Published in final edited form as:

Pediatrics. 2009 January ; 123(1): e54–e59. doi:10.1542/peds.2008-1375.

Assessing the impact of the introduction of the WHO 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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Abstract

Objective—To assess the impact of adopting the World Health Organization Child Growth Standards (WHO standards) and weight-for-height (WFH) 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 (NCHS)/WHO growth reference (NCHS reference) and WFH percent of the median criterion.

Study Design—We used data from children aged 6–59 months with acute malnutrition who were admitted to the Médecins sans Frontières malnutrition treatment 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 NCHS reference and percent of the median criterion vs. the WHO standards and the Z score criterion.

Results—A total of eight times more children (n=25,754) were classified as severely malnourished according to the WHO standards and weight-for-height (WFH) <−3 Z criterion, compared with the NCHS reference and WFH < 70% of the median criterion (n=2,989). Compared to the NCHS reference and percent of the median criterion, children included according to the WHO standards and Z score criterion 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 WHO 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 WFH on admission, compared with the NCHS reference. These children have fewer medical complications requiring inpatient

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Conflict of interest: None declared.

Financial disclosure: Research support was provided by Médecins sans Frontières and the United Nations System Standing Committee on Nutrition. Sheila Isanaka is supported in part by the National Cancer Institute (grant R25-CA098566). The funding sources had no role in the authors' work.

care and are more likely to experience shorter durations of treatment and lower mortality. The WHO standards with the Z score criterion might become a useful tool for the early detection of acute malnutrition in children, although further research on the resource implications of this transition is required.

Keywords

WHO growth standards; child malnutrition; wasting; selective feeding; therapeutic feeding; Niger

Introduction

The World Health Organization (WHO) introduced the WHO Child Growth Standards (WHO standards) for assessing the growth and development of children from birth to sixty months of age in April 2006. The WHO standards were developed using data from a multi-center 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 vs. 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 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 (5). 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.

This study 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 that would be included in severe acute malnutrition treatment programs if the WHO standards and -3 Z score criterion were applied, as compared to 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 that 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 one 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 mo. A lower bound of 60 cm was used in this population due to 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 care givers on the child's age, sex, and history of recent illness. Trained MSF nutrition assistants carried out 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 using a wooden measurement board. Weight was measured to the nearest 0.1 kg using a hanging Salter scale and to the nearest 0.01 kg using a mechanical SECA 75 scale after July 2006. WFH percent of the median on admission was determined using a sex-combined table, with intervals of 0.5 cm for length/height. Appetite was assessed and a medical examination was conducted to identify complications, such as altered mental status, severe respiratory infection, diarrhea, or dehydration. All children were screened for *plasmodium falciparum* (malaria) with a rapid test (Parachek Pf, Orchid Biomedical Laboratories, Goa, India).

On 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. Children who were 6 to 8 mo old on admission were re-vaccinated for measles at 9 mo. Children with WFH between 70% and 79% of the median did not routinely receive antibiotics after June 2006. Outpatient nutritional treatment consisted of two sachets per day of RUTF that provided 1,000 kcal/day (Plumpy'nutR from Nutriset, Malaunay, France). Care providers were asked to return with their children to the outpatient centers on a weekly basis; during these visits, weight was measured and a medical screening was conducted 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 WFH $\geq$ 80% of the NCHS reference median after two consecutive weighings before November 5 2006. On or after November 5 2006, children were discharged when they reached WFH $\geq$ 85% of the NCHS reference median on one weighing in an effort to reduce the number of re-admissions. 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 three consecutive weeks were considered to be lost to follow-up.

All the information was registered on standardized medical records. 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 below six months or above 59 months of age ($n=402$). As anthropometric criteria cannot be used to diagnose edematous malnutrition due to 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 in order 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 severe acutely malnourished and eligible for admission into therapeutic feeding programs according to the NCHS reference and $< 70\%$ of the median criterion vs. the WHO standards and < -3 Z score criterion. Severe acute malnutrition according to the NCHS reference was defined using the percent of the median since 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 as the introduction of the new standards has relied on the use of the Z score (3, 7). This comparison of the NCHS reference and $< 70\%$ of the median criterion vs. the WHO standards and < -3 Z score criterion is therefore 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 to 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 weight-for-height (weight-for-length if < 24 mo of age) percentages of the NCHS reference median using Epi Info version 6.0 software (Centers for Disease Control and Prevention, Atlanta, GA) and Z scores for the WHO standards using the *igrowup* macro package available at <http://www.who.int/childgrowth/software/en/>.

There were six treatment response outcomes of interest. Weight gain (g / kg / day) and duration of treatment (days) were treated as continuous variables. Recovery, death, loss to follow up, and need for inpatient care were considered as dichotomous variables. To compare children eligible according to the NCHS reference and percent of the median criteria vs. the “program additions,” we tested the differences in continuous and dichotomous variables with the use of linear and binomial (8) regression, respectively. Since 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 child sex and age at the time of enrollment. All P values correspond to the Wald test.

We carried out supplemental analyses after including those children with missing information on edema status on admission ($n=10,737$) as non-edematous. The results did not change after this inclusion, thus we only present the results in the population with complete data. A value of $P \leq 0.05$ 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 over eight times larger than the number of children identified with the NCHS reference and percent of the median criterion (Figure 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, sex, 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 standard 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 < 0.001). 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 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 vs. children who would be eligible according to the WHO standard and Z score criterion are determined by the “program additions,” i.e. the children eligible according to the WHO standard but not by the NCHS reference (**third column from right, Table 1**). After adjustment for age and sex, compared to 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 WFH $Z < -3$ Z score criterion would be more than eight times higher than the number identified with the use of the NCHS reference and WFH $< 70\%$ 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 WFH on admission $< 80\%$ of the NCHS reference median. The use of a program population that included children with WFH $< 80\%$ (i.e. both moderately and severely malnourished children) allowed many of the children without severe acute malnutrition using the NCHS reference (i.e. WFH $\geq 70\%$ of the median) but with severe acute malnutrition according to the WHO standards (i.e. WFH $Z < -3$) to be captured in the study population. Only a small proportion of children with WFH $Z < -3$ from the WHO standards but WFH $\geq 80\%$ of the NCHS reference median are likely to have been excluded from the study population. A comparison of cut-points shows that the WFH $< 80\%$ of the

NCHS reference median cut-off point used for inclusion into the study population is higher, and thus more inclusive, than the WHO WFH < -3 Z score cut-off point at all lengths/heights, except between 60–65 cm. In a supplemental analysis where children with lengths of 60–65 cm were excluded ($n=5,918$), the results did not change, suggesting that any potential bias introduced by the exclusion of children with WFH $Z < -3$ from the WHO standards but WFH $\geq 80\%$ 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 mo, 24 mo, and 36 mo. 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 vs. 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 further treatment but who re-gained 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 percent 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 wasted children gain less weight with supplementation (9) even though this weight gain was still greater than expected in outpatient programs (10).

The more than eight-fold increase in total program size observed in this analysis reflects the combined effects of shifting from the NCHS reference and the percent 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 < -3 Z score criterion to both the NCHS reference and the WHO standards. Seal and Kerac also found that 1.5 to 2.1 times the number of children would be identified for admission into selective feeding programs using the WHO standards and WFH $Z < -2$ Z score criterion vs. the NCHS reference and WFH $< 80\%$ median criterion and suggested that a larger increase would be expected in the number of children eligible for therapeutic feeding programs (5). Differences among estimates are likely due to the criterion used for comparison and will depend on the age, weight, and height profiles of the population.

Comparison of the cut-offs points for severe acute malnutrition using the WHO standards and WFH < -3 Z score criterion vs. the NCHS reference and WFH $< 70\%$ of the median criterion show that the cut-off point for the WHO standards is always higher, and thus more inclusive, than that for the NCHS reference. The largest relative difference between cut-off

points is found at lengths < 70 cm, a range consistent with ages between 6 and 12 mo old 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 to 12 mo of age who were identified by the WHO standards but not by the NCHS reference.

A recent re-analysis of studies on the relationship between anthropometric indicators and mortality has shown a sharp increase in the risk of death for children with WFH < -3 Z using the WHO standards (odds ratio for overall mortality comparing children with WFH < -3 Z vs. children with WFH ≥ -1 Z = 9.4, 95% CI: 5.3–16.8) (11), but additional studies that compare the performance of both the NCHS reference and WHO standards cut-off 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 based on the NCHS reference using the percent of the median criterion and the WHO standards using the Z score criterion, further 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, since fewer children would require inpatient care according to the WHO standards and Z score criterion as compared with the NCHS reference and percent of the median criterion.

Conclusion

The use of the WHO standards and the Z score criterion, compared to the NCHS reference and the percent of the median criterion, identified a total of more than eight 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. The WHO growth standards might become a useful tool for the early detection of acute malnutrition in children, although further research on the resource implications of this transition is required.

Acknowledgments

We would like to thank the Ministry of Health of Niger for their continued cooperation and support of this program. We would also like to thank Gregg Greenough, Andrea Minetti, Geza Hanczi, Isabelle Defourny and Valérie Gaboulaud for their helpful comments. We also owe thanks to Thomas Roederer who was the data manager for this program in Niger.

Abbreviations

WHO	World Health Organization
NCHS	National Centre for Health Statistics
MSF	Médecins sans Frontières
WFH	weight-for-height

RUTF ready-to-use-therapeutic food

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Figure 1.
Number of Children Identified with weight-for-height $< 70\%$ of the NCHS reference median and weight-for-height Z score < -3 of the WHO standards

Table 1

Demographic Characteristics and Treatment Response Profiles of Children Identified with Severe Acute Malnutrition using the NCHS Reference and the WHO Standards

	All Identified by NCHS WFH <70% median	All Identified by WHO WFH Z <-3	Identified by WHO WFH Z <-3 but not by NCHS < 70% median	Adjusted <i>P</i> ^I
n	2,989	25,754	22,765	
	% (N)	% (N)	% (N)	
Demographic Characteristics				
Age				----
6–12 mo	28.4 (849)	38.1 (9818)	39.4 (8969)	
13–24 mo	56.7 (1694)	50.5 (13004)	49.7 (11310)	
25–36 mo	13.1 (391)	9.3 (2404)	8.8 (2013)	
≥ 37 mo	1.8 (55)	2.1 (528)	2.1 (473)	
Sex				----
Male	53.2 (1591)	66.4 (17107)	68.2 (15516)	
Female	46.8 (1398)	33.6 (8647)	31.8 (7249)	
Nutritional Status (WHO standards)	Mean ± SD	Mean ± SD	Mean ± SD	
WFH Z on admission	-4.7 ± 0.7	-3.6 ± 0.6	-3.4 ± 0.3	<0.0001
WFH Z at discharge	-3.8 ± 1.0	-2.9 ± 0.8	-2.8 ± 0.7	<0.0001
Treatment Response				
Weight Gain (g / kg /day)	8.2 ± 7.6	5.9 ± 5.0	5.6 ± 4.5	<0.0001
Duration of Treatment (days)	46.2 ± 30.3	37.9 ± 25.5	36.8 ± 24.6	<0.0001
	% (N)	% (N)	% (N)	
Recovered	75.7 (2244)	90.7 (23255)	92.6 (21011)	<0.0001
Died	3.8 (114)	1.3 (324)	0.9 (210)	<0.0001
Lost to follow up	13.5 (401)	6.3 (1614)	5.4 (1213)	<0.0001
Need for Inpatient Care	49.0 (1421)	22.2 (5623)	18.7 (4202)	<0.0001

WFH: weight-for-height, NCHS: National Center for Health Statistics (NCHS), WHO: World Health Organization, SD: standard deviation.

^I Adjusted *P* values correspond to tests of the difference between children with WFH < 70% of the NCHS reference median vs. children with WFH Z < -3 of the WHO standards but not WFH < 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, lost 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 sex as covariates.