relationship between household food security and anthropometric status.

Table 1: Means of selected indicators for preschoolers in eight countries

	Bangladesh		Ethiopia		Ghana	
	Food-Insecure Households (n = 635)	Food-Secure Households (n = 940)	Food-Insecure Households (n = 439)	Food-Secure Households (n = 808)	Food-Insecure Households (n = 123)	Food-Secure Households (n = 141)
Nutrition outcome						
Z-scores of weight-for-age[a]	-2.46	-2.38	-2.54*	-2.09	-1.1	-1.28
Z-scores of height-for-age[a]	-2.43	-2.36	...	...	-1.1	-1.19
Z-scores of weight-for-height[a]	-1.23	-1.15	...	...	-0.59	-0.66
Morbidity						
Prevalence of diarrhea (1 = yes, 0 = no)	0.22	0.26	0.05	0.03	0.08	0.09
Number of days sick from diarrhea/recall period[b]	2.48	2.58	0.36	0.2	0.34	0.34
Ill including diarrhea (1 = yes, 0 = no)	0.15	0.15	0.13*	0.07	0.38	0.46
Total days sick/recall period[b]	3.91	3.56	1.16*	0.62	0.87	0.85
Treatment sought 1: 1 = traditional method, 0 = other	0.21	0.24	0.00	0.00	...	...
Treatment sought 2: 1 = doctor	0.16	...	...	0.00*	...	...
Treatment sought 3: 1 = health post/health center/hospital	0.06	0.04	0.00	0.003	0.67	0.7
Treatment sought 4: 1 = co-op clinic	...	...	...	...	...	...
Treatment sought 5: 1 = dispensary/pharmacy/ private clinic	...	...	...	...	...	...
Treatment sought 6: 1 = medical kit from government	...	...	0.03*	0.02	...	...
Distance to health services[c]	...	...	5.24*	5.63	...	...
Water and sanitation						
Water source (1 = piped/private well)	0.98	0.99	0.00*	0.06	0.04	0.01
Latrine (1 = yes, 0 = no)	0.29*	0.39	0.02	0.03	1.00	1.00
Water sufficient (1 = yes, 0 = no)	...	...	...	...	...	...
Drainage (1 = septic/sewage line, 0 = other)	...	...	...	...	...	...
Per capita living space (square meters)	4.18*	5.42	...	...	...	...
Household characteristics						
Household calories/adult equivalent unit	1,640*	2,803	1,752*	3,365	1,549*	3,567
Household calories per capita	...	...	1,382*	2,541	1,197*	2,741
Household size	6.41	6.52	9.08	9.00	9.41*	7.81
Food expenditure per capita[d]	1,587.1*	2,853.4	...	...	...	...
Household expenditure per capita[d]	2,294.3*	4,008.5	...	...	107,808	104,673
Total health expenditure per capita[d]	85.37*	177.40	1.74*	2.27	2,484.0	2,797.1

(continued)

Table 1: Continued

Guatemala: Food-Insecure Households (n = 47)	Guatemala: Food-Secure Households (n = 160)	Kenya: Food-Insecure Households (n = 484)	Kenya: Food-Secure Households (n = 654)	Pakistan: Food-Insecure Households (n = 531)	Pakistan: Food-Secure Households (n = 1,474)	The Philippines: Food-Insecure Households (n = 1,330),	The Philippines: Food-Secure Households (n = 1,559)	Zambia: Food-Insecure Households (n = 224)	Zambia: Food-Secure Households (n = 560)
-2.16*	-1.75	-1.69	-1.81	-1.39*	-1.67	-1.63*	-1.51	-0.63	-0.71
-3.06*	-2.56	-1.55*	-2.07	-2.33*	-2.2	-2.31*	-2.13	-2.03	-2.00
-0.48	-0.23	-0.30	-0.18	0.49*	-0.06	-0.58	-0.55	0.55	0.72
0.06*	0.18	0.08	0.06	0.24	0.21	0.03	0.03	...	...
0.21	0.58	0.32	0.29	0.95	1.00	...	...	0.09*	0.23
0.23*	0.44	0.42	0.42	0.41*	0.39	0.26	0.27	...	...
0.43	0.78	2.19	2.26	2.14*	2.7	1.54	1.64	0.63*	1.22
...	...	0.03	0.07	0.01	0.02	...	...	0.08	0.13
...	...	0.09		0.25	0.13	...	...	...	0.29*
0.21	0.12	0.25	0.25	0.07	0.05	...	...	0.10	0.17
0.04*	0.11	...	...	...	...	...	...	...	...
0.17	0.11	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
0.30	0.24	...	...	36.15*	59.08	59.92	58.04	15.4	15.04
0.62	0.71	0.09*	0.03	0.39*	0.28	...	...	0.35	0.32
...	...	0.65	0.69	0.81*	0.71	0.18	0.18	0.37*	0.21
0.36*	0.52	...	...	...	...	...	...	...	...
0.22*	0.36	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
...	...	1,629*	3,333	2,065*	2,648	1,759*	2,799	1,694*	3,611
...	...	...	...	1,704*	2,156	...	...	1,189*	2,279
8.47	7.18	12.74*	17.09	14.33*	10.28	7.57*	7.02	9.52*	6.07
385.52*	801.70	97,618	98,189	...	...	25.83	32.94	347.7*	542.7
...	...	10,956.0*	8,826.8	2,148.63*	2,812.94	37.02*	48.89	467.9*	771.9
7.92	10.45	...	...	125.23*	161.31	5.8*	6.9	1.20*	1.76

Notes: Cutoff used for classifying households as food secure or food insecure is household calories per adult equivalent unit = 2,200. N refers to sample of preschoolers. Household variables were merged with each preschooler in the household. The actual number of cases used to compute means for each variable may vary slightly. In Guatemala, food expenditure quartile was used, and the lowest quartile was the cutoff point at .05 for food-secure and -insecure groups. Leaders (...) indicate not available. * indicates significantly different between food insecure and food secure level.

[a]The Z-score is a method used in standardizing the distribution of actual weight and height of the child relative to the standard weight for a childof that age and height.

[b]Recall period for morbidity: 1 week for Ghana, Guatemala, and Kenya; 2 weeks for Ethiopia, Pakistan, and the Philippines; 1 month for Zambia; and 3 months for Bangladesh.

[c]Distance units are all kilometers except in Pakistan and the Philippines, which use minutes. In Guatemala, 1 = 3 kilometers, 0 = 3 kilometers.

[d]Expenditures reported are in local currency of the country per year. In the Philippines it is per week.

In terms of self-reported prevalence of diarrhea, with the exception of Guatemala (where preschoolers from food-secure households have a diarrhea prevalence rate three times that of food-insecure households), the prevalence figures are similar for preschoolers from both types of households in all the data sets.

Multivariate Analysis for Ethiopia, Pakistan, and The Philippines

Table 1 is descriptive and may mask confounding factors. For example, households that are food secure may contain more older preschoolers, and age tends to be negatively correlated with preschool anthropometric measures. This section details a more causal examination of the determinants of Z-score weight-for-age in Ethiopia, Pakistan, and the Philippines.[7] The regression analyses are presented in detail in Appendix Tables 5 through 7. These tables lay out the system of equations used to address the concerns of endogeneity of household calorie availability and preschooler diarrhea. Logit regressions are run for the diarrhea zero-one dependent variable and for the zero-one dependent variable corresponding to the Z-score weight-for-age cutoff of –2 standard deviations. Table 2 takes coefficient estimates from Appendix Tables 5 through 7 to predict the probability of a preschooler's being above an anthropometric cutoff of –2 standard deviations below the median value of weight-for-age for a healthy U.S. population (standards from the U.S. National Center for Health Statistics are used for all countries). Probabilities are calculated at different levels of household per capita calorie availability and at different levels of diarrhea probability, and with and without a calories-diarrhea interaction term.[8]

Table 2: Probability of not being weight deficient among preschoolers in Ethiopia, Pakistan, and the Philippines at different levels of calories per capita and selected cutoffs of predicted probability of diarrhea

	Predicted Probability of Diarrhea for Ethiopia[a]			Predicted Probability of Diarrhea for Pakistan[a]			Predicted Probability of Diarrhea for the Philippines[a]		
Household Calorie Availability per Capita	**High (0.05)**	**Medium (0.02)**	**Low (0.006)**	**High (0.29)**	**Medium (0.19)**	**Low (0.11)**	**High (0.037)**	**Medium (0.018)**	**Low (0.009)**
750 calories per capita									
Without interaction term	0.27	0.30	0.31	0.46	0.48	0.51	0.56	0.58	0.58
With interaction term	0.27	0.37	0.42	0.30	0.45	0.58	0.56	0.62	0.64
1,250 calories per capita									
Without interaction term	0.34	0.37	0.38	0.53	0.56	0.59	0.67	0.68	0.69
With interaction term	0.37	0.44	0.49	0.43	0.54	0.63	0.66	0.69	0.71
2,000 calories per capita									
Without interaction term	0.44	0.47	0.49	0.64	0.67	0.69	0.80	0.81	0.81
With interaction term	0.54	0.56	0.57	0.63	0.66	0.69	0.79	0.79	0.79

Notes: A preschooler is considered weight deficient if his or her weight-for-age Z-score is < –2. The diarrhea recall period is two weeks for each data set.

[a]Cutoffs used are the 25th, 50th, and 75th percentile of predicted probability of diarrhea.

7 Weight-for-age is chosen primarily because it is available for all data sets.

8 The predicted probability of a preschooler's being above the Z-score weight-for-age cutoff is given by: $e^z/(1 + e^z)$, where z is a linear combination of the explanatory variables and the logit regression coefficients in the last two columns of Tables 5 through 7.

For a linear formulation,

Z-score = a + b.calories ~
+ c.diarrhea probability
+ d.calories*diarrhea probability + . . .,

the interaction term permits the marginal impact of calories and diarrhea probability on Z-score weight-for-age to be interdependent, that is:

$$\partial z/\partial \text{calories} = b + d.\text{diarrhea probability}$$

and

$$\partial z/\partial \text{diarrhea probability} = c + d.\text{calories}.$$

Appendix Tables 5 through 7 show that calories have a positive and significant impact on Z-score weight-for-age for all three data sets, and diarrhea prevalence has a negative and significant impact on Z-score weight-for-age, at least at the 10 percent level. This result is consistent with a priori expectations. When included, the interaction term is significant and positive for all three countries at the 10 percent level.[9]

This positive sign on the interaction term indicates that the marginal impact of the extra calorie on Z-score weight-for-age increases as diarrhea probability increases. Conversely, the marginal impact of a loss of the extra calorie on Z-score weight-for-age also increases as diarrhea probability increases. High levels of diarrhea magnify the effects of gains and losses in household food security on child nutrition. The positive sign on the interaction term also indicates that the negative effect of diarrhea probability on Z-score weight-for-age is muted at higher levels of household calorie availability.

However, because of the nature of the dependent variable (1 if preschooler is above -2 Z-score weight-for-age, 0 otherwise), logit, not linear, estimation is used. Reported coefficient estimates from logit estimation do not correspond to marginal impacts but require a transformation for the recovery of the marginal impacts. Hence, determining the a priori sign on the interaction term is not straightforward.

Table 2 therefore takes these estimated logit coefficients and presents their effects in a more intuitive manner. Specifically, the estimates are used to predict the probability of a preschooler's being above 2 standard deviations of weight-for-age, calculated based on values of 750, 1,250, and 2,000 for daily per capita household calorie availability and low, medium, and high predicted probabilities of diarrhea. Two predicted Z-score weight-for-age probabilities are calculated for each combination of calorie and diarrhea values: one with an interaction term in the preschooler Z-score weight-for-age equation, and one without the interaction term. As far as the authors are aware, none of the previous studies of this sort have used such an interaction term.

There are several things to observe in Table 2.

- First, increased household calorie availability and decreased diarrhea probability both increase the probability of improved preschooler Z-score weight-for-age—with or without the interaction term.
- Second, for Ethiopia, the inclusion of the interaction term affects the predicted probabilities at all values of calories per capita and diarrhea probability. In fact, all the predicted probabilities are higher when an interaction term is used. For Pakistan, the inclusion of an interaction term matters only at the two lowest levels of calorie availability per capita. For the Philippine data, the inclusion of the interaction term matters only at the lowest level of calorie availability per capita.[10]

The exclusion of an interaction term therefore understates the combined impact of improved household calorie availability and reduced diarrhea probability on preschooler Z-score weight-for-height. This suggests that standard economic analyses of the causes of

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[9] The inclusion of the interaction term does, however, cause the calorie variable to become insignificant for Pakistan and the Philippines, although the two calorie terms are jointly significant for each data set.

[10] These differences may reflect different stages of general development in each of the three study communities.

child nutrition may be understating the importance of both household food availability and infant diarrhea in determining whether or not a preschool child is underweight.

- Third, the inclusion of the interaction term improves the responsiveness of Z-score weight-for-age to reductions in diarrhea probability. For Ethiopia and Pakistan, this holds for the two lower levels of calorie availability per capita and, for the Philippines, this holds only for the bottom calorie availability per capita level. For example, at 750 calories per capita for Ethiopia, without the interaction term the probability of improved Z-score weight-for-age increases from 0.27 to 0.31 as diarrhea probability moves from high to low. With the interaction term, the change in probability is from 0.27 to 0.42. Thus, increased diarrhea prevalence at low levels of household calorie availability per capita has a greater negative impact on nutrition than does increased diarrhea prevalence at high levels of household calorie availability per capita.
- Fourth, for both Ethiopia and Pakistan, the sensitivity of preschooler Z-score weight-for-age with respect to declines in household calorie availability per capita is greater at the higher diarrhea probabilities. For Pakistan, for example, the omission of the interaction term at high levels of morbidity results in a decline in the predicted probability for improved Z-score weight-for-age from 0.64 to 0.46 as household calorie availability per capita declines from 2,000 to 750. With the interaction term, the probability decline is from 0.63 to 0.30. A similar result holds for Ethiopia. For the Philippine data, at high levels of morbidity, the inclusion of the interaction term has little effect on predicted Z-score probabilities as calorie availability per capita declines. Overall, a loss of food security at high probability levels of diarrhea has a greater impact on nutrition than does a loss of food security at low probability levels of diarrhea.

In summary, the inclusion of the interaction term, particularly for the Ethiopia and Pakistan data, makes a difference to the interpretation of the preschooler nutrition regression results. At low calorie availability per capita, the inclusion of the interaction term indicates that weight-for-age is more sensitive to improved morbidity than one would expect without the term. This result holds for Ethiopia and Pakistan. Similarly, at high morbidity, the inclusion of the interaction term indicates that weight-for-age is more sensitive to changes in household calorie availability than one would expect without the term. This result also holds for Ethiopia and Pakistan.

Caveats to the Multivariate Analysis

The main contributions of the empirical analysis presented here are (1) the comparability of the three data sets in terms of measurement concepts, questionnaire design, and variable definition, (2) the use of an interaction term between calories and diarrhea, and (3) the exposition of the results in terms of predictions of preschooler Z-score weight-for-age.[11]

The analysis does, however, suffer from many of the shortcomings of other studies in its genre: (1) the use of self-reported measures on morbidity,[12] (2) the use of food availability as opposed to food intake data,[13] (3) the focus on calories as opposed to nutrients, and (4) the imprecise measures of feeding and hygiene practices (although mother's education serves as a partial proxy for some of these measures). These shortcomings point the way for the next wave of economics-of-nutrition studies in terms of improving measurement, statistical techniques, and conceptual models of nutrition.

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[11] The comparability, however, could be improved; see, for example, the different recall periods for self-reported morbidity in Appendix Table 4.

[12] The errors on self-reported morbidity tend to be positively associated with income and education and are, therefore, extremely difficult to take account of in regression analyses unless they are modeled explicitly.

[13] However, a comparison of similar results from the Philippine data set (not reported here) using calorie intake and calorie availability at the household level shows little difference between the two measures.

Implications for Future Research and Programs

The empirical analysis shows that (1) the exclusion of an interaction term understates the combined impact of improved household calorie availability and reduced diarrhea probability on preschooler Z-score weight-for-height, (2) increased diarrhea prevalence at low levels of household calorie availability per capita has a greater negative impact on nutrition than does increased diarrhea prevalence at high levels of household calorie availability per capita, and (3) a loss of food security at high levels of diarrhea probability has a greater impact on nutrition than does a loss of food security at low levels of diarrhea probability.

In short, the consequences of loss of food security are greatest at high levels of diarrhea, and the consequences of diarrhea are greatest at low levels of calorie availability. While this analysis is an improvement over past attempts to look at the relative importance of these two pillars of good nutrition, the research is, at this stage, only suggestive. But what does it suggest?

The research suggests that nutrition and food security researchers—and possibly practitioners—often overlook the synergy that exists between the various inputs into nutrition. Researchers and, to a lesser extent, practitioners tend to have a single focus, be it on food or health or care. Households cannot afford to have this single focus. Households realize that the achievement of food security is not necessarily a step up the ladder toward good nutrition.

Trends That Will Affect the Synergies between Household Food Security and Morbidity

A number of emerging trends threaten the ability of households to exploit these synergies. It is therefore imperative that policies and programs preserve and enhance the ability of households in this regard.

In theory, market liberalization should enhance a household's ability to exploit synergies by helping to de-link choices made in production and consumption activities. In the presence of well-functioning markets for goods and labor, household resources can be combined so as to maximize income, which can then be spent in a way that exploits synergisms so as to maximize utility and health. However, the data described in Table 1 indicate that increased income and food security do not necessarily increase entitlements to health inputs, perhaps because the latter are usually quasi-public goods. Markets may not exist for health care, drinking water, sanitation, and child care. Such goods require investments at a scale that is beyond a household's reach. In sum, markets may be "missing" for many of the nonfood inputs into nutrition.

A number of trends threaten to increase the negative consequences of these missing markets before the markets have time to develop. First, urbanization combined with poverty and in the absence of strong family and formal safety nets may increase the premium on good health relative to the premium on food security (see Schultz and Tansel 1995). Increasingly, urban households have to rely on good health to keep wage earners in jobs. In the rural areas the labor provided by these wage earners may have been substituted for by other family members. Second, lack of water markets and increasing competition for water between production (both agricultural and industrial) and consumption mean that production and nutrition decisions related to water are increasingly linked at the community and household level. Third, increasing rates of HIV/AIDS devastate the productive capacity of the poor in rural and urban areas, but because of the political power of urban communities, public expenditures may be pulled away from preventative health care infrastructure toward expensive urban health care that is curative in nature (see Brown, Webb, and Haddad 1994). Finally, the increased need for health and sanitation services due to the surge in the number and size of displaced populations will place increasing pressure on social service budgets, especially against the backdrop of economic reform and adjustment.

These trends raise several questions regarding practical approaches:

- Why have past multisectoral agriculture and health programs generally failed, and what lessons can be learned from successful ones?
- Why have rural markets for basic services been slow to develop, and what are the constraints? Does an expanding private sector improve access to nonfood nutrition inputs for the poor?

- How can marginalized population groups, such as women, gain improved access to food and nonfood inputs? How can trade-offs due to resource constraints be minimized?

To answer these questions, conceptual, analytical, and policy work on the many facets of food and nonfood interactions should be expanded.

Projects and Policies That Show Promise for Preserving and Enhancing the Synergies

Designing projects and policies so that households do not have to choose between credit and education, between food production and child vaccinations, and between income generation and child care is extremely difficult. Programs that combine credit services with health and nutrition programs run the risk that those intereseted in credit access with high opportunity costs are not those most interested in nutrition education. One study found that women with severe time constraints (as proxied by having preschoolers) were able to get access to project credit but, it is deduced, were less able to use it effectively (De Groote et al. 1994). Perhaps to be fully effective in improving food security the credit project would have had to reduce the time burdens on participating women. The trade-offs between income generation and child care time may be blunted by a program design more attuned to participants' child care needs. Similarly, the effects on child nutrition and survival of time saved as a result of improved water access need to be better documented; for example, do the synergisms between improved water quality and time freed up for activities such as child care exist in the field (Burger and Esrey 1995)? Exploiting these synergisms offers high potential rewards, in terms of maximizing not only synergies in delivery, but also synergies in the impact on preschooler nutrition.

In many ways, this synergistic approach is a response to the calls for "linking relief and development" and for a "relief-to-development continuum," which have recently gained a high profile (Linking relief and development 1994). These phrases represent the sentiment that, whenever necessary and possible, development interventions should use resources more effectively by providing relief while working to decrease the need for relief during the next round of shocks. The following interventions may be successful in this regard: labor-intensive public works programs that improve health and education infrastructure, innovative savings schemes that allow households to manage consumption in order to protect production capabilities, and credit schemes targeted to women that include a health and nutrition education component. Furthermore, these projects can be intertwined to create safety nets for the poor that not only catch those who fall, but also make sure they get back up.

The potential for these programs to succeed is clear from some recent research. For example, Webb et al. (1994) conclude that while most public works projects in Ethiopia are based on soil conservation or reforestation objectives, these activities are among the least desired by the participants themselves. They find that the participants most desire public works projects that are related to health and sanitation, such as health clinic construction, piped water, and latrine building.

Postscript: Is There a Definitional Continuum between Food Security and Nutrition, and Is It Useful?

The programs described here aim at raising entitlement to food and simultaneously providing the nonfood inputs that increased income does not necessarily provide. Food staves off hunger and, when combined with nonfood inputs, gives individuals a better chance of surviving the next shock and of getting on with development. As such, these programs embody the idea of linking relief and development.

Definitions of food security center on the concept of entitlement to food. However, the entitlement concept is usually only applied before the dietary intake of that food. At high levels of morbidity, the body's ability to utilize consumed food diminishes: the body's physiological or internal entitlement to food is diminished, even in the presence of adequate external entitlements. Even if the purchasing power of the household is high, the processing power of the body may be low. It may be worthwhile to broad the concept of food security to include the idea of an internal entitlement.

What is gained from broadening the concept of food security, and what is lost? This paper argues that little, if anything, is lost. It may be that when the concept of food security is broadened, it loses its focus and its political and institutional constituency. However, broadening the concept strengthens the focus on entitlements. Furthermore, this broader concept provides an entry point for nutritionists who are interested in household food security.

What else is gained? Greater emphasis is placed on the idea that solutions to household food insecurity and malnutrition are linked. This paper has argued that a number of emerging trends threaten the ability of households to exploit positive synergisms for nutrition status arising from food and nonfood consumption. Policy and programs should strive to preserve and enhance these synergisms by seeking to design programs that aim simultaneously to increase external and internal entitlements to food.

Appendix

Table 3: Summary of IFPRI work on determinants of anthropometric status

Study	Country	Main Findings	Comments
Alderman and Garcia 1993	Pakistan	Preschooler anthropometric status was not constrained by low household food availability, but by poor health and high levels of infection (-). Vitamin A consumption (+) from household food expenditure data had large impact on preschooler WH.	No food intake data were collected. Also, no individual food intake data were collected. No correction was made for unobserved heterogeneity.
Teklu, von Braun, and Zaki 1991	Sudan	Diarrhea (-), household expenditures on grain (+), < 3 meals/day (-), mother's literacy (++), father's literacy (+) had significant impacts on WA of preschooler.	Diarrhea and household grain expenditure are instrumented. No food intake data were collected. No correction was made for unobserved heterogeneity.
von Braun, de Haen, and Blanken 1991	Rwanda	Household calories from food expenditures (+ for ZHA, ZWA, ZWH), heavy worm load (- for ZHA), clean toilet (+ for ZHA, ZWA), birth order (- for ZHA, ZWA, ZWH) had significant impacts on preschooler anthropometrics.	None of the endogenous explanatory variables are instrumented. No correction was made for unobserved heterogeneity.
Bouis and Haddad 1990	The Philippines	Preschooler calorie intake (+), diarrhea and fever (-), mother's education (+) had significant impacts on preschooler WH.	None of the endogenous explanatory variables are instrumented. No correction was made for unobserved heterogeneity.
Kennedy 1989	Kenya	Preschooler calorie intake (+), diarrhea (-) had significant impacts on preschooler WA and HA (but not WH).	None of the endogenous explanatory variables are instrumented. No correction was made for unobserved heterogeneity.
von Braun, Puetz, and Webb 1989	The Gambia	Preschooler calorie intake (+), diarrhea (-), water quality (-), child of compound head (+) had significant impacts on preschooler WA and HA (but not, in general, on WH).	None of the endogenous explanatory variables are instrumented. No correction was made for unobserved heterogeneity.
von Braun, Hotchkiss, and Immink 1989	Guatemala	Per capita income (+), share of male nonagricultural income (+), share of female nonagricultural income (++), duration of breast-feeding (+) had significant impacts on preschooler WA and HA (but for WH, only income effects +).	None of the endogenous explanatory variables are instrumented. No correction was made for unobserved heterogeneity.
Kennedy and Cogill 1987	Kenya	Diarrhea (- for ZWA, ZWH), female head of household (+ for ZWA, ZHA), calories of child (+ for ZHA, ZWA) had significant effects.	None of the endogenous explanatory variables are instrumented. No correction was made for unobserved heterogeneity.
Pinstrup-Andersen and Garcia 1987	The Philippines	Household income (+ for WA), diarrhea (- for WA), poor water quality (- for WA and HA), birth order (-), nutrition education (+ for WA and HA) had significant effects.	None of the endogenous explanatory variables are instrumented. No correction was made for unobserved heterogeneity.
Kumar 1979	India	Rice ration subsidy (+), per capita own-farm income (+) had significant effects.	None of the endogenous explanatory variables are instrumented. No correction was made for unobserved heterogeneity.

Notes: WA = weight-for-age, ZWA = Z-score weight-for-age, HA = height-for-age, ZHA = Z-score height-for-age, WH = weight-for-height, ZWH = Z-score weight-for-height, (-) = negative effect on anthropometry, (+) = positive effect on anthropometry.

Table 4: Brief description of data sets

Country	Survey Year	Number of Households	Recall Period for Morbidity	Brief Description
Bangladesh	1991/1992	737	3 months	A food consumption and nutrition survey was carried out three times over a one-year period to assess the consumption and nutrition effects of two targeted food intervention programs—Rural Rationing and Vulnerable Group Development Program. The survey was conducted in eight villages in eight *thanas* (districts) located in four divisions of the country. In selecting the sample, focus was on achieving adequate variation in factors such as distress proneness and developed and undeveloped areas. Besides food intakes and socio- economic data, information on individual health, anthropometric measures, sanitation, and housing conditions was also collected. Questions asked on morbidity status were: Has any member of the family suffered from the following list of diseases during the past three months? If yes, days sick/whom consulted/if no consultation, why not? (Ahmed 1993).
Ethiopia	8/1990 to 9/1991	650	2 weeks	The data were collected from 11 rural Peasant Associations (PAs) in Sike, Omo, and Alaba *awarjas* in South Sewa Province, roughly once a month from August 1990 through September 1991. The focus of the study was to identify seasonal swings in nutritional and health status and the determinants of the seasonal swings, with a particular emphasis on seasonality in agriculture production, food availability, and labor demand. The sample frame was designed to capture the main characteristics that influence the seasonal swings. The four key factors considered were ecological zones, availability of public works programs, infra- structure access, and ethnic origin. Ten PAs were selected based on the above characteristics, and one additional site was drawn from the worst part of the region for comparison purposes. Forty households from each of the 10 PAs were randomly selected from three economic strata constructed for each of the Pas. Anthropometric measures of weight and height were taken for all members of households. Information on water and sanitation was also collected. The questions specifically asked on morbidity were: "Were any members of the household sick from malaria, measles, jaundice, cough, whooping cough, injuries, generalized ache, cough with fevers, and other? . . . If yes, please specify days sick/type of treatment sought, if any" (Kumar, Bhattarai, and Amde 1995).
Ghana	1992/1993	610	1 week	A survey was conducted to evaluate the effects of credit schemes targeted to women on household income, household food security, and the nutrition status of women and preschoolers. Two surveys were conducted in two regions, Volta and Brong-Ahafo, to capture the major types of credit schemes. Once the villages were selected that had access to the credit scheme, a random sample of households was drawn from a census of households in each of these villages. Questions on morbidity included ". . . number of days sick by disease type" (Kennedy et al. 1994).
Guatemala	1991	376	1 week	A study was conducted in 1991 in six villages as a follow-up to a similar study conducted in 1985 in the same villages. The study was undertaken to examine the long-term effects of crop diversification and commercialization, particularly of nontraditional crops, on production, income, food security, health, and nutrition in small-farm households. An attempt was made to include as many of the families from the 1985 study as possible. This resulted in a first-stage sample of 339 families, to which was added 176 families selected at random from the six villages. Households with highly incomplete data were eliminated, bringing the total household sample size to 376. Besides socioeconomic data, information on water, housing, sanitary conditions, and morbidity were collected. One child under 6 years old and one between 6 and 13 years of age were selected at random in each family for anthropometric measures. Weight and height were also taken for the spouse and/or adults 18 and above. Questions specifically on morbidity included ". . .was any child sick from diarrhea, fever, vomiting, coughing, infections (measles, chicken pox, mumps, hepatitis, etc.). If yes, number of days sick, type of treatment sought" (Immink et al. 1993).
Kenya	1992	454	7 days	This study was carried out to examine the feasibility of integrating nutrition and food security components into a commercial agriculture scheme in southwest Kenya and to design and implement a local-level monitoring system in conjunction with the district-level government. Previous work in this area concluded that income-generating agriculture projects must be combined with other nutrition and food security components in order to decrease malnutrition and improve nutrition status. The study was conducted in Nyanza Province and South Nyanza District.The households selected represented a re-surveyed random sample (Kennedy et al. 1995).

(continued)

Table 4: Continued

Country	Survey Year	Number of Households	Recall Period for Morbidity	Brief Description
Pakistan	7/1986 to 9/1991	880	2 weeks	This panel survey involving 12 visits was carried out in 1 well- developed and 3 poorly developed districts selected from four provinces to analyze different dimensions of poverty. The provinces and districts were selected purposively. The selected districts were Attock in Punjab, Badin in Sindh, Dir in North West Province, and Mastung/Kalat in Baluchistan. The villages and households in each district were selected by stratified random sampling. Along with socioeconomic data, the survey collected anthropometry and health data for children below 6 years of age in all 12 rounds and for adults in 5 of the 12 rounds. In each of the 12 rounds, observations on health conditions, specifically diarrhea and other illness, were recorded for each child under 6 years. Information on water and sanitation was also collected. Questions on morbidity included: Did you have diarrhea in the past two weeks? Who did you first see? How many days sick? Did you have other illness? If yes, how many days sick? Whom did you see? Cost for treatment? Access to health services/travel time? One important finding: The results indicate that at the household level in rural areas, children respond more strongly at the margin to health inputs than to food availability (Alderman and Garcia 1993).
The Philippines	1984/85	448	2 weeks	A total of 448 corn- and sugar-producing households were surveyed four times at four-month intervals in Bukidnon Province, Mindanao. The sample included smallholder land-owners, tenants, and landless laborers. Data were collected on landholdings, income sources, expenditure patterns, calorie intakes, and nutritional and morbidity status (Bouis and Haddad 1990).
Zambia	1986	330	1 month	A survey was carried out in the Eastern Province of Zambia to examine the growth and equity effects of technology change in agriculture. Study sites were located in each of the districts and were selected to provide a representative sample from the province and its two main ecological zones—plateau and valley. The selection of households was by stratified random sampling. A total of 330 households were selected and visited monthly during 1986. Information on agricultural production practices, labor allocation, off-farm income, food and nonfood consumption, and health and sanitation was collected. Anthropometric measures (weight and height) were taken for each individual in the household at four times during the year. Information on water and sanitation was also collected. On health, participants were asked, "Were you or any member ever sick from the following illnesses during the last month—diarrhea, respiratory infection, measles, generalized acute illness, chronic mild, chronic serious illnesses?" The number of days sick and the type of treatment sought for each of the illnesses were also asked (Kumar 1994).

Table 5: Regression summary of preschoolers, Ethiopia

		Household Calorie Availability per Capita		Preschooler Probability of Diarrhea (1 = yes)	
Variable	**Variable Name**	**Coefficient**	**t-statistic**	**Coefficient**	**Wald Statistic**
Predicted preschooler diarrhea	YDIARF1				
Predicted household calorie availability per capita	YCAL				
Interaction: predicted calorie*diarrhea	CALDIAR				
Household size	FMSIZE	-35.471	-2.36*	0.152	1.63
Number of males in household 15–65 years old	HM1565	-24.625	-1.10	0.099	0.30
Number of females in household 15–65 years old	HF1565	41.217	1.58	-0.031	0.02
Number of children in household 6–14 years old	HKID614	-77.844	-3.67*	-0.127	0.47
Number of adults greater than 65 years old	HAD65	-215.328	-3.96*	-0.645	1.51
Season: 1 = round 10, 0 = round 6	SEASON	0.043	0.00	-1.230	10.67*
Location: 1 = highland, 0 = others	ECOL1			-0.849	0.46
Location: 1 = lowland, 0 = others	ECOL2			-1.267	4.07*
Sanitation (latrine present: 1 = yes)	SANIT			-0.250	0.09
Piped water dummy: 1 = yes, 0 = other	DUMWAT1			-2.688	0.04
Protected spring/well: 1 = yes, 0 = other	DUMWAT2			-0.399	0.28
Unprotected spring/open well: 1 = yes	DUMWAT3			-0.156	0.15
Distance to nearest health services (kilometers)	DISTHS			0.247	1.11
Nearest health post dummy: 1 = yes, 0 = no	HPDUMMY			-0.513	0.58
Nearest health center dummy: 1 = yes, 0 = no	HCDUMMY			-0.628	0.18
Nearest clinic dummy: 1 = yes, 0 = no	CLDUMMY			-3.263	2.16
Price of maize (rs per kilogram)	MZPRC79	-255.942	-3.25*		
Land owned (hectares)	LANDTOTH	112.721	7.91*	-0.002	0.0001
Livestock value	LSIVAL	0.346	11.78*	-0.001	2.09
Mother's height (centimeters)	MOMHT				
Height squared	HTSQ				
Education of household head (grades)	HHEDUCAT			0.012	0.03
Education of mother (grades)	MOMED	7.484	0.41	0.066	0.17
Age of individual (months)	NAGEM				
Age squared	AGESQ				
Age group dummy: 1 = < 2 years, 0 = > 2 years	AGEGR			0.833	6.58*
Sex of individual: 1 = male, 0 = female	SEXE			-0.036	0.01
Sex of household head	HHSEX				
Marital status dummy: 1 = polygamous	MARDUM2	240.269	4.49*		
Constant		2,261.961	20.58	-2.698	5.19
AD R-Squared		0.270			
F			42.400		
-2 Log likelihood				327.60	
Model Chi-square (p < x)				62.4(.000)	

Notes: * indicates significant at 0.05 level. ** indicates significant at 0.10 level.

Table 5: Continued

Preschooler Z-Score Weight-for-Age (1 = > -2)		Preschooler Z-Score Weight-for-Age (1=>-2) (with interaction)	
Coefficient	Wald Statistic	Coefficient	Wald Statistic
-4.262	4.195*	-23.280	3.897*
0.001	6.354*	0.000	3.097**
		0.010	2.724**
-0.087	2.529	-0.098	3.200**
0.154	3.599*	0.165	4.096*
0.256	6.851*	0.264	7.203*
0.063	0.559	0.090	1.099
-0.058	0.074	0.015	0.005
-0.140	0.770	-0.093	0.328
-0.107	0.220	-0.054	0.054
-0.128	0.284	-0.093	0.147
-0.083	0.291	-0.108	0.493*
0.000	0.566	0.001	0.838
0.008	0.047	0.007	0.036
0.009	0.013	0.017	0.050
-0.066	9.625*	-0.062	8.607*
0.001	7.170*	0.001	6.583*
-0.050	0.122	-0.062	0.189
0.530	2.041	0.546	2.158
2.610	0.050	4.600	0.160
1,165.70		1,162.90	
63.03(.000)		65.8(.000)	

Table 6: Regression summary of preschoolers, Pakistan

		Household Calorie Availability per Capita		Preschooler Probability of Diarrhea (1 = yes)	
Variable	**Variable Name**	**Coefficient**	**T-statistic**	**Coefficient**	**Wald Statistic**
Predicted preschooler diarrhea	YDIARF1				
Predicted household calorie availability per capita	YCAL				
Interaction: predicted calorie*predicted diarrhea	CALDIAR				
Household size	HSIZE	-83.203	-13.00*	-0.2722	15.16*
Number of males in household greater than 16 years old	MADULT	99.319	11.18*	0.3815	16.62*
Number of females in household greater than 16 years old	FADULT	107.533	11.26*	0.2775	8.28*
Number of males in household 6–15 years old	SCHOOLM	55.801	7.12*	0.254	9.76*
Number of females in household 6–15 years old	SCHOOLF	52.660	6.78*	0.2251	7.77*
Total children 5–16 years old	SCHOOL				
Number of children in household under 6 years old	PRESCH F	-8.090	-1.05	0.1445	2.44
Season: 1 = round 10, 0 = round 6	SEASON	4.199	0.31	-0.8947	54.80*
Location dummy district 1	DUMDIST1	86.394	3.80*	-1.8069	30.52*
Location dummy district 2	DUMDIST2	346.847	13.72*	-2.1333	36.29*
Location dummy district 3	DUMDIST3	32.045	1.91*	-1.8273	23.68*
Sanitation (latrine present: 1 = yes)	DUMLAT			-0.325	2.40
Tap water dummy: 1 = yes, 0 = other sources	DUMWAT1			-0.0165	0.01
Hand pump: 1 = yes, 0 = other sources	DUMWAT2			0.0889	0.19
Well: 1 = yes, 0 = other sources	DUMWAT3			-0.159	0.60
Village-level distance to government	TGOV2			0.0011	0.30
Knowledge about rural health unit: 1 = yes	KHUN			-0.7999	6.68*
Price of wheat (rs per kilogram)	WHPRICE	-5.418	-0.34		
Land owned (acres)	LANDTOTH	1.971	2.82*		
Asset value (rs)	ASSETVAL	0.0001	2.32*		
Education of household head (years)	EDUCHH			0.0039	0.06
Education of adult female (years)	FEMEDUC	7.575	2.84*	0.0232	1.01
Age of individual (months)	AGEMOADJ			0.0083	0.38
Age squared	AGESQ			-0.0005	4.29*
Sex of individual: 1 = male, 0 = female	SEX			0.1352	0.91
Sex of household head: 1 = yes	SEXHH			-0.2952	0.13
Land*district dummy 1	LAND1	39.800	15.28*		
Land*district dummy 2	LAND2	4.811	4.11*		
Land*district dummy 3	LAND3	3.225	4.13*		
Constant		2,141.746	50.79*	1.5596	2.77**
AD R-Squared		0.49			
F			112.6		
-2 Log likelihood				1,882.7	
Model Chi-square (p < x)				205.5(.000)	

Notes: * indicates significant at .05 level. ** indicates significant at .10 level.

Table 6: Continued

Preschooler Z-Score Weight-for-Age (1 = > -2)		Preschooler Z-Score Weight-for-Age (1=>-2) (with interaction)	
Coefficient	Wald Statistic	Coefficient	Wald Statistic
-1.5108	2.80**	-9.8125	4.80*
0.0006	2.80**	-0.00006	0.02
		0.004	3.60*
-0.0066	0.15	-0.0096	0.31
0.0314	0.89	0.0407	1.5
0.058	0.69	0.069	0.98
0.166	1.20	0.150	0.92
-0.782	8.80*	-0.860	10.20*
-1.830	30.40*	-1.800	30.40*
-1.800	81.30*	-1.870	83.60*
0.055	5.60*	0.051	4.70*
0.003	0.81	0.003	0.61
0.019	0.02	0.026	0.05
0.350	0.21	1.750	2.70**
2,346.5		2342.9	
246.8(.000)		250.4(.000)	

Table 7: Regression summary of preschoolers, the Philippines

Variable	Variable Name	Household Calorie Availability per Capita (MCALPC)		Household Calorie Intake per Capita (HCALPC)	
		Co-efficient	T-Statistic	Co-efficient	T-Statistic
Predicted preschooler diarrhea	YDIARF1				
Predicted household calorie availability per capita	YMCAL				
Predicted calorie availability*predicted diarrhea	CALDIAR2|				
Household size	NUMRD	-173.750	-13.37*	-107.160	-8.76*
Number of males in household 5–17 years old	MALE517	94.528	6.14*	87.575	6.04*
Number of females in household 5–17 years old	FEML517	108.717	7.08*	58.857	4.07*
Number of males in household > 17 years old	MALEGT17	151.279	7.62*	161.785	8.66*
Number of females in household > 17 years old	FEMLGT17	24.376	1.05	47.706	2.18*
Number of male children in household < 5 years old	MALE05	43.546	3.21*	7.487	0.59
Total school age children 5–17 years old	school				
Total adults greater than 17 years old	adl				
Round dummy 1	RD1	114.190	3.83*	230.003	8.20*
Round dummy 2	RD2	-11.857	-0.36	18.039	0.57
Round dummy 3	RD3	199.559	4.83*	-101.070	-2.60*
Latrine dummy 1: 1 = water sealed/flush	DUMLAT1				
Latrine dummy 2: 1 = open/bushes	DUMLAT2				
Piped water/tank dummy: 1 = yes, 0 = other sources	DUMWAT1				
Artesian	DUMWAT2				
Well: 1 = yes, 0 = other sources	DUMWAT3				
Water boiled for children: 1 = yes, 0 = no	KIDBOIL				
Distance to nearest doctor (minutes)	TIMEDOC				
Price of rice (peso per kilogram)	PRICE	-85.470	-5.54*	19.897	1.37
Price of corn (peso per kilogram)	PRCORN	1.654	0.10	7.467	0.48
Land owned (acres)	FARMSZ	20.516	4.76*	11.646	2.87*
Average net worth of household assets	AVNETWTH	0.003	7.00*	0.001	1.46
Mother's height (centimeters)	AVHTMOTH				
Education of father (years)	FATED				
Education of mother (years)	MOMED	-0.119	-0.06	-0.525	-0.30
Age of individual (months)	AGEMO				
Age squared	AGESQ				
Sex of individual: 1 = male, 0 = female	SEX				
Constant		2,705.04	22.03*	1,751.17	15.16*
AD R-square		0.17		0.09	
F		43.8		22.4	
94Symbol"-2 Log Likelihood					
Model Chi-Square (p x)					

Notes: * indicates significant at .05 level. ** indicates significant at .10 level.

Table 7: Continued

Preschooler Probability of Diarrhea (1 = yes)		Preschooler Z-Score Weight-for-Age 1 = > -2		Preschooler Z-Score Weight-for-Age 1 =-> -2 (with interaction)	
Co-efficient	Wald Statistic	Co-efficient	Wald Statistic	Co-efficient	Wald Statistic
		-3.271	3.49**	-20.501	4.75*
		0.001	8.56*	0.001	1.97
				0.010	3.50
0.094	0.41	0.013	0.04	0.015	0.05
0.023	0.02				
-0.066	0.15				
-0.520	3.70*				
0.188	0.48				
-0.267	1.66				
		0.054	0.67	0.051	0.61
		-0.076	0.94	-0.073	0.87
-0.183	0.27	-0.083	0.31	-0.081	0.30
0.180	0.31	0.060	0.17	0.052	0.13
0.404	1.66	0.006	0.00	-0.005	0.00
0.169	0.17				
0.196	0.37				
1.044	0.12*				
0.900	7.52*				
0.067	0.06				
-0.312	0.70				
-0.005	1.08				
-0.081	2.04				
0.000003	0.31				
		0.082	60.17*	0.083	60.40*
-0.034	0.65				
-0.001	0.01	0.009	1.28	0.007	0.87
-0.089	6.52*	0.029	34.83*	0.029	34.88*
0.001	1.52				
0.533	3.07**	-1.161	113.43*	-1.152	111.52
-1.256	1.94	-13.259	58.92*	-12.667	52.49*
694.8		2,388.200		2,384.600	
82.9 (.000)		289.3(.000)		292(.000)	

References

Ahmed, A. U. 1993. Patterns of food consumption and nutrition in rural Bangladesh. Report to the United States Agency for International Development. International Food Policy Research Institute, Washington, D.C. Mimeo.

Alderman, H., and M. Garcia. 1993. *Poverty, household food security, and nutrition in rural Pakistan*. Research Report 96. Washington, D.C.: International Food Policy Research Institute.

Baqui, A. H., R. E. Black, R. B. Sack, H. R. Chowdhury, M. Yunus, and A. K. Siddique. 1993. Malnutrition, cell-mediated immune deficiency, and diarrhea: A community-based longitudinal study in rural Bangladesh children. *American Journal of Epidemiology* 137 (3): 355–365.

Beisel, W. R. 1984. Metabolic effects of infection. *Progress in Food and Nutritional Sciences* 8 (1/2): 43–75.

Bhargava, A. 1994. Modeling the health of Filipino children. *Journal of the Royal Statistical Society A* 157 (3): 417–432.

Bhaskaram, P., V. Reddy, S. Raj, and R. C. Bhatnagar. 1984. Effect of measles on the nutritional status of preschool children. *Journal of Tropical Medicine and Hygiene* 87 (1): 21–25.

Bouis, H., and L. Haddad. 1990. Effects of agricultural commercialization on land tenure, household resource allocation, and nutrition in the Philippines. Research Report 79. Washington, D.C.: International Food Policy Research Institute.

Braun, J. von., and E. Kennedy, eds. 1994. *Agricultural commercialization, economic development, and nutrition*. Baltimore, Md., U.S.A.: Johns Hopkins University Press for the International Food Policy Research Institute.

Braun, J. von, H. de Haen, and J. Blanken. 1991. *Commercialization of agriculture under population pressure: Effects on production, consumption, and nutrition in Rwanda*. Research Report 85. Washington, D.C.: International Food Policy Research Institute.

Braun, J. von, D. Hotchkiss, and M. Immink. 1989. *Nontraditional export crops in Guatemala: Effects on production, income, and nutrition*. Research Report 73. Washington, D.C.: International Food Policy Research Institute.

Braun, J, von, D. Puetz, and P. Webb. 1989. *Irrigation technology and commercialization of rice in The Gambia: Effects on income and nutrition*. Research Report 75. Washington, D.C.: International Food Policy Research Institute.

Brown, L., P. Webb, and L. Haddad. 1994. The role of labor in household food security: Implications of AIDS in Africa. *Food Policy* 19 (6): 568–573.

Burger, S. E., and S. A. Esrey. 1995. Water and sanitation: Health and nutrition benefits to children. In *Child growth and nutrition in developing countries: Priorities for action*, ed. P. Pinstrup-Andersen, D. Pelletier, and H. Alderman. Ithaca, N.Y., U.S.A.: Cornell University Press.

Campos, F., H. Flores, and B. A. Underwood. 1987. Effect of an infection on vitamin A status of children as measured by the relative dose response. *American Journal of Clinical Nutrition* 46 (1): 91–94.

Chandra, R. K. 1991. 1990 McCollum Award Lecture. Nutrition and immunity: Lessons from the past and new insights into the future. *American Journal of Clinical Nutrition* 53 (5): 1087–1101.

Cornia, A. 1994. Poverty, food consumption, and nutrition during the trasition to the market economy in Eastern Europe. *American Economic Review* 84 (2): 297–302.

De Groote, H., E. Kennedy, E. Payongayong, and L. Haddad. 1994. Credit with education for women in Mali: Impacts on food security and nutrition. Report to U.S. Agency for International Development Office of Nutrition for the IMPACT Project. International Food Policy Research Institute, Washington, D.C.

ICN (International Conference on Nutrition). 1992. Caring for the socioeconomic deprived and nutritionally vulnerable. Theme Paper No. 3. In *Major issues for nutrition strategies*. Geneva: Food and Agriculture Organization of the United Nations/World Health Organization.

Immink, M. D. C., E. Kennedy, H. Hahn, E. Payongayong, R. Sibrián, and I. Pinto-Paiz. 1993. Guatemala: Nontraditional export crops among smallholder farmers and production, income, nutrition, and quality of life effects: A comparative analysis, 1985–1991. Final report to the U.S. Agency for International Development. International Food Policy Research Institute, Washington, D.C. Mimeo.

Kennedy, E. 1989. *The effects of sugarcane production on food security, health, and nutrition in Kenya: A longitudinal analysis*. Research Report 78. Washington, D.C.: International Food Policy Research Institute.

Kennedy, E., and B. Cogill. 1987. *Income and nutritional effects of the commercialization of agriculture in southwestern Kenya*. Research Report 63. Washington, D.C.: International Food Policy Research Institute.

Kennedy, E., D. Ngare, E. Jacinto, and L. Haddad. 1995. The medium-run food and nutrition consequences of agricultural commercialization: Findings and implications in Kenya. Report to the United States Agency for International Development. International Food Policy Research Institute, Washington, D.C. Mimeo.

Kennedy, E., E. Payongayong, L. Haddad, T. Tshibaka, R. Agble, and R. Tetebo. 1994. Impacts of credit programs on food security and nutrition in Ghana. Report to the United States Agency for International Development. International Food Policy Research Institute, Washington, D.C. Mimeo.

Kumar, S. 1979. *Impact of subsidized rice on food consumption and nutrition in Kerala*. Research Report 5. Washington, D.C.: International Food Policy Research Institute.

———. 1994. *Adoption of hybrid maize in Zambia: Effects on gender roles in agriculture, food consumption, and nutrition*. Research Report 100. Washington, D.C.: International Food Policy Research Institute.

Kumar, S., S. Bhattarai, and Y. Amde. 1995. Rural public works in Ethiopia: Potential for improving food security and productivity. International Food Policy Research Institute, Washington, D.C. Mimeo.

Linking relief and development. 1994. *IDS Bulletin*, special issue 25 (4): 1–111.

Mahalanabis, D. 1991. Breast-feeding and vitamin A deficiency among children attending a diarrhoea treatment centre in Bangladesh: A case control study. *British Medical Journal* 303 (5): 493–496.

Murata, T., H. Tamai, T. Morinobu, M. Manago, H. Takenaka, K. Hayashi, and M. Mino. 1994. Effect of long-term administration of beta carotene on lymphocyte subsets in humans. *American Journal of Clinical Nutrition* 60 (4): 597–602.

Osmani, S. A. 1994. Economic reform and social welfare: The case of nutrition in Sri Lanka. *American Economic Review* 84 (2): 291–296.

Pinstrup-Andersen, P., and M. Garcia. 1987. The pilot food subsidy scheme in the Philippines:

Its impact on income, food consumption, and nutritional status. Research Report 61. Washington, D.C.: International Food Policy Research Institute.

Sahn, D. 1994. On economic reform, poverty, and nutrition in Africa. *American Economic Review* 84 (2): 285–290.

Sazawal, S. S., R. E. Black, M. K. Bhan, S. Jalla, N. Bhandari, A. Sinha, and S. Majumdar. Forthcoming. Effect of zinc supplementation on the incidence of persistent diarrhea and dysentery—A community-based, double-blind, controlled trial. *Journal of Nutrition*.

Schultz, P., and A. Tansel. 1995. *Measurement of returns to adult health: Morbidity effects on wage rates in Côte d Ivoire and Ghana*. New Haven, Conn., U.S.A.: Yale University, Department of Economics.

Stephensen, C. B., J. O. Alvarez, J. Kohatsu, R. Hardmeier, J. I. Kennedy, and R. B. Gammon. 1994. Vitamin A is excreted in the urine during acute infection. *American Journal of Clinical Nutrition* 60 (3): 388–392.

Strauss, J., and D. Thomas. 1994. Human resources: Empirical modeling of household and family decisions. In *Handbook of development economics*, Vol. 3, ed. J. Behrman and T. N. Srinivasan. Amsterdam: North-Holland.

Teklu, T., J. von Braun, and E. Zaki. 1991. Drought and famine relationships in Sudan: Policy implications. Research Report 88. Washington, D.C.: International Food Policy Research Institute.

UN ACC/SCN (United Nations Administrative Committee on Coordination–Sub-Committee on Nutrition). 1991. *Brief on policies to alleviate underconsumption and malnutrition in deprived areas*. Geneva.

UNICEF (United Nations Children's Fund). 1994. *Annual report 1994*. New York.

Webb, P., E. Richardson, Y. Yohannes, and S. Seyoum. 1994. Linking project responses to projections of need: Empirical analysis of famine vulnerability in Ethiopia. Report to the United States Agency for International Development. International Food Policy Research Institute, Washington, D.C. Mimeo.

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