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Child malnutrition in developing economies: a case study of Bangladesh

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Abstract The study investigate the impact of socioeconomic factors on malnutrition in children (under 5 years) using Bangladesh Demographic and Health Survey. The urban and rural areas are separately probed for stunting, wasting and under-weight children. The analysis revealed that birth-interval, mother's education and wealth index reduce the malnutrition in children for urban and rural household, while duration of breastfeeding and lower BMI of the mother increase the malnutrition in both urban and rural areas. Wealth index is more effective in rural areas as compared to urban ones. The male children are more likely to be malnourished in urban areas but female children are more likely to be malnourished in rural areas. The primary level of education of the women has no significant impact on nutritional status of children in urban as well as in rural areas. It has important policy implications that at least secondary level of education should be part of the education policy of Bangladesh. The incidence of diarrhea enhances the probability of stunting and wasting in both urban and rural areas of Bangladesh. From the policy perspective mother's education and birth-interval are required for achieving the nutrition status of children. For the long-run the socioeconomic status of the household expressed by wealth index is needed. The duration of breastfeeding needs to be reduced by initiation of the supplement food.

Keywords Stunting · Wasting · Under-weight · Breastfeeding · BMI · Female education · Rural and urban areas · DHS · Human development

1 Introduction

The literature on nutritional status of children substantiated that malnutrition in childhood may have irreversible long-term effects not only on the health status but also on educational and labor market performance. The adverse effects appear to be stronger for individuals who exposed to malnutrition during first two years of life (Bryce et al. 2008). Victora et al. (2008)

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Table 1 Child malnutrition in rural and urban areas of Bangladesh

Year	Urban			Rural		
	Stunting < -2 SD	Wasting < -2 SD	Underweight < -2 SD	Stunting < -2 SD	Wasting < -2 SD	Underweight < -2 SD
2007	30.5	13.5	39.7	37.6	16.9	48.1
2004	37.6	11.5	42.2	44.3	13.2	48.8

Source Bangladesh Demographic and Health Survey 2004 and 2007

showed that malnutrition in children in the first 24 months of life is associated with reduced adult height, higher blood glucose concentration, increased blood pressure, harmful lipid profile, deficit in cognitive skills and an increased chance of mental illness. Malnutrition at early childhood translates into disadvantageous socioeconomic outcomes like educational attainment and reduced labor income. Haddinot et al. (2008) contended that because of malnutrition more than 200 million of today children will fail to reach their full development potential in the future.

The malnutrition in Bangladesh in the form of stunting, wasting and under-weight children is alarmingly high both urban and rural areas. The stunting and underweight were improved in both urban and rural areas from 2004 to 2007, but wasting increased during this period. There is high risk of being malnutrition in rural than in urban settlements (see Table 1).

Bangladesh is most populated country of the world. It has 150 million population with density of 920 persons/km^2. The 63% of population is of 15–64 years and this young age structure is the main cause of population momentum. The per-capita income of the country is 848 US dollars. Bangladesh ranked 140th position in Human Development Index (HDI) and 93rd in Human Poverty Index (HPI).

So Bangladesh may be a good case study for estimating the malnutrition in children in developing economies. The rural urban disparity exists in all the developing economies. From the policy point of view separate analysis for these areas is required so that separate policy for each may be framed. The primary objective of the study is to investigate the socioeconomic determinants of malnutrition in children separately for urban and rural areas of Bangladesh.

2 Literature review

In the literature regarding nutritional status of children, a verity of the aspects has been discussed. We are mainly concerned with determinant of malnutrition, so in this section we will cover only this aspect. Female discrimination in health-seeking behavior has been focused by a number of studies particularly in South Asia. Discrimination against females in inter-family food distribution and health-care were found major determinants of malnutrition in Bangladesh during 70s and 80s (Choudhury et al. 2000). Generally, in South Asia women serve meal to their husbands and sons and eat after them along with their daughters. Their health remains poor due to inadequate food left for them (Mehrotra 2006). The mother education had a enormous effect on boys than girls welfare which reflects inferior position of women in society (Choudhury et al. 2000). The capacity of women to provide child-care is determined by its status in society (Mehrotra 2006) and women are socially and economically exploited in South Asia. Hong et al. (2006, for Bangladesh) concluded that there exists no gender differential in stunting of children indicating that there is no intra-household gender bias in feeding and health-care for children.

The impact of mother's employment on infant's nutritional status has shown ambiguous results in the literature. For the employed mothers it is difficult to take infants with them to work. The positive effect of women's work in providing better income and resources for child food and treatment may become dubious in this situation. When a child is in infancy during its first 6 months, the mother's working status may negatively affect the children's nutrition but after that age increase in income provides better milk and food for child which enhance infant's health (Mukuria et al. 2005).

In the literature parent's education has shown positive impact on child's welfare including the nutritional status. The effect of mother's education has been found about twice large to that of father's education (Christiaensen and Alderman 2001). Moreover, mother's education has strong effect on child's nutritional status than other demographic and economic variables (Mukherjee et al. 2008). Hong et al. (2006) concluded that maternal education has little or no effect on stunting in children. It may be partly due to the fact that majority of the mothers (69%) in Bangladesh have primary education, less than primary education or no formal education at all.

The studies have highly recommended that infants (aged 0–6 months) should be breastfed exclusively, followed by timely start of complementary food between the age of 6–9 months (Mukuria et al. 2006). Duration of breastfeeding for less than 6 months has been found a risk factor of malnutrition and initiation of breastfeeding within one hour after birth may reduce risk of underweight (Hien and Hoa 2009). There are other evidences of strong effect of breastfeeding on nutritional status of children. It needs to encourage breastfeeding and the bottle feeding should be discourage as a substitute of mother's milk due to hygienic reasons. Furthermore, the breastfeeding should be continued up to two years (WHO 2003).

The mother's BMI as determinant of child's malnutrition has also been probed by a number of studies. The mother's height and structure has been found to affect the child through phenotype and genotype (Garcia and Alderman 1989).

The incidence of disease as a determinant of malnutrition in children has also been focused by researchers. Diarrhea has shown a strong negative impact on child health (Ukwuani and Suchindran 2003). Poor hygienic bottle-feeding is one of the main factors of high incidence of diarrhea. For the reduction of diarrhea the improvement in environment and sanitation is proposed (Garcia and Alderman 1989).

The number of children in the household as the explanatory variable has also been remained the focus of the studies. Majority of the studies have shown negative impact of higher number of children in the household on children's nutritional status. A mother with more than two children could devote less time to childcare than mother who had one or two children. There remains more competition for available food in the families who have more than three children (Hien and Hoa 2009).

3 Methodology

3.1 Theoretical framework for model

The etiology of malnutrition is complex. Poor nutritional status is a result of a combination of basic physiological developmental processes, genetic factors, family factors, environmental conditions, and macro-level factors. In the modeling the malnutrition of children living within a multi-person unit called household, we have to look the household which maximizes a preference function:

$$U = U\left(N^i, F^i, L^i, Z^i\right) \qquad i = 1, 2, 3, \ldots, n \tag{1}$$

Household preferences depends on the nutritional health (N^i), food and nonfood consumption (F^i and Z^i respectively) and leisure (L^i) of individual i. All these are define as vectors with several dimensions. The utility derived by the household is maximized subject to (1) an income or budget constraint at given prices (p), and (2) the nutrition-production function. The health and nutrition of child i is produced by a number of explicit and implicit behavior and characteristics relating to food consumption (F^i), amount of time devoted to child care (T^i), and individual child characteristics (A^i)—observed and unobserved—such as age, sex, genetic endowments, education, as well as household characteristics (M^i) like parental education, parental genetic endowments and other observed and unobserved household and community factors (e^i), including prices. The nutritional production-function for child i may therefore be formalized in the following relations:

$$N^i = f^i\left(F^i, T^i, A^i, M^i, e^i\right) \qquad \text{where } i = 1, 2, \ldots, n \tag{2}$$

Equation (2) used in examining the determinants of children's nutritional status is now commonly used in recent literature. The main estimation equation to be used in the present study derived from this model is expressed as:

$$Z\text{-scores } HA,\ WA,\ WTHT = f\left(AGE_{ij},\ SEX_{ij},\ BORD_{ij},\ BINT_{ij},\ MEDU_{ij},\ MBMI_{ij},\ BF_{ij},\ DIAR_{ij},\ FEVER_{ij},\ COUGH_{ij},\ WEALTH_{ij},\ HHS_{ij},\ NCH_{ij}\right) \tag{3}$$

where Z-score HA, Z-score height for age; Z-score WA, Z-score weight for age; Z-score WTHT, Z-score weight for height; AGE, age of child in months; SEX, sex of child; BORD, birth-order of child; BINT, birth-interval; MEDU, mother's education; MBMI, mother's Body Mass Index; BF, breastfeeding; DIAR, diarrhea; FEVER, fever; COUGH, cough; WEALTH, Wealth Index; HHS, household size and NCH, number of children in household.

Equation (3) is the general form of series of functions, to be used for three measures of malnutrition separately and for urban and rural children discretely.

3.2 Anthropometric measurement standards

Analysis of malnutrition in children requires the basic concept of anthropometric measurement standards. Generally stunting, wasting and underweight are estimated by comparing anthropometric measurements against international or local Anthropometric Standards. DHS surveys were using 1977 National Child Health Survey (NCHS) reference, but recently they started using 2006 WHO Growth Standards to estimate prevalence of malnutrition among children. The 2006 WHO Growth Standard used data of those children, who grow under optimal conditions based on standard breastfeeding in their early years of life. It reflects a shift from descriptive approach to a prescriptive approach to access nutritional status of children.

The major drawback of using the 1977 NCHS reference was that it was based on children from a developed country which were mostly bottle-fed. It cannot be applied for all children of the world. The 2006 WHO Growth Standard is based on survey conducted in different parts of the world using criteria that would help children to achieve optimal growth and genetic potential.

The 2006

WHO Growth Standard is based on the assumption that every child from every group has same genetic potential for growth (Kothari et al. 2009). In a number of studies, wasting and stunting was found higher using the 2006 WHO Standards than the 1977 NCHS Reference. The breastfed children have been found higher prevalence of underweight in early infancy and lower afterward (de Onis et al. 2006). A study in Pakistan showed that wasting and stunting was higher according to 2006 WHO Standards as compared to 1977 NCHS reference (Nuruddin et al. 2008). Weight-for-height, height and weight-for-age was found higher in Peru, Vietnam and the Indian state of Andhra Pradesh for the children aged 6–18 months when 2006 WHO standards were used (Fenn and Penny 2008). We are going to analyze the malnutrition in children using DHS. It is the novelty of the study that we are using the 2006 WHO Growth Standard. By doing so, there may be differences in results as compared to the pervious studies.

3.3 Characteristics of variables in BDHS

The 2007 BDHS is the fifth DHS of Bangladesh. It is nationally representative survey and covers the entire population. We will use the Bangladesh Demographic and Health Survey (BDHS) 2007 for estimation of determinants of malnutrition in children. The 5,258 observations have been included in the current analysis (1,813 for urban and 3,427 for rural areas). The background characteristics of variables of BDHS and their expected effect on nutritional status of children are discussed here as.

3.3.1 Child's age and sex

In the BDHS the age of the child was calculated by subtracting date of child's measurement from child's date of birth. For analysis we have used the age of child as continuous variable. The child's sex is self-explanatory as binary variable. Male children have higher morbidity in most cultures. In others, neglect and infanticide may invert this biological relationship. In these cultures, families strive to meet their gender goods (see Rutstein 2008). The child age and sex may affect the nutritional status of children positively or negatively depending upon the socioeconomic situation of the economy. However the effect may differ for urban and rural areas.

3.3.2 Child's birth-order and interval

Birth-order gives a number in which the child was born. Birth-interval is calculated difference between the current and previous birth, counting twins as one birth. Birth-order has been taken as continuous variable while birth-interval as binary variable for the children having less than or equal to 24 months, or otherwise. It is speculated that child's birth-order may affect the nutritional status of children positively or negatively. Conceptually the birth-interval would result into good nutritional status of children in both urban and rural areas.

3.3.3 Mother's education

In the survey, the mother's education is coded into four categories, i.e. no schooling, primary schooling, secondary and collage or higher schooling. The first category serves as the reference group because the category is assumed to be the most disadvantageous. All these categories have been included in the analysis and it is hypothesized that it would result into increased nutritional status of children in both urban and rural areas.

3.3.4 Mother's BMI

Mother's Body Mass Index (BMI) represents better picture of mother's health than height and weight alone. A BMI less than 18.5 in women is considered as under-nutrition (Pullum 2008). We have included the variable as dummy variable. It is speculated that children from under-nourished mother would have been higher probability to be malnourished.

3.3.5 Months of breastfeeding

In the survey the duration of breastfeeding was calculated if the respondent was still breastfeeding the child or the child was breasted until death. In the analysis the breastfeeding was taken as continuous variable. Conceptually it is expected that breastfeeding results into good nutritional status of children in urban as well as rural households.

3.3.6 Diarrhea, fever and cough

In the survey the incidence of diarrhea, fever and cough in last two weeks were recorded. We have used these three variables as dummy variables. The interaction of malnutrition and infection is the leading cause of morbidity and mortality in most of the developing countries. In a vicious cycle, infections make malnutrition worse and poor nutrition increases the susceptibility to and severity of infectious diseases like diarrhea, fever and cough or acute respiratory infection (ARI) (Mukuria et al. 2005). We hypothesize the positive impact of incidence of these diseases on malnutritional status of children in both urban and rural areas.

3.3.7 Wealth index

The wealth index is an index of household socioeconomic status. It is used due to large number of inequalities in household income, health outcome and use of health services (Rutstein et al. 2000). The wealth index is constructed from household characteristics (having electricity, type of source of drinking water, access to sanitation facility, availability of cooking fuel, main roof material, main wall material and floor material) and ownership of durable goods (wardrobe, table, chair or bench, watch or clock, radio, television, bicycle, sewing machine and telephone) and land ownership. BDHS has divided the index into quintiles lowest to highest. The same quintiles have been included in the analysis. The inclusion of the items in construction of wealth index has the justification. For instance, incidence of diarrhea is associated with type of flooring, source of water and sanitation system. Radio and television showed the ability to receive health massages by mass media. Vehicle explains the possibilities of emergency medical transportation. The more person per sleeping room and non-electric source of lighting is related with increase in risk of being respiratory illness (Rutstein and Kiersten 2004 for more details). We hypothesized that wealth index influence the nutritional status of children positively.

3.3.8 Household size

The household size is simply the number of household members. It has been given in the survey and is used in the same form. A number of studies have used the household size as a continuous variable. We have taken this variable in binary form, i.e. household members are equal or less than four, and otherwise.[1] Conceptually the large household size results into lower per-capita expenditure on children welfare including health, education and recreation. It may be called as income dilution effect. However in the context of combined family system in South Asia, the large family size may affect the nutritional status of children positively. It is based on the fact that large number of household members pools the household income that results into welfare of children. Moreover, in the combined and large families, when the mothers are at work the other family members care the infants, resulting into good health status of children. For the rural and urban communities the effect of large families may differ. In rural areas where combined family system is prevalent, the large family size may affect the nutritional status positively. On the other hand in the urban areas where combined family system is comparatively rare the effect may be negative.

3.3.9 The number of children in the household

The number of children in the household is self-explanatory. We have included the number of children as a dummy variable i.e. number of children less than or equal to two and otherwise. It may be included as continuous variable, as a number of studies have used it in this form. The effect of number of children in the household is expected to be negative on the nutritional status of the children based on the income dilution effect for children in both urban and rural areas.

3.3.10 Urban and rural areas

In the survey, the place of residence where the respondent was interviewed either urban or rural was not the respondent's own categorization, but based on whether the cluster or sample point was located in urban or rural area. Urban areas were classified into towns, small cities which had population of over 50,000 and big cities including capital cities and cities which had population of over one million. The rural areas were assumed to be countryside. The classification of urban and rural areas in the survey has been used in the analysis.

3.4 Model estimation

The binary logistic regression of three indices of malnutrition, i.e. wasting, stunting and underweight for urban and rural areas have been run separately. Whole of the analysis is comprised of series of models, i.e. three models of each indicator of malnutrition and two sets of urban and rural households.

The stunting, wasting and underweight children have been defined as follows: The children whose height-for-age, weight-for-age and weight-for-height Z-score is less than −3.0 slandered deviations (SD) below than mean on the 2006 WHO Growth Standards are taken as severely stunted, underweight and wasted children. The children below −2.0 SD are taken moderately stunted, underweight and wasted respectively. The Z-scores are sensitive to a little change in age. Children weight-for-age Z-scores above +6 SD or below −6 SD, or with height-for-age Z-scores above +6 SD or below −6 SD and weight-for-height Z-scores above +6 SD or below −6 SD are regarded as invalid for analysis and excluded from the data for estimation. Similarly, the combinations of Z-scores where weight-for-age is above +3.09 SD and height-for-age is less than −3.09, or weight-for-age is below than −3.09 SD and height-for-age is above than +3.09 SD are also flagged as invalid data.

[1] Some of the studies have created such type of categories for nuclear families and combined families.

Table 2 Operational definitions of variables

Variables	Definitions
Dependent variable	
MSC (malnutritional status of child)	1 if the child is malnourished (stunting, wasting and under-weight), 0 otherwise
Explanatory variables	
AGE (child's age in months)	Child's age in completed months
SEX (child's sex)	1 for male, 0 for female
BORD (child's birth-order)	Child's birth-order
BINT (birth-interval)	1 for >24 months, 0 for ≤24 months,
MEDU (mother's education)	0 illiterate, 1 for primary, 2 for secondary, 3 for collage and higher
MBMI (mother's Body Mass Index)	0 for <18.5, 1 for ≥18.5
BF (breastfeeding)	Months of breastfeeding to child
DIAR (diarrhea)	1 if diarrhea in the last 2 weeks, 0 otherwise
FEVER (fever)	1 if fever in the last 2 weeks, 0 otherwise
COUGH (cough)	1 if cough in the last 2 weeks, 0 otherwise
WEALTH (Wealth Index)	0 for poorest, 1 for poorer, 2 for middle, 3 for richer, and 4 for richest.
HHS (household size)	1 if the number of household members are ≤ 4, 0 otherwise
NCH (number of children 5 or under 5 years)	1 if the number of children in the household are ≤2, 0 otherwise

The operational definitions of the dependent and explanatory variables have been shown in Table 2.

4 Results and discussion

The results of binary logistic regression for wasting, stunting and underweight for both urban and rural areas are presented in Tables 4 and 5 respectively. The percentage estimates of these measures of malnutrition for urban and rural areas are shown in Table 3.

4.1 Child's age

The nutritional status of a child varies by age. Varying levels of food intakes and healthcare are required at different stages of age. Infants of fewer than six months are recommended only breastfeeding with no other food. At this level infants need extra care than older children. The loss of weight at this stage may become cause of carrying poor health in future life. From age 6–9 months, solid food with continued breastfeeding is recommended up to 2 years and after that nutritionally adequate diet is recommended. The literature evidenced both positive and negative relation between child's age and nutritional status. The probability of malnutrition was found higher among older children (Mozumder et al. 2000 for Bangladesh; Wamani et al. 2007 for Uganda; Rahman and Chowdhury 2007 for Bangladesh; Giroux 2008 for only stunting Sub-Saharan Africa; Das and Rahman 2011 for Bangladesh). Age of child showed negative relationship with malnutrition (Choudhury et al. 2000 for Bangladesh). However, the age of child showed no effect on child health status in Zimbabwe (Mbuya et al. 2010).

In the existing literature in Sub-Saharan Africa (SSA), the wasting was found lowest among children below than 6 months of age. Wasting increases in the age from 6 months to 2 years, i.e. it increases after the introduction of solid food. The higher illness may be the main cause of this phenomenon. In most of the countries of Asia, there was high rate

Table 3 Percentage estimates of malnutrition in children

Background characteristics	Rural			Urban		
	(Stunting) Height-for-age	(Wasting) Weight-for-age	(Under-weight) Weight-for-height	(Stunting) Height-for-age	(Wasting) Weight-for-age	(Under-weight) Weight-for-height
Age (child's age in months)						
<6	19.0	29.5	17.8	12.7	21.7	19.9
6–9	24.5	28.2	17.2	20.9	20.9	11.9
10–11	19.8	35.4	31.3	30.8	20.0	16.9
12–17	34.5	39.1	24.9	24.5	26.0	20.8
18–23	49.4	46.1	24.9	42.1	35.6	17.1
24–35	57.1	48.8	18.0	43.1	36.2	14.0
36–47	57.3	47.7	14.1	45.8	39.4	12.9
48–59	49.4	48.8	15.7	37.1	41.1	12.9
Sex of child						
Male	45.8	41.9	19.5	37.5	34.1	16.4
Female	45.2	45.3	17.3	33.8	33.1	13.7
Birth-order of child						
1	42.1	40.2	17.9	31.5	30.8	12.5
2–3	43.9	43.7	18.9	33.0	31.2	15.7
4–5	50.0	46.2	20.4	51.0	42.2	17.7
6+	55.6	50.2	13.4	51.1	53.3	21.1
Birth interval in months						
≤24	45.3	42.2	17.1	36.6	34.7	14.4
>24	45.7	44.7	19.4	35.1	32.8	15.7
Mother's education						
No education	53.4	49.2	20.1	48.6	47.8	19.0
Primary	48.7	47.0	19.7	47.4	44.6	17.0
Secondary	37.5	37.2	15.7	28.2	25.4	13.2
Collage and higher	29.2	29.2	18.1	12.0	10.6	10.2
Mother's BMI						
<18.5	49.9	52.1	23.4	46.7	50.2	22.8
≥18.5	43.1	39.0	15.6	32.2	28.1	12.6
Breastfeeding months						
≤6	25.8	31.8	17.0	19.2	20.8	14.6
7–12	30.2	32.7	21.4	29.7	25.9	14.6
13–36	51.0	46.7	18.3	40.0	37.0	15.3
37+	60.6	52.2	17.5	47.7	17.5	16.2
Incidence of diarrhea						
No	45.2	42.9	17.5	34.9	32.9	14.5
Yes	48.2	49.7	29.6	43.6	40.3	22.7

Table 3 continued

Background characteristics	Rural			Urban		
	(Stunting) Height-for-age	(Wasting) Weight-for-age	(Under-weight) Weight-for-height	(Stunting) Height-for-age	(Wasting) Weight-for-age	(Under-weight) Weight-for-height
Incidence of fever						
No	44.7	41.7	17.3	34.7	31.7	13.7
Yes	46.8	46.6	20.2	37.7	37.1	17.7
Incidence of cough						
No	44.7	42.4	18.0	35.3	32.7	14.7
Yes	46.9	45.6	19.0	36.7	35.6	16.1
Wealth Index						
Poorest	54.6	52.1	21.1	56.3	52.3	16.4
Poorer	50.7	46.1	18.0	47.4	45.5	20.6
Middle	42.3	42.1	18.1	43.5	43.9	18.7
Richer	37.8	37.5	17.4	39.2	36.1	15.0
Richest	26.3	26.3	14.0	26.3	24.0	12.7
Number of household member						
≤ 4	45.1	42.1	18.1	37.8	35.0	15.3
>4	45.7	44.2	18.5	35.0	33.1	15.1
Number of children under 5 years						
≤ 2	45.5	43.9	18.6	35.3	33.2	14.7
>2	45.5	41.1	16.1	42.3	39.2	21.5
Total	38.9	37.2	15.7	35.8	33.6	15.1

of wasting among children age 10–24 months. Differences in infant feeding patterns among the communities may be the major cause of high wasting in this age group (Mukuria et al. 2005).

Our results have shown that by increase in child's age the risk of being stunting augments in urban and that of stunting and wasting increases in rural areas of Bangladesh. The increasing pattern of malnutrition in children by age is consistent with the typical pattern of increasing prevalence of childhood diseases by age such as diarrhea and acute respiratory infections. This may partly be due to beginning of feeding solid foods to a child around 6 months of age, which increases the likelihood of consuming contaminated foods and removes the inherent protection provided by breast milk. Additionally, children begin crawling around this age and are more likely to be carried out side, which explores them to additional infections (Hong et al. 2006).

The results have shown that the effect of age on malnutrition is more elastic in rural areas (see also, Mozumder et al. 2000; Mian et al. 2002; Wamani et al. 2007; Rahman and Chowdhury 2007; Giroux 2008; Hien and Hoa 2009; Das and Rahman 2011). It reflects the lack of child health facilities, poor education and lower level of income in rural area of Bangladesh. The results are supported by the urban and rural indicators of nutritional status of children reflecting poor nutritional status of children in Bangladesh (see Table 3). It revealed that most parents of Bangladesh are failing to fulfill optimal food requirements of their children. The infants may be wasted due to two reasons, (i) diarrhea may cause loss

Table 4 Results of binary logistic regression for urban children

Co-variables	Coefficient (S.E., p value)		
	(Stunting) Height-for-age (< −2.00)	(Wasting) Weight-for-age (< −2.00)	(Under-weight) Weight-for-height (< −2.00)
Age (child's age in months)			
	.009 (.004, .036)*	.005 (.004, .203)	−.019 (.006, .002)*
Sex of child (female as reference)			
Male	.174 (.105, .099)**	.042 (.108, .698)	.192 (.135, .154)
Birth-order (child's birth order)			
	.157 (.043, .000)*	.097 (.043, .025)*	.055 (.052, .296)
Birth interval (months) (<24 months as reference)			
>24 months	−.434 (.125, .001)*	−.401 (.127, .002)*	−.020 (.156, .896)
Mother's education (no education as reference)			
Primary	.102 (.146, .486)	−.060 (.147, .685)	−.083 (.186, .654)
Secondary	−.463 (.160, .004)*	−.639 (.163, .000)*	−.195 (.206, .345)
Collage and higher	−1.326 (.243, .000)*	-1.475 (.253, .000)*	−.255 (.284, .370)
Mother's BMI (thinness <18.5 as reference)			
Normal > 18.5	−.327 (.120, .007)*	−.700 (.121, .000)*	−.652 (.146, .000)*
Breastfeeding (months)			
	.023 (.006, .000)*	.029 (.006, .000)*	.017 (.008, .043)*
Incidence of cough (in last 2 weeks) (no as reference)			
Yes	−.034 (.141, .810)	−.052 (.144, .720)	−.199 (.177, .262)
Incidence of diarrhea (in last 2 weeks) (no as reference)			
Yes	.313 (.173, .070)**	.249 (.175, .155)	.473 (.199, .017)*
Incidence of fever (in last 2 weeks) (no as reference)			
Yes	.092 (.140, .509	.214 (.142, .133)	.310 (.173, .073)*
Wealth Index (poorest as reference)			
Poorer	−.209 (.238, .379)	−.052 (.239, .828)	.408 (.303, .178)
Middle	−.370 (.232, .110)	−.100 (.233, .668)	.352 (.299, .238)
Richer	−.406 (.222, .067)*	−.281 (.224, .210)	.147 (.291, .615)
Richest	−.632 (.217, .004)*	−.471 (.219, .031)*	.079 (.285, .782)
Number of household members (more than four as reference)			
Less than 4	.299 (.122, .014)*	.207 (.125, .097)**	.133 (.156, .397)
Number of children in household (5 and under) (more than two as reference)			
Less than 2	−.429 (.204, .036)*	−.447 (.208, .032)*	−.608 (.241, .012)*
Constant	−.352 (.339, .300)	−.019 (.344, .956)	−.946 (.424, .026)*

* Represents 5% level of significance and ** represents 10% level of significance

of weight in infants (less then 6 months) as compare to older children (48–59 months) and (ii) the incidence of being cough in last 2 weeks was higher in infants (less than 6 months) as compared to children of aged 48–59 months in both urban and rural areas. But it was higher in rural areas as compared to urban ones. It explained that during infancy the children of rural areas are more wasted due to lack of better health facilities in the locality and low

Table 5 Results of binary logistic regression for rural children

Co-variables	Coefficient (S.E., *p* value)		
	(Stunting) Height-for-age (< −2.00)	(Wasting) Weight-for-age (< −2.00)	(Under-weight) Weight-for-height (< −2.00)
Age (child's age in months)			
	.016 (.003, .000)*	.008 (.003, .004)*	−.013 (.004, .001)*
Sex of child (female as reference)			
Male	−.008 (.072, .906)	−.167 (.071, .019)*	.139 (.090, .122)
Birth order (child's birth order)			
	.044 (.025, .078)**	−.002 (.025, .929)	−.096 (.033, .004)*
Birth interval (months) (<24 months as reference)			
>24 months	−.246 (.083, .003)*	−.059 (.082, .471)	.228 (.105, .030)*
Mother's education (no education as reference)			
Primary	−.040 (.094, .671)	.042 (.093, .648)	−.062 (.115, .590)
Secondary	−.279 (.107, .009)*	−.165 (.106, .119)	−.309 (.134, .021)*
Collage and higher	−.371 (.218, .089)**	−.282 (.216, .192)	−.066 (.257, .797)
Mother's BMI (Thinness <18.5 as reference)			
Normal > 18.5	−.165 (.076, .031)*	−.448 (.075, .000)*	−.443 (.092, .000)*
Breastfeeding (months)			
	.022 (.004, .000)*	.017 (.004, .000)*	.007 (.005, .222)
Incidence of cough (in last 2 weeks) (no as reference)			
Yes	.166 (.096, .083)**	.044 (.095, .644)	−.168 (.118, .156)
Incidence of diarrhea (in last 2 weeks) (no as reference)			
Yes	.126 (.120, .296)	.249 (.119, .036)*	.464 (.135, .001)*
Incidence of fever (in last 2 weeks) (no as reference)			
Yes	.073 (.095, .438)	.219 (.094, .019)*	.227 (.116, .050)*
Wealth Index (poorest as reference)			
Poorer	−.066 (.099, .505)	−.160 (.098, .103)**	−.169 (.123, .169)
Middle	−.386 (.105, .000)*	−.303 (.104, .004)*	−.162 (.130, .213)
Richer	−.499 (.120, .000)*	−.410 (.118, .001)*	−.111 (.149, .456)
Richest	−.931 (.165, .000)*	−.815 (.163, .000)*	−.284 (.206, .169)
Number of household members (more than four as reference)			
Less than 4	−.053 (.089, .550)	−.168 (.088, .056)**	−.121 (.110, .272)
Number of children in household (5 and under) (more than two as reference)			
Less than 2	−.140 (.133, .294)	−.021 (.132, .873)	.111 (.172, .519)
Constant	−.567 (.196, .004)	−.223 (.193, .248)	−.827 (.246, .001)*

* Represents 5% level of significance and ** represents 10% level of significance

educational status of mothers. The results have further shown that short-run indicators of child's malnutrition that is under-weight reduces as age increases in both rural and urban areas of Bangladesh (see Choudhury et al. 2000). The effect of age in this case is more elastic in urban as compared to rural areas.

4.2 Child's birth-order and birth-interval

There are evidences of impact of birth-order of the child on child's ability and intelligence (Kristensen and Bjerkedalz 2007). The first born child has higher level of intelligence and cognitive ability than later born siblings because he has availed larger investment being the first child (Khan and Azid 2011 for Pakistan). There is also evidence of significant relationship between child's birth-order and allocation of resources to child (Behrman 1988; Horton 1988). Similarly in the literature the child's birth-order is also found related with malnutrition. Child's higher birth-order positively affects the malnutrition (Ukwuani and Suchindran 2003). For the birth-interval there are evidences of its effect on nutritional status of children. The nutritional status of child starts getting better as birth-interval lengthens and reaches the length of 30–34 months (Rutstein 2008 for 52 developing countries).

In SSA four different patterns emerged regarding relationship between malnutrition and birth-order: (i) In most countries there was positive relation between stunting and birth-order. It shows the reflection of poverty because large families have less food per-capita available as compared to small families. (ii) In six countries stunting was not related to child's birth-order. The stunting was higher in all birth-orders. It reflects the very high level of poverty in these countries. (iii) In other five countries the relationship was U-shaped. The main cause of this pattern is the improvement in child feeding patterns with increase in experience and knowledge of mother along with improvement in health and nutrition practice but at higher birth-order poverty negates this improvement. (iv) Mozambique has a unique pattern, i.e. the stunting deceases with birth-order. The south Asia has positive relationship of stunting with birth-order.

The pattern of underweight is similar to pattern of stunting in most regions of world, underweight increases by increase in birth-order. In SSA the picture is different, three countries reflect the relationship is of J-shaped and some countries showed U-shaped distribution and four countries showed no relationship between birth-order and underweight.

In our analysis the stunting and wasting in urban areas and only stunting in rural areas are positively related with birth-order (see also Ukwuani and Suchindran 2003). The effect is more elastic in urban areas as compared to rural ones. The rural–urban difference may be due to the existence of joint family system in rural areas. The family members in rural areas are available to take care of children because it may be difficult for mother to take care large number of children.

The under-weight reduces in rural areas as birth-order increases. Under-weight is a short-run indicator of health and the result reflects the betterment in the knowledge of mother about child health and feeding practices as the births to woman increases in rural areas (see also Mukuria et al. 2005). It is partially corroborated with the rural–urban differences in stunting and wasting as both increases in rural areas but at comparatively less intensity as compared to urban areas.

Our estimates have shown that the risk of being malnutrition decreases with the increase in birth-interval. The birth-interval of more than 24 months slides down the risk of being stunting and wasting in urban areas and stunting in rural areas of Bangladesh (see also Ibrahim 1999 for Pakistan; Mozumder et al. 2000 for Bangladesh). The results are supported by percentage estimates where 36.1, 34.7 and 14.4% children with less than 24 months birth-interval were stunted, wasted and underweight as compared to 35.1, 32.8 and 15.7% with more than 24 months birth-interval in urban areas and 45.3, 42.2 and 17.1 as compared to 45.7, 44.7 and 19.4% in rural areas of Bangladesh respectively (see Table 3). The larger birth-interval between two births allows the batter use of resources towards child, which ultimately improves the child's nutritional status. Biologically the larger birth-interval enhances the productive strength of the mother and maintains the reproductive health of mother. For the new-born the larger birth-interval results into better care of new-born and more time allocation for the nutrition and health. The larger birth-interval also enhances the breastfeeding duration of the new-born. The resource may also be the factor as more resources are required by the household for caring the mother and new-born during pregnancy as well as in infancy. The smaller birth-interval means requiring new resources within small span of time as compared to comparatively larger birth-interval. For the poor families it becomes difficult to bear expenditures related with child-birth and child bearing within small span of time. Generally larger number of children and smaller birth-interval in poor families aggravate the problem. The results clearly support the proposal of larger birth-interval for good nutritional status of children.

There emerged the strange phenomenon of increase in under-weight by large birth-interval in rural areas of Bangladesh. Although the rural areas have specific characteristics but the phenomenon needs explanation. The result is also supported by the percentage estimation.

4.3 Child's sex

The literature revealed that the gender has great effect on nutritional status of a child. It reflects different patterns of relationship. Girls are more likely to be severely malnourished than boys (Choudhury et al. 2000; Khan and Azid 2011 for Pakistan), because parents perceive that boys are bread-winners and supporters in old-age. On the other hand, higher prevalence of malnutrition was observed in boys than girls for a number of countries (Mian et al. 2002 for Pakistan; Ukwuani and Suchindran 2003; Giroux 2008 for Sub-Saharan Africa; Hien and Hoa 2009 for Vietnam; Mbuya et al. 2010 for Zimbabwe). More males were found stunted in poor social economic status than in the batter status as compared to girls (Wamani et al. 2004). However, Bourne (2009) found no statically significant relationship between health condition and sex of children in the age group of up to 14 years.

In South and Southeast Asia the female children are more likely to be stunted than male children. In SSA the male children are more stunted, except Eritrea where female children are more stunted. In Latina America male children have more probability to be stunted than female children, except one country (Peru) where the rate is same for males and female children (Mukuria et al. 2005).

Our results revealed that male children are more likely to be stunted in urban areas of Bangladesh (see Mian et al. 2002 for Pakistan; Ukwuani and Suchindran 2003 for Nigeria; Giroux 2008 for Sub-Saharan Africa; Hien and Hoa 2009 for Vietnam; Mbuya et al. 2010 for Zimbabwe). On the other hand in rural area the female children are more likely to be wasted. In other words female children have advantage over males in nutritional status in urban areas and disadvantages in rural areas of Bangladesh. This may be due to moderate economic and cultural system in urban areas and low level of female empowerment in rural areas of Bangladesh.

4.4 Mother's education

It is an irony that literacy rate and enrollment of females in primary education is less in South Asia as compared to other regions of the world (Mehrotra 2006). Bringing the level of mother's education up to primary level may reduce the wasting of children by 6.8 percent in Pakistan (Garcia and Alderman 1989 for Pakistan). The health status of children whose mothers were illiterate was worse than that of those mothers who passed primary level of education (Wamani et al. 2004 for Uganda). The reason may be the transferring of knowledge about child health and feeding practice through mother's schooling. An educated mother adopts such long-term measurements which secure child health. She provides good health care, hygienic food and nutrition that contribute to gain height and weight of child (Khan and Azid 2011 for Pakistan). Some studies reflect that mother's educational level had negative effect on child growth and health status (for instance, Ukwuani and Suchindran 2003 for Nigeria; Mbuya et al. 2010 for Zimbabwe). It demonstrates that during childhood mother's education remains less important than other household resources as it could not generate necessary income for substitutes of breastfeeding. Another example is of Mozambique where the children of mothers with secondary or higher education are more wasted than children of less educated mothers (Mukuria et al. 2005). In some other studies, mother's educational level was found insignificant with all indices of malnutrition (Hien and Hoa 2009 for Vietnam; Choudhury et al. 2000 for Bangladesh).

Our analysis explained that in urban areas of Bangladesh the secondary levels of education and collage and higher level of education of mothers negatively influence the stunting and underweight in children (see also Das and Rahman 2011 for Bangladesh). However the primary level of education has no significant effect on nutritional status of children. In rural areas the secondary level of education as well as collage and higher education of mother negatively influence the stunting. The secondary level of education of mothers also reduces the probability of under-weight of children in rural areas. Like the urban areas the primary education has no significant impact on child's nutritional status. There are important policy implications of mother's education regarding child's nutritional status. Generally the economists stress on compulsory primary education as well as adult literacy programs focusing on primary education. In the context of child's nutritional status at least secondary education for females is required. Bangladesh should focus on compulsory secondary level of education for all. In the long-run it will result into increasing the nutritional status of children.

The explanation for positive impact of mother's education on nutritional status of children may be through the employment status of the woman. It is also likely that effect is through the knowledge and awareness of mother regarding child's health-care. Another possibility may be that educated women have socioeconomic empowerment. The mothers with higher education significantly contribute in household income. They are actively involved in domestic life and their knowledge from education about child health and feeding practice may cause reducing risk of malnutrition in children. The findings by Mukherjee et al. (2008, for India) supports the results of current study by explaining that educated females marry late than illiterates. The early child-birth adversely affects child and mother's health. Furthermore, educated women have higher child interval and fewer children and they give better child health-care and medical attention.

4.5 Mother's BMI

The literature on nutritional status of children explains that mother's nutritional status (BMI) positively contributes to child's health and nutritional status. There is high probability that a woman with poor nutritional status has greater risk to give low birth baby. Black (1999) concluded that two-third of low birth-weight children born in developing countries were low birth-weight only due to intrauterine growth retardation (IUGR). A major contribution to malnutrition in children and a risk factor of illness in children is IUGR (Ramakrishnan et al. 1999). Hien and Hoa (2009, for Vietnam) evidenced that mother's lower BMI enhance the probability of underweight of children.

Globally, stunting, wasting and underweight have been found higher among children whose mothers were malnourished as compared to those whose mothers were adequately nourished (having BMI in between 18.5 and 24.9), except Uzbekistan where underweight and stunting in children was found higher among mothers with normal and lower BMI (Mukuria et al. 2005).

Our results have shown that mother's BMI negatively influence the three indices of malnutrition in both urban and rural areas of Bangladesh. The effect is more elastic in urban areas than in rural ones. It demonstrates the intergenerational cycle of under-nutrition in Bangladesh (see also, Victora et al. 2008; Mbuya et al. 2010 for Zambia; Das and Rahman 2011 for Bangladesh). The result is corroborated with percentage estimates. The stunting, underweight and wasting in children from mothers with below 18.5 BMI are found 49.9, 52.1 and 23.4 (46.7, 50.2 and 22.8)% and those from mothers with ≥18.5 BMI are found 43.1, 39.0 and 15.6 (32.2, 28.1 and 12.6)% in rural (urban) areas (see Table 3).

4.6 Duration of breastfeeding

In the literature, both kinds of evidences of negative and positive impact of breastfeeding on nutritional status of children is found. It is evidenced that breastfeeding duration negatively affects the wasting during infancy and positively affects the stunting during both infancy and childhood. In Zimbabwe the children who were breastfed were found less likely to be stunted than those who were never breasted (Mbuya et al. 2010). A negative effect seems theoretically clear. The positive effect reflects that women feed their children for longer duration of time due to lack of resources to provide adequate food as supplement to breast-milk (Ukwuani and Suchindran 2003 for Nigeria).

The duration of breastfeeding varies largely in developing economies. In SSA, the median duration of breastfeeding ranges from 12 months (in Gabon) to 26 months (in Burkina Faso and Ethiopia). In North Africa and West Asia, it ranges from 12 months (in Jordan and Turkey) to 18 months (in Yemen and Egypt). The median of Central Asia is 16 months. The median range of South and Southeast Asia is from 21 months (in Cambodia) to 31 months (in Bangladesh and Nepal). Bangladesh that is our case study falls in the countries showing longer duration of breastfeeding practices.

Our estimation has shown that longer duration of breastfeeding positively influence the three indices of malnutrition in urban areas and two indices i.e. stunting and wasting in rural areas of Bangladesh. It is corroborated by the percentage estimates. The stunting, underweight and wasting was 25.8, 31.8 and 17.0 (19.2, 20.8 and 14.6)% in ≤6 months duration of breastfeeding and 60.6, 52.2 and 17.5 (47.7, 17.5 and 16.2)% in above than 37 months duration of breastfeeding in rural (urban) areas of Bangladesh (see Table 3). It reflects that mothers are breastfeed for long duration to fulfill the nutritional requirement of the children as a substitute of food supplements (see also Ukwuani and Suchindran 2003 for Nigeria). It may be concluded that breast-milk is good for health of infants but for older children supplement food is required because they need additional food for growth. On the results it is proposed that supplementary food should be given to the children for their proper growth.

4.7 Diarrhea, fever and cough

In the literature, there are conflicting results regarding the impact of illness in the form of diarrhea, fever and cough on nutritional status of children. For Vietnam the incidence of diarrhea within last 2 weeks was found not related with stunting, wasting and underweight by Hien and Hoa (2009). For Pakistan, the days of illness have been found to have weak negative effect on malnutrition in children by Garcia and Alderman (1989). Choudhury et al.

(2000) found that illness within last 2 weeks positively affects the malnutrition in Bangladeshi children.

Our estimates have shown that incidence of diarrhea within last 2 weeks positively influence stunting and wasting in urban areas and wasting and under-weight in rural areas of Bangladesh (see also Das and Rahman 2011 for wasting and under-weight in Bangladesh). The results are corroborated with the percentage estimates. For the stunting and wasting the percentages of children having diarrhea in last 2 weeks was 48.2 and 49.7% in rural areas and 43.6 and 40.3% in urban areas. The explanation may be that diarrhea may cause the loss of weight in short-run, and it affects wasting and under-weight. The high prevalence of diarrhea may cause the stunting.

Our estimates have further shown that the incidence of fever in the last two weeks increases the risk of being under-weight in urban areas and wasting and underweight in rural areas of Bangladesh (see Das and Rahman 2011). The percentage of children in all measures having fever in the last two weeks has been found higher in rural as compared to urban areas of Bangladesh (see Table 3). It represents better health care by parents and health facilities in urban settlements as compared to rural ones. So the impact of diarrhea and intensity of disease both are higher in rural areas. The urgent policy formulation and implementation is proposed for rural areas to decrease the incidence of disease and ultimately to reduce the malnutrition in children.

4.8 Wealth index

Generally, in the literature the household income, household per-capita income and assets are used as proxies for socioeconomic status of the households. They ultimately affect the household welfare including the child's education and health. Garcia and Alderman (1989) used the per-capita income to explain the malnutrition in Pakistani children. It was found significant for short-term nutritional index (wasting) but not for long-term index (stunting). However, for Vietnam, the results of hierarchical logistic regression showed that there was insignificant relationship between per-capita household income and three indices of malnutrition (Hien and Hoa 2009). Population income quintile was not found significant in Jamica to explain the nutritional status of children (Bourne 2009). In some studies, a strong relationship has been found between nutritional status of children and monthly family income (Mian et al. 2002 for Pakistan). However, wealth index is assumed to be a good proxy of socioeconomic status of the household. It has diverging effect on nutritional status of children. Household wealth in Nigeria had shown weak negative effect on wasting during infancy and positive effect on stunting during childhood (Ukwuani and Suchindran 2003).

The wealth index constructed by BDHS has two main principles regarding to measure economic status (i) the distribution of health services among the poor and (ii) the ability to pay for health services. The wealth index quintiles provide the information about ability to pay health expenditures. The distribution of health services to the poor can be better represented by wealth index as compared to income or expenditure index (Rutstein and Kiersten 2004). We have used wealth index as a proxy of socioeconomic status of the household. In urban areas it negatively influence the stunting (see Das and Rahman 2011 for Bangladesh; Mbuya et al. 2010 for Zimbabwe) in richer and richest class and wasting in richest class. In rural areas wealth index affects the stunting in middle, richer and richest classes, and wasting in all four classes. Under-weight is found not affected by wealth index both in urban and rural areas. It reflects that wealth index reduces the risk of malnutrition for long-run indices but not for short-run indices. Moreover wealth index is more effective in rural areas as compared to urban areas of Bangladesh.

4.9 Number of household members and children

Theoretically the household size may affect the nutritional status of children positively or negatively. There are evidences of strong impact of household size on Z-score implying the implies the enhancement of population programs in the economy. In India children from large families (more than five members) are found to be nutritionally suffered more than children from small families because of income dilution effect (Mukherjee et al. 2008; see also, Garcia and Alderman 1989 for Pakistan).

Our results have shown that the children from smaller households (having less than or equal to four members) are more likely to be stunted and wasted in urban areas. It represents that the risk of malnutrition is higher in smaller families in urban areas (see Mozumder et al. 2000 for Bangladesh). The explanation may be that in large families a household member resorts to increase the income of the household. On the other hand in rural areas the results are reverse, i.e. the risk of wasting declines for the children from smaller households. It reflects that fewer resources are left for each person in large families as compared to small families (see Mukherjee et al. 2008; Hien and Hoa 2009).

The composition of the household has an important place in household decisions regarding investment in children. The investment may be in the form of expenditures on nutrition particularly in the expenditures on nutrition of infants and under-five children and expenditure on schooling of children more than 5 years of age. The household may be composed of children, adults (may be employed or unemployed) and old-age persons. To detangle the role of composition in child's malnutrition we have included the number of children in the household as explanatory variable. Our results have shown that children from the households having less than or equal to two children (up to 5 years of age) are less likely to be stunted, wasted or under-weight in urban areas of Bangladesh. The results of same variable are insignificant for rural areas. It explains that the household size and number of children in the household are more effective drivers in urban areas as compared to rural ones. For the urban areas the explanation may be the income dilution effect. The higher number of children (up to 5 years age) has lesser share of resources.

5 Conclusion

The study concluded that there exists a urban-rural disparity in the intensity of malnutrition in Bangladeshi children. The birth-interval, mother's education and wealth index decrease the probability of child malnutrition in urban as well as rural areas. The duration of breastfeeding and low BMI of mothers enhance the probability of malnutrition. As a policy proposal it is recommended to utilize the population program for increasing the birth-interval of the children. The mother's education should be stressed for improved nutritional status of children. Two factors, i.e. duration of breastfeeding and BMI of mothers need further stress in policy formulation. The children need supplement food instead of breastfeeding at a specific age. In the absence of supplement food or its substitution with breast-milk results into malnutrition. As a policy program the supplement food may be provided to the children at subsidized rate. The low BMI of mothers requires attention for policy making in the long-run. At present the female children in the childhood and adolescents need good nutrition for their better BMI in their motherhood to break the inter-generational cycle of malnutrition. For the short-run to the mothers during pregnancy the good nutrition and supplement food would be provided to avoid the risk of malnutrition of new-borns.

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