ARTICLE

Assessing the Impact of the Introduction of the World Health Organization Growth Standards and Weight-for-Height *z*-Score Criterion on the Response to Treatment of Severe Acute Malnutrition in Children: Secondary Data Analysis

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What's Known on This Subject

Important differences exist in the diagnosis of malnutrition with the application of the NCHS reference and WHO standards. It is expected that more children will be classified as severely acutely malnourished with the use of the new standards.

What This Study Adds

Introduction of the WHO standards would include children into severe malnutrition treatment programs who have fewer medical complications requiring inpatient care and are more likely to experience shorter durations of treatment and lower mortality compared with the NCHS reference.

ABSTRACT

OBJECTIVE. The objective of our study was to assess the impact of adopting the World Health Organization growth standards and weight-for-height z-score criterion on the response to treatment of severe acute malnutrition in children compared with the use of the National Center for Health Statistics growth reference.

METHODS. We used data from children aged 6 to 59 months with acute malnutrition who were admitted to the Médecins sans Frontières nutrition program in Maradi, Niger, during 2006 ($N = 56\,214$). Differences in weight gain, duration of treatment, recovery from malnutrition, mortality, loss to follow-up, and need for inpatient care were compared for severely malnourished children identified according to the National Center for Health Statistics reference and weight-for-height <70% of the median criterion versus the World Health Organization standards and the weight-for-height less than −3 *z*-score criterion.

RESULTS. A total of 8 times more children ($n = 25\,754$) were classified as severely malnourished according to the World Health Organization standards compared with the National Center for Health Statistics reference ($n = 2989$). Children included according to the World Health Organization standards had shorter durations of treatment, greater rates of recovery, fewer deaths, and less loss to follow-up or need for inpatient care.

CONCLUSIONS. The introduction of the World Health Organization standards with the z-score criterion to identify children for admission into severe acute malnutrition treatment programs would imply the inclusion of children who are younger but have relatively higher weight for height on admission compared with the National Center for Health Statistics reference. These children have fewer medical complications requiring inpatient care and are more likely to experience shorter durations of treatment and lower mortality rates. The World Health Organization standards with the *z*-score criterion might become a useful tool for the early detection of acute malnutrition in children, although additional research on the resource implications of this transition is required. *Pediatrics* 2009;123:e54–e59

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Key Words
WHO growth standards, child malnutrition, wasting, selective feeding, therapeutic feeding, Niger

Abbreviations
WHO—World Health Organization
NCHS—National Center for Health Statistics
MSF—Médecins sans Frontières
WFH—weight for height
RUTF—ready-to-use therapeutic food

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IN APRIL 2006, the World Health Organization (WHO) introduced the WHO child growth standards (WHO standards) for assessing the growth and development of children from birth to 60 months of age. The WHO standards were developed by using data from a multicenter international study and, as a standard rather than a reference, describe how children should grow under optimal conditions. They were developed to replace the National Center for Health Statistics (NCHS)/WHO growth reference (NCHS reference) and represent a significant move forward in the understanding and measurement of the nutritional status of children.

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[1] and in emergency settings to determine admission to and discharge from feeding programs.[2] Given that important differences in the diagnosis of malnutrition exist with the application of the NCHS reference versus the WHO standards, greater clarity is needed on the implications of introducing the WHO standards in ongoing and new malnutrition treatment programs.

Direct comparisons of the WHO standards and NCHS reference percentile values have been published,[3] as well as studies on the impact of the WHO standards on the prevalence of malnutrition.[4] Seal and Kerac[5] recently examined the operational implications of adopting the new standards, noting that the use of the new standards and the *z*-score criterion could lead to important increases in the prevalence of severe acute malnutrition and admissions to nutrition programs. Although it is expected that more children will fulfill eligibility criteria for admission into severe acute malnutrition treatment programs with the use of the new standards, it is not known whether applying the WHO standards also implies changes in the outcomes of malnutrition treatment, including weight gain, duration of treatment, and mortality.

With this study we aimed to assess the implications of introducing the WHO standards on common treatment outcomes. Using data collected in an integrated home- and facility-based malnutrition treatment program, we evaluated the differences in weight gain, duration of treatment, recovery from malnutrition, mortality, loss to follow-up, and need for inpatient care of children who would be included in severe acute malnutrition treatment programs if the WHO standards and −3 *z*-score criterion were applied compared with the NCHS reference and 70% of the median criterion.

METHODS

Study Population

The study population included all children with acute malnutrition (weight for height [WFH] < 80% of the NCHS reference median) who were enrolled in the Médecins sans Frontières (MSF) malnutrition treatment program in Maradi, Niger, during 2006 ($N = 68\ 101$). In collaboration with the Ministry of Health of Niger, the MSF nutrition program in Maradi uses an integrated home- and facility-based approach to the treatment of malnutrition. Through this approach, children with sufficient appetite and without serious complications are offered home-based treatment with the provision of ready-to-use therapeutic food (RUTF).

All children who presented to the health and nutrition centers in Maradi where MSF operated were screened for moderate or severe acute malnutrition. Children were eligible for admission into the program if they were 60 to 110 cm tall and fulfilled at least 1 of the following criteria: presence of bipedal pitting edema, mid–upper arm circumference < 110 mm, or WFH < 80% of the NCHS reference median. Height or length (from 65 to 110 cm) can be used as a proxy for age to identify children between 6 and 59 months of age. A lower bound of 60 cm was used in this population because of the high prevalence of stunting.[6] Bipedal edema was detected by the production of a pit after placing moderate pressure with the thumb on both legs over the top of the foot and lower end of the tibia for 3 seconds.

Field Procedures

At the time of admission into the malnutrition treatment program, MSF personnel obtained information from the primary caregivers on the child's age, gender, and history of recent illness. Trained MSF nutrition assistants conducted anthropometric measurements on the children with the use of standardized methods and calibrated instruments. Height (recumbent length if <85 cm) was measured to the nearest 0.1 cm by using a wooden measurement board. Weight was measured to the nearest 0.1 kg by using a hanging Salter scale (Salter Brecknell Weighing Products, Fairmont, MN) and to the nearest 0.01 kg by using a mechanical SECA 75 scale (SECA Ltd, London, United Kingdom) after July 2006. WFH percent of the median on admission was determined by using a gender-combined table with intervals of 0.5 cm for length/height. Appetite was assessed and a medical examination was performed to identify complications such as altered mental status, severe respiratory infection, diarrhea, and dehydration. All children were screened for *Plasmodium falciparum* (malaria) with a rapid test (Parachek Pf [Orchid Biomedical Laboratories, Goa, India]).

After admission into the program, all children routinely received treatment for bacterial infections and intestinal parasites, measles vaccination, and vitamin A and folic acid supplementation. Treatment for malaria was provided if indicated by the rapid test results. Children who were 6 to 8 months of age on admission were revaccinated for measles at 9 months. Children with WFH between 70% and 79% of the median did not routinely receive antibiotics after June 2006. Outpatient nutritional treatment consisted of 2 sachets per day of RUTF (Plumpy'nut [Nutriset, Malaunay, France]) that provided 4200 kJ/day (1000 kcal/day). Caregivers were asked to return with their children to the outpatient centers on a weekly basis; during these visits, weight was measured and a medical examination was performed to identify complications. At every visit, the following week's supply of RUTF (14 sachets) was distributed. Inpatient care was made available to children who presented with medical complications.

Children were discharged from the program when they reached a WFH of ≥80% of the NCHS reference median after 2 consecutive weighings before November 5, 2006. On or after November 5, 2006, children were discharged when they reached a WFH of ≥85% of the NCHS reference median on 1 weighing to reduce the number of readmissions. These discharge criteria were applied irrespective of the criterion used for admission. Program personnel also registered the dates of death and admission into inpatient care if these events took place.

Children who failed to appear for their visit on 3 consecutive weeks were considered lost to follow-up.

All the information was registered on standardized medical charts. Records of discharged children were entered into computer databases on a weekly basis.

Data Analyses

We excluded children who had missing WFH, age, or gender information (n = 313) and those who were <6 months or >59 months of age (n = 402). Because anthropometric criteria cannot be used to diagnose edematous malnutrition because of the impact of retained fluid on weight assessment, children with edema (n = 387) or missing information on edema status on admission (n = 10 737) were excluded to allow for a clearer comparison of the performance of the different admission criteria. Thus, the final sample size was 56 262.

We describe the differences between children who would be identified as severely acutely malnourished and eligible for admission into therapeutic feeding programs according to the NCHS reference and <70% of the median criterion versus the WHO standards and less than −3 z-score criterion. Severe acute malnutrition according to the NCHS reference was defined by using the percentage of the median, because this criterion is often used to determine admission into therapeutic feeding programs.[5] Severe acute malnutrition according to the WHO standards was defined by z-score criterion because the introduction of the new standards has relied on the use of the z score.[3,7] Therefore, this comparison of the NCHS reference and <70% of the median criterion versus the WHO standards and less than −3 z-score criterion is likely to most accurately simulate the actual transition that existing programs will experience.

Children who were eligible for inclusion into a severe acute malnutrition treatment program according to the WHO standards but not eligible with the NCHS reference ("program additions") were also identified and compared with those children who were eligible according to the NCHS reference and percent of the median criterion. These children reflect the impact that the addition of children newly identified by WHO standards would have on malnutrition treatment programs.

We calculated WFH (weight for length if <24 months of age) percentages of the NCHS reference median by using Epi Info 6.0 software (Centers for Disease Control and Prevention, Atlanta, GA) and z scores for the WHO standards by using the *igrowup* macro package (available at: www.who.int/childgrowth/software/en).

There were 6 treatment-response outcomes of interest. Weight gain (g/kg per day) and duration of treatment (days) were treated as continuous variables. Recovery, death, loss to follow-up, and need for inpatient care were considered to be dichotomous variables. To compare children eligible according to the NCHS reference and percent of the median criteria versus the program additions, we tested the differences in continuous and dichotomous variables with the use of linear and binomial[8] regression, respectively. Because demographic characteristics were associated with the identification of severe acute malnutrition by the NCHS reference and the WHO standards and could be related to treatment response, we adjusted the analyses for the potentially confounding effects of gender and age at the time of enrollment. All P values correspond to the Wald test.

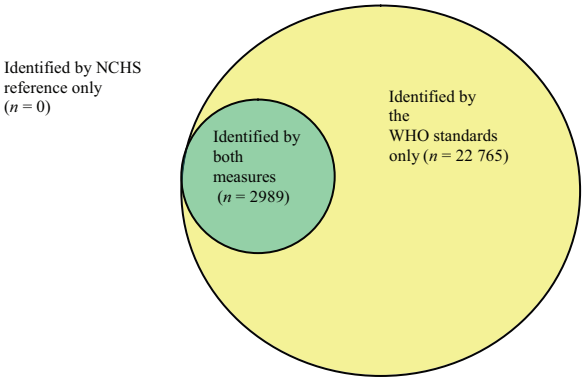

FIGURE 1
Number of children identified with a WFH of <70% of the NCHS reference median and a WFH z score of less than −3 of the WHO standards.

We conducted supplemental analyses after including those children with missing information on edema status on admission (n = 10 737) as nonedematous. The results did not change after this inclusion; thus, we only present the results in the population with complete data. A P value of ≤.05 was considered statistically significant. All analyses were conducted with the use of the Statistical Analyses System software (SAS Institute, Inc, Cary, NC). The data analyses were exempted from review by the Human Subjects Committee at the Harvard School of Public Health.

RESULTS

The total number of children identified as severely malnourished with use of the WHO standards and z-score criterion was >8 times larger than the number of children identified with the NCHS reference and percent of the median criterion (Fig 1). All children who were eligible for nutritional assistance according to the NCHS reference and percent of the median criterion were also classified as severely malnourished and eligible with the use of WHO standards and z-score criterion.

The age, gender, and nutritional profiles were different between children who would be eligible according to the NCHS reference and percent of the median criterion and children who would be eligible according to the WHO standards and z-score criterion (Table 1). Children included with the WHO standards were younger than those included with the NCHS reference (unadjusted Cochrane-Armitage P for trend < .001). These children also had higher WFH z scores on admission.

Compared with children included under the NCHS reference, children who were identified as severely malnourished by the WHO standards had lower weight gain, shorter duration of treatment, and a greater rate of recovery. The frequencies of death, loss to follow-up, and need for inpatient care among children who were identified as severely malnourished by the WHO standards

TABLE 1 **Demographic Characteristics and Treatment-Response Profiles of Children Identified With Severe Acute Malnutrition by Using the NCHS Reference and the WHO Standards**

	Children Identified by NCHS WFH <70% median	Children Identified by WHO WFH *z* Score Less Than −3	Children Identified by WHO WFH *z* Score Less Than −3 but not by NCHS <70% Median	Adjusted *P*[a]
N	2989	25 754	22 765	
Demographic characteristics, *n* (%)				
Age				
6–12 mo	849 (28.4)	9818 (38.1)	8969 (39.4)	
13–24 mo	1694 (56.7)	13 004 (50.5)	11 310 (49.7)	
25–36 mo	391 (13.1)	2404 (9.3)	2013 (8.8)	
≥37 mo	55 (1.8)	528 (2.1)	473 (2.1)	
Gender				
Male	1591 (53.2)	17 107 (66.4)	15 516 (68.2)	
Female	1398 (46.8)	8647 (33.6)	7249 (31.8)	
Nutritional status (WHO standards), mean ± SD				
WFH *z* score on admission	−4.7 ± 0.7	−3.6 ± 0.6	−3.4 ± 0.3	<.0001
WFH *z* score at discharge	−3.8 ± 1.0	−2.9 ± 0.8	−2.8 ± 0.7	<.0001
Treatment response				
Weight gain, g/kg per d	8.2 ± 7.6	5.9 ± 5.0	5.6 ± 4.5	<.0001
Duration of treatment, d	46.2 ± 30.3	37.9 ± 25.5	36.8 ± 24.6	<.0001
Recovered, *n* (%)	2244 (75.7)	23 255 (90.7)	21 011 (92.6)	<.0001
Died, *n* (%)	114 (3.8)	324 (1.3)	210 (0.9)	<.0001
Lost to follow-up, *n* (%)	401 (13.5)	1614 (6.3)	1213 (5.4)	<.0001
Need for inpatient care, *n* (%)	1421 (49.0)	5623 (22.2)	4202 (18.7)	<.0001

[a] Adjusted *P* values correspond to tests of the difference between children with a WFH of <70% of the NCHS reference median versus children with a WFH *z* score of less than −3 of the WHO standards but not a WFH of <70% of the NCHS reference median. *P* values for continuous variables (WFH *z* score, weight gain, duration of treatment) correspond to linear regression and for proportions (recovery, death, loss to follow-up, and need for inpatient care) to binomial regression with the treatment-response variable as the outcome and identification by NCHS reference or WHO standards, age, and gender as covariates.

were less than half of those observed in children identified by the NCHS reference.

The overall differences in children eligible according to the NCHS reference and percent of the median criterion versus children eligible according to the WHO standards and *z*-score criterion are determined by the program additions (ie, the children eligible according to the WHO standards but not by the NCHS reference) (Table 1). After adjustment for age and gender, compared with children eligible according to the NCHS reference, children representing the program additions had higher WFH *z* scores on admission and experienced a shorter duration of treatment, higher rate of recovery, and lower frequency of death, loss to follow-up, and need for inpatient care.

DISCUSSION

We found that the total number of severely malnourished children identified with the use of WHO standards and a WFH of less than −3 *z*-score criterion would be >8 times higher than the number identified with the use of the NCHS reference and a WFH of <70% median criterion. In addition, the demographic profile, nutritional status, and treatment response of children included in therapeutic feeding programs would significantly change with the introduction of the WHO standards. Children newly included with the use of WHO standards would be younger and have higher WFH *z* scores on admission compared with children identified as severely malnourished according to the NCHS reference. Children identified by the WHO standards would also experience greater rates of recovery and lower frequencies of death, loss to follow-up, and need for inpatient care.

This study was able to draw from an extensive program database that included a large number of children with a WFH on admission of <80% of the NCHS reference median. The use of a program population that included children with WFH of <80% (ie, both moderately and severely malnourished children) allowed many of the children without severe acute malnutrition using the NCHS reference (ie, WFH ≥70% of the median) but with severe acute malnutrition according to the WHO standards (ie, WFH *z* score less than −3) to be captured in the study population. Only a small proportion of children with a WFH *z* score of less than −3 from the WHO standards but a WFH of ≥80% of the NCHS reference median are likely to have been excluded from the study population. A comparison of cut points shows that the WFH of <80% of the NCHS reference median cutoff point used for inclusion into the study population is higher and, thus, more inclusive than the WHO WFH of less than −3 *z*-score cutoff point at all lengths/heights, except between 60 and 65 cm. In a supplemental analysis in which children 60 to 65 cm in length were excluded ($n = 5918$), the results did not change, suggesting that any potential bias introduced by the exclusion of children with a WFH *z* score of less than −3 from the WHO standards but a WFH of ≥80% of the NCHS reference median from the study population is likely to be small.

This study has several limitations. Anthropometric variables were likely measured with some imprecision and child age was measured with error as we observed digit preference for baseline-reported ages of 12, 24, and 36 months. These errors, however, are unlikely to have been differential with respect to the outcomes evaluated. There was no active follow-up of children who did not return for subsequent visits; therefore, we cannot explain the difference in loss to follow-up among those identified by the NCHS reference versus those identified by the WHO standards with certainty. Children considered to have been lost to follow-up may include children who died or children who did not return for additional treatment but who regained weight sufficiently. Finally, we were unable to account for the actual weight gain and duration of treatment from admission to discharge by applying discharge criteria defined with the WHO standards. In this analysis, comparison of weight gain and duration of treatment was conducted with respect to the observed duration of treatment, which is based on discharge criteria defined by the NCHS reference. As a result, these data can only provide an approximate indication of how the WHO standards affect weight gain and duration of treatment in nutrition programs.

We found that, compared with children identified as severely malnourished with the use of the NCHS reference and the percentage of the median criterion, children who were identified by the WHO standards and *z*-score criterion generally attained lower weight gains but responded well to treatment, with higher recovery rates, fewer deaths, and less loss to follow-up or need for inpatient care. These results are likely related to the higher mean WFH *z* scores on admission, and therefore lower risk, of children who would be included in severe acute malnutrition treatment programs with the WHO standards. The lower weight gain among children included with the WHO standards is consistent with the finding that less-malnourished children gain less weight with supplementation,[9] although this weight gain was still greater than expected in outpatient programs.[10]

The more than eightfold increase in total program size observed in this analysis reflects the combined effects of shifting from the NCHS reference and the percentage of the median criterion to the WHO standards and the *z*-score criterion and is considerably larger than estimates from other studies. Previous estimates of the change in the prevalence of severe acute malnutrition range from increases of 1.5 to 2.5 times[4] and 1.7 to 4.2 times[5] when applying the same WFH of less than −3 *z*-score criterion to both the NCHS reference and the WHO standards. Seal and Kerac[5] also found that 1.5 to 2.1 times the number of children would be identified for admission into selective feeding programs when using the WHO standards and a WFH of less than −2 *z*-score criterion versus the NCHS reference and a WFH of <80% median criterion and suggested that a larger increase would be expected in the number of children eligible for therapeutic feeding programs. Differences among estimates are likely because of the criterion used for comparison and will depend on the age, weight, and height profiles of the population.

Comparison of the cutoff points for severe acute malnutrition using the WHO standards and a WFH of less than −3 *z*-score criterion versus the NCHS reference and a WFH of <70% of the median criterion show that the cutoff point for the WHO standards is always higher, and thus more inclusive, than that for the NCHS reference. The largest relative difference between cutoff points is found at lengths of <70 cm, a range consistent with ages between 6 and 12 months in this study population. This height-dependent difference between the NCHS reference and WHO standards, together with the large proportion of young children in this population, likely contributed to the larger-than-expected increase in program size and is consistent with the large proportion of children between 6 and 12 months of age who were identified by the WHO standards but not by the NCHS reference.

A recent reanalysis of studies on the relationship between anthropometric indicators and mortality has shown a sharp increase in the risk of death for children with a WFH of less than −3 *z* score using the WHO standards (odds ratio for overall mortality comparing children with a WFH of less than −3 *z* score versus children with a WFH of greater than or equal to −1 *z* score: 9.4 [95% confidence interval: 5.3– 16.8]),[11] but additional studies that compare the performance of both the NCHS reference and WHO standards cutoff points to predict adverse outcomes, such as mortality, are warranted. Given the substantial differences in the number of program admissions and in the overall response to treatment on the basis of the NCHS reference using the percentage of the median criterion and the WHO standards using the *z*-score criterion, additional research is required to assess the resource implications of introducing the WHO standards. Additional reflection will be needed to find an appropriate balance between maintaining high sensitivity and specificity in the identification of severely malnourished children and resource constraints. The implications of the introduction of the WHO standards should also be evaluated in the context of new community-based programs for the management of severe acute malnutrition, because fewer children would require inpatient care according to the WHO standards and *z*-score criterion compared with the NCHS reference and percent of the median criterion.

CONCLUSIONS

The use of the WHO standards and the *z*-score criterion, compared with the NCHS reference and the percentage of the median criterion, identified a total of >8 times the number of children as severely malnourished. The introduction of the WHO standards and *z*-score criterion to identify children for admission into therapeutic feeding programs would imply the inclusion of children who are younger but have higher WFH *z* scores on admission than children identified for admission using the NCHS reference and percent of the median criterion. These children have fewer medical complications requiring inpatient care and are more likely to experience shorter durations of treatment and lower mortality rates. The WHO growth standards might become a useful tool for

the early detection of acute malnutrition in children, although additional research on the resource implications of this transition is required.

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