

# Comparison of the New World Health Organization Growth Standards and the National Center for Health Statistics Growth Reference Regarding Mortality of Malnourished Children Treated in a 2006 Nutrition Program in Niger

Nancy M. Dale, BScN, MPH; Rebecca F. Grais, PhD, MPP; Andrea Minetti, MD; Juhani Miettola, MD, DTM&H; Noel C. Barengo, MD, PhD, MPH

**Objective:** To compare the National Centre for Health Statistics (NCHS) international growth reference with the new World Health Organization (WHO) growth standards for identification of the malnourished (wasted) children most at risk of death.

**Design:** Retrospective data analysis.

**Setting:** A Médecins Sans Frontières (Doctors Without Borders) nutrition program in Maradi, Niger, in 2006 that treated moderately and severely malnourished children.

**Participants:** A total of 53 661 wasted children aged 6 months to 5 years (272 of whom died) in the program were included.

**Interventions:** EpiNut (Epi Info 6.0; Centers for Disease Control and Prevention, Atlanta, Georgia) software was used to calculate the percentage of the median for the NCHS reference group, and the WHO (igrowup macro; Geneva, Switzerland) software was used to calculate z scores for the WHO standards group of the 53 661 wasted children.

**Outcome Measures:** The main outcome measures are the difference in classification of children as either moderate or severely malnourished according to the NCHS growth reference and the new WHO growth standards, specifically focusing on children who died during the program.

**Results:** Of the children classified as moderately wasted using the NCHS reference, 37% would have been classified as severely wasted according to the new WHO growth standards. These children were almost 3 times more likely to die than those classified as moderately wasted by both references, and deaths in this group constituted 47% of all deaths in the program.

**Conclusions:** The new WHO growth standards identifies more children as severely wasted compared with the NCHS growth reference, including children at high mortality risk who would potentially otherwise be excluded from some therapeutic feeding programs.

*Arch Pediatr Adolesc Med.* 2009;163(2):126-130

## Author Affiliations:

Department of Public Health and Clinical Nutrition, University of Kuopio, Kuopio, Finland (Ms Dale and Dr Miettola); Epicentre (Ms Grais), and Médecins Sans Frontières, Paris, France (Dr Minetti); and Department of Public Health, University of Helsinki, Helsinki, Finland and the Unit of Epidemiology and Clinical Research, University Hospital La Paz, Madrid, Spain (Dr Barengo).

**M**ALNUTRITION IS A PARTICULAR concern in developing countries and has resulted in more than 146 million children being underweight.<sup>1</sup> It appears that 50% of all deaths in children younger than 5 years in developing countries result from malnutrition.<sup>2,3</sup>

The 2 classifications for malnourished children based on the criteria outlined by the World Health Organization (WHO) are acute malnutrition and chronic malnutrition, both severe and moderate. These classifications are based on clinical signs and anthropometric measurements from international growth charts endorsed by the WHO.<sup>4</sup>

Severe acute malnutrition (wasting) in children is defined as a having a weight-for-height of less than 70% weight-for-

height body size or less than  $-3$  SD on a weight-for-height growth chart.<sup>5</sup> Children with bilateral pitting edema are classified as having severe acute malnutrition regardless of their anthropometric measurements, and the WHO also indicates that children aged between 6 and 59 months with a mid upper arm circumference (MUAC) of less than 110 mm are considered to have severe acute malnutrition.<sup>6</sup> Children can also be classified as having severe chronic malnutrition (stunting) when they have less than 70% height-for-age body size or less than  $-3$  SD on a height-for-age growth chart. The most vulnerable children are those aged 6 months to 5 years.<sup>7</sup>

Moderate malnutrition in children is defined as less than 80% (70%-79%) but greater than or equal to 70% weight-for-height body size or less than  $-2$  SD but

greater than or equal to  $-3$  SD on a weight-for-height growth chart. Children may also be classified as moderately stunted if they have less than 80% but greater than or equal to 70% height-for-age body size or less than  $-2$  SD but greater than or equal to  $-3$  SD on a height-for-age growth chart.<sup>7</sup>

Until recently, most countries used growth standards that were developed in 1978 by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention, and the World Health Organization (NCHS international growth reference) to determine the nutritional status of children.<sup>8</sup> The NCHS population has been the reference most commonly used in national programs for individual growth monitoring and generating population-based estimates of child malnutrition, and in emergency settings to determine admission to and discharge from feeding programs. Measurements of reference are in the form of either  $z$  scores (standard deviation), or the percentage of the median.

The percentage of the median, as defined by the WHO, is "the ratio of a measured value in the individual, for instance weight, to the median value of the reference data for the same age or height, expressed as a percentage."<sup>9</sup> In the context of a nutrition program, the weight, height, and age of each child is recorded at admission. The admitting medical staff member uses a table of either weight and height, weight for age, or height for age, indicating the cut-off values for the percentage of the median or the  $z$  score. The child's measurements are then classified as a certain category (ie, moderately or severely malnourished or not malnourished) and thus determine whether the child meets the admission criteria for a particular program.

In 2006, the WHO released a new set of growth standards for children based on a 6-year longitudinal study of children from 6 countries<sup>10</sup> with the intention of replacing the NCHS international growth reference.<sup>11</sup> The new standards are thought to be more broadly representative of children throughout the world.

Since the release of the WHO growth standards there have been several studies conducted by WHO<sup>11</sup> and others<sup>12-17</sup> to compare the new standards with the NCHS international growth reference. The key difference, which has operational implications, is that the use of the WHO standards could shift the classification of many children from the category of moderately wasted into the category of severely wasted. This change in classification would require a significant increase in resources directed at treating malnutrition. Previous studies have examined the implications of the new WHO growth standards principally by analyzing data from nutritional surveys. To our knowledge, none of the studies have been based on program monitoring data from nutritional programs. While a full prospective assessment of any new standard in diagnosing acute malnutrition are of clear interest,<sup>12</sup> such studies are difficult because of the ongoing need to provide care. Thus, policy decisions will be based on existing data before these prospective assessments can be accomplished.

The objectives of this study were to analyze admissions data from the nutrition program managed by Médecins Sans Frontières (MSF) (Doctors Without Borders) in collaboration with the Niger Ministry of Health in Maradi, Niger, during the year 2006 and to compare the ability of the NCHS reference with the WHO stan-

**Table 1. Baseline Characteristics of the Study Population**

Characteristic	Participants, No. (%)
Mean (SD) age, mo	20.5 (8.3)
Male	24 998 (47)
Anthropometric data	
Using NCHS reference	
Moderate malnutrition, WFH <80% (70%-79%)	51 351 (96)
Severe malnutrition, WFH <70%	2310 (4)
Using WHO standard	
Moderate malnutrition, < $-2$ SD	31 441 (59)
Severe malnutrition, < $-3$ SD	22 220 (41)
MUAC	
<110 mm	1383 (3)
>110 mm	52 278 (97)

Abbreviations: MUAC, mid upper arm circumference; NCHS, National Center for Health Statistics; WFH, weight for height; WHO, World Health Organization.

dards to identify the children most at risk of death. The results of this study may suggest new operational strategies for nutritional programs.

## METHODS

### PROCEDURE

We conducted a retrospective data analysis of all children admitted to the MSF nutritional program in Maradi, Niger, from January 1, 2006, to December 31, 2006. The nutritional program consisted of 2 inpatient and 11 outpatient centers. Children aged 6 to 59 months were eligible for admission.

The nutrition program was based on the ambulatory strategy in which the children who did not have serious complications and were able to eat were given ready-to-use therapeutic food (RUTF; 2 packages per day to take home) at the outpatient centers each week. Only those children with serious medical complications (ie, severe anemia, shock, sepsis, severe dehydration, and inability to tolerate oral intake of food) and those requiring 24-hour close observation were admitted to the inpatient centers for further care. Children who matched the anthropometric criteria for moderate and severe malnutrition had an initial assessment by a clinician. This assessment included the measurement of the MUAC and assessment of diarrhea, vomiting, anorexia, anemia (physical examination only), and fever. The children were also checked for malaria parasitemia using a rapid diagnostic test (Paracheck Pf; Orchid Biomedical Systems, Goa, India) and whether they were immunized against measles. Compliance with the RUTF was not directly observed because it was an ambulatory program and the children ate the RUTF at home. For a short period in 2006, the families were given a protective food ration of 5 kg of a corn/soya blend and 2 L of oil, which could have potentially prevented the need to share the RUTF, but this did not continue throughout the duration of the program.

The diagnostic criteria for moderate and severe malnutrition used to admit children into the program were based on the weight-for-height percentage of the median of the NCHS growth reference. All measurements were performed using a hanging scale (Salter Brecknell, Fairmont, Minnesota) for measuring weight and a measurement board to measure length.

For analysis purposes, children were reclassified using the EpiNut (Epi Info 6.0; Centers for Disease Control and Prevention, Atlanta, Georgia) software to calculate the percentage of the median for the NCHS reference and the WHO software

(igrowup macro; Geneva, Switzerland) to calculate the z scores for the WHO growth standards, as shown in **Table 1**.

All deaths in the program were recorded in the database. Children were admitted into the program from January 1, 2006, to December 31, 2006, and the final patient was discharged from the program on May 23, 2007. Therefore, the records covered the period from January 1, 2006, to May 23, 2007.

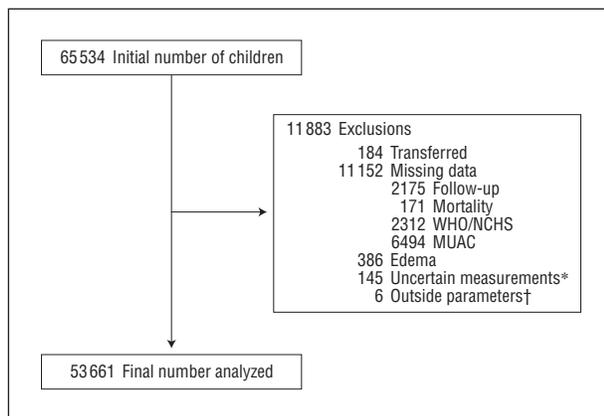
The initial number of children in the data set was 65 534. The flowchart outlines the process for exclusion in the study sample (**Figure**). Children who were transferred (n=184), lost to follow-up (n=2175), had missing data on mortality status (n=171), or missing values on WHO or NCHS indicators (n=2312) were excluded from the analysis. The follow-up was passive. Children were considered lost to follow-up if they missed 3 consecutive visits to the clinic. Children with edema (n=386) were also excluded. Although children were diagnosed and treated as severely malnourished if they presented with bilateral pitting edema, the children were admitted based on their clinical signs rather than their anthropometric measurements (in this case, weight-for-height percentage of the median).

The nutrition teams were instructed to indicate on the charts when the children had edema by checking a specific box on the chart. Children who had missing information regarding edema (n=10 842) were included in the data analysis as not having edema because they did not have sufficient evidence of edema to be classified as such and thus were admitted to the program based on their anthropometric measurements. Children were excluded if anthropometric data were questionable

(eg, NCHS z score < -5; WHO z score < -6 [n=145]; height <49 cm or >110 cm [n=6]) or if MUAC data were missing (n=6494).

## STATISTICAL ANALYSIS

Statistical analyses were performed with SPSS for Windows version 14.0 (SPSS, Chicago, Illinois). The results are expressed with numbers and relative frequencies (percentage). A new variable was created to place the children into 3 categories according to the NCHS and WHO criteria. The first category consisted of children who would have been categorized as moderately malnourished according to both the NCHS and the WHO (moderate NCHS/moderate WHO group). This category was used as the reference. The second category included children who were classified as moderately malnourished according to NCHS, but as severely malnourished according to the WHO (moderate NCHS/severe WHO group). The last category consisted of children who were classified as severely malnourished by both the NCHS and the WHO systems (severe NCHS/severe WHO group). Logistic regression analysis was used to assess differences in mortality rates between the malnutrition categories. The first model was a simple logistic regression. The second was a multiple logistic regression model including MUAC, age, sex, and place of admission as covariates. The goodness-of-fit was validated using the Hosmer-Lemeshow test. These results indicated that the models adequately fit the data. Collinearity between the variables was assessed in the final model and indicated no severe problems with collinearity. The odds ratios (ORs) and 95% confidence intervals (CIs) are presented. The model included malnutrition categories, age, sex, place of admission, and MUAC. The Cox proportional hazards model was used to estimate the association between the different standards and the risk for death. All analyses were adjusted for the following covariates: age, MUAC, place of admission (intensive care unit or ambulatory program), place of exit (intensive care unit or ambulatory program), previous case of measles, anemia, malaria, diarrhea, and high fever. The hazard ratios (HRs) were adjusted for known confounders for risk of death that derived from the published literature. The proportional hazard assumption was tested by graphical methods. Estimated HRs and their 95% CIs are presented. All analyses used 2-tailed tests. The level of statistical significance is .05 in all tests.



**Figure.** Flowchart of children excluded from analysis. \*Questionable anthropomorphic data (ie, z score < -5; World Health Organization (WHO) z score < -6; height <49 cm or >110 cm); †outside of the height parameters (ie, height <49 or >110 cm); MUAC, mid upper arm circumference; NCHS, National Center for Health Statistics.

## RESULTS

There were 53 661 children in the study. A total of 96% were classified as moderately wasted using the existing NCHS guidelines and almost 40% of those children would have been classified as severely wasted had the new WHO standard been applied (Table 1). Children classified as

**Table 2. Risk of Death at Admission for Children in the Nutritional Program According to Malnutrition Classification**

	Sample Size, No.	Dead, No. (%)	Risk, %	NNT <sup>a</sup> (95% CI)	OR (95% CI)	OR (95% CI) <sup>a</sup>
Moderate NCHS/moderate WHO <sup>b</sup>	31 370	71 (26)	0.23	1 [Reference]	1 [Reference]	1 [Reference]
Moderate NCHS/severe WHO <sup>c</sup>	19 781	129 (47)	0.65	238 (183-335)	2.88 (2.15-3.85)	2.27 (1.61-3.21)
Severe NCHS/severe WHO <sup>d</sup>	2238	72 (27)	3.22	35 (28-46)	14.21 (10.21-19.78)	4.11 (2.58-6.55)
Total	53 389	272 (100)				

Abbreviations: CI, confidence interval; NCHS, National Center for Health Statistics; NNT, numbers needed to treat; OR, odds ratio; WHO, World Health Organization.

<sup>a</sup>Adjusted for mid upper arm circumference, age, sex, and place of admission.

<sup>b</sup>Moderately malnourished by both NCHS and WHO standards.

<sup>c</sup>Moderately malnourished by NCHS reference but severely malnourished by WHO standards.

<sup>d</sup>Severely malnourished by both NCHS and WHO growth standards.

**Table 3. Total Mortality HRs According to NCHS Reference and WHO Growth Standards Measurements in Different Categories of Malnutrition**

Growth Categories	Deaths, No.	Person-Days	Adjusted HR (95% CI)		
			A <sup>a</sup>	B <sup>b</sup>	C <sup>c</sup>
Mortality risk					
Boys					
Moderate NCHS/moderate WHO	18	224 995	1.00	1.00	1.00
Moderate NCHS/severe WHO	68	470 456	2.69 (1.54-4.7)	2.184 (1.23-3.89)	1.95 (1.06-3.55)
Severe NCHS/severe WHO	36	53 173	6.05 (2.96-12.35)	2.175 (1.05-4.53)	2.66 (1.23-5.73)
Girls					
Moderate NCHS/moderate WHO	53	685 071	1.00	1.00	1.00
Moderate NCHS/severe WHO	43	203 230	3.67 (2.38-5.67)	1.98 (1.27-3.07)	1.71 (1.06-2.75)
Severe NCHS/severe WHO	36	50 263	9.3 (5.34-16.19)	2.85 (1.61-5.05)	2.16 (1.14-4.10)
Boys and girls combined					
Moderate NCHS/moderate WHO	71	910 146	1.00	1.00	1.00
Moderate NCHS/severe WHO	111	673 733	2.93 (2.13-4.02)	1.94 (1.41-2.68)	1.73 (1.23-2.43)
Severe NCHS/severe WHO	72	103 433	7.29 (4.74-11.20)	2.32 (1.50-3.60)	2.28 (1.43-3.64)

Abbreviations: CI, confidence interval; HR, hazard ratio; MUAC, mid upper arm circumference; NCHS, National Center for Health Statistics; WHO, World Health Organization.

<sup>a</sup>Adjusted for MUAC, comcat (a variable that has 3 categories according to the definition of malnutrition based on both NCHS and WHO standards: category 1, children who are classified as moderately malnourished by both NCHS and WHO growth standards [moderate NCHS/moderate WHO]; category 2, children who are classified as moderately malnourished by NCHS standards but severely by WHO standards [moderate NCHS/severe WHO]; category 3, children who were classified as severely malnourished by both NCHS and WHO standards [severe NCHS/severe WHO]), and age.

<sup>b</sup>Adjusted for MUAC, comcat, age, place of admission, and place of exit.

<sup>c</sup>Adjusted for MUAC, comcat, age, place of admission (intensive care unit or ambulatory program), place of exit (intensive care unit and ambulatory program), and previous cases of measles, anemia, malaria, diarrhea, and high fever.

severely wasted by both population references had 14 times higher risk of death in the program than those classified as moderately wasted by both references (**Table 2**). Those classified as severely wasted by the new WHO standard but moderately wasted by the NCHS reference were almost 3 times (95% CI, 2.15-3.85) more likely to die during the program than those classified as moderate by both references. Children who would have been reclassified thus accounted for almost half of the deaths in the program (129 children; 47%). After adjustment for age, sex, place of admission, and MUAC, the OR of dying was still significantly higher in the moderate NCHS/severe WHO group (OR, 2.27; 95% CI, 1.61-3.21) and in the severe NCHS/severe WHO groups (OR, 4.11; 95% CI, 2.58-6.55) compared with the reference category.

Boys and girls classified as moderate NCHS/severe WHO had a significantly increased risk of mortality compared with those classified as moderate NCHS/moderate WHO in all 3 statistical models (**Table 3**). The HR was 2.184 (95% CI, 1.23-3.89) for boys and 1.98 (95% CI, 1.27-3.07) for girls in the moderate NCHS/severe WHO category when adjusted for MUAC, age, place of admission, and place of exit. The risk increase remained significant after further adjustment for previous cases of measles, anemia, malaria, diarrhea, and high fever. The risk increase in the fully adjusted model was 95% in boys (HR, 1.95; 95% CI, 1.06-3.55) and 71% in girls (HR, 1.71; 95% CI, 1.06-2.75).

#### COMMENT

The results of this analysis confirm that the WHO growth standards classify more children as severely wasted than the NCHS reference<sup>11-17</sup> and strongly suggest that this greater

inclusiveness is of operational importance for identification of mortality risk. Children classified as moderately wasted by the NCHS reference but who are severely wasted by the WHO standard had almost 3 times the risk of dying during the program than those classified as moderately wasted by both standards. In the current cohort, this group contained almost half of the total deaths in the program.

The operational implications of classifying according to the WHO standards (eg, the change in numbers admitted into nutritional programs, increased resources) have been discussed previously.<sup>12</sup> However, the current data suggest an increased subgroup vulnerability for those who would benefit from a reclassification according to the new standard and for whom specifically targeted resource allocation may be planned.

There are 2 key limitations to this study. First, we cannot make an absolute comparison between the 2 standards because we do not have the children included in the study who would have been considered moderately wasted according to the WHO standards. Because the study is a retrospective data analysis, we are only able to discuss the relative risk of the children who were actually treated in the program and who were admitted based on the NCHS standards. The ORs and HRs should be interpreted with caution. The ideal information would only be available from a prospective study where children were randomized to assessment with either the NCHS or WHO standards, subsequent care based on the results thereof, and the survival assessed. Because the treatment of malnutrition depends on the assessed severity regardless of what instrument is used, such a study might be possible and is a clear direction for future research. Nonetheless, both classifications are based solely on clinical measurements that were performed by 2 experienced clinicians

in every case; in addition, there is no obvious source of bias between either of the classifications.

Second, the NCHS growth charts that were used to measure the children in the program were not sex-specific. The same growth chart was used for both boys and girls. The values of the combined sex chart are the means of both boys and girls. The WHO software (igrowup macro) that was used to reclassify children based on the new WHO growth standards consisted of sex-specific charts, thus limiting interpretation of results between boys and girls, but not affecting interpretation of the overall results.

We also chose to include the MUAC in the analysis of mortality risk. We made separate analysis with MUAC excluded and included, and the main directions of the results did not change. Including MUAC improved the statistical model, and all assumptions of the model held. Therefore, we chose to present the results with MUAC included in the model.

This study suggests that the new WHO growth standards are a more inclusive tool for identifying the children at high risk of mortality who require intensive therapeutic rehabilitation. Although these new standards would require organizations to increase their treatment capacity, it will permit more sensitive identification of those most at risk of death from malnutrition. Further research on the application of the new growth standards may permit the determination of better cut-off points for the classification of moderate and severe wasting, which would preserve its improved inclusiveness of high-risk cases but exclude those reclassified children who do not need to be admitted to an intensive therapeutic program. Analysis of data from a nutrition program, which includes moderately wasted children according to the WHO standards, as well as further investigation of comparable populations from other countries and treatment programs will provide better analysis of the impact of the new standards and the implications for nutritional programming.

**Accepted for Publication:** June 24, 2008.

**Correspondence:** Nancy M. Dale, BScN, MPH, Department of Public Health and Clinical Nutrition, University of Kuopio, Kuopio, Finland (dalenmca@yahoo.com).

**Author Contributions:** Ms Dale and Dr Barengo had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Dale, Grais, and Barengo. *Acquisition of data:* Dale and Barengo. *Analysis and interpretation of data:* Dale, Grais, Minetti, Miettola, and Barengo. *Drafting of the manuscript:* Dale, Grais, and Barengo. *Critical revision of the manuscript for important intellectual content:* Grais, Minetti, and Miettola. *Statistical analysis:* Barengo. *Obtained funding:* Dale. *Administrative, technical, and material support:* Minetti. *Study supervision:* Grais and Miettola.

**Financial Disclosure:** None reported.

**Funding/Support:** The study was funded by Médecins Sans Frontières France (Dr Minetti); Epicentre (Ms Grais); and independently (Ms Dale).

**Additional Information:** Approval was granted by the Research Ethics Committee, Hospital District of Northern Savo, Kuopio, Finland.

**Additional Contributions:** The authors would like to thank the Médecins Sans Frontières teams in Maradi, Niger, for their support, with particular mention to Thomas Roederer, the data manager at the time of this study and Nael Lapidus, the public health intern at Epicentre. The authors would also like to thank Brian P. Kavanagh of the Hospital for Sick Children in Canada; Milton Tectonidis, a nutrition specialist for Médecins Sans Frontières Access Campaign; and Geza Harcsi, a nutrition specialist for Médecins Sans Frontières France, for their advice during the revision of the paper. We also thank the Ministry of Health, Niger, for their continued support.

## REFERENCES

1. Progress for children. The United Nations Children's Fund Web site. [http://www.unicef.de/fileadmin/content\\_media/presse/Progress\\_for\\_children/PFC4\\_-\\_FINAL\\_14\\_March\\_2006.pdf](http://www.unicef.de/fileadmin/content_media/presse/Progress_for_children/PFC4_-_FINAL_14_March_2006.pdf). Accessed August 15, 2007.
2. World Health Organization global database on child growth and malnutrition. World Health Organization Web site. [http://whqlibdoc.who.int/hq/1997/WHO\\_NUT\\_97\\_4.pdf](http://whqlibdoc.who.int/hq/1997/WHO_NUT_97_4.pdf). Accessed July 26, 2007.
3. Rice AL, Sacco L, Hyder A, Black RE. Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. *Bull World Health Organ*. 2000;78(10):1207-1221.
4. de Onis M. Measuring nutritional status in relation to mortality. World Health Organization Web site. [http://whqlibdoc.who.int/bulletin/2000/Number%2010/78\(10\)1271-1280.pdf](http://whqlibdoc.who.int/bulletin/2000/Number%2010/78(10)1271-1280.pdf). Accessed July 15, 2007.
5. World Health Organization, World Food Programme, United Nations System Standing Committee on Nutrition, United Nations Children's Fund. Community-based management of severe acute malnutrition. World Health Organization Web site. [http://www.who.int/nutrition/topics/statement\\_commbased\\_malnutrition/en/index.html](http://www.who.int/nutrition/topics/statement_commbased_malnutrition/en/index.html). Accessed July 17, 2007.
6. Guidelines for the inpatient treatment of severely malnourished children. World Health Organization Web site. <http://www.who.int/nutrition/publications/malnutrition/en/index.html>. Accessed July 21, 2007.
7. Management of severe malnutrition: a manual for physicians and other senior health workers. World Health Organization Web site. <http://whqlibdoc.who.int/hq/1999/a57361.pdf>. Accessed July 17, 2007.
8. Dibley MJ, Goldsby JB, Staehling NW, Trowbridge FL. Development of normalized curves for the international growth reference: historical and technical considerations. *Am J Clin Nutr*. 1987;46(5):736-748.
9. Physical status: the use and interpretation of anthropometry: report of a WHO expert committee. World Health Organization Web site. [http://whqlibdoc.who.int/trs/WHO\\_TRS\\_854.pdf](http://whqlibdoc.who.int/trs/WHO_TRS_854.pdf). Accessed July 25, 2007.
10. WHO Multicentre Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. *Acta Paediatr Suppl*. 2006;450:76-85.
11. de Onis M, Onyango AW, Borghi E, Garza C, Yang H. Comparison of the World Health Organization (WHO) child growth standards and the National Centre for Health Statistics/WHO international growth reference: implications for child health programmes. *Public Health Nutr*. 2006;9(7):942-947.
12. Seal A, Kerac M. Operational implications of using 2006 World Health Organization growth standards in nutrition programmes: secondary data analysis. *BMJ*. 2007;334(7596):733.
13. Onyango AW, de Onis M, Caroli M, et al. Field testing the WHO child growth standards in four countries. *J Nutr*. 2007;137(1):149-152.
14. Deshmukh PR, Dongre AR, Gupta SS, Garg BS. Newly developed WHO growth standards: implications for demographic surveys and child health programs. *Indian J Pediatr*. 2007;74(11):987-990.
15. Nuruddin R, Lim MK, Hadden WC, Azam I. Comparison of estimates of undernutrition for pre-school rural Pakistani children based on the WHO standard and the National Center for Health Statistics (NCHS) reference [published online May 27, 2008]. *Public Health Nutr*. doi:10.1017/S1368980008002383.
16. Schwarz NG, Grobusch MP, Decker ML, et al. WHO 2006 child growth standards: implications for the prevalence of stunting and underweight-for-age in a birth cohort of Gabonese children in comparison to the Centers for Disease Control and Prevention 2000 growth charts and the National Center for Health Statistics 1978 growth references [published online ahead of print January 2, 2008]. *Public Health Nutr*. 2008;11(7):714-719.
17. Fenn B, Penny ME. Using the new World Health Organisation growth standards: differences from 3 countries. *J Pediatr Gastroenterol Nutr*. 2008;46(3):316-321.