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Determinants of Nutrient Consumption and Health Status of Individual Family Members in Rural India: A Latent Variable Analysis

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INTRODUCTION

The empirical literature on the determinants of nutrient intakes and health status of individuals in less-developed countries is rather extensive. This is the case because of the perception that health and nutrition are important forms of human capital and critical components of what is often called the "basic needs" of people and because of the possibility that health and nutrition influence labor productivity and effort. Until very recently, however, this literature has focused almost exclusively on income effects, usually with regard to average household (as opposed to individual) nutrient intakes. Most of the few recent exceptions to this generalization have other limitations: (i) They consider only consumption goods prices despite the implication of the recent literature on farm household models that, if markets are incomplete or if labor productivity depends on consumption,[1] agricultural product and input prices[2] also determine the consumption behavior of farm households. (ii) They implicitly assume that nutrient intakes are related closely to health outcomes that presumably are of primary interest.[3] (iii) They do not consider individual nutrient and health outcomes despite the increasing evidence that intrahousehold allocation among various types of individuals is not equal. The more sophisticated of these studies with regard to specification of the household demand systems, moreover, assume fixed conversion factors between nutrients and food expenditures for fairly aggregate food groups despite increasing suggestions that within-group substitution occurs due to non-nutrient factors like taste, appearance, status value, degree of processing, and desire for variety. Finally, a recent study by Pitt and Rosenzweig does consider individual health outcomes, but does not include estimates for individual nutrient intakes nor the possibility that wages depend on nutrient intakes or health status.[4]

In this paper we present the first estimates to our knowledge of the impact of food and agricultural prices and of assets on the nutrient consumption and health status of different groups of individuals within a household (viz., husbands, wives, sons, daughters). The data we use are for rural South India for 1976-78. Unlike most previous studies, we consider a wide range of nutrient intakes, including calories, proteins, calcium, iron, beta-carotene, thiamine, niacin, riboflavin, and vitamin C, as well as a wide range of health outcomes, including anthropometric

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measures of height, weight, fat-fold, and arm circumference, and recall data on morbidity. The various types of nutrient intakes and health outcomes are treated as imperfect indicators of unobserved nutrient consumption and health status within a latent variable framework.

MODEL AND ESTIMATION

Our basic onceptual framework considers the household as a consumer and a producer in a context in which incomplete produt and labor markets and/or a link between labor productivity and nutritional/health status preclude separable treatment of consumer demand from agricultural production and labor force decisions. The household is assumed to behave as if it maximizes a single utility function,[5] defined over the health status, leisure, and food and nonfood consumption of each individual household member. This maximization is subject to several constraints: (i) biological health production functions for each member, which characterize the "production" of health status from his or her nutrient and other health-related inputs and from time inputs in health-related activities of that individual and of the adults in the household, conditional on the health endowments of that individual and on various environmental influences; (ii) nutrition production functions for each individual, which convert quantities of different types of foods into nutrients consumed; (iii) an agricultural production function, which characterizes the production of agricultural goods from conventional labor and nonlabor inputs and from the health and nutrition status of working members of the household; (iv) wage functions for each working member, which relate the wage rate earned by an individual to his or her schooling, experience, nutrient consumption, and health status; and (v) a full-income constraint for the household.

Thus, nutrient consumption and health may affect directly the nonfarm productivity of labor time and indirectly the wage-rate earned by an individual if markets reward any enhanced productivity.

Maximization of the utility function subject to all of the above constraints leads to a number of first-order conditions which, when solved in terms of the exogenous variables in the model (assuming interior solutions), result in a system of reduced-form equations for food and nonfood consumption, health status, nutrient consumption, labor supply, and the wage rate for each individual as well as equations for agricultural output and inputs for the entire household. In the absence of complete produt and factor markets or in the presence of health/ nutrient links to labor productivity, these demand equations have as arguments all prices (consumption and production), all assets (farm and nonfarm), personal characteristics and health endowments of all household members, and relevant family and location-specific environmental variables. Only the demand equations for nutrient consumption and health status are of interest here and are estimated in this study.

A linear approximation for the reduced-form submodel for individual nutrient consumption and individual health status can be written compactly as:

(1) $$N_i^* = a_i P + b_i X + u_i,$$

(2) $$H_i^* = c_i P + d_i X + v_i, \quad i = 1, n$$

where N_i^* is an unobserved unidimensional representation of nutrient consumption status of individual i within the household,

H_i^* is an unobserved unidimensional representation of health status of individual i within the household,

P is a vector of obsrved (consumption and agricultural) prices,

X is a vector of exogenous assets and other variables,

n is the number of individuals in the household, and

u_i and v_i are unobserved stochastic terms (assumed to have zero means, constant variances, and to be uncorrelated with P and X).

In this model we are positing that individual nutrient intake (N_i^*) and individual health status (H_i^*) each are unidimensional concepts, as is common in much of the relevant literature.[6] Both N_i^* and H_i^* are unobserved variables; what we observe instead are imperfect indicators of N_i^* and H_i^*. These indicators are imperfect because of measurement errors in the original raw data collection, problems in defining the appropriate nutrient and health standards for individuals of different ages and gender, and the fact that each observed indicator only partially represents the nutrient or health status concept of interest. We, therefore, treat N_i^* and H_i^* as latent variables[7] and have additional indicator relationships for each:

(3) $$N_i = \alpha_i N_i^* + e_i, \quad i = 1, n$$

(4) $$H_i = \beta_i H_i^* + w_i \quad j = 1, n$$

where N_i is a vector of indicators of nutrient consumption status for individual i,

H_i is a vector of indicators of health status for individual i, and

e_i and w_i are vectors of unobserved stochastic terms (assumed to have zero means and a nondiagnonal covariance matrix).

In such a framework there are not sufficient degrees of freedom to allow all covariances among the stochastic terms to be identified. It is therefore not possible for us to estimate a model in which all of the covariances are free. The choice of which elements in the covariance matrix to estimate and which to restrict to zero has been based on the data themselves and not on economic theory.[8]

Since the units of the unobserved nutrient consumption and health status variables are arbitrary, the parameter vectors α and β in relations in relations (3) and (4) are identified only after adoption of a normalization. We use the normalization that the coefficient of N^* in relation (3) for proteins equals one and that the coefficient of H^* in relation (4) for arm circumference equals one. The impact of nutrient consumption and health status on the observed nutrient consumption and health indicators, therefore, is measured relative to the impact on proteins and arm circumference, respectively.

Relations (1)-(4) are estimated by maximum likelihood methods (LISREL).[9] Since we are interested in the differing impact of prices and assets on individual members within a household (which implies different equations for each member), and since there are a large (and varying) number of members in each household, four member types were defined, for each of which separate equations were estimated. These member types are: husbands, wives, sons, and daughters.[10] Other household members are excluded from the analysis. Since the regressors for the nutrient consumption and health status equations for all member types are identical, separate estimation of all eight equations yields as efficient estimates as would joint estimation even if there are nonzero error correlations among the nutrient consumption and health status equations of different member types.[11]

DATA

We use the ICRISAT VLS (International Crops Research Institute for the Semi-Arid Tropics Village Level Studies) data set for rural south India to estimate relations (1) through (4) for husbands, wives, the average for their sons, and the average for their daughters. The ICRISAT VLS data are panel data that have been collected at regular intervals since 1975 on production, expenditure, time allocation, prices, wages, and socioeconomic characteristics for 240 households in six carefully selected "typical" villages in three different agroclimatic zones in SAT India. Within each village 10 households are randomly selected representatives of agricultural labor and nonland holding households and another 30 are a stratified (by size of land holding) random sample of cultivating households. For the 1976/77 and 1977/78 crop years, nutrition surveys were taken in which were recorded individual nutrient intakes in the past 24 hours and anthropometric measures of health status.[12]

We use the data over the two crop years of the nutrition survey for all households that include the necessary data for a married couple and their children, if any. Table 1 gives the means and standard deviations for the basic variables. We use nine nutrient intakes (calories, protein, calcium, iron carotene, thiamine, niacin, riboflavin, and vitamin C) as observed indicators of nutrient consumption status, each of which is definined relative to an age-sex specific standard for the sample. These standard levels of each intake are calculated from the polynomial (of degree three) relationship between the level of that intake and age, estimated separately for males and females, using the entire sample of individuals. A similar standardization procedure is adopted for the four anthropometric indicators of health status used (viz., height, weight, arm-circumference, and triceps fatfold).[13] The fifth indicator of health status pertains to morbidity, and is a dichotomous variable for whether or not any illness was experienced by the individual during the reference period. The statistics in Table 1 suggest that fairly large variation occurs across individuals for the nutrient consumption and health status indicators. For all of the nutrient and health indicators the intrahousehold variances are considerable, ranging from a minimum of 15 percent of the total variance for Roboflavin to 48 percent of the total variance for calcium (last column in Table 1). For the health indicator the majority of the variance is intrafamilial, with the minority interfamilial. The substantial importance of intrafamilial variance in these age and gender standardized nutrient and health variables points to the importance of considering individual nutrient and health status, not household averages as usually is done.

Our observed (exogenous) variables for the right sides of rela (1)-(2) include prices of consumption and production goods (viz., millet, sorghum, rice, pulses, and milk); prices of agricultural inputs (viz., farm-yard manure and bullock power);[14] and family-specific asset and endowment variables (viz., total value of all assets,[15] and age and years of schooling of the husband and the wife). There are other prices that we have not included, particularly those of nonfood consumption goods and "modern" farm inputs such as fertilizer. However, since these are almost always produced outside of our sample villages and are actively traded spatially, their prices do not vary much across these villages. Fertilizer prices, in fact, are uniform spatially due to governmental policies. The effect of these prices on nutrient consumption and health status would only be captured in the intercept terms of the relevant equations (which, in any case, are not estimated by us). Also, unlike Pitt and Rosenzweig, we do not include health infrastructural variables in our estimated model, since there is not observed variance in the availability of hospitals and clinics across the sample villages. For such small villages the major variations that households face are in the consumption, product and input prices and not in community health facilities as well might be the case for a more heterogenous sample in terms of population size as used by Pitt and Rosenzweig.

Table 1
Variable Dictionary: Means and Variances, and Shares of Intrahousehold Variance SAT India, 1976/77 - 1977/78
(Standard Deviations in Parentheses)

	Husbands	Wives	Average of sons	Average of Daughters	Percent of Variance that is Intrahousehold
Proteins[a]	101.5 (33.2)	98.3 (35.8)	99.4 (35.3)	104.7 (38.2)	34
Calories[a]	102.2 (28.1)	98.3 (30.4)	101.1 (30.1)	104.0 (33.1)	34
Calcium[a]	103.0 (70.7)	96.2 (62.5)	103.8 (55.2)	105.0 (59.5)	48
Iron[a]	101.6 (41.4	100.5 (42.4)	99.9 (42.3)	99.9 (43.0)	42
Beta-Carotene[a]	95.8 (84.1)	94.6 (87.0)	98.5 (86.0)	100.9 (78.6)	31
Thiamine[a]	100.7 (48.1)	99.6 (48.6)	99.6 (50.3)	104.8 (50.0)	22
Riboflavin[a]	100.1 (64.0)	105.1 (80.6)	105.2 (78.9)	111.1 (81.2)	15
Nicacin[a]	101.6 (37.1)	98.5 (39.8)	100.7 (41.5)	106.4 (49.4)	30
Vitamin C[a]	108.1 (95.8)	97.5 (75.9)	105.1 (81.2)	112.7 (93.8)	19
Weight[a]	99.7 (15.5)	99.1 (14.0)	98.3 (15.0)	97.0 (17.1)	
Height[a]	100.1 (4.8)	98.7 (4.1)	100.4 (5.4)	101.7 (6.8)	47
Arm Circumference[a]	99.5 (10.0	99.6 (10.0)	99.1 (7.7)	99.0 (9.8)	
Fat-fold[a]	99.2 (41.0)	101.2 (43.1)	97.8 (19.3)	97.7 (28.1)	
Illness (morbidity)[b]	0.44 (0.4)	0.50 (0.4)	0.42 (0.3)	0.43 (0.4)	
Price of Millet (Rs/kg)		1.12 (0.17)			
Price of Sorghum (Rs/kg)		1.09 (0.10)			
Price of Kice (Rs/kg)		1.27 (0.35)			
Price of Pulses (Rs/kg)		2.95 (0.66)			
Price of Milk (Rs/litre)		2.49 (0.91)			
Price of Farm-Yard Manure (Rs/kg)		3.91 (0.73)			
Price of Bullock Power (Rs/day)		10.75 (1.89)			
Value of all assets (Rs)		29,754 (7,718)			
Age of husband (years)		44 (11.75)			
Schooling of husband (Years)		1.9 (2.59)			
Age of wife (Years)		39 (10.54)			
Schooling of wife (Years)		0.7 (1.79)			

Notes: [a]All nutrient intakes and anthropometric variables are defined relative to age-gender-specific standards. See text for more details.
[b]The morbidity variable is a dichotomous variable with a value of one if the respondent reported that he or she was ill in the past year and zero otherwise.

ESTIMATES

Table 2 presents the reduced-form LISREL estimates for relations (1) and (2) (nutrient consumption and health status equations). Table 3 reports the corresponding α and β estimates for relations (3) and (4) indicator relationships). We now summarize the major characteristics of these estimates.

The consumption, product, and agricultural input prices are observed to have numerous significant effects on the nutrient consumption status of all types of members, often of quite large magnitudes. For the husbands, for examplel five of the seven price coefficients are significantly different from zero at the 5 percent level (which is used throughout this paper unless otherwise indicated), while for the wives all seven price coefficients are significant. Thus the responses of individual nutrient consumption status to prices are pervasive -- and that includes the responses to agricultural input prices, as predicted by the household-farm model, in addition to the responses to the consumption and product prices. Policies which alter relative prices, therefore, may have substantial impact on rural nutrient consumption status.

The largest effects on nutrient consumption status are generated by the price of sorghum, for which crop the sample households are net sellers, so that the strong income-production effect dominates. Other large price effects include the positive ones with respect to the price of milk and farm-yard manure, for both of which these households also are net suppliers,[16] which again highlights the critical production-income-consumption nexus of these households. The milk elasticities are of particular interest because the only consistently-signed price elasticity for nutrient intakes that Pitt and Rosenzweig report for Indonesia are the negative consumption ones for milk. However, in the present case in which the household consumption and farm production decisions are combined, the milk price elasticities of nutrient consumption status are positive for all members and, in some cases, relatively large.

The price elasticities of nutrient consumption status for the other prices -- millet, rice, pulses, and bullock hours -- tend to be negative (always so for significant coefficient estimates). In these cases, the negative values reflect the dominance of negative own-demand effects, perhaps refinforced by some cross-price effects. For rice these households are net buyers (although there is some production), but in the other three cases they tend to be net suppliers -- so the negative demand responses apparently are outweighing the impact of any positive income-product effects.

There are also some interesting compositional effects.

Table 2

LISREL Reduced-Form Estimates of the Determinants of Nutrient Consumption and Health Status of Members within a Household: SAT India, 1976/77 - 1977/78[a]

Independent variables	Relation 1 - Nutrient Consumption Status (N*) of: Husbands	Wives	Average of sons	Average of daughters	Relation 2 - Health Status (H*) of: Husbands	Wives	Average of sons	Average of daughters
Price of:								
Millet	-46.24* [-0.52] (4.5)	-35.90* [-0.40] (3.0)	-49.52* [-0.55] (3.8)	-59.54* [-0.67] (3.8)	2.27 [-0.03] (0.7)	-6.51* [-0.07] (2.1)	0.20 [-0.00] (0.1)	-3.25 [-0.04] (0.9)
Sorghum	370.94* [4.04] (4.1)	517.19* [5.64] (4.9)	445.39* [4.85] (3.8)	211.80 [2.31] (1.6)	16.89 [0.18] (0.6)	49.50 [0.54] (1.8)	15.23 [0.17] (0.8)	4.95 [0.05] (0.1)
Rice	-25.77* [-0.33] (3.7)	-23.81* [-0.30] (2.8)	-21.99* [-0.28] (2.3)	-14.81 [-0.19] (-1.3)	1.41 [0.02] (0.7)	-0.09 [-0.00] (0.0)	0.10 [0.00] (0.1)	3.63 [0.05] (1.3)
Pulses	-11.54 [-0.34] (1.8)	-16.02* [-0.47] (2.1)	-17.53* [-0.52] (2.0)	-18.78 [-0.55] (1.8)	0.51 [0.02] (0.3)	-1.49 [-0.04] (0.8)	-0.24 [-0.01] (0.2)	-5.72* [-0.17] (2.1)
Milk	36.27* [0.90] (6.6)	44.68* [1.11] (7.0)	36.55* [0.91] (5.2)	26.96* [0.67] (3.4)	-0.59 [-0.01] (0.4)	-1.23 [-0.03] (0.8)	-0.71 [-0.02] (0.6)	-3.11 [-0.08] (1.5)
Farm-Yard manure	57.25* [2.24] (3.4)	87.07* [3.40] (4.5)	75.88.* [2.97] (3.5)	37.15 [1.45] (1.5)	1.14 [0.04] (0.2)	7.45 [0.29] (1.5)	2.36 [0.09] (0.7)	4.09 [0.16] (0.7)
Bullock Power	-2.95 [-0.32] (1.7)	-4.98* [-0.54] (2.4)	-3.89 [-0.12] (1.7)	0.39 [0.04] (0.1)	0.13 [0.02] (0.3)	-0.41 [-0.04] (0.6)	0.20 [0.02] (0.5)	1.22 [0.13] (1.8)
Value of all assets	0.01 [2.98] (0.2)	0.03 [3.93] (1.2)	0.02 [5.95] (0.7)	0.09* [25.78] (2.6)	0.01 [2.98] (1.6)	-0.01 [2.98] (0.7)	-0.00 [-0.00] (0.5)	0.00 [0.00] (0.6)
Age of husband	-0.26* [0.11] (2.1)	0.03 [0.01] (0.1)	0.10 [0.04] (0.6)	-0.08 [-0.04] (0.4)	-0.08* [-0.04] (2.0)	0.26* [0.11] (5.1)	0.01 [0.00] (0.5)	-0.07 [-0.13] (1.5)
Schooling of husband	0.02 [0.00] (0.3)	1.19 [0.02] (1.6)	-0.54 [-0.01] (0.6)	0.35 [0.01] (0.4)	0.36 [0.01] (1.9)	0.46.* [0.01] (2.3)	-0.20 [-0.00] (1.5)	0.38 [0.01] (1.5)
Age of wife	0.59* [0.27] (3.8)	0.75* [0.29] (3.2)	0.06 [0.02] (0.2)	0.24 [0.09] (0.8)	0.13* [0.05] (2.4)	-0.09 [-0.04] (1.5)	0.09* [0.04] (2.4)	0.14 [0.05] (1.9)
Schooling of wife	-2.07* [-0.01] (2.1)	-2.86 [-0.02] (2.6)	0.85 [-0.01] (0.6)	-2.51 [-0.02] (1.7)	0.49 [0.00] (1.7)	0.39 [0.00] (1.3)	1.23* [0.01] (5.0)	0.19 [0.00] (0.5)
x^2	917.13	741.74	712.30	638.15	292.55	261.34	220.51	134.70

Notes: [a]Asymptotic absolute t-test values are given in parentheses and elasticities evaluated at sample means in brackets. For variable definitions and model specification, see text.

Table 3
LISREL Nutrient Consumption and Health Status Indicators (Reduced-Form Model): SAT India, 1976/77 - 1977/78[a]

Observed indicators (N_j, H_k)	Relation 3 - Nutrient Consumption Status (N*) of:				Relation 4–Health Status (H*) of:			
	Husbands	Wives	Average of sons	Average of daughters	Husbands	Wives	Average of sons	Average of daughters
Proteins	1.00[b]	1.00[b]	1.00[b]	1.00[b]				
Calories	0.81*	0.82*	0.83*	0.85*				
	(37.2)	(44.1)	(36.3)	(36.1)				
Calcium	0.04*	0.53*	0.39*	0.66*				
	(0.3)	(5.6)	(4.2)	(6.3)				
Iron	1.07*	1.01*	1.03*	0.96*				
	(26.5)	20.8)	(22.0)	(17.6)				
Carotene	0.80*	0.80*	0.85*	0.77*				
	(5.8)	(5.9)	(6.4)	(6.1)				
Thiamine	1.29*	1.25*	1.29*	1.19*				
	(59.0)	(48.6)	(40.3)	(41.2)				
Riboflavin	0.46*	0.64*	0.46*	0.63*				
	(4.1)	(4.9)	(3.4)	(4.1)				
Niacin	1.06*	1.04*	1.10*	1.05*				
	(37.2)	(35.6)	(28.0)	(22.9)				
Vitamin C	0.21	0.11	-0.10	0.05				
	(1.2)	(0.9)	(0.7)	(0.3)				
Arm circumference					1.00[b]	1.00[b]	1.00[b]	1.00[b]
Weight					1.73*	1.41*	3.01*	1.97*
					(21.4)	(12.1)	(9.7)	(9.2)
Height					0.20*	0.25*	0.70*	0.76*
					(5.0)	(6.8)	(9.2)	(9.0)
Triceps fold					3.05*	2.96*	0.29	1.00*
					(12.4)	(9.6)	(1.2)	(3.6)
Illness (morbidity)					-0.01*	0.01*	-0.01	-0.01
					(2.0)	(2.4)	(1.4)	(1.0)

Notes: [a]Asymptotic absolute t-test values are given in parentheses. Coefficients reported here are estimated jointly with estimates reported in Table 2. For variable definitions and model specification, see text.

[b]The scale of the latent variables, nutrient consumption and health status, is arbitrary, so there is one arbitrary normalization possible in each relationship. We have set the coefficient of protein in relation (3) and of arm circumference in relation (4) equal to unity.

*Coefficient significantly different from zero at the 5 percent level.

First, adjustments in nutrient consumption status are not uniform across different individuals. Intrahousehold allocation procedures treat different types of members differently in response to price changes. Of a total of seven possible price effects on nutrient consumption status, all seven are significant for the wives, six for sons, five for the husbands, and only two for daughters. The magnitudes of the adjustments also tend to be largest for the wives, though the differences in the elasticities for wives, husbands, and sons are not significant. The results thus suggest that, within households, the wives, husbands, and sons accept the greater nutritional burden of adjustment to unfavourable price movements and receive the greater nutritional bonus in response to favorable price changes, while keeping the nutrient consumption status of daughters relatively stable.

This intrahousehold adjustment pattern may come as a surprise, especially in the light of evidence such as that reported in Resenzweig and Schultz and in Behrman suggesting that girls receive less nutrients then boys in rural India on the basis of observed differentials in infant mortality rates for boys and girls and of estimation of an intrahousehold nutrient allocation model, respectively. However there is no basic inconsistency. The conjunction of all of these results suggest that daughters on the average receive less standardized nutrients than do male children, but the quantities that the daughters receive are changed less around the average due to price responses than is the case for sons.

The second interesting compositional effect pertains to the response of different types of observed nutrient intakes to prices. The estimated indicator relationships (relation 3) suggest that thiamine, iron, niacin, and proteins are most and riboflavin, vitamin C, and calcium are least associated with unobserved nutrient consumption status for all household members, with calories intermediate. This means that the absolute effects of prices on consumption are greatest for the former group of nutrients and smallest for the latter.[17] In a sense, thus, proteins, thiamine, iron, and niacin are treated as relative "luxuries" whose intakes are adjusted more readily in response to price changes than are those of calories, riboflavin, vitamin C, and calcium.

We turn now to the estimated impact of assets and other predetermined variables. The significant direct impacts of the asset variables on individual nutrient consumption status are limited. The human capital characteristics significantly directly affect only the nutrient consumption status of the husbands and wives, with positive impacts of the wives' ages and negative effects of their education on both husbands' and wives' nutrient consumption status. Additionally, the husbands' ages affect their own nutrient consumption status adversely (and significantly).

The negative effects of the wives' education on their own and their husbands' nutrient consumption status does <u>not</u> seem to reflect that more-educated women distribute nutrients more towards children and other household members as seems to be suggested by Engle and Folbre, since the coefficient estimates of the wives' schooling are negative (though not significant) in the nutrient relations for children. The negative impact of the wives' schooling on adult nutrient intakes, instead, may reflect the negative impact of a higher opportunity cost for the use of the time of more schooled women. If so, it is interesting that the impact on nutrient intakes of such opportunity costs is significant only for adults, and not for children. Whatever the mechanism, that the only significant direct effect of women's education is negative contrasts sharply with some previous empirical estimates and with hypotheses that emphasize the positive impacts of women's education on nutrition due to increasing their influence on household allocation (given her presumed relatively great interest in nutrition) or improving their capacity for selecting more nutritional foods.

The only significant direct impact of physical assets is for the daughters' nutrient intakes. In this case the implied elasticity is quite large, suggesting that the relative nutrient position of daughters within households improves substantially with physical wealth.

That there are only three significant coefficient estimates out of 12 possibilities for the direct effects of the human (i.e., schooling) and physical capital variables, however, should not lead one to conclude that such assets or the income generated from them are unimportant in nutrient determination. To the contrary, the positive nutrient consumption elasticities for sorghum, milk and manure prices implies that the indirect income response is positive, and both human and physical assets may contribute to the income response.

The health status equations, unlike the nutrient consumption status equations, do not yield any strong results. There is much less evidence of an impact of prices on health status than on nutritional status.[18] The only price coefficient estimates that are significantly nonzero at the 5 percent level are the negative ones with respect to the price of millet for the wives and with respect to the price of pulses for daughters.

The number of significant asset effects on health status also are limited. The husbands' ages have a significantly negative association with their own health -- possibly reflecting an aging or cohort effect, and a significant positive impact on their wives' health status. In addition, husbands' and wives' schooling generally have positive effects (always so for significant estimates) on the health status of different members. Thus, although the wives' schooling thas a significant adverse effect on their own and their husbands' nutrient consumption status probably due to the relation to the opportunity cost of time, it has a significant positive impact on their sons' health status, perhaps due to a better choice of health inputs or better use of given health inputs, but apparently not due to nutrient intake choices. Moreover, physical assets have no significant coefficient estimate in the health determination relations even at the 10 percent level. Since there is little evidence of significant price effects on health status, furthermore, there is little scope for human capital or physical assets to alter health status indirectly through the price coefficients as apparently may occur in the nutrient relations.

The indicator relationships for health (Table 3) suggest that weight and triceps fatfold (the latter not for sons) are most closely associated with unobserved health status, whereas height is least associated. As one would expect, height is associated very weakly with unobserved health status in the case of adults but has a much stronger association in the case of children (although the association between weight and health status is still stronger than that between height and health status for children). The morbidity measure is significantly associated with the unobserved health status only for adults, but with the wrong sign for wives.

The difference between the widespread significant coefficient estimates for nutrient consumption status and the limited ones for health status is striking, given that presumably a major reason for interest in nutrient intakes is their impact on health. This comparison suggests that <u>current</u> nutrient impacts may not be that important in the determination of measured health status. Direct estimates of the health status production function, using two-stage LISREL estimates for unobserved, endogenous nutrient consumption status, indicate no significant positive impact of current nutrient consumption status on health status for either adults or children (Tables 4 and 5). This finding is consistent with the

Table 4

LISREL Simultaneous System Structural Estimates of the Health Production Functions of Individual Family Members: SAT India, 1976/77-1977/78[a]

	Health Status (H*) of:			
	Husbands	Wives	Average of Sons	Average of Daughters
Age of husband	-0.08 (1.0)	0.56* (4.8)	0.10 0.6	0.01 (0.0)
Schooling of husband	0.28 (1.3)	0.39 (1.8)	-0.43 (-1.0)	1.25* (2.3)
Age of wife	0.17* (2.0)	-0.34* (2.6)	0.28 (1.7)	0.15 (0.6)
Schooling of wife	0.43 (1.4)	0.26 (0.9)	2.30* (3.5)	-0.73 (1.0)
Nutrient Consumption Status (N*)[b]	-0.01 (0.5)	-0.06* (2.1)	0.04 (1.3)	0.04 (1.1)
X^2	1307.38	981.41	880.79	868.80

Notes: [a]Asymptotic absolute t-test values are given in parentheses. For variable definitions and model specification, see text.

[b]Endogenous variable. Instruments used for nutrient consumption status are prices and assets.

*Coefficient significantly different from zero at the 5 percent level.

Table 5
LISREL Health Status Indicators (Structural 2SLS Model): SAT India, 1976/77 - 1977/78[a]

Observed Indicators (N_j, H_k)	Health Status (H*) of: Husbands	Wives	Average of Sons	Average of Daughters
Weight	1.72* (20.7)	1.42* (11.5)	1.00[b]	1.00[b]
Height	0.32* (8.5)	0.26* (7.0)	0.26* (11.7)	0.34* (8.1)
Arm Circumference	1.00[b]	1.00[b]	0.36* (11.5)	0.54* (9.0)
Triceps fold	2.90* (10.6)	2.88* (9.2)	0.09 (1.0)	0.78* (5.0)
Illness (morbidity)	-0.00 (1.1)	0.01* (2.5)	-0.00 (1.1)	-0.00 (1.6)

Notes: [a]Asymptotic absolute t-test values are given in parentheses. Coefficients reported here are estimated jointly with those reported in Table 4. For variable definitions and specification, see text.

[b]Coefficient normalized to unity.

*Coefficient significantly different from zero at the 5 percent level.

simultaneous presence of significant price effects in the nutrient consumption status equations and their virtual absence in the health status equations. Such results may reflect that short-run changes in nutrient intakes alter metabolism and perhaps produtivity rather than the type of health indicators that we use, as argued by Seckler, Sukhatme, Behrman and Deolalikar. Alternatively, they simply may reflect the fact that health status, being a cumulative outcome of current and past nutrient intakes, may not be adequately 'explained' by current prices and assets.

CONCLUSIONS

Our estimates suggest that nutrient consumption in the rural south Indian sample under study responds strongly to prices, both of food and of agricultural products and inputs. Such responses are more pervasive and more important than direct responses to asset differentials, though the price responses are large and positive for some items for which these households are net suppliers -- namely, sorghum, bullock power, and manure. They are negative for items of which they are net buyers, like rice, and for some other agricultural products for which they may be net suppliers but for which the price-consumption responses apparently outweigh the price-production ones. There are important compositional changes in response to price variations: among nutrients, proteins, thiamine, iron, and niacin intakes are treated as "luxuries" in the sense that adjustments are large relative to those for calories, riboflavin, vitamin C, and calcium. Among different members of the household, adjustments are much greater for adults and sons than for daughters.

Since nutrient consumption status is widely perceived to be of concern in itself -- perhaps in part because of perceived productivity effects -- these results have important implications for positive analysis and for policy analysis. In such analysis sensitivity is required to the possibility of large price responses and important compositional changes within such households. This means, for example, that a host of policies that work through prices -- for instance, agricultural input subsidies, agricultural price floors and ceilings, taxes, and quantitative restrictions on agricultural exports and imports -- may have substantial implications for nutrient consumption of such households, or at least for the nutrient consumption of certain types of individuals in such households.

Our estimates of health status, on the other hand, do not include much impact of prices nor of assets. The link between current nutrient inputs and our health indicators appears to be weak. This weak link may suggest that changed nutrient intakes are reflected in changed metabolism and changed productivities that have important positive or negative effects on full income and welfare that are not captured by our health indicators. Alternatively, the weak link may simply reflect the fact that health status, being a cumulative outcome of nutrient intakes since childhood, is influenced more by past and less by current prices and assets. If this is indeed the case, collection of retrospective or panel data on past prices, income, and assets become critical in household surveys in order to understand the determinants of adult health status.

NOTES

1. The farm household literature focuses explicitly on the possibility of incomplete markets, but a labor productivity link to consumption (even if markets are complete) also eliminates the possibility of separating the production and the consumption decisions.

2. If labor market wages do not depend on consumption, they also should be included. However we allow for a labor productivity-healthy/ nutrition link in our work below since Deolalikar (1986) presents eividence of such a link.

3. Presumably nutrient intakes are not of interest in themselves in the sense that they enter directly into the utility function (though food intakes may enter directly into the utility function due to non-nutritional characteristics like taste and status, see below), but because they affect health which may enter directly in the utility function and also may affect productivity.

4. Wages are assumed to be exogenous and therefore unaffected by health and nutrient intake, in contrast to the results reported recently by Deolalikar (1986) and Strauss (1986). On the other hand, the Pitt and Rosenzweig study includes representation of community variables like hospital and clinics that the present study does not include because of a lack of variance for such variables in the sample that we use.

5. There may be bargaining among household members rather than a single unified utility function that is maximized, as emphasized by Folbre (1984, 1986), Manser and Brown (1980), and McElroy and Horney (1981). However, available data do not permit testing a bargaining model with a fixed structure against a single utility function model (see Rosenzweig 1984 and Rosenzweig and Schultz 1984). Therefore nothing is lost in our specification if we proceed as if the household maximizes a single utility function defined over outcomes for individuals.

6. Though for some purposes it may be preferable to conceive of different dimensions of both nutrient intakes and health.

7. The latent variable methodology has been used previously in the health economics area by Wolfe and Vander Gaag (1981), Wolfe and Behrman (1984), and Behrman and Wolfe (1986).

8. The criterion we have followed for choosing among all possible covariance restrictions is based on the derivatives of the fitting function with respect to each fixed (at zero) error correlation. The latter is called the modification index in LISREL and is defined as half the sample size times the ratio between the squared first-order derivative and the second-order derivative. It can be shown that this index equals the expected decrease in χ^2 if a single constraint (i.e., zero correlation) is relaxed and all other estimated parameters are held fixed at their estimated values. Some experimentation with alternative sets of restrictions on the covariance matrix showed no appreciable change in the parameter estimates, which suggests that our results are quite robust across alternative specifications.

9. See Joreskog and Sorbom (1983) or Long (1983) for detailed discussions of LISREL.

10. The husbands and wives are those for the nuclear family reported as head in the case of extended families and the sons and daughters are their children under 16 years of age.

11. Also all variables, observed as well as latent, are measured in deviations from their respective sample means. Hence, no intercept terms are estimated for any of the relations. This does not represent any loss of information for us since the intercept does not have a particularly interesting interpretation in a single sample analysis such as ours.

12. To obtain data on individual food intakes, the food preparer in each household was issued standard-size bowls and spoons, and asked to serve food to each member in these bowls. The investigators then obtained information on the number of servings of each type of food to individual members from the food preparer on the basis of 24-hour recall. Such a procedure, of course, results in measurement error in the nutrient indicators, which is one cause of the stochastic terms in the indicator relations for nutrients in (3) above. These measurement errors might be systematic (e.g., indicating greater equality of portions across individuals than actually is the case), but it does not seem likely that they are systematically associated with the prices, which are the variables of major concern below.

13. As an alternative, we also defined the nutrient intakes and anthropometric indicators relative to Indian (as opposed to sample-specific) standards. With respect to Indian standards, most individuals in the sample are subpar. The empirical results were virtually unchanged with the alternative definition.

14. For all consumption, production, and input items, a given household may be a net seller or a net buyer.

15. Disaggregation and total assets into quantity of land, quality of land (irrigation), and other assets resulted in no differences in results from those reported here.

16. Since manure is an important source of cooking fuel and of construction material in the sample villages, it is used extensively by nonfarm and nonagricultural households as well as by agricultural households.

17. Solving relation (3) for N_i^* and substituting the result in relation (1) gives:

$$N_i = \alpha_i a_i P + \alpha_i \cdot b_i X + \alpha_i u_i + e_i.$$

Hence, the absolute effect of prices (or, for that matter, the X variables) on a particular nutrient intake depends on the indicator relationship parameter α_i. However, the effect of one price relative to another (e.g. P_1/P_2) is identical for all types of nutrient intakes.

18. Pitt and Rosenzweig (1986) report similar results in their estimates for Indonesia, with only prices for fish and vegetables having significant coefficient estimates.

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