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HEALTH, NUTRITION, RURAL HOUSEHOLD INCOMES AND LABOR ALLOCATION: ECONOMETRIC EVIDENCE FROM BANGLADESH

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ABSTRACT

This paper estimates the returns to health and nutrition in both farm and off-farm activities of agricultural households in rural Bangladesh. The findings of this paper indicate that the health of adults in rural Bangladesh influences the households' choice of employment activities as well as their incomes given their participation decisions. Adult height has a significant positive effect on off-farm self-employment incomes as well as total household incomes. Higher adult BMIs also appear to increase total household incomes.

1. Introduction

The consequences of adult ill-health are far reaching. Ill-health among adults often threatens the financial security and well-being of both adults and their dependents. The effects of adult ill-health can stretch across generations, since undernutrition during pregnancy has a negative effect on the birth weight of infants. There is also evidence to indicate that adult nutrition has had a profound impact on national economic growth and development (Fogel, 1994). A growing number of socio-economic studies have examined the private returns to improved health and nutrition in developing countries. The majority of studies in rural settings have focused on the returns to farm production or the returns to health in the wage labor market. Using a new data set from Bangladesh, where adult malnutrition is still widespread, this paper reexamines the returns to health and nutrition in both farm and off-farm activities of rural households. Since households respond to economic opportunities by reallocating resources it is possible that part of the gains of improved nutrition and health will be realized via a reallocation of labor from farm to off-farm activities. [1]

Adult health and nutrition status in this study is measured by height and BMI. Adult height is ostensibly an indicator of childhood nutrition status, reflecting the accumulated past nutritional experience of individuals from infancy to adulthood. BMI, on the other hand, reflects the body's energy stores independent of height and is an indicator of current nutritional status. Clinical as well as socio-economic studies have associated both stunting (as reflected by height) and wasting (as measured by BMI) during adulthood with reduced physical work capacity, and increased susceptibility to morbidity and mortality (Garrow and James, 1993; Shetty and James, 1994).

The findings of this paper reveal that there are significant returns to health and nutrition in the rural economy of Bangladesh. The health of adults in rural Bangladesh influences the households' choice of employment activities as well as their incomes given their participation decisions. Adult height has a significant positive effect on off-farm self-employment incomes as well as total household incomes. Higher adult BMIs also appear to increase off-farm incomes and total household incomes perhaps reflecting the sizable returns to strength in an economy that is still characterized by relatively labor intensive employment activities.

[1] The importance of considering both farm and off-farm work of rural households in estimating returns to education and health in developing countries has been revealed by the recent work by Yang (1994), Jolliffe (1996), Fafchamps and Quisumbing (1999), and Taylor and Yuñez-Naude (2000).

The paper commences with a brief summary of results from existing studies that have estimated the returns to health and nutrition. The following sections outline the theoretical basis for the study and then go on to describe the data and variables used in the estimations. The final section discusses the estimation methods, the results and conclusions.

2 Literature Review

A concrete theory linking wages and productivity advanced by Leibenstein (1957) and later refined by Stiglitz (1976), and Bliss and Stern (1978) is considered to have laid the foundations for the economic study of nutrition and productivity. In recent years several studies have attempted to empirically examine the linkages between nutrition and labor productivity, and have concluded that there are substantial returns to health in labor markets in developing countries. Analyses that have used rural market wages as measures of productivity have found that there are sizable positive returns to health as measured by BMI, weight-for-height, caloric intake and height. Deolalikar reports an elasticity of rural wages with respect to weight-for-height of 0.66 in his study set in India. Using the same data set, and taking seasonality variability into account, Deolalikar and Behrman (1989) found that weight-for-height had an elasticity of 0.66 during the slack months, and 0.27 during peak months. The coefficient on calorie intakes in this study was only significant during peak months (with an elasticity 0.27). The authors suggest that their results may be attributed to the fact that peak season tasks such as harvesting may require greater sustained human energy expenditure than slack season tasks, but may not require as much innate strength as reflected by weight-for-height. Sahn and Alderman(1988) report that per-capita calorie intakes had a positive and significant impact on the productivity of rural Sri-Lankan men, but not for women. Their results suggest that productivity as measured by wages will increase by 2% if calorie intake is increased by 10% (Sahn and Alderman, 1988: 176). In Haddad and Bouis' (1991) study set in the Philippines, height was a significant predictor of wages for adults although coefficient estimates for BMI and calorie intake were not significant. The study reported an elasticity of wages with respect to height of 1.36 suggesting that productivity increases in their survey area would be realized with improved childhood nutrition and health.

Schultz and Tansel examine the effect of adult morbidity on rural wages in Cote d'Ivoire and Ghana (1997). Using a quadratic function of days of acute disabling illness in their wage estimations, the authors find that disabled days are associated with a 33% and 25% reduction of wages in Cote d'Ivoire and Ghana, respectively (Schultz and Tansel, 1997: 278). Finally, in one of the only published studies of urban wages, Strauss and Thomas (1997) report an elasticity of wages with respect to height of 3.92 and with respect to BMI of 4.74 for Brazilian men. They also find evidence of positive returns to calorie intakes at low intake levels. The authors calculate an elasticity with respect to calories of 1.6 for men in the bottom quartile of energy intake (1700 calories/day). However, the effect became negative and insignificant for those who consumed greater than 1950 calories.

Among studies that use output, profit or incomes as measures of productivity there is also evidence of positive returns to health and nutrition. Strauss (1986) reported a rural calorie-output elasticity of 0.34 at the sample mean. At daily energy intakes per consumer equivalent of 1,500 calories Strauss found that the calorie output elasticity was as high as 0.49. When energy intake reached 4500 calories output elasticity fell to 0.12. Although Deolalikar (1988) did not find a significant calorie productivity relationship in his study of farm output in India, he found that the elasticity of weigh-for-height with respect to farm output was 1.9 and significant. Deolalikar's results may suggests that although the human body can adapt to inadequate nutrition in the short-run, it cannot adapt to it as easily in the medium or long run (Deolalikar, 1988: 412). Pitt and Rosenzweig (1986) examine the effect of illness of the household head and his/her spouse on farm profits in Indonesia. The results of this study could not support the hypothesis that illness affected farm profits.

Fafchamps and Quisumbing's (1999) study set in rural Pakistan was one of the first to attempt to estimate the gains in both productive efficiency and allocative efficiency due to improved education and health. The authors examine whether human capital raises productivity in crop production, livestock rearing and non-farm self-employment. The results of this study indicate that BMI enjoys significant positive returns in crop production. Furthermore, the authors find that taller men and those with higher BMIs were more likely to undertake non-farm work and herding (Fafchamps and Quisumbing, 1999: 390).

3 Theoretical Framework

The impact of adult health on household income and labor supply can be examined under the framework of an agricultural household model (Singh, Squire and Strauss, 1986).

Assume a household jointly maximizes utility such that $U = U(Y_{f,}^{c} Y_{o}^{c}, l, H)$. Y_f^c and Y_o^c are the household consumption of farm and non-farm commodities respectively, l is the household consumption of leisure and H is the household health status. The household maximizes utility subject to certain production functions, time and budget constraints. The household's production function for farm (f) and non-farm (o) goods can be written as:

$$Y_i = Y_i(E, H, X_i, L_i, Z) \quad i = f, o$$

Y_i is the household produced farm and non-farm commodities, L_i represents family labor in farm and off-farm production activities, X_i represents market purchased variable inputs,[2] and Z represents semi-fixed factors used in production. In addition to labor, variable inputs and fixed factors, the production of both farm and off-farm goods is affected by the household's education (E) and health status (H).

The household's time constraint is:

$$T = L_f + L_o + L_w + l$$

Where L_w represents household labor in off-farm wage and salaried employment. The time constraint essentially implies that total household labor time (T) is divided between farm work, off-farm self-employment work, wage and salaried work and leisure.

The household's cash-income constraint is:

$$P_f Y_f^c + P_o Y_o^c = P_f Y_f + P_o Y_o - P_x X_f - P_x X_o + w L_w + V$$

Where P_f is the output price of the farm commodity, P_o is the output price of the non-farm product, P_x is a vector of prices for farm and off-farm variable inputs, w is the market wage rate and V represents household exogenous income such as remittances and relief income. The time and budget

[2] Hired labor is included in the vector X.

constraint can be collapsed to derive the full-income constraint:

$$P_f Y_f + P_o Y_o + wl = P_f Y_f + P_o Y_o - P_x X - wL_o - wL_f + wT + V \qquad (*)$$

where $X = X_o + X_f$.

In the presence of perfect markets profit maximization implies that the returns to variable inputs are equated with their prices.

$$P_i \frac{\partial Y_i}{\partial X_i} = P_x$$

$$P_i \frac{\partial Y_i}{\partial Li} = w$$

These equations can be solved to yield the reduced form demand functions for family labor and variable inputs:

$$L_i^* = L_i(P_i, P_x, w, Z, E, H)$$

$$X_i^* = X_i(P_i, P_x, w, Z, E, H)$$

A key feature of the agricultural household model is that in the presence of perfect markets for labor, inputs and outputs, the household's consumption and production decisions are separable. As a result, the household problem can be solved recursively, first maximizing household profits from farm and off-farm self employment activities, and then maximizing utility subject to equation (*) where the right hand side is replaced by the value of full income associated with profit maximizing.

In order to analyze the effect of household health status on household income let farm and off-farm income be represented by Π_f and Π_o respectively.

$$\Pi_f = P_f Y_f - P_x X_f$$

$$\Pi_o = P_o Y_o - P_x X_o$$

Substituting the profit maximizing levels of labor and variable inputs into the household farm and off-farm income functions we get:

$$\Pi_f^* = P_f Y_f(E,H,X_f^*(P_i,P_x,w,E,H,Z),L_f^*(P_{i,}P_x,w,E,H,Z),Z) - P_x X_f^*(P_{i,}P_x,w,E,H,Z)$$

$$\Pi_o^* = P_o Y_o(E,H,X_o^*(P_{i,}P_x,w,E,H,Z),L_o^*(P_{i,}P_x,w,E,H,Z),Z) - P_x X_o^*(P_{i,}P_x,w,E,H,Z)$$

Let $\Pi^* = \Pi_f^* + \Pi_o^*$ represent total household income at the profit maximizing levels.

Taking derivative of Π^* with respect to H we obtain:[3]

$$\frac{\partial \Pi^+}{\partial H} = P_f \frac{\partial Y_f}{\partial H} + P_f(\frac{\partial Y_f}{\partial L_f}\frac{\partial L_f}{\partial H}) + (P_f \frac{\partial Y_f}{\partial X_f} - P_x)\frac{\partial X_f}{\partial H} + P_o \frac{\partial Y_o}{\partial H} + P_o(\frac{\partial Y_o}{\partial L_o}\frac{\partial L_o}{H}) + (P_o \frac{\partial Y_o}{\partial X_o} - P_x)\frac{\partial X_o}{\partial H}$$

The first three terms in the above expression decompose the effect of health on farm incomes into a productivity effect and allocation effects. Similarly the effect of health on off-farm incomes is reduced into a productivity effect and allocation effects. Although we can assume that the direct effect of health on farm and off-farm output is positive ($\frac{\partial Y_i}{\partial H} > 0$), the effect of health on net farm or off-farm income is ambiguous because of the allocation effects ($\frac{\partial L_i}{\partial H}$ and $\frac{\partial X_i}{\partial H}$) .

4 Data & Variables

The data used in this study is from a recent household survey conducted in rural Bangladesh by IFPRI, BIDS and INFS.[4] The primary purpose of the survey was to evaluate the impact of new agricultural technology adoption (commercial vegetable production and polyculture fish production) on rural household incomes and health. The surveys were carried out in three sites, namely Jessore, Mymensingh and Saturia. These three sites cover 5 Thanas and 47 villages of Bangladesh. As part of the survey, 956 households were interviewed four times during a sixteen month period[5] and information was gathered on a wide range of household activities including agricultural production, self-employment, off-farm wage work, household expenditures, food consumption, time allocation and anthropometrics. In total, data was collected on approximately 5500 individuals. For the pur-

[3]In his seminal article on education in production Welch (1970) demonstrated that the returns to education include allocative ability in addition to the direct productivity or "worker" effect. Welch also established the fact that engineering production functions only reveal the worker effect whereas profit or value added functions can capture both the productivity and allocative effects of education (Welch, 1970:45).

[4]IFPRI (International Food Policy Research Institute), BIDS (Bangladesh Institute of Development Studies) and INFS (Institute of Nutrition and Food Science) Dhaka University.

[5]June 1996-September 1997.

poses of estimation, this paper uses data from rounds 2-4 of the survey thereby capturing a full calendar year for each household.[6]

Household Labor Allocation

In the survey each household reported labor allocation of individual household members in major employment activities. The data collected is extremely detailed with households reporting family labor use at the individual task level for each employment activity.[7] Households similarly reported their off-farm labor allocation by individual members in wage activities and self-employment activities.

The individuals participating in the survey engage in a diverse range of employment activities. Thirty six percent of adult males reported that their main occupation was farming. Approximately 9% work in salaried employment, and similar numbers work as agricultural day laborers or in small trade activities.[8] Labor allocation in different activities in the survey sites is strongly segregated along gender lines. Eighty two percent of women reported that household work was their major occupation. Religious and cultural norms in many of the villages discourage women from working in the rice paddies. Women are therefore primarily responsible for the post-harvest agricultural activities that are carried out within the confines of the domestic courtyard (winnowing, par-boiling and drying). On average, during the year, 19% of household labor time[9] is spent in crop activities, 25% rearing livestock, 32% in self-employment, 16% in wage employment and 7% in salaried employment. Table 1 and Table 2 provide a breakdown of labor by formal employment activities disaggregated by age and gender. Sixty two percent of the total labor time in the 12 month period analyzed in this paper was provided by adult men. Adult women contributed 23% of total labor time in employment activities.[10] Adult males and adolescent males provide much of the labor for crop activities up to and including the time of harvest. Adult females and adolescent females on

[6]The estimates use data from rounds 2-4 since the recall period for the agricultural production data collected in round 1 differs between households.

[7]For example, individuals participating in crop production activities report the time they spent on ploughing, transplanting, weeding, harvesting etc.

[8]These numbers are using round 4 data for all individuals between 18 and 65 years of age.

[9]Household labor time refers to household labor hours in employment activities other than household work.

[10]These numbers do not take into account the household work performed by women and men. Time allocation data, from the 24 hour time allocation section of the survey, reveals that women (in round 4) on average spend 37% of time in work activites (household work, farm work and off-farm work). Men on the other hand spend 25% of time in work activities.

the other hand bear the brunt of responsibility for post-harvest tasks. Both men and women spend comparable amounts of time raising livestock, although men do the majority of work related to aquaculture, wage employment, self employment and salaried employment.

Table 1: Labor Allocation in all Employment Activities

Labor Type	Share
Adult male (18-65)	62%
Adult female (18-65)	23%
Adolescent male (12-18)	8%
Adolescent female (12-18)	2%
Child (<12)	2%
Old male (>=65)	3%
Old female (>=65)	<1%

Table 2: Shares of Labor Allocated to Individual Employment Activities by Age and Gender

Labor Type	Crops	Crops (p.harv)	Ponds	Livestock	Wage	Self	Salary
Adult male	75%	17%	75%	32%	80%	80%	73%
Adult female	4%	65%	13%	47%	7%	10%	19%
Adolescent male	14%	4%	5%	10%	10%	6%	3%
Adolescent female	1%	8%	1%	3%	1%	1%	2%
Child	3%	2%	1%	5%	0%	1%	0%
Old male	3%	1%	5%	3%	2%	3%	3%

Household Income

Corresponding to their participation in employment activities, households derive their income from a diverse range of activities both on and off the farm. Eighty two percent of surveyed households obtained income from both farm and off-farm activities. Household farm income was calculated by adding profits from crop production, fish production and income from livestock activities. Crop profits were computed by valuing crops harvested and subtracting the costs of variable inputs purchased by the household including seeds, fertilizers, pesticides, and hired labor. Valuing the total harvest, as opposed to sales only, acknowledges the fact that the majority of households consume a significant portion of their farm products and save a portion of their crops for use as seed in addition to what they sell in the market.[11] Pond profits and livestock income were derived in a similar fash-

[11] The value of crop wasted was not taken into account, but this was a very small fraction of production and unlikely to significantly bias estimates.

ion.[12] Off-farm self employment income was reported on a monthly basis (net of the value of fixed capital) and was aggregated for each household. Total off-farm income was calculated by adding wage income, self-employment income and income from salaried employment.

On average 35% of household income was derived from farm activities (crops, ponds and livestock).[13] Self-employment income constitutes an additional 30% of household income, followed by wage income and salary income, 11% and 10% respectively. Nine percent of household incomes are from remittances. Table 3 summarizes average household incomes in taka by employment activities and land ownership (a proxy for wealth). Crop profits account for 50% of household incomes for households owning greater than 2 acres of land. On the other extreme, crop incomes account for slightly less than 10% of total household incomes for households that own less than 0.1 acres of land. Households that are landless, or virtually landless, rely on wage and self-employment activities as their major sources of earnings. The wage employment activities are generally labor intensive tasks such as harvesting, weeding and transplanting crops and non-agricultural work such as earth digging and construction.

Table 3: Income in Taka by Source and Area of Land Owned by Household

Land owned	Crops	Ponds	Livestock	Wage	Self-employment	Salary Income
<0.1 acre	1,991.95	196.05	1,000.54	6,228.61	9,869.16	1,363.68
<0.5 acre	5,178.10	644.22	1,827.73	5,637.28	13,683.61	2,038.95
<1 acre	7,895.89	1,234.86	2,128.87	4,822.90	11,364.07	3,314.81
<2 acres	10,665.24	1,433.57	3,171.36	2,318.09	7,233.86	4,792.64
>2 acres	26,542.33	3,829.75	4,269.57	655.10	10,547.80	6,178.01

Health, Nutrition and Education

As mentioned in the introduction, the study uses height and BMI as measures of adult health status. Anthropometric data (weight, height and the mid upper arm circumference) were collected from all household members as part of the survey. In order to arrive at a measure for household health status, individual height and BMI were aggregated to the household level by calculating the average height and BMI of adult household members (18-65 years of age) participating in a

[12] I include livestock revenues (from the sale of animal products such as eggs, milk and small animals) and not profits in the total income calculation.

[13] Computed income does not include income from non-plot production, the value of collected food, or net food transfers to the household.

given activity. [14] The number of years of formal schooling completed by the household head, and the average years of schooling of adults in the household excluding the household head are used as measures of education. Taylor and Yuñez-Naude point out that households in rural Mexico diversify their incomes through their children, and hence the schooling of household members besides the household head is an important factor determining total household incomes (Taylor and Yuñez-Naude, 2000: 288).

Table 4: Human Capital and Household Labor Allocation of Adult Men and Women†

	Crops (inc post-harv)	Pond	Livestock	Wage	Self-emp	Salary
Male						
Years of Education	4.46	5.74	3.85	1.72	3.70	7.63
Height (cm)	161.86	162.58	161.64	161.30	162.40	162.94
BMI	18.56	18.83	18.40	18.20	18.60	19.66
MUAC (mm)	244.26	247.96	243.04	240.95	244.07	254.32
Land Owned (acres)	1.94	2.72	2.06	0.69	1.24	1.84
Number of Adults	1,169	337	595	473	601	147
Female						
Years of Education	2.28	2.17	1.74	0.55	1.45	5.05
Height (cm)	149.87	150.36	149.82	151.00	150.15	151.19
BMI	18.79	18.52	18.72	18.46	18.53	19.52
MUAC (mm)	230.27	229.38	229.79	227.13	226.08	234.97
Hemoglobin count	11.71	11.69	11.75	11.64	11.86	11.91
Land Owned (acres)	1.90	1.54	1.26	0.36	0.58	0.95
Number of Adults	1,069	95	935	59	172	40

† Numbers are averages by employment activity and gender.

Adults in the survey households have a very low level of education. Adult men have an average of 4 years of formal education while women have merely 2 years of formal education. Twenty four percent of adult men and 40% of adult females in the sample are not literate. Table 4 summarizes the human capital variables by labor allocation, and gender. Average per capita calorie intake is around 2,500 calories with adult females consuming approximately 700 calories less than adult males. The average BMI of adult men and women in the survey households was 18.56 and 18.73 respectively. Table 5 summarizes the percentage distribution of chronic energy deficiency (CED) by gender and expenditure quintiles.[15] As revealed in Table 5, approximately 18% of adult men and 22% of adult

[14] In other words, the variable representing BMI in the farm income function is the mean BMI of adult household members participating in crop production, pond production and livestock production.

[15] BMI in the range of 18.5-25 are considered normal. A BMI value of 17-18.4 is an indicator of mild malnutrition (CED I). BMIs of 16-16.9 provide evidence of moderate malnutrition (CED II) and BMIs less than 16 are almost a sure sign of severe malnutrition(CED III) (Shetty and James, 1994: 19).

Table 5. Percentage Distribution of CED in Adults by Gender and Expenditure Quintile										
	Male					**Female**				
Quintile	CED III	CED II	CED I	Normal	BMI > 25	CED III	CED II	CED I	Normal	BMI > 25
1	7.66	15.32	39.64	37.39	0.00	9.30	15.70	34.88	39.53	0.58
2	10.86	15.36	41.57	31.09	1.12	10.80	14.55	26.76	47.42	0.47
3	4.66	9.68	36.92	48.75	0.00	8.30	13.10	23.14	54.15	1.31
4	5.54	10.38	26.99	55.02	2.08	13.14	8.90	25.00	51.27	1.69
5	3.10	7.93	30.69	54.14	4.14	10.55	6.25	25.00	54.30	3.91
Total	6.24	11.51	34.82	45.88	1.56	10.49	11.30	26.49	50.00	1.72

women appear to be moderately to severely malnourished as reflected by their BMI.

Prices, Wages, Fixed Capital and Household Demographics

Prices, wages and fixed capital appear as arguments in both the household income and labor demand functions. The prices of boro rice,[16] wheat and jute are used to reflect output prices. Input prices include the price of urea per kg and the price of hiring a power tiller (price per decimal).[17] Fixed capital in farm activities is measured by the value of agricultural equipment owned by the household.[18] Households participating in self-employment activities directly reported the value of fixed capital used in self-employment. The wage rate used is the boro harvesting wage for adult male workers. All prices and wages are village level averages.[19] Finally, variables representing household size and composition are included in both the participation and income functions. These variables include the share of adult males (18-65 years), the share of adult females, the share of adolescent males (13-18 years), the share of adolescent females (13-18 years) and the share of elderly males and females ($\geq$ 65 years). Benjamin shows that in the absence of perfect labor markets, household composition is an important determinant of farm labor use (Benjamin, 1992: 287). Estimates of household labor supply and labor demand functions indicated that household labor supply is a determinant of household labor demand, thereby providing evidence of non-separability between production and consumption decisions for households in the survey villages in Bangladesh.

4 Estimation Methods

[16]Rice in Bangladesh is grown in three distinct seasons: aus (April -August), aman (August-December) and boro (January to May) (Hossain, 1988: 24).

[17]A decimal is equivalent to 0.01 acres.

[18]Calculated from the module on household asset ownership.

[19]Output prices were computed from the module on crop disposition. Households reported quantities and values of crops sold. These figures were then used to calculate a unit price at the village level. The rental price of power tillers and the boro wage are reported in a separate module on community level characteristics.

It is assumed that income from farm or off-farm activities is observed only if the household chooses to participate in the activity. A household participates in a given activity i if the household's total expected income associated with participation in the activity, π_i, is greater than or equal to the household's total expected income from not participating, π_i'.[20]

$$\Pi_i \neq 0 \quad \text{if} \quad \pi_i \geq \pi_i'$$

$$\Pi_i = 0 \quad \text{otherwise}$$

Assuming a random expected income model, income is comprised of a deterministic component and an unobserved, stochastic component

$$\pi_i = \overline{\pi_i} + \varepsilon_i$$

Let

$$\overline{\pi_i} = \alpha_{0i} + \alpha_{1i} H + \alpha_{2i} U_i$$

where U_i denotes other determinants of income excluding health in activity i.

Therefore net income Π_i is observed with a probability of

$$\Pr(\Pi_i \neq 0) = \Pr[\varepsilon_{i'} - \varepsilon_i < J_i] \qquad (**)$$

where

$$J_i = \alpha_{0i} - \alpha_{0i'} + (\alpha_{1i} - \alpha_{1i'})H + (\alpha_{2i} - \alpha_{2i'})U_i$$

Assuming ε_i and $\varepsilon_{i'}$ are approximately normal with zero means and a finite variance covariance matrix that is constant over all observations, in the first stage I estimate (**) using a maximum likelihood probit model. The estimated coefficients from the probit model for farm and off-farm participation are then used to calculate the inverse mills ratio $IMR_i = -\frac{\phi(J_i)}{\Phi(J_i)}$ where $\phi()$ denotes the standard normal density function and $\Phi()$ denotes the normal distribution function, both evaluated

[20] The econometric setup here draws heavily on Taylor and Yuñez-Naude, 2000.

at J_i. In the second stage, farm and off-farm income functions are estimated including the inverse Mills ratio to correct for sample selection bias. Variables representing whether the father of the household head farmed, and the amount of cultivable land inherited by the household are used to identify the selection equation.

BMI is treated as an endogenous variable in the second stage estimation. Since height is predetermined during adulthood it is assumed to be exogenous. There are a number of reasons why BMI should be treated as an endogenous variable in the income functions. First, income and health status are simultaneously determined. While better health may improve worker productivity, higher productivity, and in turn increased incomes, may be used to make further health investments. Second, there may exist unobservable factors that influence both health and incomes. Finally, BMI may be measured with error. Estimation by ordinary least squares will therefore result in biased and inconsistent coefficient estimates due to the correlation between health status and the error term in the income function. In order to correct for the endogeneity of health status, the farm and off-farm income functions are estimated using 2SLS.

Estimates of adult BMI demand functions were used to guide the selection of instruments for the 2SLS estimation. Finding plausible instruments is challenging since the instruments should be correlated with BMI, but there should not be any direct association between the instruments and household incomes. Studies that have estimated the returns to health using wage functions have relied on food prices and non-labor incomes to instrument endogenous health variables. The set of instruments used in this paper include a dummy variable representing whether or not the village had a closed sewage drainage system, a dummy variable representing whether the village had a primary school, and the village prices of fuel (kerosene) and cigarettes. The existence of a primary school in the village has a significant and positive coefficient when included in the estimates of adult BMI demand functions. It could be hypothesized that primary schools also provide a venue for adult education or extension classes and thus have a positive effect on adult nutritional knowledge and health. The use of community variables representing the health and disease environment is only valid in a setting where families do not move to different villages because of their characteristics. This assumption is probably valid in the survey sites in Bangladesh as there does not appear to be a great deal of in or out migration. The majority of land owned by households was inherited from their parents.

5. Results

Since the selected instruments are only weakly correlated with BMI, the participation and incomes functions were first estimated using adult height as the sole measure of health status. These results are summarized in Table 7 and Table 8. Table 6 provides summary statistics of the variables used in the study. The final estimation sample was comprised of 927 households.[21] As would be expected, land ownership and the value of farm capital increase the probability that a household will participate in farm employment. At the same time, land ownership is associated with a decrease in the likelihood of participation in off-farm employment activities. Health status appears to affect participation in employment activities. Specifically, households with taller adults are less likely to participate in rural wage employment. Larger households and households with more adult males have a higher probability of participating in off-farm employment perhaps reflecting the fact that larger households are more likely to diversify their incomes. There appear to be significant regional differences in household participation in farm and off-farm employment with households in Mymensingh being less likely to engage in off-farm employment, other factors held constant. Education of the household head is a key determinant of whether a household participates in salary and wage employment. Households where the household head has a higher level of education, as reflected by years of schooling, are more likely to participate in salary employment and are less likely to participate in wage employment.

The results from the incomes function estimates reveal that adult height has large positive returns in off-farm self-employment. A 1% increase in adult height is associated with a 8.5% increase in household self-employment incomes. Adult height also has a positive and significant coefficient in the combined self-employment and wage income function. Overall, increasing adult heights by 1% will increase total household incomes by 1.4%. Not only are households with more educated household heads more likely to participate in off-farm self-employment and salary activities, but these households also enjoy significant positive returns to education in these activities. Increasing the education of the household head by 1% will increase household salary incomes by 4.6% and

[21] Nine households were dropped because they had negative farm incomes. Twenty additional households were dropped because of missing anthropometric or education data.

household self-employment incomes by 0.80%, respectively(evaluated at the means). The inverse mills ratio is significant in the self-employment and total off-farm income functions indicating that self selection into activities is an important factor in determining household incomes.

Tables 9 and 10 summarize the results of the participation equations and the income functions when BMI is included as an explanatory variable. BMI is treated as an exogenous variable in these estimates. Although the coefficients are likely to be biased they enable us to compare the OLS estimates with the instrumental variable estimates in tables 11 and 12. The inclusion of BMI does not significantly change the results of the participation and income functions. The most noticeable difference is that the variable representing the education of the household head appears to be slightly smaller, but still significant. The coefficient on BMI is positive and significant in the combined wage and self-employment income function, as well as in the off-farm and total household incomes functions. The results indicate that increasing adult BMI by 1% will increase total household incomes by 0.70%.

Tables 11 and 12 summarize the results of the participation and income functions when BMI is instrumented. The tables also provide the F-tests and R^2 values for the regressions of BMI on the excluded instruments, along with the p-values from the Hausman test, tests of overidentification and the Rivers and Vuong exogeneity test for the probit model (Rivers and Vuong, 1988). Instrumenting BMI in the participation equation leads to universal rejection of exogeneity in the probit participation equations. The coefficients on BMI are significant in all the participation equations and appear to indicate that households with higher adult BMIs are less likely to work on the farm and more likely to participate in off-farm employment activities with the exception of salary employment. Hausman tests comparing the 2SLS estimates (not reported here) with the OLS estimates failed to reject the null hypothesis that the OLS estimates are consistent and asymptotically efficient, thereby indicating that the income functions can be estimated via OLS. The use of additional instruments indicating the presence of a pharmacy in the village, the number of markets in a village and the distance to the nearest market did not change these results. [22]

[22] It should be noted that the excluded instruments are only weakly correlated to BMI. Staiger and Stock (1994) show that 1/F in the regression of the excluded instruments on the endogenous regressor is an approximation of the bias of the 2SLS estimates towards the OLS estimates. The authors suggest an F statistic of 10 as a critical value for the test of the validity of the excluded instruments.

The noticeable difference between the estimates where BMI is treated as an exogenous variable and the estimates presented in tables 10 and 11 is that the IMR is no longer significant in the off-farm and self-employment equations. Moreover the coefficient on the IMR in all the income function estimates is significantly smaller. This result may be suggesting that BMI is capturing the unobserved heterogeneity in characteristics that affects the selection into different employment activities. On the other hand, these results may be biased because of the weak instruments.

6. Conclusions

This paper estimates the returns to health and nutrition in both farm and off-farm activities of rural households in Bangladesh. Econometric results indicate that health, like education, influences households' choice of employment activities and their incomes given their choices. The rewards to better adult health as measured by height and BMI appear to be fairly substantial. A 1% increase in adult height (1.56 cm) is likely to increase total household incomes by 498 taka (evaluated at the means). Similarly, a 1% increase in average adult BMI (.19 units) is likely to increase household incomes by 257 taka. Education also enjoys fairly large returns, especially in off-farm employment activities. Overall a 1% increase in the education of the household head (an additional 0.03 years of schooling) is likely to increase household incomes by 213 taka. In its 1999 Annual Report the World Bank states that under-investing in human capital in South Asia is partially responsible for the fact that South Asia has 40% of the world's poor even though the region only accounts for 20% of the world's population. The results of this paper seem to affirm that improved human capital investments would result in higher incomes for rural households in Bangladesh.

Table 6. Summary of Variables			
Variable	**Obs**	**Mean**	**Std. Dev.**
Ln(Farm income)	899	8.740147	1.595061
Ln(Self-employment income)	558	8.914154	1.612515
Ln(Salary income)	179	9.096764	1.404424
Ln(Wage income)	433	8.461267	1.351966
Ln(Off-farm income)	789	9.513506	1.034388
Ln(Total household income)	927	10.0696	0.777188
Ln(land)	927	4.057104	1.639739
Ln(farm capital + 1)	927	4.336576	3.535625
Ln(non-farm capital + 1)	927	3.036274	3.965565
Ln(Height)	927	5.047718	0.0293015
Ln(BMI)	927	2.917509	0.0826754
Education of HH head	927	2.997843	4.077012
Average Education	927	2.201802	2.192215
Age	927	35.8878	6.635235
Age^2	927	1331.913	511.8823
Ln(household size)	927	1.653667	0.4113282
Share of adult males	927	0.2718534	0.1333163
Share of adult females	927	0.2624784	0.1109744
Share of adol. Males	927	0.0682911	0.1084328
Share of adol. Females	927	0.0596777	0.0995234
Share of old Males	927	0.0225199	0.0698551
Share of old Females	927	0.0169275	0.054036
Ln(price of boro rice)	927	1.72022	0.0480303
Ln(price of wheat)	927	1.997477	0.0906995
Ln(price of jute)	927	2.223476	0.1220806
Ln(price of pwr tiller)	927	1.038345	0.3773394
Ln(price of urea)	927	1.690884	0.0467849
Ln(boro wage)	927	4.159699	0.1692829
Site 1	927	0.3290183	0.4701103
Site 2	927	0.3344121	0.4720392
Cultivable land inherited	927	0.3846093	0.4648757
Father in agriculture	927	0.6217806	0.4714157
flag_ag	927	0.0560949	0.2302292
Farm height	924	5.049736	0.032202
Self-employment height	532	5.073632	0.0428238
Salary height	145	5.074088	0.0446447
Wage height	392	5.076656	0.0366055
Off-farm height	758	5.075714	0.037883
Farm BMI	924	2.917743	0.0837192
Self-employment BMI	532	2.918881	0.0993747
Salary BMI	145	2.96983	0.1278587
Wage BMI	392	2.897373	0.0819788
Off-farm BMI	758	2.920351	0.0986521

TABLE 7: PROBIT RESULTS FOR ACTIVITY PARTICIPATION (ONLY INCLUDING HEIGHT)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	farm	**self**	**salary**	**wage**	**off-farm**
Ln(land)	0.480 (3.87)**	-0.135 (3.02)**	-0.101 (1.89)†	-0.147 (2.93)**	-0.516 (5.30)**
Ln(non-farm capital + 1)	-0.024 (0.67)				
Ln(farm capital + 1)	0.174 (2.78)**	-0.020 (1.38)	-0.022 (1.25)	-0.009 (0.54)	-0.011 (0.53)
Age	-0.028 (0.19)	-0.050 (0.92)	0.051 (0.72)	0.036 (0.59)	-0.014 (0.18)
Age^2	0.000 (0.03)	0.000 (0.64)	-0.001 (0.62)	-0.001 (0.91)	0.000 (0.07)
Ln(household size)	0.452 (0.76)	0.814 (5.50)**	0.644 (3.82)**	-0.081 (0.50)	0.872 (4.18)**
Share of adult males	1.904 (1.52)	0.436 (1.09)	0.507 (1.04)	1.968 (4.22)**	1.214 (2.18)*
Share of adult females	1.122 (0.69)	0.839 (1.70)†	0.226 (0.38)	-1.151 (2.01)*	0.119 (0.17)
Share of adol. males	1.710 (1.00)	0.570 (1.24)	0.029 (0.05)	1.516 (2.93)**	0.774 (1.25)
Share of adol. females	0.483 (0.38)	0.305 (0.63)	0.545 (0.96)	1.134 (2.07)*	0.673 (0.90)
Share of old males	2.760 (0.82)	-0.931 (1.23)	1.023 (1.13)	-0.189 (0.22)	0.216 (0.24)
Share of old females	-1.523 (0.61)	0.308 (0.36)	1.270 (1.32)	-1.524 (1.62)	-0.169 (0.15)
Height	3.004 (0.62)	0.948 (0.57)	-0.403 (0.20)	-5.468 (2.78)**	0.155 (0.06)
Education of HH head	0.050 (0.92)	-0.009 (0.73)	0.090 (6.11)**	-0.071 (4.55)**	0.027 (1.60)
Average Education	-0.045 (0.50)	-0.017 (0.61)	0.136 (4.39)**	-0.213 (6.23)**	-0.016 (0.44)
Ln(price of boro rice)	-8.993 (2.00)*	0.919 (0.72)	3.069 (2.01)*	0.607 (0.45)	3.397 (1.57)
Ln(price of wheat)	3.640 (1.45)	-0.086 (0.15)	-0.264 (0.36)	-0.890 (1.15)	-0.703 (1.01)
Ln(price of jute)	1.233 (1.00)	0.733 (1.83)†	-1.022 (2.18)*	0.344 (0.73)	0.113 (0.22)
Ln(price of pwr tiller)	-0.700 (1.36)	0.110 (0.72)	0.149 (0.81)	-0.104 (0.61)	0.555 (2.38)*
Ln(price of urea)	1.737 (0.25)	1.997 (1.01)	4.065 (1.72)†	-0.706 (0.31)	0.118 (0.04)
Ln(boro wage)	-2.090 (1.49)	0.528 (1.19)	1.051 (1.99)*	-0.245 (0.48)	1.040 (1.68)†
Site 1 dummy	-0.010 (0.01)	0.103 (0.43)	0.237 (0.83)	0.116 (0.43)	-0.145 (0.41)
Site 2 dummy	-1.356 (1.44)	0.135 (0.53)	0.440 (1.43)	-1.209 (4.07)**	-0.681 (1.96)*
Father in agriculture	0.070 (0.24)	-0.166 (1.69)†	0.122 (1.04)	-0.094 (0.87)	-0.362 (2.36)*
Flag missing obs.	-0.118 (0.29)	-0.202 (1.04)	0.183 (0.78)	0.413 (1.78)†	-0.191 (0.76)
Cultivable land inherited	2.450 (0.90)	-0.248 (1.76)†	-0.277 (1.67)†	-0.165 (0.92)	-0.277 (1.52)
Constant	-3.020 (0.10)	-12.941 (1.34)	-15.541 (1.32)	30.887 (2.70)**	-7.669 (0.55)
Observations	927	927	927	927	927
Absolute value of z-statistics in parentheses.					
* significant at 5%; ** significant at 1%; † significant at 10%					

TABLE 8: INCOME FUNCTIONS (ONLY INCLUDING HEIGHT)						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	Farm	**Self-emp**	**Salary**	**Wage**	**Off-farm**	**Total**
Ln(land)	0.525	0.163		-0.076	-0.098	0.039
	(11.23)**	(1.72)†		(1.25)	(2.82)**	(2.31)*
Ln(non-farm capital + 1)		0.169			0.063	0.039
		(11.68)*			(7.88)**	(7.97)**
Ln(farm capital + 1)	0.078					0.012
	(6.45)**					(1.64)
Age	0.055	0.028		0.109	0.050	0.012
	(1.13)	(0.37)		(1.29)	(1.34)	(0.40)
Age^2	-0.001	0.000		-0.001	-0.001	0.000
	(1.03)	(0.03)		(1.09)	(1.15)	(0.43)
Ln(household size)	0.309	-0.317	0.408	0.189	0.533	0.709
	(2.77)**	(0.97)	(1.46)	(0.87)	(4.77)**	(11.36)*
Share of adult males	0.624	0.617	-0.199	1.594	1.020	1.041
	(1.89)†	(1.00)	(0.25)	(2.36)*	(3.39)**	(5.44)**
Share of adult females	0.318	-1.088	-1.937	0.103	0.031	0.306
	(0.74)	(1.71)†	(1.37)	(0.13)	(0.09)	(1.41)
Share of adol. males	-0.045	0.648	-2.030	1.411	0.444	0.842
	(0.11)	(1.06)	(2.03)*	(1.60)	(1.08)	(3.92)**
Share of adol. females	-0.093	-0.836	-2.155	0.091	0.256	0.086
	(0.21)	(1.25)	(1.92)†	(0.11)	(0.78)	(0.43)
Share of old males	-0.306	0.770	-6.043	1.182	-0.743	-0.285
	(0.52)	(0.69)	(3.51)**	(0.83)	(1.13)	(0.62)
Share of old females	0.626	0.072	-0.489	-1.358	-0.215	-0.067
	(0.97)	(0.06)	(0.25)	(0.89)	(0.28)	(0.14)
Education of HH head	-0.012	0.034	0.083	-0.029	0.049	0.021
	(1.15)	(1.84)†	(1.94)†	(0.73)	(4.41)**	(3.45)**
Average education	-0.011	0.010	0.194	-0.089	-0.001	-0.008
	(0.46)	(0.25)	(2.57)*	(1.15)	(0.04)	(0.61)
Height	1.365	8.537	3.558	-0.862	0.922	1.368
	(1.12)	(5.05)**	(1.29)	(0.43)	(0.88)	(1.85)†
Ln(price of boro rice)	-0.320	-1.821			-0.648	0.123
	(0.26)	(1.21)			(0.81)	(0.22)
Ln(price of wheat)	0.618	-0.406			1.153	0.499
	(1.70)†	(0.43)			(2.23)*	(1.83)†
Ln(price of jute)	-0.664	-0.449			0.161	-0.054
	(2.04)*	(0.72)			(0.54)	(0.27)
Ln(price of pwr tiller)	-0.008	-0.189			-0.116	0.075
	(0.06)	(0.81)			(1.09)	(1.19)
Ln(price of urea)	1.818	-2.554			3.873	1.736
	(1.21)	(1.06)			(2.67)**	(1.78)†
Ln(boro wage)	-0.487	-0.559		0.764	0.424	0.094
	(1.41)	(0.95)		(1.18)	(1.28)	(0.44)
Site 1 dummy	0.858	-0.143	0.215	-0.184	0.118	0.412
	(4.40)**	(0.46)	(0.82)	(0.88)	(0.71)	(3.66)**
Site 2 dummy	0.419	0.017	-0.049	0.167	0.463	0.191
	(2.07)*	(0.05)	(0.19)	(0.45)	(2.32)*	(1.52)
IMR	-0.924	-2.461	0.259	-0.019	-0.720	
	(1.39)	(3.52)**	(0.46)	(0.04)	(2.52)*	
Constant	-3.142	-22.959	-10.078	7.102	-7.159	-3.697
	(0.45)	(1.95)†	(0.75)	(0.69)	(1.15)	(0.84)
Observations	896	528	145	392	757	927
R-squared	0.52	0.39	0.36	0.07	0.23	0.39
Robust t-statistics in parentheses.						
* significant at 5%; ** significant at 1%; † significant at 10%						

TABLE 9: PROBIT RESULTS FOR ACTIVITY PARTICIPATION (BMI EXOGENOUS)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	farm	**self**	**salary**	**wage**	**off-farm**
Ln(land)	0.477 (3.82)**	-0.135 (3.01)**	-0.105 (1.95)†	-0.137 (2.73)**	-0.513 (5.24)**
Ln(non-farm capital + 1)	-0.028 (0.77)				
Ln(farm capital + 1)	0.179 (2.84)**	-0.020 (1.38)	-0.021 (1.22)	-0.009 (0.55)	-0.011 (0.54)
Age	-0.045 (0.31)	-0.050 (0.91)	0.042 (0.60)	0.064 (1.02)	-0.010 (0.14)
Age^2	0.000 (0.15)	0.000 (0.63)	0.000 (0.48)	-0.001 (1.36)	0.000 (0.12)
Ln(household size)	0.487 (0.81)	0.814 (5.50)**	0.645 (3.82)**	-0.099 (0.60)	0.873 (4.19)**
Share of adult males	1.772 (1.40)	0.436 (1.09)	0.526 (1.08)	1.925 (4.11)**	1.203 (2.16)*
Share of adult females	1.308 (0.81)	0.840 (1.70)†	0.200 (0.33)	-1.136 (1.98)*	0.145 (0.21)
Share of adol. males	1.708 (1.00)	0.569 (1.24)	0.061 (0.11)	1.426 (2.73)**	0.753 (1.21)
Share of adol. females	0.508 (0.41)	0.305 (0.63)	0.559 (0.98)	1.139 (2.06)*	0.687 (0.92)
Share of old males	2.646 (0.80)	-0.932 (1.23)	1.058 (1.17)	-0.345 (0.39)	0.201 (0.22)
Share of old females	-1.560 (0.63)	0.309 (0.36)	1.176 (1.21)	-1.319 (1.37)	-0.148 (0.13)
Ln(Height)	3.558 (0.80)	0.948 (0.57)	-0.367 (0.18)	-5.524 (2.78)**	0.153 (0.06)
Ln(BMI)	0.969 (0.55)	-0.007 (0.01)	0.574 (0.85)	-2.007 (3.05)**	-0.386 (0.49)
Education of HH head	0.051 (0.93)	-0.009 (0.72)	0.089 (6.02)**	-0.069 (4.37)**	0.028 (1.65)†
Average Education	-0.045 (0.50)	-0.017 (0.60)	0.133 (4.27)**	-0.205 (5.97)**	-0.015 (0.41)
Ln(price of boro rice)	-9.254 (2.05)*	0.919 (0.72)	3.059 (2.00)*	0.611 (0.45)	3.398 (1.56)
Ln(price of wheat)	3.769 (1.48)	-0.086 (0.14)	-0.294 (0.40)	-0.817 (1.05)	-0.681 (0.97)
Ln(price of jute)	1.285 (1.03)	0.733 (1.82)†	-1.056 (2.24)*	0.410 (0.87)	0.139 (0.26)
Ln(price of pwr tiller)	-0.779 (1.47)	0.110 (0.72)	0.135 (0.73)	-0.066 (0.39)	0.563 (2.41)*
Ln(price of urea)	1.787 (0.26)	1.997 (1.01)	4.104 (1.74)†	-0.666 (0.29)	0.150 (0.05)
Ln(boro wage)	-2.192 (1.54)	0.529 (1.18)	1.011 (1.91)†	-0.109 (0.21)	1.068 (1.72)†
Site 1 dummy	0.063 (0.08)	0.103 (0.42)	0.270 (0.94)	0.024 (0.09)	-0.165 (0.46)
Site 2 dummy	-1.274 (1.35)	0.134 (0.53)	0.463 (1.49)	-1.291 (4.29)**	-0.694 (1.99)*
Father in agriculture	0.065 (0.22)	-0.166 (1.69)†	0.122 (1.04)	-0.092 (0.84)	-0.361 (2.35)*
Flag missing obs.	-0.119 (0.29)	-0.202 (1.04)	0.172 (0.73)	0.434 (1.85)†	-0.180 (0.71)
Cultivable land inherited	2.536 (0.89)	-0.248 (1.76)†	-0.276 (1.67)†	-0.163 (0.90)	-0.281 (1.54)
Constant	-7.929 (0.28)	-12.926 (1.33)	-16.991 (1.43)	35.609 (3.06)**	-6.874 (0.49)
Observations	924	927	927	927	927
Absolute value of z-statistics in parentheses.					
* significant at 5%; ** significant at 1%; † significant at 10%					

TABLE 10: INCOME FUNCTIONS (BMI EXOGENOUS)						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	farm	**self-emp**	**salary**	**wage**	**off-farm**	**total**
Ln(land)	0.524	0.162		-0.079	-0.102	0.034
	(10.98)**	(1.70)†		(1.46)	(3.00)**	(2.02)*
Ln(non-farm capital + 1)		0.169		-0.129	0.060	0.038
		(11.59)**		(6.02)**	(7.51)**	(7.73)**
Ln(farm capital + 1)	0.078					0.013
	(6.45)**					(1.74)†
Age	0.055	0.028	0.202	0.089	0.027	0.005
	(1.11)	(0.36)	(1.06)	(1.08)	(0.70)	(0.16)
Age^2	-0.001	0.000	-0.002	-0.001	0.000	0.000
	(1.01)	(0.02)	(0.88)	(0.92)	(0.49)	(0.17)
Ln(household size)	0.310	-0.314		0.308	0.531	0.711
	(2.77)**	(0.96)		(1.45)	(4.84)**	(11.42)**
Share of adult males	0.624	0.620		1.692	1.019	1.052
	(1.89)†	(1.00)		(2.70)**	(3.44)**	(5.51)**
Share of adult females	0.310	-1.089		0.387	-0.054	0.285
	(0.72)	(1.71)†		(0.56)	(0.16)	(1.32)
Share of adol. males	-0.045	0.652		1.172	0.496	0.885
	(0.11)	(1.06)		(1.35)	(1.23)	(4.18)**
Share of adol. females	-0.097	-0.837		0.271	0.196	0.094
	(0.22)	(1.25)		(0.38)	(0.60)	(0.46)
Share of old males	-0.307	0.769		1.325	-0.673	-0.259
	(0.52)	(0.69)		(0.92)	(1.03)	(0.54)
Share of old females	0.623	0.062		-1.086	-0.514	-0.151
	(0.97)	(0.05)		(0.71)	(0.64)	(0.30)
Ln(Height)	1.292	8.534	5.293	-0.766	0.755	1.402
	(1.05)	(5.05)**	(2.12)*	(0.43)	(0.73)	(1.91)†
Ln(BMI)	0.016	0.053	1.356	0.745	1.575	0.725
	(0.03)	(0.10)	(1.33)	(0.77)	(3.74)**	(2.22)*
Education of HH head	-0.012	0.034	0.078	-0.019	0.045	0.020
	(1.14)	(1.83)†	(2.16)*	(0.52)	(4.03)**	(3.16)**
Average Education	-0.011	0.009	0.062	-0.073	-0.013	-0.012
	(0.46)	(0.24)	(1.04)	(0.98)	(0.54)	(0.86)
Ln(price of boro rice)	-0.298	-1.817		-2.540	-0.582	0.089
	(0.24)	(1.21)		(1.68)†	(0.73)	(0.16)
Ln(price of wheat)	0.616	-0.410		0.676	1.139	0.440
	(1.68)†	(0.44)		(0.66)	(2.33)*	(1.64)
Ln(price of jute)	-0.668	-0.448		-0.473	0.102	-0.096
	(2.03)*	(0.72)		(0.72)	(0.35)	(0.48)
Ln(price of pwr tiller)	-0.007	-0.190		0.088	-0.153	0.060
	(0.05)	(0.81)		(0.43)	(1.44)	(0.95)
Ln(price of urea)	1.823	-2.540		1.690	3.977	1.715
	(1.21)	(1.05)		(0.62)	(2.78)**	(1.77)†
Ln(boro wage)	-0.483	-0.563	-1.400	1.137	0.295	0.049
	(1.41)	(0.95)	(1.43)	(1.76)†	(0.91)	(0.23)
Site 1 dummy	0.857	-0.139	0.546	-0.085	0.190	0.450
	(4.42)**	(0.44)	(1.54)	(0.26)	(1.15)	(3.99)**
Site 2 dummy	0.420	0.018	0.100	0.288	0.504	0.213
	(2.08)*	(0.06)	(0.40)	(0.58)	(2.58)*	(1.70)†
Constant	-2.862	-23.094	-20.632	4.475	-9.985	-5.346
	(0.39)	(1.95)†	(1.49)	(0.38)	(1.61)	(1.19)
IMR	-0.954	-2.456	-0.195	-0.201	-0.749	
	(1.42)	(3.50)**	(0.40)	(0.40)	(2.69)**	
Observations	896	528	145	392	757	927
R-squared	0.53	0.39	0.32	0.19	0.25	0.39
Robust t-statistics in parentheses						
* significant at 5%; ** significant at 1%; † significant at 10%						

TABLE 11: PROBIT RESULTS FOR ACTIVITY PARTICIPATION (BMI ENDOGENOUS)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	farm	**self**	**salary**	**wage**	**off-farm**
Ln(land)	0.753 (3.75)**	-0.452 (8.06)**	-0.032 (0.54)	-0.023 (0.41)	-0.676 (6.37)**
Ln(non-farm capital + 1)	0.024 (0.53)				
Ln(farm capital + 1)	0.147 (2.26)*	0.015 (0.97)	-0.030 (1.66)†	-0.026 (1.48)	0.008 (0.37)
Age	0.298 (1.31)	-0.534 (7.13)**	0.162 (1.95)†	0.257 (3.36)**	-0.272 (2.79)**
Age^2	-0.005 (1.48)	0.007 (7.27)**	-0.002 (1.94)†	-0.004 (3.77)**	0.004 (2.79)**
Ln(household size)	0.553 (0.86)	0.880 (5.62)**	0.663 (3.92)**	-0.078 (0.47)	0.886 (4.14)**
Share of adult males	1.551 (1.19)	0.955 (2.24)*	0.406 (0.83)	1.792 (3.76)**	1.498 (2.65)**
Share of adult females	2.554 (1.36)	-0.497 (0.93)	0.570 (0.93)	-0.526 (0.88)	-0.628 (0.86)
Share of adol. males	-0.926 (0.43)	3.739 (6.56)**	-0.741 (1.17)	0.215 (0.36)	2.396 (3.27)**
Share of adol. females	0.163 (0.12)	0.948 (1.84)†	0.435 (0.76)	0.935 (1.66)†	0.865 (1.13)
Share of old males	0.418 (0.14)	0.361 (0.44)	0.684 (0.75)	-0.866 (0.96)	0.963 (1.02)
Share of old females	2.881 (0.85)	-5.215 (5.12)**	2.611 (2.36)*	1.048 (0.95)	-3.232 (2.43)*
Ln(Height)	2.733 (0.60)	3.396 (1.91)†	-0.901 (0.43)	-6.367 (3.15)**	1.778 (0.71)
Ln(BMI)	-37.597 (1.91)†	49.710 (10.60)**	-11.990 (2.66)**	-22.215 (4.83)**	25.199 (4.49)**
Education of HH head	0.158 (1.98)*	-0.134 (7.35)**	0.120 (6.45)**	-0.021 (1.13)	-0.032 (1.49)
Average Education	0.155 (1.15)	-0.248 (6.97)**	0.195 (5.06)**	-0.109 (2.72)**	-0.136 (3.00)**
Ln(price of boro rice)	-9.691 (1.94)†	-1.240 (0.92)	3.561 (2.31)*	1.796 (1.28)	3.049 (1.40)
Ln(price of wheat)	6.597 (2.19)*	-4.189 (5.70)**	0.620 (0.77)	0.998 (1.13)	-2.726 (3.22)**
Ln(price of jute)	3.077 (1.99)*	-2.386 (4.56)**	-0.224 (0.40)	1.633 (2.94)**	-1.500 (2.34)*
Ln(price of pwr tiller)	0.067 (0.09)	-0.820 (4.56)**	0.396 (1.93)†	0.344 (1.75)†	0.079 (0.31)
Ln(price of urea)	5.448 (0.73)	-0.453 (0.21)	4.399 (1.86)†	0.598 (0.26)	0.007 (0.00)
Ln(boro wage)	0.423 (0.21)	-2.216 (4.16)**	1.801 (3.00)**	1.154 (1.94)†	-0.478 (0.69)
Site 1 dummy	-1.648 (1.31)	2.522 (7.43)**	-0.373 (1.02)	-1.004 (2.77)**	1.193 (2.58)**
Site 2 dummy	-2.553 (2.06)*	1.502 (5.05)**	0.057 (0.17)	-1.849 (5.63)**	0.138 (0.35)
Father in agriculture	0.107 (0.35)	-0.219 (2.12)*	0.120 (1.02)	-0.092 (0.83)	-0.406 (2.57)*
Flag missing obs.	0.456 (0.88)	-0.811 (3.73)**	0.322 (1.33)	0.700 (2.87)**	-0.446 (1.68)†
Residuals	38.933 (1.98)*	-50.756 (10.67)**	12.915 (2.82)**	20.578 (4.45)**	-26.172 (4.58)**
Cultivable land inherited	2.712 (0.86)	-0.229 (1.53)	-0.284 (1.71)†	-0.181 (0.99)	-0.281 (1.50)
Constant	75.332 (1.46)	-126.098 (8.46)**	11.579 (0.74)	79.109 (5.16)**	-69.393 (3.44)**
Observations	924	927	927	927	927

Absolute value of z-statistics in parentheses.

* significant at 5%; ** significant at 1%; † significant at 10%

TABLE 12: INCOME FUNCTIONS (BMI ENDOGENOUS)						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	farm	**self-emp**	**salary**	**wage**	**off-farm**	**total**
Ln(land)	0.530	-0.071		-0.072	-0.148	0.034
	(11.15)**	(1.33)		(1.34)	(4.32)**	(2.03)*
Ln(non-farm capital + 1)		0.157		-0.125	0.057	0.038
		(9.64)**		(5.90)**	(6.96)**	(7.24)**
Ln(farm capital + 1)	0.079					0.013
	(6.49)**					(1.88)†
Age	0.057	-0.017	0.195	0.087	0.029	0.005
	(1.14)	(0.23)	(1.03)	(1.05)	(0.76)	(0.20)
Age^2	-0.001	0.000	-0.002	-0.001	0.000	0.000
	(1.04)	(0.34)	(0.86)	(0.88)	(0.60)	(0.23)
Ln(household size)	0.308	0.553		0.313	0.600	0.711
	(2.75)**	(3.26)**		(1.48)	(5.32)**	(10.66)**
Share of adult males	0.625	1.099		1.628	1.147	1.052
	(1.90)†	(1.83)†		(2.68)**	(3.93)**	(5.59)**
Share of adult females	0.307	-0.384		0.420	-0.065	0.285
	(0.72)	(0.63)		(0.61)	(0.19)	(1.26)
Share of adol. males	-0.034	1.245		1.118	0.563	0.885
	(0.08)	(2.11)*		(1.28)	(1.40)	(4.14)**
Share of adol. females	-0.097	-0.457		0.228	0.242	0.094
	(0.22)	(0.69)		(0.32)	(0.74)	(0.42)
Share of old males	-0.267	-0.458		1.308	-0.711	-0.259
	(0.45)	(0.43)		(0.91)	(1.08)	(0.76)
Share of old females	0.612	0.468		-1.030	-0.538	-0.151
	(0.95)	(0.38)		(0.67)	(0.67)	(0.38)
Ln(Height)	1.295	9.443	5.317	-0.650	0.810	1.402
	(1.05)	(5.78)**	(2.13)*	(0.38)	(0.79)	(1.79)†
Ln(BMI)	0.021	0.020	1.398	0.791	1.511	0.725
	(0.04)	(0.04)	(1.36)	(0.82)	(3.60)**	(2.74)**
Education of HH head	-0.012	0.015	0.076	-0.015	0.046	0.020
	(1.14)	(0.85)	(2.28)*	(0.42)	(4.09)**	(3.25)**
Average Education	-0.011	-0.003	0.057	-0.066	-0.014	-0.012
	(0.47)	(0.08)	(1.02)	(0.95)	(0.57)	(0.92)
Ln(price of boro rice)	-0.321	-0.829		-2.502	-0.354	0.089
	(0.26)	(0.55)		(1.66)†	(0.42)	(0.15)
Ln(price of wheat)	0.619	-0.614		0.734	0.974	0.440
	(1.69)†	(0.64)		(0.73)	(2.01)*	(1.62)
Ln(price of jute)	-0.669	0.584		-0.508	0.152	-0.096
	(2.04)*	(1.13)		(0.76)	(0.52)	(0.51)
Ln(price of pwr tiller)	-0.011	-0.106		0.090	-0.116	0.060
	(0.08)	(0.46)		(0.44)	(1.08)	(0.83)
Ln(price of urea)	1.855	-0.282		1.800	3.878	1.715
	(1.23)	(0.12)		(0.66)	(2.70)**	(1.88)†
Ln(boro wage)	-0.496	-0.008	-1.411	1.123	0.364	0.049
	(1.45)	(0.01)	(1.43)	(1.72)†	(1.12)	(0.24)
Site 1 dummy	0.862	-0.031	0.548	-0.082	0.198	0.450
	(4.46)**	(0.10)	(1.53)	(0.25)	(1.18)	(3.98)**
Site 2 dummy	0.416	0.136	0.105	0.346	0.413	0.213
	(2.06)*	(0.41)	(0.43)	(0.70)	(2.17)*	(1.80)†
IMR	-0.838	-0.353	-0.234	-0.274	-0.322	
	(1.31)	(1.46)	(0.56)	(0.60)	(1.17)	
Constant	-2.913	-38.450	-20.639	3.528	-10.453	-5.346
	(0.40)	(3.65)**	(1.48)	(0.30)	(1.68)†	(1.18)
Observations	896	528	145	392	757	927
R-squared	0.52	0.38	0.32	0.19	0.25	0.39
R&V Exog. test (p-value)	0.05	0.00	0.00	0.00	0.00	
Hausman test (p-value)	0.40	0.60	0.57	0.90	.27	0.60
Overidentification test (p-value)	0.31	.85	0.21	0.21	.76	.99
F-test (Excluded Instruments)	5.41	1.83	2.00	2.61	2.97	5.64
R2 (Excluded Instruments)	0.02	0.01	0.05	0.16	0.02	0.02

Robust t-statistics in parentheses.

* significant at 5%; ** significant at 1%; † significant at 10%

References

[1] Behrman, J. R., and A. B. Deolalikar. “Agricultural Wages in India: The Role of Health, Nutrition, and Seaonality.” in D. E. Sahn (ed.) *Seasonal Variability in Third World Agriculture.* Baltimore: The Johns Hopkins University Press, 1989.

[2] Benjamin, D. “Household Composition, Labor Markets, and Labor Demand: Testing for Separation in Agricultural Household Models.” *Econometrica* 60, no. 2 (1992): 287-322.

[3] Bliss, C. and N. Stern. “Productivity Wages and Nutrition Part I: The Theory.” *Journal of Development Economics* 5 (1978): 331-62.

[4] Bound, J., D. A. Jaeger, and R. M. Baker. “Problems With Instrumental Variables Estimation When the Correlation Between the Instruments and the Endogneous Explanatory Variable Is Weak.” *Journal of the American Statistical Association* 90, no. 430 (1995): 443-50.

[5] Deolalikar, A. B. “Nutrition and Labor Productivity in Agriculture: Estimates From Rural South India.” *The Review of Economics and Statistics* 70 (1988): 406-13.

[6] Fafchamps, M., and A. R. Quisumbing. “Human Capital, Productivity and Labor Allocation in Rural Pakistan.” *The Journal of Human Resources* 34, no. 2 (1999): 369-406.

[7] Fogel, R. “Economic Growth, Population Theory, and Physiology: The Bearing of Long-Term Processes on the Making of Economic Policy." *The American Economic Review* 84 (1994): 379-395.

[8] Garrow, J. S., and W. P. T. James. *Human Nutrition and Dietetics.* Edinburgh: Churchill Livingstone, 1993.

[9] Haddad, L. J., and H. E. Bouis. “The Impact of Nutritional Status on Agricultural Productivity: Wage Evidence From the Phillipines.” *Oxford Bulletin of Economics and Statistics* 53 (1991): 45-68.

[10] Hossain, M. *Nature and Impact of the Green Revolution in Bangladesh.* IFPRI Research Report 67, Washington, DC: IFPRI, 1998.

[11] Jolliffe, D. "Schooling, Cognitive Skills, and Household Income: An Econometric Analysis Using Data From Ghana." Ph.D. diss., Princeton University, 1996.

[12] Leibenstein, H. *Economic Backwardness and Economic Growth.* New York: John Wiley & Sons, 1963.

[13] Pitt, M. M., M. R. Rosenzweig. "Agricultural Prices, Food Consumption, and the Health and Productivity of Indonesian Farmers." in Singh, Squire and Strauss (eds.) *Agricultural Household Models: Extensions, Applications and Policy.* Baltimore: The Johns Hopkins University Press, 1996.

[14] Pitt, M. M., M. R. Rosenzweig, and M. N. Hassan. "Productivity, Health, and Inequality in the Intrahousehold Distribution of Food in Low-Income Countries." *The American Economic Review* 80, no. 5 (1990): 1139-56.

[15] Rivers, D. and Q. H. Vuong. "Limited Information Estimators and Exogeneity Tests for Simultaneous Probit Models." *Journal of Econometrics* 39 (1988): 347-366.

[16] Sahn, D. E., and H. Alderman. "The Effects of Human Capital on Wages and the Determinants of Labor Supply in a Developing Country." *Journal of Development Economics* 29 (1988): 157-83.

[17] Schultz, T. P., and A. Tansel. "Wage and Labor Supply Effects of Illness in Cote D'Ivoire and Ghana: Instrumental Variable Estimates for Days Disabled." *Journal of Development Economics* 53, no. 251-286 (1997).

[18] Shetty, P. S., and W. P. T. James. *Body Mass Index: A Measure of Chronic Energy Deficiency in Adults.* FAO Food and Nutrition Paper 56, Rome (1994).

[19] Singh, I., L. Squire, and J. Strauss. *Agricultural Household Models: Extensions, Applications, and Policy.* Baltimore: The Johns Hopkins University Press, 1986.

[20] Stiglitz, J. E. "The Efficiency Wage Hypothesis, Surplus Labor and the Distribution of Income in L.D.C's." *Oxford Economic Papers* 28 (1976): 185-207.

[21] Strauss, J. “Does Better Nutrition Raise Farm Productivity?” *Journal of Political Economy* 94 (1986): 297-320.

[22] Taylor, J. E., and A. Yuñez-Naude. “The Returns From Schooling in a Diversified Rural Economy." *American Journal of Agricultural Economics* 82(2000): 287-297.

[23] Thomas, D., and J. Strauss. “Health and Wages: Evidence on Men and Women in Urban Brazil.” *Journal of Econometrics* 77 (1997): 159-85.

[24] Welch, F. “Education in Production.” *Journal of Political Economy* 78, no. 1 (1970): 33-59.

[25] Yang, D. T. “Knowldege Spillovers and Labor Assignments of the Farm Household.” Ph.D. diss., University of Chicago, 1994.