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Estimates of malnutrition in children 6-59monhts of age based on the WHO standard reveal higher prevalence compared to the NCHS reference in a cross-sectional sample of children from North Cameroon

Ngwa Akonwi Fuh[1*], M'bobda Momdjo Christelle[1], Tchuente Tonou Boris Ronald[1], Nguedjo Wandji Maxwell[1], Ngondi Judith Laure[1] , Julius E. Oben[1]
1. Department of Biochemistry, Yaoundé I University, PO Box 812

ABSTRACT

The assessment of nutritional status based on the 2006 WHO (World Health Organisation) Standards versus the 1977 NCHS (National Center for Health Statistics) Reference has revealed some differences. A chief criticism of the use of the 1977 NCHS Reference has been that, because the reference is based on children from a developed country it should not be applied for all children around the world. The 2006 WHO Standards, they are assumed to be more robust in assessing the nutritional status of the children, especially infants, than was the case for the 1977 NCHS Reference. In the present paper, we compare the estimates of wasting, stunting and underweight obtained from the 2006 WHO standard and the 1977 NCHS reference for the Cameroonian. A total of 1481 children under five years were interviewed in a cross sectional survey including 1343 from 6-59 months. The nutrition status of the children was assessed using the 1977 NCHS Reference and the 2006 WHO Standards. The Hong-de Onis algorithm was also applied separately for children in all age groups, stratified by region and by sex. The 2006 WHO standard compared to the 1977 NCHS standard classify more children as underweight and stunted (8.0% vs 6.8% and 41.0% vs 38.1% respectively). Both references classified 56.8% of children as not stunted, 91.2% as not wasted and 69.4% as not underweight. More children are classified as undernourished using the algorithm compared to directly applying the 2006 WHO Standards except for the 6-11months age group. The assessment of malnutrition using 2006 WHO Standards classify significantly more children as underweight and stunted and is closer to that of a healthy population than the 1977 NCHS Reference.

Keywords: 2006 WHO standard, 1977 NCHS Reference, Weight-for-height, Weight-for-age, Height-for-age.

*Corresponding Author Email: ngwaakonwi@yahoo.fr
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INTRODUCTION

Cameroon is a Central African state, located in the Gulf of Guinea between the latitude 2 and 13 degrees north and longitude 9 and 16 degrees has a rich human mosaic of over 200 ethnic groups and almost as many languages. Of the ten regions of the country, the two northernmost regions, the North and the Far North are part of the semi-arid Sahel. They are limited to the north by Lake Chad to the east by the Republic of Chad and Central African Republic, to the west by the Republic of Nigeria and South by the region of Adamawa.

It is in these two regions that malnutrition rates are highest in the country and many health indicators are the worst according to the Multiple Indicator Cluster Survey conducted in 2006 (MICS 2006)[3] This survey showed that rates of global acute malnutrition among children 0-59 months were 15.1% and 14.2% respectively in the North and Far North and the chronic malnutrition rate was 50.8% and 41.6% using the 2006 WHO Standard.

For many years, the 1977 NCHS Reference has been the most widely used standard and has been used in DHS surveys to assess prevalence of childhood malnutrition. Recently, however, the DHS program has started using the 2006 WHO Standards and has produced some of the first nationally representative statistics on children's nutritional status using this new international standard. Unlike the 1977 NCHS Reference[1] the 2006 WHO Standards[2] describe how children ―should grow‖ by using standards based on breastfeeding children who grow under optimal conditions in their early years of life. Thus the introduction of the new standards represents a shift from a ―descriptive‖ approach to a ―prescriptive‖ point of view in assessing childhood nutritional status.

A number of studies based on various populations have assessed differences in nutritional status based on the 2006 WHO Standards versus the 1977 NCHS Reference. In 2006 a study found that the prevalence of stunting is higher throughout childhood using the 2006 WHO Standards than the 1977 NCHS Reference. The prevalence of underweight among breastfed children is higher during early infancy and lower afterward. For wasting, the main difference occurs during infancy, when the prevalence of wasting is higher using the 2006 WHO Standards. The prevalence of overweight is also higher when the 2006 WHO Standards are used[4]. Report published by de Onis and colleagues substantiate similar differences between nutritional status based on the 2006 WHO Standards and the 1977 NCHS Reference[5].A study in Sind Province, Pakistan, to compare estimates of under-nutrition among preschool children also reported higher prevalence of stunting and wasting by the 2006 WHO Standards compared with the 1977 NCHS

Reference. The differences between the two standards were noticeable for severely wasted and stunted infants[6]. In rural Malawi the nutritional status of children using the 2006 WHO Standards and the 1977 NCHS Reference reported differences in the prevalence of stunting, wasting, and underweight similar to those reported in other studies. This study also reported that underweight prevalence during early infancy that was 3.5 times higher using the 2006 WHO Standards than the 1977 NCHS Reference[7]. Another study by Schwarz et al.[8] of nutritional status of children in Gabon showed considerable differences in patterns of growth faltering depending on which standard was used to assess the prevalence of stunting and underweight. The proportion stunted and underweight was highest when children were assessed using the 2006 WHO Standards compared with either the 1977 NCHS Reference or the 2000 CDC Growth Charts. Another study[9] in Peru, Vietnam, and the Indian state of Andhra Pradesh of children age 6 to 18 months found higher mean weight-for-length/height and weight-for-age using the 1977 NCHS Reference than the 2006 WHO Standards. Like other studies, this study also reported higher prevalence of stunting and a lower prevalence of underweight for the 2006 WHO Standards compared with the 1977 NCHS Reference.

Based on the limited number of published studies, it appears that the 2006 WHO Standards reflect the rapid growth of early infancy better than the 1977 NCHS Reference [3]. However, in emergency situations such as those in a refugee camp, the 2006 WHO Standards have been found to significantly increase the number of children who would be admitted to the feeding programs, because acute malnutrition (weight-for-height) is higher when compared with the 1977 NCHS Reference[10,11].

A chief criticism of the use of the 1977 NCHS Reference has been that, because the reference is based on children from a developed country who were mostly bottle-fed, this single standard should not be applied for all children around the world. An earlier DHS study has disproved this hypothesis, however, by showing that elite children (that is, children of more advantaged socioeconomic status and thus assumed to be well-fed) from a number of surveyed countries have the same distribution of nutritional indicators as that of the 1977 NCHS Reference. When the 2006 WHO Standards were developed, the study sample comprised children from different parts of the globe, using criteria that would help children to achieve their optimal growth and to attain their genetic potential.

Given the rigorous methods adopted to develop the 2006 WHO Standards, they are assumed to be more robust in assessing the nutritional status of the children, especially infants, than was the case for the 1977 NCHS Reference.

Hence, we expect that the nutritional status of the children from our study would be similar to that of the children on which the 2006 WHO Standards. To investigate this hypothesis, our study compares the nutritional status of the children according to the 1977 NCHS Reference with their status according to the 2006 WHO Standards. Our assumption is that the distribution of nutritional status of children should be normally distributed by either standard. Cameroon is among the countries where the 1977 NCHS reference is used in the national program. Since a greater population of the malnourished children stem from the North and Far North regions of Cameroon, it is highly relevant to examine the impact of this change of growth standard on various parameters of nutritional status by using information from a local population-based survey. In the present paper, we compare the estimates of wasting, stunting and underweight obtained from the 2006 WHO standard and the 1977 NCHS reference for the Cameroonian population and discuss the implications of changing the growth standard for national child health programs.

MATERIALS AND METHOD

Sampling:

The sampling method is random sampling in two-stage cluster, stratified for the two regions: North and Far North. Forty-three clusters were selected randomly in the Far North region and 45 clusters in the North region. For each cluster, 16 households to be surveyed were drawn. A total of 1481 children under five years were interviewed, including 1343 from 6-59 months. The preparatory phase of data collection included several tasks including the completion of the survey protocol, the development and / or adaptation of questionnaires, the selection of interviewers and supervisors, cartographers and data entry clerks, meetings with Health authorities in both regions for the administrative approval and involvement in the study, ethical clearance submission to the Ethics Committee, development tools, training and logistical preparation.

Standardization test:

For the standardization of data collection agents, three posts for data collection were installed in health facilities where ten women with children 6 to 59 months were invited. Two runs were done with emphasis on the mastery and control of critical points to make the measurement of any anthropometric parameter acceptable. Z-score is an indicator used in data analysis which measures how far a given data point is from the mean of the data. Z-scores were derived by subtracting the population mean from an individual raw score and then dividing the difference by

the population standard deviation. We use z-scores because they allow us to identify a fixed point in the distributions of different indices across different ages and sex for conducting useful further analysis. The z-scores in this study are calculated as the difference between the height (length)/weight value for an individual child and the mean/median height (length)/weight value of the reference/standard population for the same age and sex, divided by the standard deviation of the reference/standard population.

***Data collection**:*

Trained field workers took anthropometric measurements of children. Weight was recorded to the nearest 0.1 kg using a portable UNICEF electronic UNISCALE (Item No. 0141015). Weighing scales were calibrated daily using 5 kg weight. During weighing, children were lightly clad and without shoes/slippers. Recumbent length (for children less than 24 months) was measured to the nearest centimeter by portable Leicester Height chart with a sliding foot piece. For children older than 24 months, standing height was obtained. Severely malnourished children were referred to a local hospital or a health center for further assessment and care.

***Ethical consideration**:*

The study was approved by the National ethical committee (Ethical clearance N° 2014/04/447/CE/CNERSH/SP and administrative approval was obtained from the Regional Delegates of Public Health. Consent was sought from each participant and the parents of children were required to sign a consent form before data collection. Given the risk of cross-contamination of children who are measured lying down, the yards of plastic portable Leicester Height chart type were used during the study. After each measurement, the fathom was disinfected with a hypochlorite solution.

***Data analysis**:*

Simple univariate tables were created to assess the nutrition status of the children using the 1977 NCHS Reference and the 2006 WHO Standards. The mean z-scores and differences between the mean z-scores were calculated for each of the three anthropometric indices, height-for-age, weight-for-height, and weight-for-age. Bivariate tables were constructed for each of the target group to show the difference by background characteristics in the mean z-scores of each of the three indices. In the absence of 2006 WHO Standards-based estimates of malnutrition, The Hong-de Onis algorithm[12]was also applied separately for children in all age groups, stratified by region and by sex.

RESULTS AD DISCUSSION

Differing classifications of children as Stunted, Wasted and Underweight according to Standard

A child can be classified as Malnourished (wasted, stunted or underweight) by one standard but not the other. In a whole, Table 1 indicates that both the 1977 NCHS Reference and the 2006 WHO Standards classified 56.8% of children as not stunted, and both classified 38.0% of children as stunted. The remaining 5.2% are children who were classified as stunted on the 2006 WHO Standards but not on the 1977 NCHS Reference (and virtually no child was classified as stunted on the 1977 NCHS Reference but not on the 2006 WHO Standards.)

Table 1 Differences in stunting in children 6-59months by 1977 NCHS Reference and 2006 WHO standard

	Percentage of children Not stunted by 1977NCHS and 2006 WHO	Percentage of children stunted by both 1977NCHS and 2006 WHO	Percentage of children stunted by 1977NCHS and not by 2006 WHO	Percentage of children Not stunted by 1977NCHS but are stunted by 2006 WHO	N
Far North	54.8	40.5	0.0	4.7	834
North	58.7	35.6	0.0	5.6	870
Male	54.3	38.8	0.0	6.8	885
Female	59.1	37.3	0.0	3.6	819
6 - 11 Months	69.8	25.9	0.0	4.2	189
12 - 23 Months	54.3	42.4	0.0	3.3	337
24 - 35 Months	48.7	41.8	0.0	9.4	392
36 - 47 Months	53.1	41.0	0.0	5.9	371
48 - 59 Months	63.9	33.7	0.0	2.4	415
Total	56.8	38.0	0.0	5.2	1704

For wasting, 91.2% were classified as not wasted by both 1977 NCHS and 2006 WHO standard, 5.9% were classified as wasted by both standards, only about 1% was classified as wasted on 1977 NCHS and not by 2006 WHO and 2% classified as wasted by 2006WHO but not 1977 NCHS (Table 2).

Table 2 Differences in Wasting in children 6-59months by 1977 NCHS Reference and 2006 WHO standard

	Percentage of children Not Wasted by 1977NCHS and 2006 WHO	Percentage of children Wasted by both 1977NCHS and 2006 WHO	Percentage of children Wasted by 1977NCHS and not by 2006 WHO	Percentage of children Not Wasted by 1977NCHS but are Wasted by 2006 WHO	N
Far North	90.8	5.6	1.2	2.4	834
North	91.6	6.2	0.6	1.6	870
Male	90.8	6.7	0.5	2.0	885
Female	91.5	5.2	1.2	2.0	819
6 - 11 Months	82.6	5.3	0.0	8.5	189
12 - 23 Months	81.9	12.8	3.6	1.8	337
24 - 35 Months	93.6	4.8	0.8	0.8	392
36 - 47 Months	97.0	2.7	0.0	0.3	371
48 - 59 Months	93.5	4.6	0.0	1.9	415
Total	91.2	5.9	0.9	2.0	1704

For Underweight, 69.4% were classified as not wasted by both 1977 NCHS and 2006 WHO standard, 24.6% were classified as wasted by both standards, 5.8% was classified as wasted on 1977 NCHS and not by 2006 WHO and only 0.2% classified as wasted by 2006WHO but not 1977 NCHS (Table 3).

Table 3 Differences in Underweight in children 6-59months by 1977 NCHS Reference and 2006 WHO standard

	Percentage of children Not underweight by 1977NCHS and 2006 WHO	Percentage of children underweight by both 1977NCHS and 2006 WHO	Percentage of children underweight by 1977NCHS and not by 2006 WHO	Percentage of children Not underweight by 1977NCHS but are underweight by 2006 WHO	N
Far North	64.5	28.1	7.4	0.0	834
North	74.1	21.4	4.3	0.2	870
Male	69.7	24.4	5.7	0.1	885
Female	69.2	24.9	5.9	0.1	819
6 - 11 Months	73.0	22.8	3.2	1.1	189
12 - 23 Months	53.4	34.7	11.9	0.0	337
24 - 35 Months	65.3	28.1	6.6	0.0	392
36 - 47 Months	76.0	19.9	4.0	0.0	371
48 - 59 Months	78.8	18.3	2.9	0.0	415
Total	69.4	24.6	5.8	0.1	1704

Application of the Algorithm for translating NCHS 1977 Reference values into 2006 WHO Estimates

The Hong-de Onis algorithm was also applied separately for children in age groups 6-11 months, 12-23 months, 24-35 months, 36-47 months and 48-59 months for all the three anthropometric indices (Weight for Height, weight for Age and height for age). These analysis were also done across the three categories of severity (<-2SD, between -2 and -3 SD and <-3SD).

It was noticed much more children are classified as undernourished using the algorithm and from directly apply the 2006 WHO Standards. However, the reverse was true for the 6-11 months age group were the predicted prevalence was significantly lower than the calculated prevalence ($p<0.0001$) Table 4.

Table 4 Wasting, Stunting and underweight Prevalence estimates calculated using 1977 NCHS Reference based prevalence to derive 2006WHO standards equivalents prevalence by using algorithm published by Yang and de Onis, 2008

	Weight for Height (below -2SD)			Weight for Age (below -2SD)			Height-for-age (below -2 SD)			
	1977 NCHS	**2006 WHO (Predicted)**	**2006 WHO (From Data)**	**1977 NCHS**	**2006 WHO (Predicted)**	**2006 WHO (From Data)**	**1977 NCHS**	**2006 WHO (Predicted)**	**2006 WHO (From Data)**	**N**
Far North	7.0 (4.7 – 10.4)	8.5 (6.2 - 11.6)	8.1 (5.5 – 10.5)	36.2 (31.8 – 40.8)	32.4 (21.9-44.9)	25.4 (21.2 – 29.6)	41.2 (36.8 – 45.7)	47.2 (42.0-52.5)	41.4 (36.4 – 46.4)	825
North	6.7 (4.5 – 9.7)	8.2 (6.0-11.1)	7.9 (5.3 – 10.5)	25.1 (21.7 – 28.9)	22.2 (14.3-32.7)	21.1 (16.9 – 25.3)	35.2 (31.5 – 39.1)	41.4 (36.4-46.6)	40.3 (35.2 – 45.4)	899
Male	7.0 (4.1 - 9.9)	8.5 (6.2 - 11.6)	9.1 (6.8 – 12.4)	30.0 (26.3 – 33.9)	26.6 (17.6-38.2)	23.4 (19.4 – 27.4)	38.6 (34.5 – 42.8)	44.7 (39.5-50.0)	43.5 (39.5 – 47.5)	828
Female	6.7 (4.8 - 9.3)	8.2 (6.0-11.1)	7.0 (5.3 – 9.5)	30.9 (26.8 – 25.3)	27.5 (18.2-39.2)	23.9 (19.8 – 28.0)	37.6 (34.0 – 41.4)	43.7 (38.6-49.0)	38.7 (34.6 – 42.8)	896
6 - 11 Months	6.9 (5.1 – 7.8)	8.4 (6.1-11.4)	14.4 (15.3 – 17.2)	29.2 (27.5 – 31.3)	25.9 (17.0-37.3)	24.2 (23.9 – 25.1)	28.0 (26.1 – 31.0)	34.1 (29.5-39.1)	30.2 (29.8 -33.6)	218
12 - 23 Months	16.5 (14.1 – 17.9)	18.6 (14.0-24.3)	13.2 (7.0 – 20.4)	47.0 (46.1 – 48.3)	42.7 (30.4-55-9)	31.6 (23.0 – 40.2)	44.4 (40.9 – 48.1)	50.2 (44.9-55.5)	43.5 (35.7 – 51.3)	328
24 - 35 Months	4.1 (3.4 – 5.1)	5.2 (3.8-7.2)	6.3 (1.2 – 12.2)	33.9 (31.9 – 34.9)	30.2 (20.3-42.5)	28.0 (20.7 – 35.3)	42.6 (39.8 – 44.1)	48.5 (43.3-53.8)	50.5 (43.5 – 57.5)	389
36 - 47 Months	3.5 (2.8 – 4.1)	4.5 (3.3-6.2)	3.4 (0.1 – 7.1)	22.9 (21.0 – 23.5)	20.2 (12.9-30.1)	19.9 (13.5 – 26.3)	40.2 (38.0 – 42.1)	46.2 (41.0-51.5)	45.1 (38.2 – 52.0)	376
48 - 59 Months	4.8 (4.0 – 5.2)	6.0 (4.4-8.3)	6.3 (3.7 – 8.9)	21.5 (19.3 – 23.1)	18.9 (12.0-28.4)	17.0 (11.2 – 22.8)	32.2 (30.9 – 33.3)	38.4 (33.5-43.5)	32.6 (25.0 – 40.2)	413
Both regions	6.8 (5.2 – 8.9)	8.3 (6.1-11.3)	8.0 (6,2 – 9,8)	30.4 (27.5 – 33.6)	27.0 (17.8-38.7)	23.7 (20.7 – 26.7)	38.1 (35.2 – 41.0)	44.2 (39.1-49.5)	41.0 (38.5 – 44.5)	1724

Looking at the discrepancy between the predicted prevalence and the calculated prevalence across the severity of wasting, we noticed that for both moderate and severe wasting, the predicted prevalence was higher compared to the calculated prevalence but for the 6-11 months age group where the reverse was true.

The algorithm produced predicted prevalence of underweight and stunting that was higher than the calculated prevalence. The average gap between these two was 3.3 percent points for underweight, 0.3 percent points for wasting and 3.2 percent points for stunting. The predicted prevalence of wasting was higher only for two forms i.e. Global wasting (z score < -2 SD) and Moderate wasting (z score between -2 and -3 SD) but not for severe wasting (z score < - 3 SD). The closest results of the algorithm to the actual 2006 WHO standard z-score in absolute value are obtained between the ages of 24 – 59 Months. This indicates that using the algorithm probably works better when the child is 2 years and above.

Comparing the three different indices, the gap between the predicted and the calculated prevalence was smallest in wasting across all its forms (Global, moderate and severe) compared to stunting and underweight. This may indicate that the algorithm may be best suited for use in Wasting for children above 2 years of age.

The prevalence of severe acute malnutrition is significantly ($p < 0.00001$) higher in the north compared to the Far North while the prevalence of Global acute malnutrition is higher in the Far North compared to the North. The global malnutrition, there is a higher prevalence in the Far North with respect to the North ($p = 0.0021$). This can be explained by the fact that the food security situation is of major concern in the North compared to the Far North. In the Far north, agriculture is the main activity of 4 major divisions: Mayo Kani, Mayo Tsanaga, Mayo Danay and Mayo Sava. These regions are the bread basket of the Far North and reduce the rate of malnutrition. Also, Type two nutrients especially Zinc and Iron play a major role in the setting in of Malnutrition. Deficiency in iron will lead to anemia and decrease in muscle mass resulting in marasmus. Another unpublished study carried out by this researcher revealed that Acute phase proteins adjusted zinc deficiency was higher in the Far North (89.0%) compared to the North (82.6%). Zinc deficiency is associated with poor immune function— particularly cellular immunity[13] —and zinc supplementation of malnourished children improves immune function[14]. Lymphoid atrophy decreased delayed cutaneous hypersensitivity responses, reduction in numbers of T4 helper cells, and deficient thymic hormone activity have been described in association with zinc deficiency. B cell dysfunction and impairment of phagocytosis specifically, have also been described.

According to recent classification tables, when a child has bi pitting edema, the child is automatically considered a severely malnourished. The higher rates of severe acute malnutrition obtained in the North region can be attributed to the higher number of children with edema obtained in the North. The setting in of edema has been related to deficiency in type 2 nutrients. The recent Demographic and Health survey in Cameroon[15] the prevalence of Anemia was significantly ($p<0.001$) higher in the North (68.2%) compared to the Far North region (63.5%). The prevalence of severe anemia was twice in the North compared to the Far North (2.5% and 1.2% respectively).

Iron is an essential substance needed for metabolism process, such as for transporting oxygen to the tissues for energy production in cells. Iron is also important for transporting electrons in the mitochondria for cell respiration process, and for synthesizing Deoxyribo Nucleic Acid (DNA). Some studies have reported increase of IL-6 and IL-4 expression in iron deficiency anemia (IDA)[16] Another study carried out on 81 children suffering from iron deficiency showed that IL-2 production due to PHA (phytohaemagglutinin) stimulation was lower in iron deficiency cases than that of non-iron deficiency cases, but the level of IL-2 of both groups of cases was not different if not stimulated by PHA. The reduction of IL-2 production causes disorder of the immune system and Cell mediated Immunity (CMI) disturbance[17]

Interleukin production as a response to antigen is an integral and important part of adaptive immune responses. Whereas CMI is the immune response that extricates antibody, but involves more the activation process of T cells into T cells effectors, activation of macrophages and NK (natural killer) cells, as well as stimulation of Interleukin production. Decreased iron reserve will reduce the function CMI such as in the form of delayed hypersensitivity, lymphocytes proliferation due to antigen stimulation, Natural Killers cytotoxicity. Studies have revealed that iron deficiency caused function reduction of the immune system by way of lowered function of the thymus, proliferation impairment of T cells and thymocytes [18]. On the other hand, some studies on humans have shown varied results. The number of T cells tends to decrease in pure iron deficiency, but this condition can be cured by iron supplementation. Thus the high GAM rates obtained in the Far North compared to the North can attributed to high levels of iron deficiency in the Far North. This is in line with research carried out in Cameroon [19] which indicates that the iron deficiency in the Far North (76.0%) was significantly higher ($p<0.0001$) when compared to the North (60.19%)

Also, Boys seem more affected by this form of malnutrition than girls. We noticed that the prevalence of Acute malnutrition amongst children 6-23 months was higher than the 24-59 months age group (p=0.00142)

Similarly to Acute malnutrition, the prevalence of Wasting and stunting was higher for the Far North region when compared to the North region. In an associated study, the level of morbidity as a factor contributing to the deterioration of the nutritional status was evaluated. Results show that the overall morbidity score of the study was higher for the Far North compared to the North. Marasmus (wasting) is a condition most often associated with protein deficiency and infections like gastroenteritis, respiratory tract infection, diarrhea and malaria. Thus the high morbidity of infection in the Far North may be associated to Wasting and stunting.

Comparison of WHO and NCHS Standards

It is expected that important differences between the WHO standards and the NCHS reference would be observed that vary by age group and growth indication.

Our results support the findings of other studies [2,6] that the prevalence of stunting in children under 5 years of age is higher using the 2006 WHO standards when compared to the 1977 NCHS reference. The relative increase obtained from our study is 2.9% points. It is expected though that stunting will increase throughout childhood when assessed using the WHO standards compared with the NCHS reference. Despite the close tracking of the WHO and NCHS medians (except from 24 to about 35 months when WHO children are on average taller due to the NCHS disjunction at this age), the tighter variability of the WHO standards affects the placement of the usual cut-off for stunting, i.e. -2SD. Our study also supports the finding of [4] that children in the WHO standards are of the same average length/height (or taller in some age groups) as those in the NCHS reference thus dispelling concerns that breast-fed infants might fail to meet their potential for growth of fat-free tissue because of marginal intakes of energy, protein and/or other nutrients.

Also, this study revealed a higher prevalence of underweight exists with the 1977 NCHS Reference. These findings are similar to other findings [19]This is also similar to the findings of M. Onis et al 2006 who found out that the prevalence of underweight was higher between 0-6 months of age and then became significantly lower from 6 months of age and above when estimated using the WHO standards compared to the NCHS standards.

Furthermore, these results found that the use of the 2006 WHO Standards classify a higher proportion of children 6-59months as wasted; these results are similar to the results of a study carried out amongst Pakistani children [4].

Looking at the differing classifications of children as stunted, wasted and underweight for each standard, 5.2% of the children were classified as stunted on the 2006 WHO standard but not on the 1977 NCHS Reference while all the children classified as stunted on the 1977 NCHS reference were also classified as stunted on the 2006 WHO Standard. This suggests that the 2006 WHO Standards allows for the inclusion of many more children as stunted. For wasting, though up to 2 % of the population was classified as Wasted by 2006 WHO and not 1977 NCHS, only 0.9% of the population was classified as Wasted by 1977 NCHS and not 2006 WHO standard. The Gap between the two decreases significantly with increasing age indicating that the 1977 NCHS may be suited for children of ages 24 months and above.

With regards to underweight, the scenario is the contrary with the 1977 NCHS reference classifying up to 5.8% more children as underweight(Table 1). This is in line with the expectations of WHO experts [6] who found out that underweight rates generally will be higher when based on 2006 WHO standard compared with rates based on 1977 NCHS reference during the first half of infancy (0-6months) and lower thereafter.

The use of the Hong and de Onis algorithm to convert the prevalence statistics based on 1977 NCHS Reference to 2006 WHO Standard generally yields higher rates of malnutrition than the direct application of the 2006 WHO standard. This is not true for Severe wasting where the predicted prevalence is lower than that obtained from the direct application of the 2006 WHO Standard. This can be explained by the fact that the presence of edema is an indicator to be classified as severely wasted irrespective of the anthropometric parameters. Bloem[21] reports that the prevalence of wasting using either the 2006 WHO Standards or the 1977 NCHS Reference varies by setting. Hence, interpretation of these results is complex and reliance on a single algorithm is not justified. The use and interpretation of the prevalence using the 2006 WHO Standards derived from the suggested algorithm values should be done with caution, especially when determining trends.

Calculations of the mean z-scores for height-for-age are higher with the 2006 WHO Standards and that the mean z-scores for weight-for-age are higher with the 1977 NCHS Reference as revealed by our results. According to Gibson[22], the variation in weight-for-height could be because it is a sensitive indicator influenced by short-term events, and wasting can develop rapidly from fluctuations in food supply and prevalence of infectious diseases

The WHO standards are based on a sample of healthy breast-fed infants and they provide a better tool than the NCHS reference for monitoring the growth of breast-fed infants. The establishment of the breast-fed child as the norm for growth and development brings coherence among the

tools used to assess growth and national and international infant feeding guidelines that recommend breast-feeding as the optimal source of nutrition during infancy. It also provides a basis for advocating the protection, promotion and support of breast-feeding and adequate complementary feeding. In this regard, the WHO standards make meaningful contributions to reducing child morbidity and mortality.

The WHO standards demonstrate that healthy children from around the world who are raised in healthy environments and follow recommended feeding practices have strikingly similar patterns of growth[23] The ancestries of the children included in the WHO standards were widely diverse. They included peoples from Europe, Africa, the Middle East, Asia and Latin America. In this regard they are similar to growing numbers of populations with increasingly diverse ethnicities. The growth of the children in the various sites was very similar because their environments were similarly healthy. This indicates that we should expect the same potential for growth in any region. It also implies that deviations from this pattern must be assumed to reflect adverse conditions that require correction, e.g. lack of breast-feeding, nutrient-poor or energy-excessive complementary foods, unsanitary environments, deficient health services and/or poverty.

The NCHS reference is currently used in about 100 countries[24] The shift to the WHO standards provides a unique opportunity to underscore the importance and utility of monitoring linear growth; to rethink and redesign surveillance systems so that they are more useful in decision-making and less burdensome in terms of data collection; and, most importantly, to accelerate the integration of activities to promote infant and young child nutrition with broader efforts that encompass maternal and child health, full immunization and adequate attention to physical, motor and cognitive development.

CONCLUSION

There is no doubt that using the 2006 WHO Standards will increase the estimated prevalence of stunting and wasting in children 6-59 months. However, estimates of the proportion of children who are underweight will be lower. We conclude from our analysis that the assessment of malnutrition using 2006 WHO Standards is closer to that of a healthy population than the 1977 NCHS Reference for weight-for-age and weight-for-height. However, the assessment of height-for-age using the 1977 NCHS Reference more closely follows that of a healthy population than the 2006 WHO Standards. The 2006 WHO Standards may also serve as a better tool to assess the emerging problem of Malnutrition early in life. These findings have implications for evaluating children's nutritional status and for trend analysis. We recommend that malnutrition tabulations

should be made using both the 1977 NCHS Reference and the 2006 WHO Standards during the transition from use of the older ―descriptive reference to the new ―prescriptive standard. We also recommend not using the suggested algorithm for converting the 1977 NCHS point estimates into 2006 WHO Standards point estimates for assessing trends in malnutrition of young children.

List of Abbreviations

NCHS: National Centre for Health Statistics
WHO: World Health Organization
CMI: Cell mediated Immunity
GAM: Global Acute Malnutrition
PHA : phytohaemagglutinin
IDA: Iron Deficiency Anemia
DNA: Deoxyribo Nucleic Acid
IL : interleukine
SD: Standard Diviation
CDC: Centre for Disease Control
MICS: Multiple Indicator Cluster Survey
NK : Natural Killer

AUTHORS' CONTRIBUTIONS

NAF and MMC participated in the conception and design of the study, TTBR and NWM and coordinated the data collection and analysis. NJL and JEO assisted in critically reviewing the proposal, design of the study, and data analysis. NAF prepared the manuscript for publication. All authors read and approved the final manuscript.

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Author's information

NAF: Department of Biochemistry, University of Yaounde 1 and UNICEF
MMC; Department of Biochemistry, University of Yaounde 1
TTBR: Department of Biochemistry, University of Yaounde 1
NWM: Department of Biochemistry, University of Yaounde 1

NJL: Senior Lecturer Department of Biochemistry, University of Yaounde 1

JEO: Professor Department of Biochemistry, University of Yaounde 1

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