Nutrition, Health and Rural Labor Productivity: Preliminary Wage Evidence from Bangladesh

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1 Introduction

Nutrition affects labor productivity and economic growth in several different ways. Among adults current nutritional status affects the duration of labor force participation and the intensity of work effort. Past nutritional status predicts the probability of developing chronic diseases and consequently influences labor force participation. Recent work by economists has begun to reveal the profound impacts of inadequate nutrition on labor force participation and economic growth. On the basis of historical evidence from the late 18th Century Fogel (1994a, 1994b) has revealed that large numbers of people in England and France were prevented from participating in the labor force because of low levels of energy consumption. Fogel estimates that roughly 30 percent of the growth of per capita income in Britain between 1790 and 1980 (Fogel, 1994a: 383) can be attributed to improved nutrition. In its study of the economic costs of malnutrition the World Bank estimated that in 1990 protein-energy malnutrition, vitamin A deficiency, iodine deficiency and anemia caused a direct loss of 46 million disability adjusted life years (DALYS). This figure increases substantially if one takes into account the mortality from other diseases that are attributed to mild or moderate malnutrition (World Bank, 1993: 76-77). Childhood nutrition affects long run health status and learning abilities which may have further implications for productivity and economic growth (Pollitt,1990).

The relationship between nutrition and productivity and its implications for economic growth and development continues to be an important consideration for many developing economies whose populations are still frequently unable to meet their energy requirements. In recent decades several economists have attempted to quantify the economic costs of inadequate nutrition in developing economies. Two distinct strands of inquiry can be identified from among the body of literature that has emerged. The first focuses on the link between short run (calorie intake) versus long run (height) indicators of nutrition status and productivity. The second examines the relationship between illness and productivity [1]. This paper attempts to reexamine the link between

[1] A concrete theory linking wages and productivity advanced by Leibenstein (1957)and later refined by Stiglitz (1976), and Bliss and Stern (1978a) is considered to have laid the foundations for the economic study of nutrition and productivity.

nutrition and labor productivity using survey data from rural Bangladesh. Specifically it will investigate whether nutrition and health status as reflected by height are rewarded in the wage labor market in Bangladesh. Bangladesh provides an ideal case study since its agricultural system dominated by wet rice cultivation is labor intensive. Moreover, the dietary deficiencies of both macro and micro nutrients prevailing amongst its population are among the most severe in Asia.

Commencing with a brief review of empirical studies on the nutrition-productivity link, this paper will then outline the underlying theoretical model. The following sections will describe the empirical model and data. The final section contains the results and conclusions.

2 Empirical Studies of Nutrition, Health and Labor Productivity

Strauss's study of the effect of nutrition on labor productivity in rural Sierra Leone was one of the first attempts to test the nutrition productivity hypothesis using total farm output as the measure of productivity (Strauss, 1986). The study estimated a Cobb-Douglas production function to test the hypothesis that farm output is a function of effective family and hired labor hours, variable non-labor inputs, fixed capital and land. Effective labor hours were specified as being a quadratic function of daily caloric intake per consumer equivalent. Strauss's results concluded that caloric intake exerted a significant positive effect on farm labor productivity with a calorie–output elasticity of 0.34 (Strauss, 1986: 314) at the sample mean. The study also found evidence to support the theoretical hypothesis that energy intake and productivity are related via an S-shaped function. At daily intakes per consumer equivalent of 1,500 calories the output elasticity was 0.49. When energy intake reached 4,500 calories output elasticity fell to 0.12.

Employing household survey data from India, Deolalikar (1988) was able to estimate both a wage equation and a farm production function in order to explore the empirical relationship between nutrition and productivity. Deolalikar's (1988) study found that energy intake or short-run nutrition status was not a significant determinant of wages or farm output. However, weight for height as measured in Kg/cm was a statistically significant predictor in both the wage and production function equations. These results suggest that while 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). Further, as mentioned by the author, it may be that weight-for-height is a better indicator of nutritional status than calorie intake. Sahn and Alderman (1988) consider the effect of nutrition status on rural wages in Sri-Lanka. The authors find that per capita calorie intake has a positive and significant impact on productivity for men, but not for women. Behrman & Deolalikar (1989) reexamine the nutrition–productivity hypothesis taking seasonal variability into consideration. For the Indian sample used in this study the results demonstrated that while calorie intake was important in determining wages in peak seasons (the elasticity was 0.27), weight-for-height was more important during the slack months (elasticity of 0.67).

Utilizing data from the Phillipines, Haddad and Bouis (1991) examine the nutrition–productivity hypothesis using height as a predictor of long-run nutritional status and testing between different models which take both unobserved time-invariant and time-varying heterogeneity into consideration. For the Phillipine sample their study found that while height is a significant predictor of wages, energy intake as determined from a 24 hour food recall survey was not a significant predictor of wages. More recently, Thomas and Strauss (1997) simultaneously explore the impact of four separate dimensions of health on urban wages in Brazil. Using household survey data from 1974–1975 their study empirically tests the relationship between wages and per capita calories, per capita protein, BMI [2] and height. The results of this study conclude that height is associated with higher wages for both self-employed men and those who work in the market sector. Being taller and having a higher BMI however is rewarded most in self-employment. As the authors elaborate, many of the self-employed in urban Brazil work as manual laborers and returns to strength are sizeable.

3 The Underlying Economic Model

The impact of nutrition and health on labor productivity can be examined under the framework of a Agricultural Household Model. [3]

[2] BMI refers to the body mass index which is equal to $(weight/(height)^2)$. Weight is generally measured in kilograms and height in metres.

[3] see Singh, Squire & Strauss, 1986.

We can assume that a household jointly maximizes utility such that:

$$U = U(X^c, Y, l)$$

$U(.) =$ The household Utility Function

$X^c =$ Household consumption of food (calorie intake)

$Y =$ Household consumption of non-food items

$l =$ Household consumption of leisure

The Household maximizes utility subject to certain production functions, time and budget constraints.
The Farm Household Production Function is as follows:

$$X = f(L^e, L_h, V, A)$$

$X =$ Farm output

$L^e =$ Household labor in efficiency units*

$L_h =$ Hired Labor

$V =$ Vector of variable non-labor agricultural inputs

$A =$ Vector of fixed factors in agriculture

* As per the efficiency wage literature $L^e = L_f g(X^c)$.

L^e reflects both the quality $g(X^c)$ and quantity L_f of labor supplied by the farm household. L_f represents family labor hours. (In this paper labor quality is reflected by height (an indicator of long run health status).

The time constraint:

$$T = L_f + L_o + l$$

$T =$ Total Healthy time available to the Household*

$L_f =$ Labor time on the family farm

$L_o =$ Family labor hired out

$l =$ Household consumption of leisure

* Total Healthy time is equal to TT (total time endowment) – TS (sickdays). Alternatively we could write total time to be a function of food consumption and health status i.e. $TT = f(X^c, \psi)$. This follows from the work of Grossman (1972: 227).

The Budget Constraint:

$$P_x X^c + P_y Y + wL_h = P_x X + w^f L_o - P_v V + E$$

$P_x =$ Price of food

$P_v =$ Vector of prices of variable inputs

$P_y =$ Vector of prices for non-food items

$w =$ Wage per clock hour for hired labor

$w^f =$ wage per clock hour for family labor

$E =$ Exogenous Income

$w^f = w^e g(.)$ where w^e is wage per efficiency hour
Combining the time and budget constraint we derive the full-income constraint such that:

$$P_x X^c + P_y Y + wL_h = P_x X + w^f (T - L_f - l) - P_v V + E$$

The Lagrangian for the optimization problem can thus be written as:

$$£ = U(X^c, Y, l) + \lambda(P_x X(L^e, L_h, V, A) + w^f (T - L_f - l) - P_v V + E - P_x X^c - P_y Y - wL_h)$$

The first order necessary conditions for the utility maximization problem are:

(1) $\frac{\partial U}{\partial X^c} + \lambda(P_x L_f \frac{\partial X}{\partial L^e}\frac{\partial g}{\partial X^c} + w^e \frac{\partial g}{\partial X^c}(T - L_f - l) - P_x) \leq 0$

(2) $\frac{\partial U}{\partial Y} - \lambda(P_y) \leq 0$

(3) $\lambda(P_x \frac{\partial X}{\partial L^e}\frac{\partial L^e}{\partial L_f} - w^f) \leq 0$

(4) $\lambda(P_x \frac{\partial X}{\partial L_h} - w) \leq 0$

(5) $\lambda(P_v \frac{\partial X}{\partial V} - P_v) \leq 0$

(6) $(P_x X(L^e, L_h, V, A) + w^f (T - L_f - l) - P_v V + E - P_x X^c - P_y Y - wL_h) \geq 0$

Condition 4 is of particular interest. $\frac{w^f}{g(.)} = P_x \frac{\partial Y}{\partial L^e}$. The wage per efficiency hour is equal to the marginal value product of efficiency labor.

4 The Empirical Model and Data

Based on the premise that wages reflect the marginal productivity of labor this study investigates the link between nutrition, health and labor productivity by estimating wage equations for individuals participating in the wage labor force in Bangladesh. The study estimates semi-logarithmic wage equations for adult men and women postulating that wages are a function of various individual characteristics, height, household characteristics, education, total land owned by the household, and the season.

$$lnWage = \alpha_0 + \alpha_1 X + \alpha_2 Height + \alpha_3 Y \quad (1)$$

X is a vector of individual characteristics, and Y is a vector of household characteristics such as land ownership and non-labor income.

Separate wage equations are estimated for those employed in the agricultural labor force and those employed in the rural non-agricultural labor force. The Heckman procedure is used to correct for self-selection bias in the wage equations (Greene, Madalla). At the current time height is the only variable used to represent the stock of nutritional and health status. Previous studies (Haddad & Bouis (1991), Thomas & Strauss (1997))have found that height is a good measure of cumulative health status. Further work is being pursued to include multidimensional measures of health, but no results are reported at this stage.

The recognition that indicators of nutritional status such as caloric intake, BMI and weight-for-height are endogenous variables in wage or production function estimations has been an important consideration in studies which have empirically tested the nutrition–productivity link. Endogeneity in nutrition–productivity estimates arises due to unobserved time invariant heterogeneity (e.g. genetic endowment), time-varying heterogeneity (seasonality and measurement error) and the simultaneous determination of wages and nutrient intakes/health outcomes. As a result of endogeneity, estimation via ordinary least squares (OLS) leads to biased estimates. In this study height is assumed to be exogenous based on the fact that height is predetermined during adulthood.

The estimations in this paper are based on household survey data collected in rural Bangladesh by the International Food Policy Research Institute (IFPRI), the Bangladesh Institute of Development Studies (BIDS) and the Institute of Nutrition and Food Science (INFS) at the University of Dhaka as part of a collaborative project to study the linkages between agricultural production and nutrition outcomes in Bangladesh. A major objective of the study was to determine the feasibility of improving nutrition and health status through food based strategies (commercial vegetable production and polyculture fish production) as opposed to fortification or supplementation programs which in the past have proven to be very costly and difficult to implement. The data was collected over a 15 month period in four separate rounds covering an entire agricultural cycle.[4] A total of 956 households were interviewed in three survey sites in Bangladesh, namely Saturia, Mymensingh and Jessore. The three sites together cover 49 villages and 4 thanas (administrative subdivisions) of Bangladesh. For a detailed description of the sampling methodology see IFPRI, 1998. The data set is particularly suitable for addressing the research objectives of the proposed study since it contains detailed information on various aspects of agricultural production in addition to providing estimates of household food consumption, anthropometry and morbidity.

Table 1 provides a breakdown of households employed in agricultural and non-agricultural wage labor in the sample. Approximately 31% of households in the sample participate in some form of agricultural wage labor and 20% of households participate in non-agricultural wage labor. The primary tasks performed by agricultural wage labor include harvesting, weeding, ploughing and transplanting. In this sample 94% of agricultural labor is employed in the four above mentioned activities. Non-agricultural wage labor is involved in a variety of tasks ranging from load-bearing, road repairing, and carpentry. As would be expected, households with lower incomes are more likely to participate in rural wage labor. [5]

As reflected in Table 2, few women in rural Bangladesh participate in wage employment. There is also evidence that on average women earn less than men in the wage labor force in Bangladesh. In this sample, women are more likely to participate in non-agricultural wage labor than in agricultural wage labor. Earth cutting and working as a maid servant were the tasks most commonly performed by women. The wage rate is a daily wage averaged across all agricultural/non agricul-

[4]The first round of data was collected between June 26, 1996 and September 17, 1996. The subsequent rounds took place between October 18 and December 27, 1996, February 15 and May 5, 1996 and June 26 and September 24, 1997.

[5]Monthly per capita expenditures are used as a proxy for income.

Table 1. Breakdown of Households Participating in Agricultural and Non-Agricultural Wage Labor by Expenditure Terciles.						
	Agricultural			Non-Agricultural		
Expenditure Tercile	Tercile1	Tercile 2	Tercile 3	Tercile1	Tercile2	Tercile3
Round 1	139	105	54	78	45	28
Round 2	117	76	51	76	56	26
Round 3	115	75	49	100	58	38
Round 4	126	83	63	82	58	31

tural tasks and weighted by the proportion of time spent by individuals in different activities. The agricultural wage rate reported by the Bangladesh Bureau of Statistics for 1997 was approximately 50 Taka across all Divisions in Bangladesh which is comparable to the wage rates computed in this study. Regional variations in the agricultural wage rate also match the variations reported by the Bureau of Statistics.

Table 2. Participants by Gender and Average Wage Rates in the Wage Labor Force in Bangladesh												
	Saturia				Mymensingh				Jessore			
	Agriculture		Non-Agric.		Agriculture		Non-Agric.		Agriculture		Non-Agric.	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Number of Individuals across all rounds	20	417	71	241	0	77	2	69	20	500	23	200
Average Wage Rate	33	64	27.9	66.3		57	14.5	53.77	35	50	34.14	55.52
Standard Deviation	19	20	9.6	31.36		14	6.36	21.57	18	15	22.46	12.34

4.1 Results

Table 3 summarizes the variables (and sample means) used in the regression analysis in this paper. The sample used in the final analysis consists of 8,127 adults, of whom 818 work in the agricultural wage labor force and 483 in the non-ag wage labor force.

Table 3. Descriptive Statistics of Variables used in the Regression Analysis		
Variable Label	Variable Description	Mean of Variables
		Full Sample
Age	Age in years	36.47
Age^2	Age squared	1559.38
Sex	Gender, 0-male 1-female	0.508
Height	Height in centimeters	155.71
Education	Years of schooling completed	3.33
Totlown	Total land owned by the HH (in Decimals)	158.42
Non-Labor	Non-labor income per capita (in Taka)	680.82
Sanitation	Score for HH Sanitation & Hygiene	29.66
Head	Household head	0.31
Son	Son of household head	0.22
Saturia	Dummy for survey site	0.38
Mymen	Dummy for survey site	0.26
HHsize	Household Size	6.51
Inf05	Number of infants 0–5 yrs	0.65
Child69	Number of children 6–9 yrs	0.51
Round1	Survey round dummy	0.26
Round2	Survey round dummy	0.25
Round3	Survey round dummy	0.25
Number of Observations		8172

Table 4 summarizes the results of the first stage probit estimates which determine the probability of participating in the agricultural and non-agricultural wage labor forces, respectively [6]. A number of important features are evident from these results. Firstly, the ownership of land is a significant determinant of whether an individual participates in the wage labor force. Non-labor income (the sum of remittance incomes, gifts received and relief income) is also a negative and significant predictor of participation in the rural wage labor force. Height, used as a proxy for the stock of health, is negative and significant in the agricultural wage labor force participation equation. Adults with a higher stock of health (as reflected by height) are less likely to participate in the agricultural wage labor force. The variables HEAD and SON represent the relationship to the household head. HEAD represents the household head and SON represents the son of the household head. In both labor supply equations these variables are positive and significant.

[6] In the probit equations 1=participation in the wage labor force, 0=non-participation in the wage labor force.

Table 4. Labor Supply Equations.		
	Agricultural Wage Labor	Non-Agricultural Wage Labor
Constant	5.1039 (6.119)	-0.5699 (-0.658)
Age	0.0344 (2.869)	0.0712 (5.113)
Age^2	-0.0005 (-3.861)	-0.0009 (-5.606)
Sex	-2.138 (16.841)	-0.8697 (-7.455)
Height	-0.0168 (-3.611)	-0.0012 (-0.257)
Education	-0.1109 (-12.738)	-0.0656 (-6.920)
Totlown	-0.0022 (-7.005)	-0.0016 (-5.130)
Non-Labor	-0.0002 (-4.424)	-0.0002 (-4.760)
Sanitation	-0.0223 (-4.191)	-0.0177 (-3.179)
Head	0.2984 (2.483)	0.3433 (2.882)
Son	0.3811 (3.263)	0.3888 (3.234)
Saturia	-0.1785 (-3.329)	0.3012 (5.270)
Mymen	-1.3972 (-12.021)	-0.4431 (-4.342)
HHsize	-0.0456 (-2.899)	-0.0434 (-2.554)
Inf05	-0.0688 (-1.662)	-0.1129 (-2.561)
Child69	-0.0117 (0.263)	0.1284 (2.901)
Round1	0.1652 (2.355)	-0.0525 (-0.693)
Round2	-0.0562 (-0.775)	-0.1037 (-1.352)
Round3	-0.1611 (-2.184)	0.1048 (1.438)
	Psuedo $R^2 = 0.41$ $\chi^2 = 2169.50$ $p = 0.0000$	Psuedo $R^2 = 0.246$ $\chi^2 = 886.90$ $p = 0.0000$
Z-statistics in parentheses		

Following the estimation of the labor supply equations, wage equations were estimated. The results of the wage equations are summarized in Table 5. In the agricultural wage labor force, gender, height, the amount of land owned, survey site, and season are significant predictors of wage labor. The results in Table 5 confirm that women earn significantly less than men. Agricultural wages are lowest in round 2 possibly depicting the seasonality in rice prices [7]. While there is a conspicuous variation in agricultural wage rates across seasons, no such trend is observable for non-agricultural wage labor. SANITATION is a composite score representing the household environment and sanitation conditions. SANITATION is a significant determinant of whether or not an individual participates in wage labor force, although it is not a significant determinant of wage rates. Finally, it would appear that in rural Bangladesh, health status as reflected by height is rewarded in both the agricultural and non-agricultural wage labor markets. In both wage equations the variable height is significant and positive. Sample selection bias as captured by (IMR) the Inverse Mills Ratio is significant in the non-agricultural wage equation, but not in the agricultural wage equation.

5 Summary and Conclusion

This paper has tried to determine whether nutrition and health status as reflected by height are significant predictors of participation in the agricultural and non-agricultural wage labor force in rural Bangladesh, and whether health is rewarded in wage markets in Bangladesh. The preliminary analysis reveals that nutrition and health status as reflected by height is a significant determinant of labor force participation in agricultural wage labor, the same is not true for non-agricultural wage labor. Moreover, persons with a larger stock of health as reflected by height are rewarded in the wage labor market. Further analysis will be carried out with multidimensional measures of health and nutritional status to determine the robustness of these results and explore other facets of health and nutritional status which contribute to improved labor productivity. Future work will also investigate the synergistic relationship between nutrition and illness and the importance of diet diversity.

[7] Rice prices are also the lowest in round 2 across villages in the survey sample.

Table 5. Wage Equations: Dependent variable (lnwage)		
	Agricultural Wage Labor	Non-Agricultural Wage Labor
Constant	3.7422 (-11.064)	3.3048 (6.126)
Age	0.0029 (0.656)	0.0319 (3.286)
Age^2	0.0000 (-0.540)	-0.0004 (-3.540)
Sex	-0.5153 (-5.078)	-0.8372 (-11.526)
Height	0.0043 (2.364)	0.0053 (1.763)
Totlown	0.0004 (2.344)	0.0002 (0.837)
Sanitation	0.0009 (0.422)	0.0007 (0.188)
Saturia	0.2280 (10.631)	0.1447 (3.616)
Non-Labor	0.0000 (0.762)	0.0000 (-1.274)
Mymen	0.1735 (2.266)	-0.0868 (-1.070)
Hhsize	-0.0049 (-0.915)	-0.0167 (-1.583)
Round1	-0.1009 (-3.706)	-0.0792 (-1.603)
Round2	-0.1612 (-5.731)	-0.0501 (-0.985)
Round3	-0.1359 (-4.628)	0.0034 (0.072)
IMR	-0.0178 (-0.396)	0.1684 (2.834)
	$R^2 = .279$ $F[14,803] = 22.16$ $p = 0.0000$	$R^2 = 0.404$ $F[14,468] == 22.64$ $p = 0.000$
T-Statistics in parentheses		

Bibliography

[1] Bangladesh Bureau of Statistics. *1997 Yearbook of Agricultural Statistics of Bangladesh.*Dhaka: Bangladesh Bureau of Statistics, 1998.

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

[3] Bliss, C. and N. Stern. "Productivity, Wages and Nutrition Part I: The Theory."*Journal of Development Economics* 5 (1978): 331-362.

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

[5] 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 (1994a): 379-395.

[6] Fogel, R. "The Relevance of Malthus for the Study of Mortality Today: Long-Run Influences on Health, Mortality, Labor Force Participation, and Population Growth." in Lindahl-Kiessling, K. and H. Landberg. *Population, Economic Development, and the Environment.* New York: Oxford University Press, 1994b.

[7] Greene, W.H. *Econometric Analysis.* Englewood Cliffs, NJ: Prentice-Hall, 1990.

[8] Grossman, M. "On the Concept of Health Capital and the Demand for Health."*Journal of Political Economy* (1972) .

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

[10] IFPRI. *Commercial Vegetable Polyculture Fish Production in Bangladesh: Their Implications on Income, Household Resource Allocation and Nutrition.* Draft Final Report, (1) 1998.

[11] IFPRI. *Commercial Vegetable Polyculture Fish Production in Bangladesh: Their Implications on Income, Household Resource Allocation and Nutrition.* Draft Final Report, (2) 1998.

[12] Leibenstein, H. *Economic Backwardness and Economic Growth.*New York: John Wiley and Sons, 1957.

[13] Pollitt, E. *Malnutrition and Infection in the Classroom.* Paris: UNESCO, 1990.

[14] 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) 157-183.

[15] Singh, I, L. Squire, and J. Strauss (eds). *Agricultural Household Models: Extensions, Applications and Policy.* Baltimore: Johns Hopkins, 1986.

[16] 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.

[17] Strauss, J. "Does Better Nutrition Raise Farm Productivity?" *Journal of Political Economy* 94 : 297-296.

[18] Thomas, D. and J. Strauss. "Health and Wages: Evidence on Men and Women in Urban Brazil. " *Journal of Econometrics* 77 (1997): 159-185.

[19] World Bank. *World Development Report.* New York: Oxford University Press, 1993.

[20] World Bank. *Enriching Lives: Overcoming Vitamin and Mineral Malnutrition in Developing Countries.* Washington DC: The World Bank, 1994.