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SOCIOECONOMIC AND DEMOGRAPHIC VARIATION IN NUTRITIONAL STATUS OF UNDER-FIVE BANGLADESHI CHILDREN AND TREND OVER THE TWELVE-YEAR PERIOD 1996–2007

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Summary. The nutritional status of under-five-year-old children is a sensitive indicator of a country's health status as well as economic condition. The objectives of this study were to analyse trends in the nutritional status in Bangladeshi children over the period 1996–2007 and to examine the associations between nutritional and socioeconomic status variables. Bangladesh Demographic Health Surveys (BDHS) were the source of data, and a total of 16,278 children were examined. The *Z*-scores of the children were analysed as continuous as well as categorical variables (stunted, underweight and wasted). The socioeconomic status variables used were region, urban–rural residence, education and occupation of the parents, house type and household possession score. A series of General Linear Model and Sequential Linear and Binary Logistic Regression analyses were done to assess the relationship between demographic and socioeconomic variables and nutritional status. The trends of *Z*-scores were analysed by survey, as well as by child birth cohort. Region, house type, educational level of parents and household possession score showed significant associations with all three *Z*-scores of children after removing the effects of age, period of DHS and other explanatory variables in the model. No significant sex difference was observed between any of the *Z*-scores. There were improvements in mean WAZ and HAZ between 1996 and 2007 but deterioration in mean WHZ over this period. The obesity rate was below 2% in 2007, although the absolute numbers of obese children had nearly doubled in this 12-year period. Children from poorer households showed greater improvement than their better-off counterparts. The study reveals that over the years there has been substantial improvement in nutritional status of under-five children in Bangladesh and

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the main gains have been amongst the lower socioeconomic groups; it is also evident that malnutrition in Bangladesh is a multidimensional problem, like poverty itself, and warrants a proper policy mix and programme intervention.

Introduction

Childhood malnutrition, both under- and over-, remains one of the main public health challenges of the 21st century, particularly in low- and middle-income countries (Victora *et al.*, 2010; WHO, 2015). At the endpoint of the Millennium Development Goals (MDGs), countries and the international community agreed that nutrition was one of the great missed opportunities of the past 15 years, and that despite progress, improvements in nutrition still represent a massive unfinished agenda (Horton & Lo, 2013). Overall 165 million children had stunted growth in 2011 and almost 3.1 million children under 5 years die every year from undernutrition, which is 45% of the total child deaths in 2011 (Horton & Lo, 2013). At the same time obesity in children is becoming a major concern and the World Health Organization (WHO, 2015) reported that 42 million children under the age of five worldwide were overweight or obese in 2013. So improving nutrition occupies a prominent place in the Sustainable Development Goals (SDG) for 2015–2030 recently approved by the international community.

Lowering undernutrition rates among children, along with reducing gender disparities, was one of the key MDGs for Bangladesh (United Nations, 2005). Since the 1990s, undernutrition in Bangladesh has declined gradually. However, the pace of this decline does not match the rapid improvements in other development indicators such as child and maternal mortality, education, poverty reduction and rice production (REACH Partnership, 2014). Despite some improvement, undernutrition remains serious and Bangladesh has failed to achieve the MDG-1 target of a child underweight rate of 33% by 2015. At the same time recent studies have revealed an increasing prevalence of overweight and obesity in school-aged children in Bangladesh (Bulbul & Hoque, 2014).

In order to determine the most effective strategies for reducing the burden of malnutrition and accelerating development, it is important that the determinants of malnutrition are known (Mohsena *et al.*, 2016). Moreover, the relationship between socioeconomic and demographic status and nutrition has important policy implications since international agencies currently tend to disregard nutritional status (as measured by anthropometry) as being a good predictor of poverty. In Bangladesh, Helen Keller International (HKI) reported only a 15% difference in the prevalence of stunting between the lowest and highest wealth quintiles (Helen Keller International/Institute of Public Health and Nutrition, 2006). This striking finding has been confirmed by other national surveys, which have shown that economic growth and greater household wealth are not strongly related to improved nutrition, with just over one in four under-five children (26%) being stunted and 12% wasted, even in the highest household wealth quintile – clear evidence that undernutrition is not restricted to the poor (REACH Partnership, 2014). However, in numerous studies socioeconomic status have been identified as a leading predictor of an individual's health (Pollack *et al.*, 2007; Mohsena *et al.*, 2010). In this context, this paper is an attempt to re-examine evidence on the

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linkage between the nutritional status of children and the socioeconomic status of the family using household survey data from Bangladesh.

Methods

The Bangladesh Demographic and Health Surveys (BDHS) were the source of data. These contain information on 9127, 10,544, 11,440 and 10,996 families in the 1996–1997, 1999–2000, 2004 and 2007 surveys, respectively (Mitra *et al.*, 1997; National Institute of Population Research and Training *et al.*, 2001, 2005, 2009). This study focused on the nutritional status of children, so only families with under-five children were considered. The socioeconomic and demographic variables included in the study were: education and occupation of the parents; region (six divisions); residence (urban/rural); housing condition (type of floor, wall and roof); ownership of radio, television, bicycle, motorcycle, telephone; availability of electricity; water supply; type of latrine; and family size. Education level was categorized as none, primary, secondary and higher. Occupation was categorized as none, services, sales, skilled manual, agricultural worker and household/domestic/unskilled labour. Water supply was categorized as surface water, tube well or piped water, and toilet facilities as none, sanitary and unsanitary latrines. Family size was categorized as 1–4, 5–8 and 9+ family members. From the available information on type of floor, roof and wall, housing condition was categorized into five types as all-thatched, tin roof, tin wall and roof, brick wall or roof and all-brick structure. A new variable called 'possession score' was created using information about ownership of radio, television, bicycle and availability of electricity. All those variables were binary, having 'yes' (1) or 'no' (0) categories, and adding these gave scores ranging from 0 to 4. The 'possession score' was chosen as a previous study in Bangladesh indicated that this provided much greater discrimination of undernutrition than the wealth index generated by the Principal Component Analysis technique (Mohsena *et al.*, 2010). Children without data on height, weight, age or sex were excluded. The *Z*-scores, for measuring nutritional status, were calculated and the cut-offs recommended by WHO were used. So if a child's height-for-age *Z*-score (HAZ) was below –6 or above +6, their weight-for-age *Z*-score (WAZ) was below –6 or above +5, their weight-for-height *Z*-score (WHZ) was below –5 or above +5 and their BMI-for-age *Z*-score (BAZ) was below –5 or above +5 they were excluded (WHO Multicentre Growth Reference Study Group, 2006). Children lacking any information on the selected socioeconomic and demographic variables were excluded. A total of 16,278 children with complete information were analysed, of whom 3560 were from the 1996–1997 survey (hereafter called 1996), 4039 from the 1999–2000 survey (hereafter 2000), 4731 from the 2004 survey and 3948 from the 2007 BDHS.

The *Z*-scores of the children were analysed as continuous, as well as categorical, variables. A *Z*-score of <-3.00 SD indicated severe undernutrition, while <-2.00 SD indicated underweight (WAZ), wasted (WHZ) or stunted (HAZ). Obesity was measured by using BMI *Z*-scores of $>+2.00$ SD. Trends of *Z*-scores were analysed by survey, as well as by birth cohort of the child. Four surveys were conducted in 1996–1997, 1999–2000, 2004 and 2007, while four birth cohort groups were generated at five-year interval as $\leq$1995, 1996–2000, 2001–2005 and $\geq$2006. A series of General Linear Model

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(GLM) analyses were used to analyse the relationship between demographic and socioeconomic variables and nutritional status. All the other explanatory variables in the model, the linear and quadratic effects of age and period of DHS were entered in the analysis before testing the variable of interest. When the *Z*-score was analysed as a categorical variable, Binary Logistic Regression (BLR) analyses were undertaken with the socioeconomic and demographic variables. For this, the usual cut-offs of <−2.00 *Z*-scores were considered for classifying child as undernourished.

Cramer's *V* was used to measure effect size. If its value was <0.1 there was negligible association; 0.1 to <0.2 indicated a weak association; 0.2 to <0.4 moderate association; 0.4 to <0.6 relatively strong association; 0.6 to <0.8 strong association; and 0.8 to 1.0 a very strong association (Mascie-Taylor, 2010).

Results

A total of 16,278 children aged 0–5 years (25.52 months ±16.48) were selected, of whom 50.8% were male and 49.2% female. The majority of children (70%) lived in rural areas. The overall mean WAZ, HAZ, WHZ and BAZ were −1.75, −1.87, −0.96 and −0.81, respectively. The means of all *Z*-scores were almost the same for male and female children in the pooled data, as well as in the four surveys separately (after Bonferroni correction as well) (Fig. 1).

The study found substantial increases in the percentages of children with normal nutritional status over the four surveys; in 1996–1997 half of the children were underweight and almost three-fifths were stunted, whereas in 2007 almost 60% of children fell in the normal range for both WAZ and HAZ. There was a reduction in the percentage with severe stunting over the four surveys, from 30% in 1996 to 16% in 2007. The percentage of children with severe underweight and wasting only fell between 1996 and 2000 (Fig. 2). Over the four surveys the percentage of children who were stunted fell from 57% to 41%, but the prevalence of underweight and wasting only fell substantially between 1996 and 2000. The results on the pooled data revealed that nearly half (47.3%) of the 0- to 59-month-old children were stunted, of whom 21% were severely stunted. Underweight and wasting prevalence were 41.7% and 16.8%, respectively, of which 14% were severely underweight and 4.2% were severely wasted. The rate of obesity among children increased from 0.8% to 1.4% over this time period.

For assessing the association of *Z*-scores and socioeconomic factors General Linear Model analysis on the pooled data was undertaken and the results are presented in Table 1. After controlling for age, period of demographic surveys and all other demographic and socioeconomic variables, educational level of parents, number of possessions, house type and toilet facilities were all strongly associated with WAZ scores. As the educational level of parents increased so did the child's mean WAZ score, and the difference between owning four possessions and none and between all-brick and all-thatched households was 0.3 SD. Children living in households with a sanitary toilet had, on average, a better WAZ than those living in households with either an unsanitary latrine or no toilet. Regional heterogeneity was present, with the highest WAZ mean in Khulna and lowest in Sylhet. The table also shows that upward trends of HAZ means were evident from no education to higher education of parents, and from poor to good housing. After controlling for all the other socioeconomic and

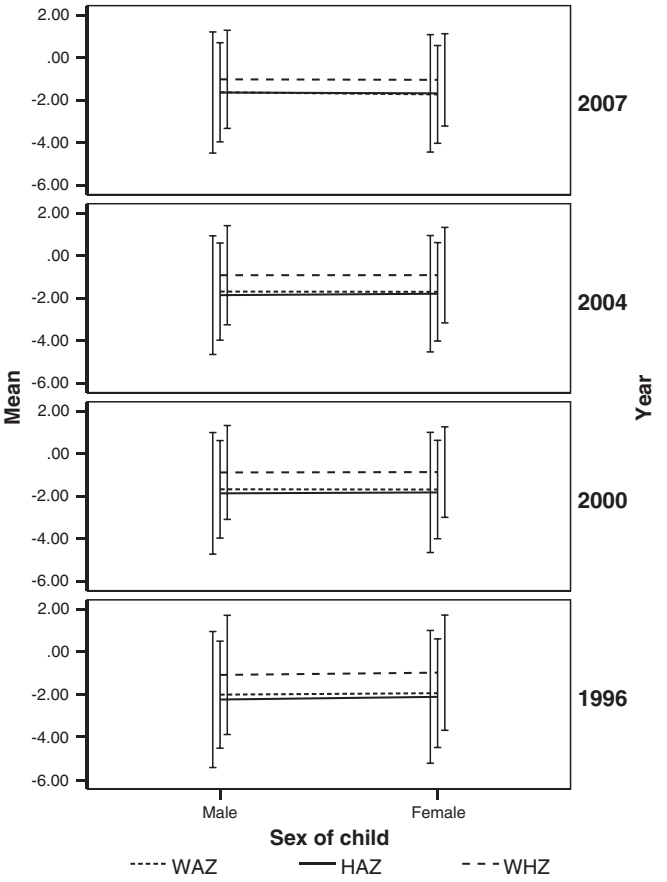

Fig. 1. Mean *Z*-scores of under-five-year-old children by sex according to the four survey years 1996, 2000, 2004 and 2007. Error bars: ±2 SD.

demographic variables, a trend of improvement in mean HAZ scores was observed with increase in the number of possessions in the household. Regional heterogeneity in HAZ score was also found, with the highest HAZ mean in Khulna and the lowest in Barisal. Regional variation was found for mean WHZ score, and children from Sylhet had the worst mean while Dhaka had the best mean. The number of possessions, maternal education, house type and toilet facility in the household also showed significant associations with WHZ, and there were upward trends in mean from non-educated to higher educated mothers and from none to four possessions.

Binary Logistic Regression analyses were undertaken to see how well the socioeconomic and demographic variables predicted underweight, stunting and wasting (Table 2). After adjustment for the other socioeconomic and demographic variables, children of less-educated parents and those from households with fewer possessions were more likely to be underweight, as well as stunted. For example, children with non-educated mothers were twice more likely to be underweight and stunted than children whose mothers had higher education. Children of educated fathers

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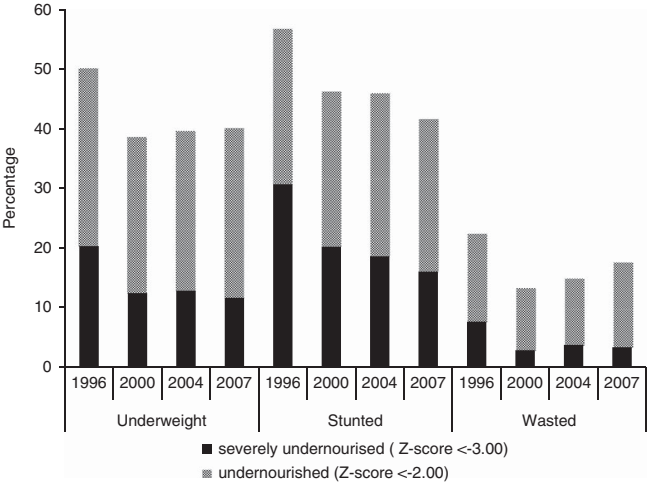

Fig. 2. Percentages of severely undernourished (Z-score <-3.00) and undernourished (Z-score <-2.00) under-five Bangladeshi children according to the survey years 1996, 2000, 2004 and 2007.

were also less likely to be underweight or stunted compared with children of illiterate fathers. Children having no toilet facilities in their house were 1.3 times more likely to be underweight and stunted compared with children having sanitary latrine facilities. Children living in all-thatched households were 1.4 times more likely to be underweight and 1.7 times more likely to be stunted compared with children living in all-brick households. Maternal education level, possession score and house type were also significant predictors of wasting. Prediction of normal children in the models ranged from 66% to 100%; while 44% of those underweight and 67% of those stunted children were correctly predicted. Table 3 presents the effect sizes and moderate levels were achieved for WAZ and HAZ on education of mother, possession score, house type and toilet. There was also a moderate level of effect size for WAZ with father's education. All values for WHZ were negligible or weak.

Figure 3 presents the changes in mean Z-scores over the four surveys. Mean WAZ improved considerably between 1996 and 2000, but thereafter there were no significant changes. Mean HAZ improved between 1996 and 2000 and again between 2004 and 2007. Mean WHZ improved between 1996 and 2000 but then deteriorated until 2007. The trends of Z-scores were also examined in relation to birth cohorts, but as can be seen in Table 4 the percentages of undernourished children in six-monthly age groups did not reveal any definite trends. *Post hoc* tests also showed that there were no significant differences in means between different birth cohorts.

Discussion

This study examined the relationship between selected socioeconomic and demographic variables and the nutritional status of under-five-year-old children in four Bangladesh Demographic Health Surveys conducted between 1996 and 2007.

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Table 1. Relationship between anthropometric *Z*-scores of under-five Bangladeshi children and demographic and socioeconomic variables (pooled data from 1996, 2000, 2004 and 2007 DHS surveys)

		WAZ				HAZ				WHZ			
		Mean	Difference	*F*	*p*	Mean	Difference	*F*	*p*	Mean	Difference	*F*	*p*
Region	Barisal	−1.51	−0.08	9.66	<0.001	−1.70	0.01	12.43	<0.001	−0.75	−0.14	6.28	<0.001
	Chittagong	−1.57	−0.02			−1.70	0.00			−0.85	−0.04		
	Dhaka	−1.46	−0.13			−1.64	−0.05			−0.74	−0.15		
	Khulna	−1.40	−0.19			−1.47	−0.22			−0.79	−0.09		
	Rajshahi	−1.46	−0.13			−1.52	−0.17			−0.84	−0.05		
	Sylhet	−1.59				−1.69				−0.88			
Residence	Urban	−1.51	0.02	0.55	ns	−1.62	0.01	0.07	ns	−0.82	0.02	0.63	ns
	Rural	−1.49				−1.62				−0.80			
Occupation of fathers	Did not work	−1.46	−0.06	1.81	ns	−1.56	−0.11	1.88	ns	−0.79	0.01	0.75	ns
	Professional	−1.49	−0.03			−1.58	−0.10			−0.83	0.05		
	Skilled manual	−1.54	0.03			−1.67	−0.01			−0.83	0.05		
	Sales	−1.47	−0.04			−1.59	−0.08			−0.79	0.01		
	Agriculture	−1.52	0.00			−1.64	−0.03			−0.81	0.03		
	Unskilled	−1.52				−1.68				−0.78			
Occupation of mothers	Did not work	−1.53	−0.06	2.69	<0.05	−1.64	0.00	0.37	ns	−0.83	−0.09	4.18	<0.001
	Professional	−1.38	−0.21			−1.60	−0.04			−0.63	−0.29		
	Skilled manual	−1.52	−0.07			−1.65	0.01			−0.81	−0.12		
	Sales	−1.39	−0.20			−1.53	−0.12			−0.73	−0.20		
	Agriculture	−1.59	0.00			−1.66	0.02			−0.92	−0.01		
	Unskilled	−1.59				−1.64				−0.92			
Education of fathers	No education	−1.61	0.29	17.67	<0.001	−1.78	0.36	23.88	<0.001	−0.83	0.09	2.02	ns
	Primary	−1.59	0.26			−1.73	0.32			−0.83	0.10		
	Secondary	−1.48	0.15			−1.56	0.14			−0.83	0.10		
	Higher	−1.32				−1.42				−0.73			
Education of mothers	No education	−1.67	0.45	25.01	<0.001	−1.78	0.44	17.76	<0.001	−0.92	0.27	9.03	<0.001
	Primary	−1.60	0.37			−1.74	0.41			−0.85	0.20		
	Secondary	−1.50	0.27			−1.62	0.29			−0.81	0.16		
	Higher	−1.23				−1.34				−0.65			

Table 1. *Continued*

		WAZ				HAZ				WHZ			
		Mean	Difference	*F*	*p*	Mean	Difference	*F*	*p*	Mean	Difference	*F*	*p*
Possession score	0	−1.65	0.27	19.80	<0.001	−1.83	0.37	24.48	<0.001	−0.85	0.07	1.98	ns
	1	−1.58	0.20			−1.73	0.28			−0.83	0.05		
	2	−1.52	0.14			−1.65	0.20			−0.82	0.04		
	3	−1.36	−0.03			−1.44	−0.01			−0.75	−0.03		
	4	−1.38				−1.45				−0.78			
House type	All thatched	−1.64	0.30	14.25	<0.001	−1.74	0.32	10.63	<0.001	−0.92	0.18	6.38	<0.001
	Tin roof	−1.57	0.23			−1.70	0.28			−0.84	0.10		
	Tin wall and roof	−1.48	0.14			−1.64	0.22			−0.77	0.03		
	Brick wall/roof/floor	−1.46	0.12			−1.60	0.18			−0.77	0.03		
	All brick	−1.34				−1.42				−0.74			
Water	Surface water	−1.48	−0.03	0.43	ns	−1.62	−0.03	0.36	ns	−0.78	−0.02	1.79	ns
	Tube well	−1.52	0.01			−1.60	−0.04			−0.85	0.05		
	Piped water	−1.51				−1.64				−0.80			
Toilet	No toilet	−1.60	0.21	22.93	<0.001	−1.72	0.21	16.33	<0.001	−0.87	0.13	7.86	<0.001
	Insanitary	−1.51	0.12			−1.63	0.12			−0.81	0.07		
	Sanitary	−1.39				−1.51				−0.74			
Number of household members	1–4	−1.48	−0.04	1.23	ns	−1.57	−0.10	4.72	<0.05	−0.82	0.04	1.33	ns
	5–8	−1.51	−0.01			−1.62	−0.05			−0.82	0.04		
	9+	−1.51				−1.67				−0.78			

Table 2. Binary Logistic Regression analysis of *Z*-scores of under-five Bangladeshi children by demographic and socioeconomic variables (pooled data from 1996, 2000, 2004 and 2007 DHS surveys)

		WAZ (underweight vs normal)				HAZ (stunted vs normal)				WHZ (wasted vs normal)			
		OR	95% CI	χ^2	*p*	OR	95% CI	χ^2	*p*	OR	95% CI	χ^2	*p*
Region	Barisal	0.94	0.82–1.08	34.73	<0.001	1.04	0.90–1.20	40.63	<0.001	0.76	0.63–0.90	25.01	<0.001
	Chittagong	1.01	0.90–1.14			1.01	0.89–1.14			0.96	0.83–1.11		
	Dhaka	0.86	0.76–0.97			0.95	0.84–1.08			0.74	0.64–0.86		
	Khulna	0.74	0.65–0.85			0.76	0.66–0.87			0.92	0.78–1.09		
	Rajshahi	0.84	0.74–0.95			0.79	0.70–0.90			0.85	0.73–0.99		
	Sylhet[a]												
Residence	Urban	1.06	0.97–1.16	1.70	ns	1.03	0.94–1.13	0.46	ns	1.03	0.91–1.15	0.18	ns
	Rural[a]												
Occupation of fathers	Did not work	0.92	0.66–1.29	4.68	ns	0.76	0.54–1.07	7.84	ns	0.92	0.59–1.44	2.57	ns
	Professional	1.00	0.79–1.26			0.89	0.71–1.13			1.20	0.89–1.60		
	Skilled manual	1.02	0.92–1.14			0.96	0.86–1.07			0.97	0.85–1.11		
	Sales	0.93	0.83–1.03			0.88	0.79–0.99			1.03	0.89–1.19		
	Agriculture	0.98	0.89–1.09			0.98	0.88–1.09			1.01	0.88–1.15		
	Unskilled[a]												
Occupation of mothers	Did not work	0.94	0.86–1.03	6.36	ns	1.00	0.91–1.10	1.13	ns	0.80	0.72–0.89	18.32	<0.005
	Professional	1.00	0.65–1.53			0.85	0.55–1.32			0.76	0.44–1.30		
	Skilled manual	0.90	0.73–1.11			0.98	0.79–1.22			0.75	0.56–0.99		
	Sales	0.75	0.56–1.01			0.93	0.69–1.25			0.68	0.45–1.03		
	Agriculture	1.10	0.86–1.40			1.07	0.83–1.37			0.99	0.75–1.30		
	Unskilled[a]												
Education of fathers	No education	1.74	1.46–2.07	50.42	<0.001	1.88	1.58–2.24	61.31	<0.001	1.25	0.99–1.58	6.40	ns
	Primary	1.69	1.43–2.01			1.73	1.46–2.05			1.18	0.94–1.48		
	Secondary	1.36	1.15–1.60			1.41	1.20–1.65			1.28	1.03–1.59		
	Higher[a]												
Education of mothers	No education	2.01	1.59–2.56	40.37	<0.001	1.99	1.57–2.51	37.01	<0.001	1.36	1.01–1.83	12.10	<0.01
	Primary	1.80	1.42–2.27			1.92	1.53–2.41			1.17	0.87–1.56		
	Secondary	1.57	1.26–1.96			1.66	1.34–2.05			1.10	0.84–1.45		
	Higher[a]												

Table 2. *Continued*

		WAZ (underweight vs normal)				HAZ (stunted vs normal)				WHZ (wasted vs normal)			
		OR	95% CI	χ^2	*p*	OR	95% CI	χ^2	*p*	OR	95% CI	χ^2	*p*
Possession score	0	1.91	1.55–2.36	68.99	<0.001	1.90	1.54–2.33	76.03	<0.001	1.24	0.95–1.62	11.60	<0.05
	1	1.70	1.38–2.09			1.72	1.41–2.10			1.19	0.91–1.54		
	2	1.53	1.24–1.88			1.53	1.25–1.86			1.10	0.85–1.42		
	3	1.18	0.95–1.46			1.12	0.91–1.38			0.92	0.70–1.21		
	4[a]												
House type	All thatched	1.44	1.21–1.71	23.23	<0.001	1.67	1.40–1.99	38.69	<0.001	1.45	1.16–1.82	16.63	<0.005
	Tin roof	1.27	1.09–1.48			1.60	1.37–1.87			1.30	1.06–1.60		
	Tin wall and roof	1.15	0.98–1.34			1.53	1.30–1.79			1.12	0.91–1.39		
	Brick wall/roof/floor	1.11	0.94–1.30			1.42	1.21–1.67			1.15	0.92–1.42		
	All brick[a]												
Water	Surface water	0.92	0.73–1.15	0.58	ns	0.92	0.73–1.17	1.54	ns	0.93	0.69–1.25	0.41	ns
	Tube well	0.97	0.82–1.14			0.90	0.77–1.06			1.00	0.80–1.23		
	Piped water[a]												
Toilet	No toilet	1.38	1.23–1.56	30.29	<0.001	1.32	1.17–1.49	20.66	<0.001	1.10	0.95–1.28	1.75	ns
	Insanitary	1.20	1.10–1.31			1.15	1.06–1.26			1.03	0.92–1.15		
	Sanitary[a]												
Number of household members	1–4	0.88	0.79–0.98	6.22	<0.05	0.85	0.76–0.95	8.90	<0.05	1.03	0.89–1.17	1.12	ns
	5–8	0.95	0.87–1.04			0.91	0.83–1.00			1.06	0.94–1.20		
	9+[a]												

[a]Reference group, OR = Odds Ratio, CI = Confidence Interval.

Table 3. Effect size of the explanatory variables for the two categories of *Z*-scores (underweight/stunted/wasted and normal) for under-five children

	WAZ (underweight and normal)				HAZ (stunted and normal)				WHZ (wasted and normal)			
Variable	$\chi 2$	Cramér's *V*	*p*	ES[a]	χ^2	Cramér's *V*	*p*	ES[a]	χ^2	Cramér's *V*	*p*	ES[a]
Region	57.63	0.1	<0.001	weak	57.35	0.1	<0.001	weak	36.51	0.1	<0.001	weak
Residence	117.05	0.1	<0.001	weak	142.22	0.1	<0.001	weak	27.86	0.04	<0.001	negligible
Occupation of fathers	239.86	0.1	<0.001	weak	289.40	0.1	<0.001	weak	32.29	0.04	<0.001	negligible
Occupation of mothers	126.72	0.1	<0.001	weak	126.57	0.1	<0.001	weak	62.86	0.1	<0.001	weak
Education of fathers	636.13	0.2	<0.001	moderate	721.43	0.2	<0.001	weak	87.03	0.1	<0.001	weak
Education of mothers	674.35	0.2	<0.001	moderate	675.81	0.2	<0.001	moderate	113.15	0.1	<0.001	weak
Possession score	611.85	0.2	<0.001	moderate	651.88	0.2	<0.001	moderate	108.50	0.1	<0.001	weak
House type	500.75	0.2	<0.001	moderate	564.17	0.2	<0.001	moderate	136.59	0.1	<0.001	weak
Water	71.85	0.1	<0.001	weak	72.71	0.1	<0.001	weak	19.75	0.04	<0.001	negligible
Toilet	417.79	0.2	<0.001	moderate	380.75	0.2	<0.001	moderate	70.27	0.1	<0.001	weak
Number of house members	24.33	0.04	<0.001	negligible	20.47	0.04	<0.001	negligible	6.49	0.02	<0.05	negligible

[a]ES = Effect Size.

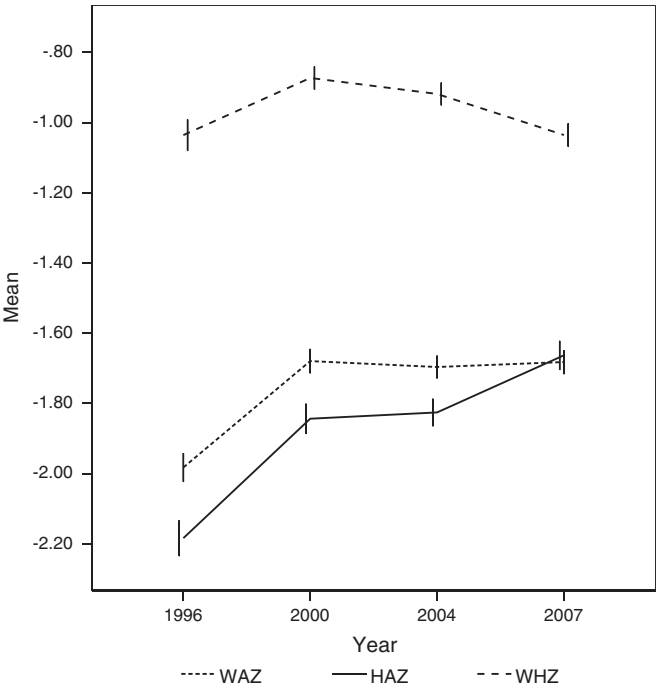

Fig. 3. Trends of mean *Z*-scores (WAZ, HAZ and WHZ) of under-five Bangladeshi children over the survey periods of 1996, 2000, 2004 and 2007. Error bars: 95% CI.

Gender disparities are of particular concern in Bangladesh given the well documented existence of pro-son bias in South Asia and its influence on child health outcomes (Dancer *et al.*, 2008). In patriarchal societies, it was common for the intra-household allocation of resources to strongly favour sons, to the detriment of daughters' health and educational status (Mohsena *et al.*, 2010). The present study, however, found that overall there was no significant gender difference in child nutritional status and the three mean *Z*-scores were almost identical in boys and girls.

Bangladesh is a small country, composed of eight divisions and cultural, religious and linguistic diversity is not large, so it is perhaps surprising that childhood nutritional status is not evenly distributed throughout the country (Mohsena *et al.,* 2015). However, similar to previous findings (Rahman & Chowdhury, 2007; Das *et al.*, 2008) this study also showed that the prevalence of all forms of undernutrition varied significantly by divisions. The overall prevalence of stunting ranged from 50.3% in Barisal to 40.4% in Khulna. Sylhet had the highest prevalence of wasting (19.9%) and Barisal the lowest (14.7%). The overall prevalence of underweight ranged from 45.8% in Sylhet to 35.1% in Khulna. Regional heterogeneity in mean HAZ score was observed with higher means in Khulna and Rajshahi. For both WAZ and WHZ, children from Sylhet had the worst means, whereas those from Khulna and Dhaka had the best means for WAZ and WHZ. These findings suggest that Sylhet and Barisal need most attention from policymakers to decrease inter-regional disparity. The largest regions, Dhaka and Chittagong, account

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Table 4. Age-adjusted percentages of undernourished (−2.00 *Z*-score) children by birth cohort to assess trends in undernutrition

		Age (months)																	
		0–6		7–12		13–18		19–24		25–30		31–36		37–42		43–48		49–54		55–60	
	Birth cohort	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Underweight	≥2006	150	30.1	131	28.9	111	32.8														
	2001–2005	195	27.6	177	32.2	348	43.2	431	46.9	461	44.4	353	44.4	214	42.5	140	42.6	142	47.8	98	45.6
	1996–2000	385	31.9	347	39.3	245	40.6	208	44.8	177	40.9	164	47.4	224	37.6	251	43.7	145	36.8	99	46.3
	≤1995			43	60.6	223	49.0	208	52.4	198	49.7	197	57.8	164	55.2	151	55.5	226	42.7	185	53.0
Stunted	≥2006	104	20.9	111	24.5	106	31.4	4	57.1												
	2001–2005	156	22.1	169	30.7	384	47.7	499	54.4	563	54.2	436	54.8	270	53.7	168	51.1	138	46.5	86	40.0
	1996–2000	309	25.6	298	33.7	300	49.7	275	59.3	248	57.3	221	63.9	316	53.0	318	55.4	169	42.9	112	52.3
	≤1995			32	45.1	259	56.9	283	71.3	273	68.6	237	69.5	190	64.0	183	67.3	283	53.5	195	55.9
Wasted	≥2006	85	17.1	98	21.6	72	21.3														
	2001–05	100	14.1	99	18.0	174	21.6	179	19.5	164	15.8	108	13.6	61	12.1	46	14.0	48	16.2	27	12.6
	1996–00	227	18.8	225	25.5	112	18.5	62	13.4	51	11.8	33	9.5	61	10.2	59	10.3	50	12.7	23	10.7
	≤1995			25	35.2	139	30.5	89	22.4	61	15.3	60	17.6	43	14.5	48	17.6	57	10.8	52	14.9

for the majority of the total population of the country. Needless to say, progress towards the SDG target of preventable deaths in Bangladesh will not occur without progress in these two key regions.

Childhood undernutrition was previously typically seen as a less severe problem in urban than in rural areas, whereas, recently the accelerated rates of urbanization observed in the developing world have raised new concerns regarding increasing rates of urban undernutrition (Smith *et al.*, 2005). Understanding the existence of urban–rural discrepancies in nutrition thus becomes an issue for a country in designing effective programme and policy responses specifically tailored to the needs of different population groups. In the present study, no significant mean differences for any of the *Z*-scores between urban and rural children were found after adjusting for the other potential confounding variables.

There is a continuing debate regarding the influence of maternal education on child health outcomes (Frost *et al.*, 2005). In the present study, parental education (both maternal and paternal) showed strong associations with childhood underweight and stunting, even after controlling for all other socioeconomic and demographic variables and with Bonferroni correction. For WHZ, although paternal education was non-significant, maternal education was associated with wasting in a graded fashion. In a recent study, Headey *et al.* (2015) opined that a large gain in parental education was one of the important drivers of change in nutritional outcomes in Bangladesh.

Disparities in health outcomes between the poor and the rich are attracting increasing attention from researchers and policymakers, thereby fostering a substantial growth in the literature on health equity (Van de Poel *et al.*, 2008). The present study shows that the better-off have suffered less from undernutrition and inequality has been much more pronounced for stunting and underweight than for wasting. This finding is similar to previous evidence, which demonstrated that socioeconomic status had a smaller effect on the conditions that precipitated wasting (Zere & McIntyre, 2003; Uthman, 2008; Van de Poel *et al.*, 2008; Kanjilal *et al.*, 2010). In the present study, upward trends in means of all three *Z*-scores were evident from poor to good housing while all three mean *Z*-scores were found to decrease consistently from households with a sanitary toilet to an unsanitary one and to no toilet. Because wealth was already controlled for through the possession score in this study, the results obviously reflect the importance of environmental hygiene on undernutrition. In Bangladesh only one-third of the population has access to a sanitary toilet, so improving sanitation is an important intervention to reduce all forms of undernutrition.

The current study examined the trends of *Z*-scores over four surveys and found that overall the mean WAZ and HAZ improved between 1996 and 2007, whereas the mean WHZ worsened over this time period. Despite efforts to improve the nutritional status of young children, there has not been much improvement in the nutritional status of under-five-year-old children, particularly since 2000. A significant improvement was evident in the reduction of severe undernutrition, but unexpectedly the percentage of undernourished children, between −2.00 and −3.00 *Z*-values of WAZ and HAZ, did not show any decline over the period. Wasting, using both −3.00 and −2.00 cut-offs, worsened over time, increasing from 13.3% in the 2000 BDHS to 17.7% in the 2007 BDHS. Bhutta *et al.* (2009) were concerned that food and economic crises, if unaddressed, could have a significant impact on health and nutrition outcomes in the

short term and estimated that childhood stunting rates would increase by 3–7% and those for wasting by 8–16%, at least in East Asia and the Pacific. The present study echoes their concern regarding the prevalence of wasting in Bangladesh.

Recently, overweight and obesity in children have been gaining attention. While the systematic analysis of national prevalence for overweight and obese adults and children in Bangladesh for the Global Burden of Disease Study 2013 found that less than 2% of the population was obese (Ng *et al.*, 2014), a separate scoping review of the literature found that the prevalence ranged from 1 to 18%, depending on the reference standard (Rahman *et al.*, 2014). The present study shows that the obesity rate was below 2% up to 2007, although the absolute numbers of obese Bangladeshi children, as measured by the BAZ score, nearly doubled in this 12-year period from 1996 to 2007.

The limitations of this study included lack of information on food consumption, macro- and micronutrients and physical activity, which are important components in estimating nutritional status. The cross-sectional nature of the data did not allow the drawing of causal inferences. The time periods of the surveys in different years were not sufficient to assess the impact of seasonality over nutritional status.

In conclusion, the achievement of the two Millennium Development Goals that aimed to reduce undernutrition and child mortality by 2015 remains an unfinished agenda item as childhood undernutrition in Bangladesh is still widespread. Although obesity in young children is not considered to be a major public health problem in Bangladesh so far, the rate is on the rise. Multilevel analyses, after controlling for confounders, indicated a strong household socioeconomic status–undernutrition gradient, with robust relationships between possession scores and education of mother and nutritional outcome of the children. The findings suggest that if childhood undernutrition is to be reduced, policies and strategies for poverty alleviation, promotion of education for mothers and the provision of basic sanitation facilities are crucial issues that need to be pursued because they have a big impact on children's nutritional status. There exists highly significant regional heterogeneity in undernutrition in Bangladesh and the high levels in the Sylhet region are puzzling given the high level of remittances received in that region and its better economic development. Hence, an appropriate policy guideline focusing on improving the nutritional intake of poor children, especially in regions with a higher prevalence of childhood undernutrition, is needed; more focused programmes targeting behavioural changes should be implemented and evaluated.

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