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DETERMINANTS OF CHILDREN'S NUTRITIONAL STATUS ACROSS AGRICULTURAL AND NON-AGRICULTURAL HOUSEHOLDS IN RURAL BANGLADESH

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ABSTRACT

While child health reflects a country's state of well-being; Bangladesh struggles to make a comprehensive success in reducing its widespread child under-nutrition. The key interest of this paper is to understand what determines the nutritional status of rural children in Bangladesh and how these determinants compare between agricultural and non-agricultural households. Based on a sample of 1,444 children drawn from rural Bangladesh, this study estimates the extent to which measures of child under-nutrition (underweight and stunting) are associated with child, parent, household, and community level variables. The estimates of Logit regressions suggest that variables such as birth weight, parents' health, mother's education, and prevalence of health care facilities at village significantly reduces the probability of underweight and stunting. This paper also finds that agricultural and non-agricultural households differ in respect of what determines the children's nutrition in these households. The policy implication of this study is that government initiatives aiming at reducing child under-nutrition in rural Bangladesh should recognise that any generic measures may not bring about the optimal result given the diversity of rural households. Thus, this paper may be useful in designing better interventions for improving health and nutrition of the rural children of Bangladesh as well as similar Southeast Asian countries.

Keywords: Nutritional status, rural children, agricultural households, Bangladesh

I. INTRODUCTION

Under-nutrition is associated with more than half of all child deaths globally (BBS & UNICEF, 2015) and it affects young children most seriously in the developing countries (UNICEF, 1998). Since children represent the future labor force of a country, their nutritional status is therefore regarded as an important development indicator (Chen & Li, 2009). If children suffer from under-nutrition at an early age then their cognitive and physical abilities are likely to be impaired, which rarely gets corrected later (Rahman et al., 2009). Therefore, widespread child under-nutrition may be massively daunting for any economies. While the developing countries have an elevated need for productive labor force; unfortunately at least one in three children under five years are malnourished in these countries (UNICEF, 2019). Hence reducing the incidence of child under-nutrition remains at the core of all

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development initiatives in these countries following the Sustainable Development Goals (SDGs) (UN, 2015).

In Bangladesh, the incidence of child under-nutrition is still considerably high, especially in the rural areas (NIPORT et al., 2016). Although the country has been successful in achieving the major Millennium Development Goals (MDGs) including child and maternal mortality (GoB, 2016); about one-third of the country's under five children still suffer from under-nutrition (NIPORT & ICF, 2019). Recognizing this, the national policy planners are giving utmost priority in addressing child under-nutrition in Bangladesh (GoB, 2018). As a matter of fact, the national policymakers are keen on understanding how they can better design policy interventions and what specific strategies may work given the diversity of household livelihood choices in the rural Bangladesh. In such a context, a study on understanding factors that are associated with the likeliness of child under-nutrition across agricultural and non-agricultural households using recent data, will be a step towards achieving national development goals.

Although several past studies (Alom et al., 2012; Bhuiyan et al., 2018; Fakir & Khan, 2015; M. Hossain, 2020; Jesmin et al., 2011; Kamal, 2011; Majumder & Islam, 1993; Rahman et al., 2008, 2009; Rayhan & Khan, 2006; Siddiqi et al., 2011) have looked into the issue of child under-nutrition; they have not adequately researched the fact that determinants of child nutrition may vary across household's livelihood primarily because households that differ in livelihood may have different constraints. Thus, the key contribution of this study is that not only does it estimate the determinants of nutritional status using representative data from the entire rural Bangladesh, commendably it also computes the determinants across agricultural and non-agricultural rural households. To put it another way, the main research question posited in this study is to assess if there is any difference in the set of factors that determine children's nutritional status in agricultural and non-agricultural households of the rural Bangladesh. This research question has policy relevance in that it will help the development planners and nutritionists to judge whether or not livelihood specific nutrition interventions would be required to combat the issue of child malnutrition in rural Bangladesh.

Drawing on a sample of young children obtained from two waves of a nationally representative household survey, this study first estimates the effect of child, parents, household and village level factors on the likeliness of underweight and stunting. Following the binary Logit model, this study also estimates how the probability of being underweight or stunted changes with respect to a change in any of the determining factors. Finally, this study compares those results across agricultural and non-agricultural households.

II. MATERIAL AND METHODS

Source of data and the sample

The Bangladesh Integrated Household Survey (henceforth BIHS), which is one of the most comprehensive household surveys available in Bangladesh until now (Ahmed, 2016), provides the data for this research. Notably the BIHS is representative of the rural areas of all administrative divisions of Bangladesh. It has collected particularly comprehensive child health related information from those households in which a child up to the age of 24 months resides. Although the BIHS surveyed 6,500 households in 2012 and 6,436 households in the second wave in 2015; the numbers of households in which a young child up to 24 months resides are 1,136 in the first wave and 1,011 in the second wave. Thus, young children's health and care related information is available for 2,174 households in both waves; however, the sample of this study consists of 1,444 households: 866 households from the first wave and 578 households from the second wave. Such a reduction of the sample size occurs mainly because of the exclusion of households in which the young child is not the biological child of the household head. For instance, households in which the surveyed young child is a grandchild, nephew, or niece of the household head have been excluded. Furthermore, the sample size reduces because of absence of relevant information as well as inappropriate anthropometric data. Eventually the sample of this study comprises 1,444 children, one child from each household.

Measurement of the nutritional status of the children

The key variable in this research is children's nutritional status, which is generally denoted by the anthropometric indicators following the guideline of the World Health Organization (WHO). In this study, two anthropometric indicators, namely weight-for-age Z score (WAZ) and height-for-age Z score (HAZ) have been considered, respectively, to denote whether a child is underweight and stunted. Interested readers are referred to the WHO manual (WHO, 2006), stated in the reference, for more information on how the anthropometric indicators are calculated.

The low height-for-age indicates cumulative deprivation of adequate nutrition over a long period of time, hence it is considered as an indicator of long-term nutritional status (NIPORT et al., 2016). A value of HAZ less than -2 and -3, respectively, means chronically stunted and severely stunted. Therefore, a binary variable 'stunted' is defined such that it takes the value 1 if the HAZ is less than or equal to -2 and 0 otherwise. On the other hand, low weight-for-age could mean either a child has low weight-for-height or low height-for-age. The WAZ score below -2 and -3, respectively, means chronically underweight and severely underweight. Following this, another indicator variable 'underweight' is defined such that it takes 1 if the WAZ is less than or equal to -2 and 0 otherwise. These two nutritional status markers 'underweight' and 'stunted' are used as the dependent variable in this paper.

Estimation strategy

The conceptual framework of malnutrition has depicted that the causes of child under-nutrition can be multisectoral extending to individual, parental, household and societal level factors (UNICEF, 1990). In addition to this conceptual framework, several previous studies (Asfaw et al., 2015; Choudhury et al., 2017; M. M. Hossain et al., 2015; Rahman et al., 2009) have guided the estimation strategy adopted here which involves regressing indicator of child nutrition on a set of observable child, parents, household, and community level variables. The main intention here is to find variables that have significant association with the probability of child under-nutrition.

Let the probability of a child being underweight (or stunted) is P_i and the probability of a child not being underweight (or stunted) is given by $1–P_i$. Their ratio, known as odds ratio, tells the likeliness of being underweight or stunted. The Logit regression requires regressing log of odds ratio on the set of observable child (C), parent (P), household (H), and village (V) level variables as shown in the following equation.

$$ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + C_i\beta_i + P_i\beta_i + H_i\beta_i + V_i\beta_i + u_i$$

Here β_0 represents intercepts, β_i represents the partial effect of a predictor variable on the log of odds, and u_i represents the error term. While β_i estimates how the log of odds changes for a unit change in the predictor variable; its exponents i.e., $\exp(\beta_i)$ helps us to find the changes in odds ratio in percentage term for a unit change in the predictor, holding the effect of other variables unchanged. Hence, for the ease of interpretation, Table 2 and 3 presents the odds ratio instead of β_i. However, the odds ratios do not measure the effect of an incremental change in a predictor variable on the probability of a child being undernourished. In order to find the effect of an incremental change in the predictor on the probability of being underweight (or stunted), the study estimates marginal effect which is given by the following expression

$$\frac{\partial}{\partial X_i}\left(ln(\frac{P_i}{1-P_i})\right) = \hat{\beta}_i(1-\hat{P}_i)\hat{P}_i$$

Here X_i represents a predictor variable considered in the above Logit model and its corresponding estimated coefficient is given by $\hat{\beta}_i$. In addition to reporting the odds ratio, Table 2 and 3 also report the marginal effect of each predictor variable of the above model.

Choice of the predictor variables

The set of child, parent, household, and village level characteristics contains several predictors or explanatory variables. The selection of these predictor variables is guided by both the existing theoretical model (UNICEF, 1990) and empirical model (Grima & Genebo, 2002; Rahman et al., 2008; Rahman & Chowdhury, 2007; Rayhan & Khan, 2006).

The vector of child level characteristics includes age, if currently breastfed, birth order, birth interval with elder sibling, and birth weight. Age generally determines a child's food intake and the level of care it requires, which in turn may have relation with current nutritional status. Therefore, it is considered as an important predictor variable. However, the relation between age and nutritional status (height or weight) may be non-linear for which a quadratic term should also be considered in any analysis. Among the other child level characteristics, whether or not a child currently receives breast milk, gender, and birth order are likely to have effect on nutritional status. For example, being a high birth order child may be associated with receiving less care and nutrient (Jesmin et al., 2011). Likewise, gender may be associated with exhibiting different biological traits. Moreover, being a girl may also be associated with receiving less care and nutrition as the relative importance of girls in rural Bangladeshi societies tend to be low.

A child's birth gap with its elder sibling may matter for nutritional status as well (Rayhan & Khan, 2006). A short birth interval means that the child's mother did not get enough time to regain the decay associated with the birth of the previous child. This may translate into a high risk of giving birth of a malnourished baby. As it follows, birth weight–which is an indicator of whether the child was born healthy–may influence the current nutritional status of a child (Jesmin et al., 2011; Rayhan & Khan, 2006).

Parental characteristics are most vital for determining children's health, which has adequately been stated in the relevant literature. Almost all previous research suggests that parents' demographic characteristics are important for children's nutritional status. However, evidence of the beneficial effect of parental education, particularly of mothers' education, is mixed and suffers from the potential endogeneity (Glewwe, 1999, 2005). Even after addressing for the concern of potential endogeneity through a variety of approaches, evidence on the effect of maternal education still remains mixed across studies (Ali & Elsayed, 2018; Aslam & Kingdon, 2012; Glewwe, 1999; Makate & Makate, 2016).

Mother's age may be important in that child of adolescent mothers are more likely to suffer from malnutrition than children whose mothers are not adolescents. Besides, the age of a mother reflects her experience, and it may be possible that children of experienced mothers suffer less from malnutrition, compared with the children of inexperienced mothers (Siddiqi et al., 2011). Studies (Fakir & Khan, 2015) have also highlighted that mothers' knowledge as regards food and nutrition may be crucial for children's nutritional status because such knowledge supposedly translates into mothers being aware of appropriate infant and young child feeding practices. Mothers' exposure to media (television) is often found crucial for children's nutrition (Rahman & Chowdhury, 2007) because mothers' may learn from child health promoting, awareness building programs aired on the TV.

In order to capture the effects of household health-environment and socioeconomic factors, several variables such as whether the household has access to health service providers (health workers), household size, number of children in the household, per capita household expenditure, household dietary diversity, type of latrine, and source of drinking water (a tube-well or tape) are usually considered in the previously cited studies. Accordingly, these variables are also considered in the current analysis.

Household's expenditure reflects proxy of household's permanent income and the household dietary diversity reflects a household's food security. A household's access to health workers may enable it to get proper information which may be vital for escaping child mortality and morbidity. Additionally, good sanitation and safe drinking water are crucial for ensuring a safe, healthy environment required for proper functioning of other health related inputs. In addition to these, whether or not a household is an agricultural[2] household needs to be taken into account as the BIHS covers both agricultural and non-agricultural rural households.

Finally, to capture the village-level health environment, four variables are considered which include: availability of any health care facilities (government-run clinic, private clinic, or medicine shop) at the village, years of operation of the health care facilities at the village, availability of any NGO-run nutrition program at the village, and years of operation of an NGO-run nutrition program at the village. Furthermore, all other regional variations can be accounted for by controlling for division[3] indicators. Thus, the Logit regression takes the following specification

$$\begin{aligned}\ln\left(\frac{P_i}{1-P_i}\right) = {} & \beta_0 + \beta_1 girl_i + \beta_2 age_i + \beta_3 agesq_i + \beta_4 breastfed_i + \beta_5 order_i \\ & + \beta_6 gap2y_i + \beta_7 gap3\_4y_i + \beta_8 gap4y_i + \beta_9 bweight_i + \beta_{10} fedu_i \\ & + \beta_{11} fheight_i + \beta_{12} mage_i + \beta_{13} medu_i + \beta_{14} care_i + \beta_{15} mnk_i \\ & + \beta_{16} media_i + \beta_{17} hworker_i + \beta_{18} hsz_i + \beta_{19} cu12_i + \beta_{20} lpce_i \\ & + \beta_{21} dds_i + \beta_{22} farmhh_i + \beta_{23} toilet_i + \beta_{24} water_i + \beta_{25} hcf_i \\ & + \beta_{26} yhacf_i + \beta_{27} npv_i + \beta_{28} ynpv_i + \beta_{29} wave_i + \beta_{30} division_i + u_i\end{aligned}$$

III. RESULTS AND DISCUSSION

Summary statistics

Firstly, the mean and standard deviation of the variables of interest are reported in Table 1. The share of the underweight children in the sample is about 28 percent and the incidence of the stunted children is comparatively high (about 35 percent). Stunting, which is a measure of long-term deprivation of nutrition, is a high-risk factor of mortality and evidently one-third of the sample children are at risk.

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[2] The BIHS surveyed both agricultural and non-agricultural households from the rural Bangladesh. This has been taken into account in order to capture any difference in children's nutritional status across the types of households.

[3] Division is the largest administrative unit in Bangladesh.

Among the sample children, there is roughly an equal share of male and female children whose average age is about 11 months. It can also be seen that about 98 percent of the sample children receive breast milk, mean birth order has been between 2 and 3. Nearly a quarter of the sample children have a birth gap of up to 2 years or less. Among the rest of the children, the majority of the children (about 64 percent) have a birth interval of more than 4 years. The remainder, i.e., about 13 percent children has a birth gap between 3 to 4 years. The average birth weight of the children is about 3 kg.

With regard to the demographic characteristics of the parents, it is observed that the average age of the mothers is about 27 years, and they are, as expected, shorter than the fathers. Interestingly, the average schooling years are higher for the mothers compared with the fathers. However, on an average, the level of education is below primary for both parents. About 28 percent households have access to any health service providers. Average household size lies just below 5 persons, and the number children live in the sample household is about 2. The log of per capita monthly expenditures is 8.4 and the mean dietary diversity score for the sample households is 8.5. About 58 percent of the households rely on agriculture for their livelihood and nearly 43 percent households use a water-sealed toilet, and about 56 percent households drink water from a tube-well or tape source.

With regard to the characteristics of the communities where the sample children live in, it can be observed that health care facilities are available in about 51 percent villages, and the duration of such healthcare facilities being operated at the villages is at least 10 years on an average. Likewise, in about 33 percent villages, there are NGO-run nutrition programs in operation, and such programs have been running for about at least 8 years on an average. The division-wise distribution of the sample is also shown in Table 1.

Table 1: Summary statistics of the variables of interest

Variables	Mean or share	SD
Dependent variable		
Underweight=1, otherwise 0	27.63%	
Stunted=1, otherwise 0	34.76%	
Child level independent variables		
Girl=1, otherwise 0	48.96%	
Child's age (months)	11.274	6.570
Age squared	170.245	156.597
Being breast-fed=1, otherwise 0	97.50%	
Birth order	2.587	1.418
Birth gap up to 2 years=1, otherwise 0	23.61%	
Birth gap between 3 to 4 years=1, otherwise 0	12.81%	
Birth gap >4years=1, otherwise 0	63.57%	
Birth weight (Kg)	2.907	0.414
Birth weight missing=1, otherwise 0	70.63%	

Variables	Mean or share	SD
Parental characteristics		
Father's completed years of education	3.383	3.754
Father's height (cm)	161.968	5.383
Father is missing=1, otherwise 0	15.37%	
Mother's age	27.009	5.467
Mother's height (cm)	150.597	5.835
Mother's completed years of education	4.732	3.525
Mother’s knowledge about IYCF	3.547	1.788
Mother’s exposure to media	40.72%	
Household level characteristics		
Access to health workers=1, otherwise 0	27.97%	
Household size	4.882	1.556
Number of children in the HH	2.197	1.000
Log per capita monthly expenditures	8.427	1.768
Dietary diversity score	8.519	1.978
Agricultural household=1, otherwise 0	58.31%	
Used water sealed toilet=1, otherwise 0	42.72%	
Access to tube-well water=1, otherwise 0	55.81%	
Community level characteristics		
Health care facility available in village=1, otherwise 0	50.76%	
Years of operation health care facility in village	10.607	15.416
Nutrition program runs in village=1, otherwise 0	32.75%	
Years of operation of NGO in village	8.191	9.850
Barisal	8.73%	
Chittagong	16.34%	
Dhaka	31.65%	
Khulna	11.50%	
Rajshahi	8.17%	
Rangpur	7.89%	
Sylhet	15.72%	
Wave: 2015=1, otherwise 0	40.03%	
Observations	1,444	

Note: SD means standard deviation

Discussion on regression results

Table 2 and 3 represent the odds ratio and marginal effect of the predictor variables, which are obtained by the Logit regression, both for the underweight and stunted models, respectively. In both Tables, the model has been estimated from pooled sample first and afterwards for agricultural households and non-agricultural households separately. For each sample, odds ratio and marginal effect of the predictor variables have been reported. Having had a glance at Table 2 and 3, it can be observed that some rather than all variables have statistically significant influence on the probability of underweight and stunting.

Determinants of underweight

From column 1 at Table 2, we can see that the odds ratio relating to birth weight, father's height, mother's height, mother's education, care, mother's exposure to media, household's defecation facility, and health care facility are significant. It can be seen that all of these odds ratio are less than one which indicates that there is an opposite relationship between the probability of being underweight and the predictors. The inverse relationship has further been confirmed by the sign of the marginal effect of these variables.

Table 2: Odds ratio and marginal effect of the underweight model

Variables	All HH		Non-agricultural HH		Agricultural HH	
	Odds ratio	Marginal effect	Odds ratio	Marginal effect	Odds ratio	Marginal effect
Girl=1, otherwise 0	1.079	0.014	0.951	-0.008	1.227	0.041
	(0.138)	(0.024)	(0.209)	(0.033)	(0.201)	(0.032)
Child's age (months)	1.066	0.012	1.017	0.003	1.079	0.015
	(0.042)	(0.007)	(0.067)	(0.010)	(0.055)	(0.010)
Age squared	0.999	-0.000	1.002	0.000	0.998	-0.000
	(0.002)	(0.000)	(0.003)	(0.000)	(0.002)	(0.000)
Being breast-fed=1, otherwise 0	0.620	-0.088	0.577	-0.082	0.568	-0.112
	(0.227)	(0.068)	(0.442)	(0.114)	(0.256)	(0.090)
Birth order	0.998	-0.000	0.964	-0.005	0.991	-0.002
	(0.083)	(0.015)	(0.138)	(0.021)	(0.098)	(0.020)
Birth gap up to 2 years=1,	1.242	0.040	2.406*	0.122*	0.827	-0.039
otherwise 0	(0.347)	(0.051)	(1.137)	(0.067)	(0.302)	(0.074)
Birth gap between 3 to 4	1.153	0.025	2.418**	0.123**	0.720	-0.065
years=1, otherwise 0	(0.287)	(0.044)	(1.051)	(0.057)	(0.230)	(0.064)
Birth gap >4years=1, otherwise 0	1.165	0.028	1.672	0.063	0.859	-0.031
	(0.255)	(0.039)	(0.689)	(0.047)	(0.237)	(0.058)
Birth weight (Kg)	0.499***	-0.128***	0.335***	-0.162***	0.532**	-0.125**
	(0.110)	(0.040)	(0.120)	(0.051)	(0.155)	(0.057)
Father's completed years of	0.990	-0.002	0.968	-0.005	0.996	-0.001
education	(0.021)	(0.004)	(0.035)	(0.005)	(0.028)	(0.006)
Father's height (cm)	0.964***	-0.007***	0.975	-0.004	0.956***	-0.009***
	(0.012)	(0.002)	(0.022)	(0.003)	(0.014)	(0.003)
Mother's age	0.992	-0.001	0.969	-0.005	1.007	0.001
	(0.016)	(0.003)	(0.028)	(0.004)	(0.021)	(0.004)
Mother's height (cm)	0.937***	-0.012***	0.931***	-0.011***	0.941***	-0.012***
	(0.011)	(0.002)	(0.019)	(0.003)	(0.015)	(0.003)
Mother's completed years of	0.937***	-0.012***	0.933*	-0.010*	0.940*	-0.012*
education	(0.022)	(0.004)	(0.034)	(0.005)	(0.030)	(0.006)
Care index	0.890**	-0.021**	0.829**	-0.028**	0.910	-0.019
	(0.042)	(0.009)	(0.073)	(0.013)	(0.054)	(0.012)
Mother's knowledge about IYCF	0.969	-0.006	0.905	-0.015	1.000	0.000
	(0.037)	(0.007)	(0.059)	(0.010)	(0.050)	(0.010)
Mother's exposure to media=1,	0.750*	-0.053*	0.816	-0.030	0.707*	-0.069*
otherwise 0	(0.114)	(0.028)	(0.205)	(0.037)	(0.141)	(0.040)
HH has access to health	1.036	0.007	0.787	-0.036	1.158	0.029
worker=1, otherwise 0	(0.160)	(0.029)	(0.202)	(0.038)	(0.228)	(0.039)
Household size	1.022	0.004	1.140	0.019	0.950	-0.010

Variables	All HH		Non-agricultural HH		Agricultural HH	
	Odds ratio	Marginal effect	Odds ratio	Marginal effect	Odds ratio	Marginal effect
	(0.060)	(0.011)	(0.102)	(0.013)	(0.079)	(0.017)
Number of children in the HH	0.972	-0.005	0.893	-0.017	1.092	0.018
	(0.115)	(0.022)	(0.191)	(0.032)	(0.161)	(0.029)
Log per capita monthly	0.935	-0.012	1.161	0.022	0.867	-0.028
expenditures	(0.117)	(0.023)	(0.253)	(0.032)	(0.143)	(0.033)
Dietary diversity scores	1.000	-0.000	0.922	-0.012	1.042	0.008
	(0.041)	(0.008)	(0.062)	(0.010)	(0.057)	(0.011)
Agricultural household=1,	1.142	0.024				
otherwise 0	(0.161)	(0.026)				
Used water sealed toilet=1,	0.735*	-0.057*	0.527**	-0.095**	0.816	-0.040
otherwise 0	(0.127)	(0.032)	(0.170)	(0.047)	(0.170)	(0.041)
Access to tube-well water=1,	1.002	0.000	1.050	0.007	0.928	-0.015
otherwise 0	(0.133)	(0.024)	(0.239)	(0.034)	(0.159)	(0.034)
Health care facility available in	0.640**	-0.082**	0.817	-0.030	0.550**	-0.119**
village=1, otherwise 0	(0.121)	(0.035)	(0.251)	(0.045)	(0.140)	(0.050)
Years of operation health care facility in village	1.008	0.002	1.014	0.002	1.003	0.001
	(0.006)	(0.001)	(0.009)	(0.001)	(0.009)	(0.002)
Nutrition program run in	1.181	0.031	1.454	0.056	1.136	0.025
village=1, otherwise 0	(0.202)	(0.032)	(0.397)	(0.040)	(0.270)	(0.047)
Years of operation of NGO in	0.999	-0.000	0.997	-0.001	0.996	-0.001
the village	(0.010)	(0.002)	(0.016)	(0.002)	(0.014)	(0.003)
Wave: 2015=1, otherwise 0	0.920	-0.015	0.405	-0.134	1.273	0.048
	(0.422)	(0.085)	(0.325)	(0.118)	(0.774)	(0.121)
Chittagong	0.856	-0.028	0.965	-0.005	0.761	-0.054
	(0.247)	(0.053)	(0.495)	(0.074)	(0.321)	(0.082)
Dhaka	0.982	-0.003	1.590	0.077	0.758	-0.055
	(0.252)	(0.048)	(0.803)	(0.077)	(0.231)	(0.062)
Khulna	0.580*	-0.089*	0.205**	-0.133*	0.729	-0.062
	(0.180)	(0.052)	(0.149)	(0.069)	(0.256)	(0.070)
Rajshahi	1.517	0.087	1.673	0.087	1.325	0.062
	(0.480)	(0.065)	(1.160)	(0.121)	(0.488)	(0.081)
Rangpur	1.141	0.026	0.613	-0.060	1.360	0.068
	(0.381)	(0.065)	(0.464)	(0.090)	(0.524)	(0.086)
Sylhet	0.994	-0.001	1.399	0.054	0.792	-0.047
	(0.281)	(0.053)	(0.723)	(0.080)	(0.282)	(0.072)
Constant	Yes		Yes		Yes	
Observations	1,444	1,444	602	602	842	842
Pseudo R2	0.110		0.174		0.104	

Note: All models contain controls for missing of father's information and missing of a child's birth weight. Robust standard errors are in parentheses. ***, **, and * indicates significant at 1%, 5%, and 10%, respectively.

The odds ratio of birth weight is statistically highly significant and it suggest that as birth weight increases, holding the rest of variables fixed, the likeliness of a child being underweight diminishes. The marginal effect of birth weight implies that if a child is born 1 kg heavier then the probability that the child will be underweight falls by 0.13 (column 2). The extent to which birth weight reduces the probability of being underweight is slightly high in non-agricultural households (0.16).

The importance of parent's own health in predicting children's nutritional status is well evident in Table 2. The odds ratio on father's height indicates that children of taller father are less likely to be underweight and the probability of underweight falls by 0.007(column 2); while holding the effect of other variables unchanged. Similarly, it can be seen that the likeliness of being underweight is less for children of tall mothers and the probability of a child being underweight falls by 0.012 if height of mothers increases by one cm. While mother's height is found to be significant for reducing the probability of underweight in both agricultural and non-agricultural households; father's height does not seem to have any significant association in the case of non-agricultural households. This possibly hints the relative importance mother's nutritional status in determining children's nutritional status.

One of the crucial causes of child malnutrition, highlighted in literature, is inadequate care. In the underweight model, as evident in column 1 in Table 2, the odds ratio of care index is less than one and is statistically significant. From the marginal effect (column 2) it can be inferred that if the care index increases by one unit the probability of underweight falls by 0.02 (column 2) which is slightly higher in the case of non-agricultural households. Although the care index has an expected sign in the case of children of agricultural households, its effect on reducing the probability of underweight does not seem to be statistically significant, holding the effect of the rest of the variables unchanged.

Consistent with the expectation that mother's education has a significant relationship with children's health and nutrition, the odds ratio of mother's education is found to be statistically significant in Table 2 i.e., children of more educated mothers are less likely to be underweight than children of mothers with fewer education. Since childbearing is a customary task imposed on mothers, it is of no surprise that the relative importance of education of the primary caregiver appears to be statistically significant. Although Srinivasan, Zanello, and Shankar (2013) found that fathers' education is also significant for the Bangladeshi children's nutritional status, there is not any such evidence in Table 2. It may be argued that since the father is not the direct caregiver, the benefit of his incremental education would not translate into children's better nutritional status. The marginal effect (column 2) implies that the probability of underweight decreases by 0.012 for an extra year of education completed by a mother, when the effects of the rest of variables are held unchanged. Notably the significance of mother's education is found in both non-agricultural and agricultural households. Thus, clearly the significance of this policy variable for improving rural children's nutrition becomes evident.

Although father's education does not seem to have any significant association with child nutrition, its relevance in child wellbeing can rarely be ignored. Father's education supposedly leads to improved socioeconomic condition (Thomas et al.,

1991) which, in turn, is likely to ensure mothers' accessibility to essential health inputs and thereby enabling mothers to use different health inputs optimally. Commendably, to control for any such potential income augmenting effect of father's education, the Logit model controls for household income as a proxy for socioeconomic status.

Mother's exposure to media and household's defecation facility has inverse relationship with the likeliness of being underweight, indicated by their odds; nonetheless their statistical significance seems to be slightly weak (significant at 10 percent level of significance). Additionally, their effect seems to be household specific, for example, using improved toilet reduces the probability of being underweight in agricultural households but its effect is not significant. Likewise, mother's exposure to media seems to reduce the probability of underweight but the effect is statistically significant in the case of non-agricultural households.

Availability of health care facilities within easy reach of households in rural areas can be crucial for improving children's nutritional status in that it helps households to save children's life and to receive medical advice. Evidently the marginal effect of the availability of health care facility suggests that the probability of being underweight is 0.08 less for children who live in a village where health care facility is available as opposed to the children who live in a village without such facility. Although the significance of this service availability seems to be household specific, nonetheless it has an expected sign in the case of non-agricultural households (column 4). Despite variability in significance, it is still a crucial factor as it is a policy variable through which child underweight can be reduced.

The rest of variables considered in the model seem to have expected relationships with the probability of underweight; however, their odds ratios or marginal effects have not been discussed here on account of their statistical insignificance.

Determinants of stunting

From column 1 at Table 3, we can see that the odds ratios relating to some variables such as girl, child's age, birth weight, father's height, mother's height, and care are statistically significant. Notably odds ratios of all these variables but child's age are less than one, which means that these variables are inversely related with the likeliness of children being stunted. The marginal effect of these variables, which is reported in column 2 at Table 3, further confirms that the probability of a child being stunted decreases for a unit increase in each of these variables, holding the effect of the rest of the variables constant. Unlike these variables, age has a positive relationship with the probability of being stunted. This is plausible because age and height are non-linearly related.

From column 1 at Table 3, it can be seen that girl dummy is statistically significant at 5 percent level of significance and the odds ratio suggests that girls are less likely to be stunted in comparison with boys. Being a girl reduces the probability of stunted by 0.06 as shown by the marginal effect (column 2). The effect of child's gender on the likeliness of being stunted seems to be household specific. For example, although girls are less likely to be stunted both in the agricultural and non-agricultural households; the effect is statistically significant only for the non-agricultural households. This hints to the gender differentiation in the likeliness of stunting in rural Bangladesh, which should draw attention of the policy makers in the country.

Table 3: Odds ratio and marginal effect of the stunted model

Variables	All HH		Non-agricultural HH		Agricultural HH	
	Odds ratio	Marginal effect	Odds ratio	Marginal effect	Odds ratio	Marginal effect
Girl=1, otherwise 0	0.773**	-0.056**	0.604**	-0.095**	0.892	-0.026
	(0.095)	(0.027)	(0.130)	(0.041)	(0.141)	(0.036)
Child's age (months)	1.189***	0.037***	1.245***	0.041***	1.156***	0.033***
	(0.050)	(0.009)	(0.092)	(0.014)	(0.061)	(0.012)
Age squared	0.997*	-0.001*	0.996	-0.001	0.997	-0.001
	(0.002)	(0.000)	(0.003)	(0.001)	(0.002)	(0.000)
Being breast-fed=1, otherwise 0	1.045	0.010	0.751	-0.054	1.100	0.022
	(0.429)	(0.089)	(0.577)	(0.145)	(0.541)	(0.112)
Birth order	0.973	-0.006	1.041	0.008	0.913	-0.021
	(0.078)	(0.017)	(0.156)	(0.028)	(0.093)	(0.023)
Birth gap up to 2 years=1, otherwise 0	1.059	0.012	1.239	0.037	1.059	0.013
	(0.272)	(0.055)	(0.562)	(0.077)	(0.355)	(0.078)
Birth gap between 3 to 4 years=1, otherwise 0	1.192	0.039	1.934	0.126*	0.990	-0.002
	(0.281)	(0.051)	(0.796)	(0.075)	(0.300)	(0.070)
Birth gap >4years=1, otherwise 0	0.985	-0.003	1.280	0.043	0.856	-0.035
	(0.213)	(0.046)	(0.508)	(0.067)	(0.231)	(0.062)
Birth weight (Kg)	0.648**	-0.094**	0.514**	-0.125**	0.711	-0.077
	(0.124)	(0.041)	(0.174)	(0.063)	(0.162)	(0.052)
Father's completed years of education	1.003	0.001	0.975	-0.005	1.024	0.005
	(0.020)	(0.004)	(0.035)	(0.007)	(0.026)	(0.006)
Father's height (cm)	0.943***	-0.013***	0.912***	-0.017***	0.956***	-0.010***
	(0.011)	(0.003)	(0.020)	(0.004)	(0.013)	(0.003)
Mother's age	1.010	0.002	1.001	0.000	1.016	0.004
	(0.016)	(0.004)	(0.029)	(0.006)	(0.021)	(0.005)
Mother's height (cm)	0.935***	-0.015***	0.925***	-0.015***	0.942***	-0.014***
	(0.011)	(0.003)	(0.019)	(0.004)	(0.014)	(0.003)
Mother's completed years of education	0.988	-0.003	0.980	-0.004	0.984	-0.004
	(0.022)	(0.005)	(0.036)	(0.007)	(0.030)	(0.007)
Care index	0.920*	-0.018*	0.983	-0.003	0.904*	-0.023*
	(0.040)	(0.009)	(0.075)	(0.014)	(0.052)	(0.013)
Mother's knowledge about IYCF	1.026	0.006	1.069	0.013	0.993	-0.001
	(0.038)	(0.008)	(0.069)	(0.012)	(0.047)	(0.011)
Mother's exposure to media=1, otherwise 0	1.046	0.010	0.854	-0.030	1.230	0.047
	(0.153)	(0.032)	(0.208)	(0.046)	(0.233)	(0.043)
HH has access to health worker=1, otherwise 0	0.961	-0.009	0.598**	-0.097**	1.238	0.049
	(0.139)	(0.031)	(0.151)	(0.047)	(0.228)	(0.042)
Household size	1.015	0.003	1.004	0.001	1.060	0.013
	(0.059)	(0.012)	(0.101)	(0.019)	(0.082)	(0.018)
Number of children in the HH	1.153	0.031	0.880	-0.024	1.302*	0.060*
	(0.131)	(0.024)	(0.199)	(0.043)	(0.184)	(0.032)

Variables	All HH		Non-agricultural HH		Agricultural HH	
	Odds ratio	Marginal effect	Odds ratio	Marginal effect	Odds ratio	Marginal effect
Log per capita monthly expenditures	0.953	-0.010	1.220	0.037	0.809	-0.048
	(0.117)	(0.027)	(0.258)	(0.040)	(0.132)	(0.037)
Dietary diversity scores	0.971	-0.006	0.902	-0.019	1.003	0.001
	(0.040)	(0.009)	(0.063)	(0.013)	(0.054)	(0.012)
Agricultural household=1, otherwise 0	1.008	0.002				
	(0.140)	(0.030)				
Used water sealed toilet=1, otherwise 0	0.929	-0.016	0.880	-0.024	0.939	-0.014
	(0.156)	(0.036)	(0.292)	(0.062)	(0.190)	(0.046)
Access to tube-well water=1, otherwise 0	0.914	-0.019	0.946	-0.010	0.903	-0.023
	(0.117)	(0.028)	(0.206)	(0.041)	(0.148)	(0.037)
Health care facility available in village=1, otherwise 0	0.838	-0.038	0.937	-0.012	0.735	-0.070
	(0.148)	(0.038)	(0.280)	(0.056)	(0.171)	(0.053)
Years of operation health care facility in village	1.003	0.001	0.996	-0.001	1.007	0.002
	(0.006)	(0.001)	(0.010)	(0.002)	(0.008)	(0.002)
Nutrition program run in village=1, otherwise 0	0.852	-0.035	0.725	-0.061	0.953	-0.011
	(0.138)	(0.035)	(0.184)	(0.048)	(0.216)	(0.052)
Years of operation of NGO in the village	1.016	0.003	1.026*	0.005*	1.009	0.002
	(0.010)	(0.002)	(0.015)	(0.003)	(0.014)	(0.003)
Wave: 2015=1, otherwise 0	0.485	-0.156	0.183**	-0.320**	0.907	-0.022
	(0.220)	(0.098)	(0.148)	(0.152)	(0.540)	(0.135)
Chittagong	0.863	-0.033	0.762	-0.054	0.949	-0.012
	(0.242)	(0.063)	(0.400)	(0.108)	(0.371)	(0.092)
Dhaka	0.768	-0.058	0.724	-0.063	0.774	-0.059
	(0.195)	(0.057)	(0.379)	(0.108)	(0.231)	(0.070)
Khulna	0.657	-0.089	0.618	-0.090	0.670	-0.090
	(0.193)	(0.063)	(0.375)	(0.118)	(0.230)	(0.077)
Rajshahi	1.392	0.079	1.514	0.094	1.316	0.067
	(0.431)	(0.073)	(1.043)	(0.155)	(0.464)	(0.085)
Rangpur	0.910	-0.021	0.386	-0.158	1.178	0.039
	(0.289)	(0.071)	(0.257)	(0.116)	(0.433)	(0.089)
Sylhet	0.815	-0.045	1.090	0.018	0.660	-0.093
	(0.231)	(0.063)	(0.589)	(0.114)	(0.233)	(0.079)
Constant	Yes		Yes		Yes	
Observations	1,444	1,444	602	602	842	842
Pseudo R2	0.133		0.214		0.112	

Note: All models contain controls for missing of father's information and missing of a child's birth weight. Robust standard errors are in parentheses. ***, **, and * indicates significant at 1%, 5%, and 10%, respectively.

Birth weight once again appears to be significant in reducing the likeliness of stunting as it has been found in the case of underweight model. The marginal effect of birth weight suggests that the probability of being stunted decreases by 0.09 (column 2) if a child is born with an extra kg and the effect seems to be considerably higher (column 4) in the non-agricultural households. Although birth weight does seem to have an opposite effect on the probability of stunting in the case of children of agricultural households, surprisingly the effect is not statistically significant.

Father's height and mother's height have been found statistically highly significant in reducing the likeliness of stunting and the effect is statistically significant for both agricultural and non-agricultural households. If we take two children who are similar in all respects but their father's height varies by 1 cm, then the probability that the child of a taller father is stunted is 0.01 less. Likewise, the probability that a child is stunted is 0.01 less if height of the child's mother increases by 1 cm; while the effect of the rest of the variables are held unchanged.

Care index, as expected, has a statistically significant odds ratio which is less than one meaning that it has an inverse relationship with the likeliness of being stunted. Although it is weakly significant in the stunting model; still there is no denial that care is crucial for children's nutritional status.

Among the rest of explanatory variables, household's access to health worker is found to have a statistically significant association in non-agricultural households i.e., children in the non-agricultural households that have access to health workers are less likely to be stunted than children of the non-agricultural households that lack in such access to health worker. However, its significance disappears in the pooled sample. Similarly, children in the non-agricultural households are more likely to be stunted if they live in a village in which NGOs have been operating for longer time, yet the association is weakly significant.

IV. CONCLUSION AND POLICY IMPLICATION

The empirical findings of this paper have some key implications for health and nutrition monitoring in Bangladesh. In other words, this study may be useful to the national planners who design interventions in order to improve rural children's health and nutrition in Bangladesh. This paper suggests that although the nutritional status of rural children is determined by a common set of factors that are broadly consistent across agricultural and non-agricultural household, still there are a few exceptions. This is noteworthy for the policymakers because in order to improve the nutritional status of rural children from different livelihood segments, adequate attention must be paid for recognizing the fact that the determinants of children's nutritional status are not identical across agricultural and non-agricultural households in rural Bangladesh.

The study has revealed that parents, especially of maternal, and community characteristics are more influential than any other factors in reducing the probability of under-nutrition among young children in rural Bangladesh. Mothers' education appears to have significance in reducing children's underweight, which reaffirms the proclamation made in the development literature that promoting female education has other benefits. The finding of this study calls for changing stubborn patriarchal social norms in Bangladesh because such social norms obstruct the development of women's human resource. Admittedly, girls and women in Bangladesh still face more challenges as regards health and education relative to boys and men.

This study also points out that household level characteristics—especially household access to health worker, and improved defection facility—are all conducive to reducing the chance of child under-nutrition. Although household income, apparently do not have a perceivable influence on reducing child under-nutrition after controlling for child, parents, household, and community level variables, it still may be important. Apart from these factors, child nutrition can also be improved by some other policy variables, for instance, availability of the health care facilities in a village. Evidently health care facilities within easy reach of the rural households help reducing the probability that the children will be undernourished. Therefore, it may well payoff if the national policy makers pay adequate attention to expanding quality health care facilities at village level across the country.

In conclusion, the findings of this study are expected to be useful evidence to the policymakers, nutritionists, researchers, and other interested bodies working for the development of Bangladesh. The findings would pave the ways for the planners to design effective and efficient policies and programs for reducing the incidence of child under-nutrition in rural Bangladesh and similar other countries in south Asia.

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