Use of the new World Health Organization child growth standards to describe longitudinal growth of breastfed rural Bangladeshi infants and young children

Kuntal K. Saha, Edward A. Frongillo, Dewan S. Alam, Shams E. Arifeen, Lars Å. Persson, and Kathleen M. Rasmussen

Abstract

Background. *Although the National Center for Health Statistics (NCHS) reference has been widely used, in 2006 the World Health Organization (WHO) released new standards for assessing growth of infants and children worldwide.*

Objective. *To assess and compare the growth of breastfed rural Bangladeshi infants and young children based on the new WHO child growth standards and the NCHS reference.*

Methods. *We followed 1,343 children in the Maternal and Infant Nutrition Intervention in Matlab (MINIMat) study from birth to 24 months of age. Weights and lengths of the children were measured monthly during infancy and quarterly in the second year of life. Anthropometric indices were calculated using both WHO standards and the NCHS reference. The growth pattern and estimates of undernutrition based on the WHO standards and the NCHS reference were compared.*

Results. *The mean birthweight was 2,697 ± 401 g, with 30% weighing < 2,500 g. The growth pattern of the MINIMat children more closely tracked the WHO standards than it did the NCHS reference. The rates of stunting based on the WHO standards were higher than the rates based on the NCHS reference throughout the first 24 months. The rates of underweight and wasting based on the WHO standards were significantly different from those based on the NCHS reference.*

Conclusions. *This comparison confirms that use of the NCHS reference misidentifies undernutrition and the timing of growth faltering in infants and young children, which was a key rationale for constructing the new WHO standards. The new WHO child growth standards provide a benchmark for assessing the growth of breastfed infants and children.*

Key words: Bangladesh, child growth, infant growth, MINIMat, WHO growth standards

Background

Anthropometric indices are widely used to assess the health and nutritional status of individuals or groups of infants and children in both developed and developing countries [1–3]. Most nutrition intervention programs for infants and children have a growth-monitoring component in which infants and children are measured routinely to follow their growth [4, 5]. In clinical services, growth during infancy and childhood is monitored to assess adequacy of feeding, health, and development. Anthropometric indices are also used for rapid nutritional assessment, screening, and prognostic purposes in nutrition emergencies [6–8]. The attained weight and length and/or their increments are compared with international growth standards for infants and children.

The National Center for Health Statistics (NCHS) reference for child growth has been widely used since 1979 to compare the nutritional status of infants and children throughout the world. The NCHS reference, however, may not adequately reflect the growth of breastfed infants and children [9–13]. In addition,

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there is a potential for misclassification of infants in developing countries as abnormal gainers in weight and length at both ends of nutritional status if the NCHS reference data are used [14]. In particular, the NCHS child growth reference may not be appropriate for making judgments about growth faltering in developing-country populations, where most infants and young children are breastfed for a long period [15]. Consequently, the World Health Organization (WHO) conducted the Multicentre Growth Reference Study (MGRS) to develop growth standards for infants and children under 5 years of age [16]. As a result of their methodological strength, the new WHO child growth standards should provide an appropriate benchmark for the assessment of the nutritional status of infants and children in developing countries [17].

We report here the use of the new WHO child growth standards as well as the NCHS reference in a large cohort of breastfed infants and young children in rural Bangladesh. We conducted this study to determine the growth pattern of infants and young children in rural Bangladesh using both the WHO standards and the NCHS reference, whether the pattern of prevalence estimates of undernutrition across the first 2 years according to the WHO standards differs from the pattern based on the NCHS reference, and how the timing of apparent growth faltering differs depending on the standard or reference.

Methods

Data

We used the data from the Maternal and Infant Nutrition Intervention in Matlab (MINIMat) study, a large intervention trial in which children were followed from birth until 24 months of age. The enrollment of pregnant women in the MINIMat study took place between November 2001 and October 2003. We selected all infants (n = 1,343) who were born by December 2003 and had completed their 24-month follow-up in December 2005. Weight and length measurements of the children were obtained on 17 occasions: at birth, monthly during the first 12 months, and quarterly thereafter until the children were 24 months old. A detailed description of the MINIMat study design, data collection, and quality control of data has been provided elsewhere [18].

Informed consent was obtained from the women to their participation in the study. The study was approved by the Research Review Committee and the Ethical Review Committee of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) and the Cornell University Committee on Human Subjects.

Measurements of weight and length

All weight measurements, including birthweights, were obtained with the use of electronic or beam scales that were precise to 10 g (UNICEF Uniscale). Locally manufactured, collapsible length boards precise to 1 mm were used to measure recumbent lengths of the children, including birth length. The interviewers who collected birth measurements and follow-up data were specially trained on anthropometric measurements. All measuring scales were standardized daily.

Age of infants and children

We chose children for this study based on the timing of their growth measurement. From 1 to 6 months of age, we selected those infants who were measured within a window of 1 week of their target age for measurement. We selected those children who were measured within a window of 2 weeks at 9 months and later times. Thus, 220 to 256 children during 9 to 24 months and 577 to 802 infants during 1 to 6 months of age were excluded because they were measured at ages outside of our defined time window. We examined whether the infants who were excluded during the first 6 months of age differed from the infants who were included in the sample. We compared these two groups of children according to their birthweight and birth length; maternal age, weight, and education; and household wealth index and food security. We used the t-test for equality of means for continuous variables and contingency table and Pearson chi-square tests for categorical variables. There were no significant differences between the two groups in the selected variables (data not shown).

Anthropometric indices

Weight and length measurements were converted to z-scores for weight-for-age (WAZ), length-for-age (LAZ), and weight-for-length (WLZ) according to the WHO MGRS child growth standards [19]). We used Anthro 2005 from the WHO website (http://www.who.int/childgrowth/) to create these indices. To calculate the z-score for body-mass-index-for-age (BMIZ), the body mass index (BMI, the weight in kilograms divided by the square of the height in meters) was computed first and was then converted to BMIZ according to the WHO MGRS child growth standards. Anthropometric indices were also calculated based on the NCHS reference [20] using EpiInfo 3.3.2.

A cutoff of −2 z-scores for these indices was used for classifying infants or children as undernourished (< −2 z-scores) or well nourished (≥ −2 z-scores). Underweight and stunting were defined as < −2 z-scores of WAZ and LAZ, respectively. Wasting was defined as < −2 z-scores of WLZ or BMIZ. Mild, moderate, and severe malnutrition were defined as z-scores < −1, < − 2, and < −3, respectively. Overweight was defined as ≥ + 2 z-scores of WLZ or BMIZ.

Analyses

Sex-specific data for weight-for-age, length-for-age, weight-for-length, and BMI-for-age were compared with the data from the WHO standards [19] and the NCHS population [20, 21]. Timing of growth faltering was assessed using both the WHO standards and the NCHS reference. Rates of underweight, stunting, and wasting were estimated using both the WHO standards and the NCHS reference. Data were analyzed by descriptive analytical methods, by comparing means using an independent-sample *t*-test, and by analysis of variance for comparison of gains in weight and length. The *t*-test for equality of means was used for continuous variables and the χ^2 test was used for comparing categorical data. All statistical analyses were performed with SPSS 14.0 for Windows.

Results

General characteristics of the sample

The general baseline characteristics of the sample children and their parents are presented in **table 1**. The mean birthweight and birth length of the newborns were 2,697 ± 401 g and 47.8 ± 2.1 cm, respectively. Overall, 30% of the newborns weighed less than 2,500 g.

Attained weight and length

The mean weights and weight velocities of the boys and girls at different ages are presented in **figure 1A**. The mean lengths and length velocities of these boys and girls are presented in **figure 1B**. There was a steep decrease in the weight velocities of these children during the first year. In contrast, the weight velocities during the second year of life were stable. A similar pattern was observed for the length velocities of these children (**fig. 1B**).

TABLE 1. Baseline and general characteristics of the children and their parents (n = 1,243)[a]

Characteristic	Boys (n = 644)	Girls (n = 599)	p value
Birthweight (g)	2741 ± 411	2650 ± 384	< .001
Birth length (cm)	48.0 ± 2.1	47.5 ± 2.1	< .001
Birthweight < 2,500 g (%)	26.0	34.5	< .01
Median duration of exclusive breastfeeding (days)	121		
Body weight (kg)			
3 mo	5.47 ± 0.71	5.04 ± 0.72	< .01
6 mo	6.99 ± 0.91	6.42 ± 0.82	< .01
9 mo	7.75 ± 1.05	7.07 ± 0.95	< .01
12 mo	8.28 ± 1.07	7.59 ± 1.02	< .01
18 mo	9.21 ± 1.20	8.51 ± 1.08	< .01
24 mo	10.03 ± 1.30	9.39 ± 1.19	< .01
Body length (cm)			
3 mo	58.3 ± 2.4	57.0 ± 2.4	< .01
6 mo	64.3 ± 2.7	62.7 ± 2.5	< .01
9 mo	68.3 ± 2.7	66.7 ± 2.5	< .01
12 mo	71.5 ± 2.8	69.8 ± 2.6	< .01
18 mo	76.7 ± 3.2	74.9 ± 3.0	< .01
24 mo	81.1 ± 3.5	79.7 ± 3.4	< .01
Maternal characteristics			
Age (yr)	26.3 ± 5.8		
Weight (kg)	46.5 ± 6.6		
Median (range) parity	1 (1–7)		
Education (yr)	5.0 ± 4.1		
Father's education (yr)	5.4 ± 4.5		

a. Plus–minus values are means ± SD.

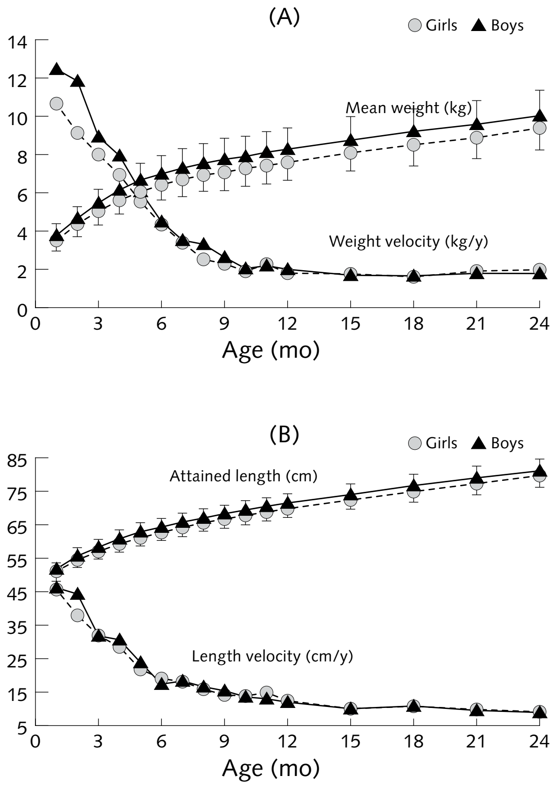

FIG. 1. (A) Attained weight and weight velocity and (B) attained length and length velocity of boys and girls from birth to 24 months of age. Values are means ± SD

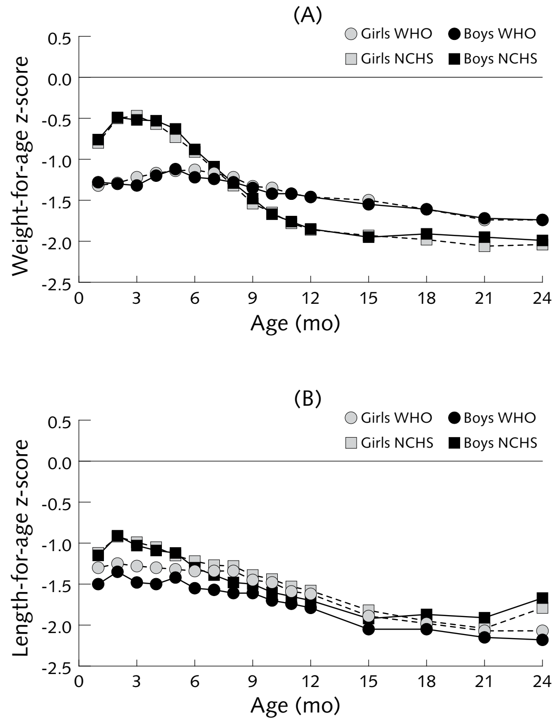

FIG. 2. (A) Weight-for-age z-scores (WAZ) and (B) length-for-age z-scores (LAZ) of boys and girls from 1 to 24 months of age based on the WHO standards and the NCHS reference

Anthropometric indices

When the WHO standards were used, the mean WAZ was around −1.5 z-scores from 1 to 24 months of age (**fig. 2A**). Both boys and girls had < −1.5 z-scores of mean WAZ during the first year of life. Both boys and girls, however, had < −1.5 z-scores of mean WAZ during the second year of life. In contrast, the mean WAZ values based on the NCHS reference were well above −1 z-score during the first half of infancy and then headed downward toward −2 z-scores at 12 months and continued at this level until 24 months of age.

In general, the mean LAZ based on the WHO standards was less than that based on the NCHS reference from 1 to 24 months of age (**fig. 2B**). When the WHO standards were used, girls had greater LAZ, particularly before 15 months of age. After this age, both groups declined toward −2 z-scores. In contrast, LAZ based on the NCHS reference was similar for boys and girls except for the age of 15 months onwards. During the first year of life, the mean LAZ was between −1 and −1.5 z-scores. The mean LAZ values during the second year of life, however, were between −1.5 and −2 z-scores, particularly after 15 months of age.

The mean WLZ for both boys and girls was greater than zero at 1 month and gradually decreased to −0.2 z-score by 6 months of age when WHO standards were used (**fig. 3**). After this age, the mean WLZ for both boys and girls declined toward −1 z-score and flattened from 18 months onward. In contrast, the mean WLZ based on the NCHS reference was greater than zero during the first 6 months of life and gradually decreased to −1 z-score at 12 months. The mean WLZ values were between −1 and −1.5 z-scores during the second year of life. All mean anthropometric indices—except WLZ based on the NCHS reference, which increased in the first 3 months and decreased thereafter—decreased with age of the infants and children.

Underweight, stunting, and wasting

At 24 months of age, 41% of the children were underweight, 54.5% were stunted, and 13.6% were wasted, based on the WHO standards. The rates of underweight (WAZ < −2) based on the WHO standards were two to three times higher than the rates based on the NCHS reference during the first 6 months (**fig. 4A**). In contrast, the rates of underweight based on the WHO standards were less than the rates based on the NCHS reference during the second year of life. In particular, the rate of underweight based on the WHO standards increased from 21% at 1 month to 41% at 24 months of age. On the other hand, the rate of underweight based on the NCHS reference increased from 7% at 1 month to 54.8% at 24 months.

The rates of stunting (LAZ < −2) based on the WHO standards were higher than those based on the NCHS reference throughout the first 24 months of life (**fig. 4B**). During the first 6 months, the rates of stunting based on the WHO standards were almost double the rates of stunting based on the NCHS reference. Thereafter, the rates of stunting based on the WHO standards were higher, but the magnitudes of the differences decreased until 24 months of age. In particular, the rate of stunting based on the WHO standards increased from 28% at 1 month to 54.5% at 24 months. On the other hand, the rate of stunting based on the NCHS reference increased from 16% at 1 months to 38% at 24 months. When the WHO standards were used, more boys than girls were stunted, particularly in the first year of life.

The rates of wasting (WLZ < −2) based on the WHO standards were higher than the rates of wasting based on the NCHS reference during the first year of life (**fig. 4C**). In particular, the wasting rates were higher during the first 6 months when the WHO standards were used. The rates of wasting based on the NCHS reference were close to zero during the first 6 months and gradually increased to 20.2% at 24 months of age. On the other hand, the rate of wasting based on the WHO standards increased from 5.0% at 1 month to 13.6% at 24 months. After 18 months, the rates of wasting based on the WHO standards were less than those based on the NCHS reference.

Severe undernutrition (z-score < −3) based on the WHO standards was prevalent in this sample. At 24 months of age, the rates of severe wasting, stunting, and underweight were 15%, 24%, and 3%, respectively. In general, the rates of severe undernutrition were higher in boys than in girls. Less than 1% of boys were overweight (WLZ ≥ + 2) at any observation period. No girls were identified as overweight in this sample.

The patterns of WAZ, LAZ, underweight, and stunting shown in the figures reveal that, when the NCHS reference was used, the infants appeared to begin faltering in weight and length at about 4 months. In contrast, when the WHO standards were used, there was no rapid increase in faltering at any point in the first 24 months, but rather a gradual deterioration of growth relative to the standards.

Discussion

In this study, we used the new WHO child growth standards to evaluate the longitudinal growth of infants and young children in a low-income country

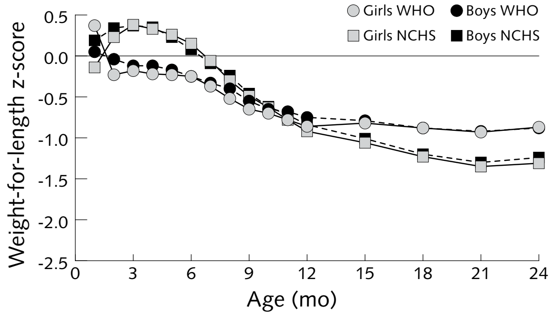

FIG. 3. Weight-for-length z-scores (WLZ) of boys and girls from 1 to 24 months of age based on the WHO standards and the NCHS reference

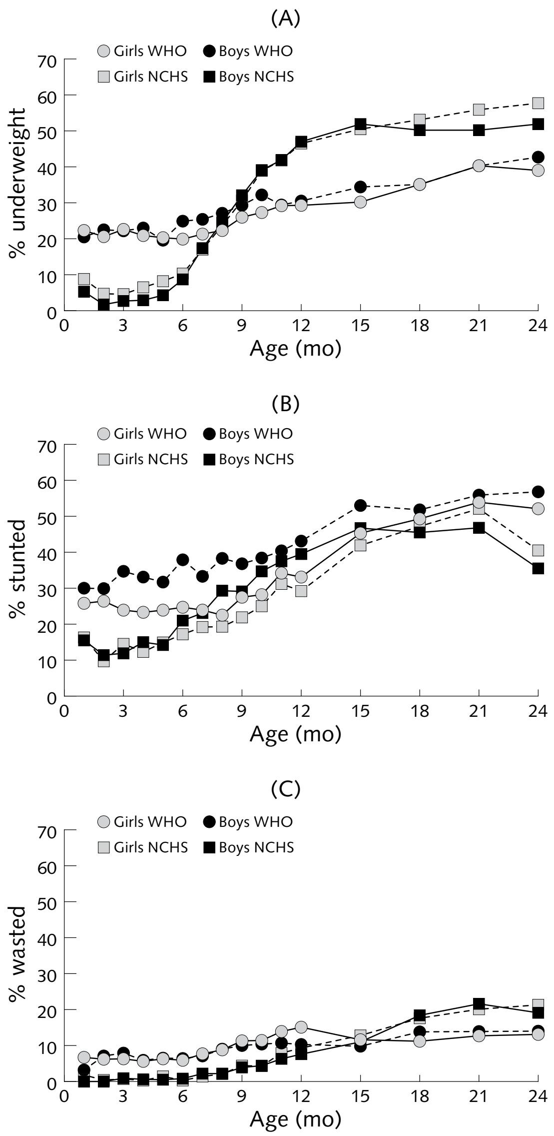

FIG. 4. Rates of (A) underweight, (B) stunting, and (C) wasting based on the WHO standards and the NCHS reference in boys and girls from 1 to 24 months of age

and compared their growth using both the new WHO standards and the NCHS reference. The results of this study provide strong evidence of a difference in apparent growth patterns, depending on the references used. In particular, the results provide important information regarding the differences in the estimates of undernutrition when the new WHO standards are used instead of the NCHS reference to evaluate growth in the first 24 months of life.

Our results for the comparison of the estimates of undernutrition based on the WHO standards and the NCHS reference were expected [22, 23]. Similar differences in the estimates of undernutrition based on the WHO standards and the NCHS reference were reported in recent studies that used cross-sectional data from the Demographic and Health Surveys in Bangladesh and the Dominican Republic [24] and three nutrition surveys in refugee camps in Africa and Asia [25]. The present study reports the first use of longitudinal data to compare the growth and the estimates of undernutrition of infants and young children based on the WHO standards and the NCHS reference.

The MINIMat study data had a number of advantages for assessing the growth pattern of infants and children up to 24 months of age. The sample size was large enough for valid descriptive statistics of the subjects. The number of observations (17 observations for each child from birth to 24 months of age) and the intervals of follow-up (monthly in the first year and quarterly in the second year) required for the growth assessment of infants and young children also were adequate. Very few studies have had data available from weight and length measurements obtained monthly during infancy and quarterly during the second year of life. This combination of factors permitted us to capture accurate growth dynamics of this sample and thus allowed us to describe it with high precision.

As expected, the mean attained weights and lengths of the boys were greater than those of the girls ($p < .001$) throughout this age range. In contrast, a higher proportion of boys than girls were underweight and stunted in this cohort. Nonetheless, the growth of both boys and girls was significantly compromised. Compared with the WHO standards, the weight deficits of the MINIMat cohort were 0.9, 1.37, and 2.10 kg at 6, 12, and 24 months of age, respectively. The length deficits at these ages were 3.2, 4.3, and 6.7, respectively.

The rates of underweight based on the WHO standards were two to three times higher than those based on the NCHS reference during the first half of infancy. In contrast, the rates of underweight based on the NCHS reference were higher than those based on the WHO standards during the second year of life. When the WHO standard was used instead of the NCHS reference, the relative decrease in the rate of underweight at 24 months of age was about 25% (from 54.8% based on the NCHS reference to 40.9% based on the WHO standards).

Stunting rates based on the WHO standards were higher than the rates based on the NCHS reference from birth to 24 months of age, particularly during the first year of life. During the first year of life, the stunting rates based on the WHO standards were almost double the rates based on the NCHS reference. When the WHO standard was used instead of the NCHS reference, the relative increase in the rate of stunting at 24 months of age was about 43% (from 38% based on the NCHS reference to 54.5% based on the WHO standards).

Use of the WHO standards suggested that some infants in this sample were wasted even during the first 6 months of life and that the prevalence of wasting gradually increased as they grew older. When the WHO standards were used instead of the NCHS reference, the relative decrease in the rate of wasting at 24 months of age was about 32.7% (from 20.2% based on the NCHS reference to 13.6% based on the WHO standards). The NCHS reference excludes infants less than 49 cm in length, and the new WHO standards include infants with lengths as low as 45 cm. Only seven infants (0.5%) in this sample were less than 49 cm in length, and the results on the length-specific indicators (LAZ and WLZ) and the rates of stunting and wasting (based on either WLZ or BMIZ) were not affected.

The differences in the estimates of underweight, stunting, and wasting according to the WHO standards and the NCHS reference have significant implications for targeting children for nutrition intervention programs to prevent undernutrition in Bangladesh, as well as in other low-income countries, and also for monitoring and evaluation of nutrition intervention programs. Using the NCHS reference would lead to the conclusion that growth faltering in these poor Bangladeshi infants occurs rapidly after about 4 months, suggesting that action to improve nutrition around that age is particularly warranted. Using the WHO standards instead leads to the conclusion that growth faltering occurs substantially but gradually over the first 24 months, beginning at 6 to 8 months of life, and is likely to be associated with poor complementary feeding practices at these ages [26]. This finding suggests that action to improve complementary feeding practices throughout this period is warranted.

The new WHO standards included BMI-for-age and BMI-for-age z-scores as indicators of growth for this age group, and we used them to evaluate the MINIMat children. Although BMI can be used as an indicator for screening older children and adolescents for underweight and overweight [27], the use of BMI as an indicator of growth before 24 months of life is still limited. The major criticism of using BMI as an indicator of growth in this age group is the imprecision of BMI measurements due to scaling of weight against the square of length [28]. Squared length (in meters squared) may not be the best scaling function of length for this age range [29]. Our results suggested that the rates of wasting based on BMI in the MINIMat subjects were higher than the rates of wasting based on weight-for-length during infancy. In contrast, the situation was reversed during the second year of life (data not shown). Therefore, the use of BMI may overestimate wasting in this population during infancy and underestimate it during the second year of life.

We calculated weight and length velocities of the MINIMat cohort (**figs. 1** and **2**). Because WHO has not released the data on growth velocity from the MGRS, we were unable to compare our data on growth velocities with the WHO MGRS data. The patterns of weight and length velocities of the MINIMat cohort were almost identical with the patterns observed in a Swedish cohort [30]. Future studies will be required to investigate the growth velocities of the MINIMat cohort when data on growth velocities from the WHO MGRS are released.

We documented the growth pattern of a cohort of infants and young children in rural Bangladesh relative to the new WHO child growth standards and the NCHS reference. The data from this study will be useful for comparison with future studies on infant and young child growth in Bangladesh and other low-income countries. Our results suggest that there are significant differences in the estimates of underweight, stunting, and wasting and the apparent timing of growth faltering when WHO standards are used instead of the NCHS reference. These differences will have significant programmatic implications, particularly in targeting infants and young children for nutrition intervention programs to prevent undernutrition in low-income countries.

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