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Omitting edema measurement: how much acute malnutrition are we missing?[1–3]

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ABSTRACT

Background: Acute malnutrition is a major public health issue in low-income countries. It includes both wasting and edematous malnutrition, but the terms *wasting* and *acute malnutrition* are often used interchangeably. Little is known about the burden of edematous malnutrition, and few large-scale surveys measure it.

Objective: Most acute malnutrition might be captured by the measurement of wasting alone, but this is unknown. This article aims to fill this gap.

Design: This article presents a secondary data analysis of 852 nutrition cross-sectional survey data sets of children aged 6–59 mo. The data sets assembled included surveys from East, West, South, and Central Africa; the Caribbean; and Asia. The overlap between edematous malnutrition and wasting was assessed, and the impact of including/excluding edema on acute malnutrition prevalence estimates was evaluated.

Results: The prevalence of edematous malnutrition varied from 0% to 32.9%, and children were more likely to have bilateral edema in Central and South Africa (OR: 4; 95% CI: 2.8, 5.6). A large proportion of children with edematous malnutrition were not wasted [62% and 66% based on midupper arm circumference (MUAC) and weight-for-height (WFH), respectively], and most were not severely wasted (83% and 86% based on MUAC and WFH, respectively). When wasting and global acute malnutrition prevalence estimates as well as severe wasting and severe acute malnutrition prevalence estimates overall were compared, the differences between estimates were small (median of 0.0% and mean of 0.3% based on WFH and MUAC for global estimates and slightly higher median of 0.1% and mean of 0.4% based on MUAC and WFH, respectively, for the severe forms), but the picture was different at the regional level.

Conclusions: The terms *acute malnutrition* and *wasting* should not be used interchangeably. The omission of the measurement of edema can have important repercussions, especially at the nutrition program level. *Am J Clin Nutr* 2015;102:1176–81.

Keywords: acute malnutrition, nutrition surveillance, edematous malnutrition, wasting, kwashiorkor, mid-upper arm circumference, weight-for-height

INTRODUCTION

Acute malnutrition is a major public health issue throughout the developing world. Current definitions recognize 2 types—wasting (marasmus) and edematous malnutrition (kwashiorkor). UNICEF's latest report on the State of the World's Children (1) estimates that 10% of children aged <5 y in least developed countries are wasted. Of the 6.9 million estimated deaths among children aged <5 y annually, >800,000 deaths (12.6%) (2) are attributed to wasting (3–8). Similar estimates are not available for edematous malnutrition.

Edematous malnutrition is characterized by the presence of bilateral pitting edema, at a minimum on the dorsum of both feet, and is an independent criterion for identifying severe acute malnutrition (SAM).[6] Wasting is defined as weight-for-height (WFH) <−2 SD from the WHO mean reference value and/or midupper arm circumference (MUAC) <125 mm. Severe wasting is defined as WFH <−3 SD and/or MUAC <115 mm. Global acute malnutrition (GAM) is characterized as WFH <−2 SD and/or MUAC <125 mm and/or edema. SAM is defined as WFH <−3 SD and/or MUAC <115 mm and/or edema (9).

Ongoing surveillance of acute malnutrition is an essential instrument for the detection of nutritional emergencies and for planning interventions. Although there are debates about its use (10), the WHO classification of acute malnutrition prevalence is used by most organizations to assess the severity of a crisis. Although it is meant to be applied to GAM estimates, it is based on the prevalence of wasting by using WFH alone: the "reference

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[6] Abbreviations used: GAM, global acute malnutrition; MUAC, midupper arm circumference; SAM, severe acute malnutrition; WFH, weight-for-height.

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estimates" used for policy and program planning are mainly based on Demographic and Health Surveys and Multiple Indicator Cluster Surveys, which rarely take edema cases into account (11–13).

Although the importance of bilateral edema measurement has been discussed for several decades (14) and the case fatality rate among children with edematous malnutrition ranges from 1.5% to 27% (15–19), it is not part of the World Health Assembly Indicators (20). It was not discussed in the latest *Lancet* series on maternal and child nutrition (21) and is mentioned only once in the notes of the latest Global Nutrition Report (22). Furthermore, the Generation Nutrition campaign, a network of major nutrition civil society organizations (23), has been using *wasting* and *acute malnutrition* interchangeably. This is largely because little is known about the burden of edematous malnutrition.

Because of the common pathways between wasting and edematous malnutrition (24), most edemas cases could be expected to be included in the measurement of wasting, but this is unknown. Experts highlighted this gap in 2013 (25, 26), and this article aims to fill it by *1*) describing prevalence estimates from surveys collected, *2*) assessing the overlap between edematous malnutrition and wasting overall and per region, and *3*) evaluating the overall and regional contribution of edematous malnutrition to prevalence estimates.

METHODS

Study design and inclusion criteria

A total of 1068 cross-sectional survey data sets from various settings were shared by 6 organizations (UNICEF, Food Security and Nutrition Analysis Unit, Epicentre/Médecins Sans Frontières, Action Against Hunger, Concern Worldwide, and Goal). No formal sample size calculation was used. The study size depended on the availability of surveys and on specific inclusion criteria. Eligible data sets had to *1*) include anthropometric data, including MUAC, edema, age, weight, and height, as well as meta-data on country, livelihood, residence, cluster (if cluster surveys), and date, and *2*) have a minimum of 25 clusters if cluster surveys (27, 28). The last criterion aimed to minimize selection bias. The surveys were exhaustive or clustered surveys. The data sets were cleaned and records with extreme or missing values were excluded. Children were excluded if any of the following data were missing: age, sex, height, weight, MUAC, and edema. Those with highly improbable extreme values ("flags") were also excluded from analysis: MUAC <85 mm or >200 mm, age <6 mo or >59 mo, weight-for-age <−6.0 SD or >+5.0 SD, height-for-age <−6.0 SD or >+6.0 SD, and WFH <−5.0 SD or >+5.0 SD (WHO "flags" were applied on SD for WFH, weight-for-age, and height-for-age).

Database

Of the 1068 surveys collected, 852 were included in the secondary data analysis (55 exhaustive surveys and 797 clustered surveys). The 852 surveys contained 694,108 children, of whom 25,134 had highly improbable values and were excluded from the analysis. The database included 6 variables for anthropometric measures (sex, MUAC, edema, age, weight, and height), 6 metadata variables [organization, country, livelihood, residence, cluster (when cluster surveys), and date], and 3 indexes based on WHO standards (WFH, weight-for-age, and height-for-age) added by using the WHO's "Child Growth Standards" package (29).

Data analysis

The prevalence of severe and global wasting and acute malnutrition (based on MUAC and WFH) and the prevalence of edema cases were computed for each survey and described (mean, median, range, variance) overall. A mixed-effect multivariable logistic regression with edema as a binary dependent variable was computed with variables showing univariable associations with edema. The overlaps between the number of wasted and severely wasted children (MUAC or WFH) and edema cases were examined by building Venn diagrams overall and by region. The impact of edematous malnutrition on global estimates was assessed by plotting wasting/severe wasting vs. GAM/SAM estimates overall and per region. The summary statistics of the differences between wasting and GAM and severe wasting and SAM were computed for MUAC and WFH. RStudio (RStudio Inc.) (30) and STATA 13 (StataCorp) (31) were used for all analyses.

Ethical standards disclosure

Because the project involved secondary data analysis, ethics approval for the project was sought and obtained from the Ethics Committee of the London School of Hygiene and Tropical Medicine.

RESULTS

In total, 852 surveys from 38 countries were included in the analysis, and the final database comprised a total of 668,975 children aged 6–59 mo. Surveys were conducted from 1992 to 2011, with 95% from 2000. The most represented region was East Africa, with 65.0% of the surveys conducted in the region (**Table 1**). The sample size of the surveys varied from 122 to 3491 children. The mean sample size was 785, and the median was 815. Before the development of the Standardized Monitoring and Assessment of Relief and Transitions method for anthropometric and mortality surveys (32), most nutritional surveys were conducted by using a 30-by-30 cluster survey approach, which translates into a large number of surveys with a sample size close to 900 children.

Summary of prevalence results from the 852 surveys

The database included 3230 edema cases, and 65,680 children were classified as wasted according to MUAC and 93,406 according to WFH. The prevalence of wasting and severe wasting

TABLE 1
Surveys per region (n = 852)

Region	Surveys, n (%)
East Africa	554 (65.0)
West Africa	97 (11.4)
Central and South Africa	128 (15.0)
Caribbean	13 (1.5)
Asia	60 (7.0)

as well as the prevalence of SAM and GAM observed overall varied across the surveys. Wasting varied from 1% to 47.7% based on MUAC and from 0.4% to 42.8% based on WFH. Similarly, GAM ranged between 1% and 48.7% and 1.4% and 42.9% based on MUAC and WFH, respectively. The prevalence of bilateral edema across surveys ranged from 0% to 32.9%, and 325 of 852 (38.1%) surveys had no cases (**Table 2**). The median prevalence of edema cases was very low (≤0.2%) in all regions expect Central and South Africa (0.6%). The mean was also fairly low in all regions (≤0.6% or less) except in Central and South Africa (1.2%) (**Supplemental Table 1**).

The logistic regressions of edema as a dependent variable showed statistically significant univariable associations with the following independent variables: livelihoods, residence, region, and age (categorical variable). Adding region, residence, livelihood, or age in a multivariable logistic regression resulted in a statistically significant improvement in model fit (likelihood ratio test). The model is presented in **Table 3**. Edema cases were 4 times more likely to be found in Central and South Africa (OR: 4.0; 95% CI: 2.8, 5.6; $P < 0.001$) and 0.7 times less likely to occur in children aged >36 mo (OR: 0.7; 95% CI: 0.6, 0.7; $P < 0.001$).

Overlap between edematous malnutrition and wasting overall and per region

A large proportion of children with edematous malnutrition were not wasted. About two-thirds of children with bilateral edema were not wasted, based on MUAC (62%) or WFH (66%). Most children with edema were not severely wasted based on MUAC (83%) or WFH (86%) (**Figure 1**). The proportions of overlap were similar in all regions (**Supplemental Figure 1**). Central and South Africa had the largest proportion of cases (1394 of 3230).

Although more children were classified as wasted by using WFH compared with MUAC overall (92,302 using WFH compared with 64,447 using MUAC), the overlap between MUAC and edema was larger than between WFH and edema (MUAC included 1233 edema cases, whereas WFH included 1104) (see Figure 1).

TABLE 2
Summary estimates of the surveys included in the analysis (n = 852)[1]

	Minimum/maximum, %	Lower/upper quartile, %	Median/mean, %
MUAC			
<125 mm	1.0/47.7	5.9/12.7	8.8/9.9
<115 mm	0.0/20.6	0.9/2.9	1.7/2.2
MUAC			
GAM	1.0/48.7	6.0/13.1	9.0/10.2
SAM	0.0/35.3	1.1/3.3	1.9/2.6
WFH			
<−2 SD	0.4/42.8	8.7/19.2	13.4/14.2
<−3SD	0.0/19.1	1.4/4.4	2.7/3.2
WFH			
GAM	1.4/42.9	9.0/19.6	13.7/14.5
SAM	0.0/35.2	1.7/4.8	3.0/3.7
Bilateral edema	0.0/32.9	0.0/0.5	0.1/0.5

[1]GAM, global acute malnutrition; MUAC, midupper arm circumference; SAM, severe acute malnutrition; WFH, weight-for-height.

TABLE 3
Logistic regression of bilateral edema (852 surveys)

Independent variable	OR[1] (95% CI)	SE	χ^2	P value[2]
Region				
East Africa	—	—	—	—
Asia	0.679 (0.405, 1.136)	0.179	−1.47	0.141
Caribbean	2.359 (0.979, 5.681)	1.058	1.91	0.056
Central and South Africa	3.976 (2.837, 5.572)	0.685	8.02	<0.001
West Africa	0.743 (0.497, 1.110)	0.152	−1.45	0.147
Residence				
Rural	—	—	—	—
Displaced population	1.496 (1.080, 2.074)	0.249	2.42	0.016
Other	0.840 (0.567, 1.245)	0.169	−0.87	0.385
Urban	0.475 (0.297, 0.761)	0.114	−3.09	0.002
Livelihood				
Agriculture	—	—	—	—
Agropastoral	0.569 (0.418, 0.775)	0.090	−3.58	<0.001
Other	1.102 (0.775, 1.567)	0.198	0.54	0.589
Pastoral	0.980 (0.666, 1.441)	0.193	−0.1	0.917
Age group, mo				
6–35	—	—	—	—
36–59	0.659 (0.610, 0.711)	0.026	−10.67	<0.001

[1]Robust OR (mixed-effect logistic regression cluster by survey).
[2]Wald test.

Overall and regional impact of edematous malnutrition on prevalence estimates

The scatterplots of wasting vs. GAM suggested that only few outlier surveys had substantially different estimates based on MUAC or WFH. The inclusion of edema cases had a stronger impact when looking at severe wasting vs. SAM (**Figure 2**). A similar pattern was observed in each region, especially in East Africa, West Africa, and Asia (see **Supplemental Figure 2**).

The differences between wasting and GAM and severe wasting and SAM overall are summarized in **Table 4**. Differences between global estimates were small overall (median = 0.0% and mean = 0.3%) and slightly higher between severe wasting and SAM (median = 0.1% and mean = 0.4%) for MUAC and WFH. Although the impact of edema inclusion was greater in the Caribbean and Central and South Africa, where the prevalence of edema were higher, the differences between global estimates were not substantial. The differences were more important in Central and South Africa, especially when looking at the differences between severe wasting and SAM (median = 0.4% and 0.5% for MUAC and WFH, respectively; mean = 1.0% and 1.1% for MUAC and WFH, respectively) (Supplemental Figure 2 and **Supplemental Table 2**).

DISCUSSION

Although *wasting* and *acute malnutrition* are often used interchangeably, our results emphasize that they are not equivalent. This has different implications depending on the purpose of the nutritional assessment. Two-thirds of edema cases are missed by measuring wasting only, and >80% missed by assessing severe wasting whether using MUAC or WFH. The difference in prevalence between wasting and GAM and between severe wasting and SAM is rarely statistically significant overall, but the picture is different at the regional level.

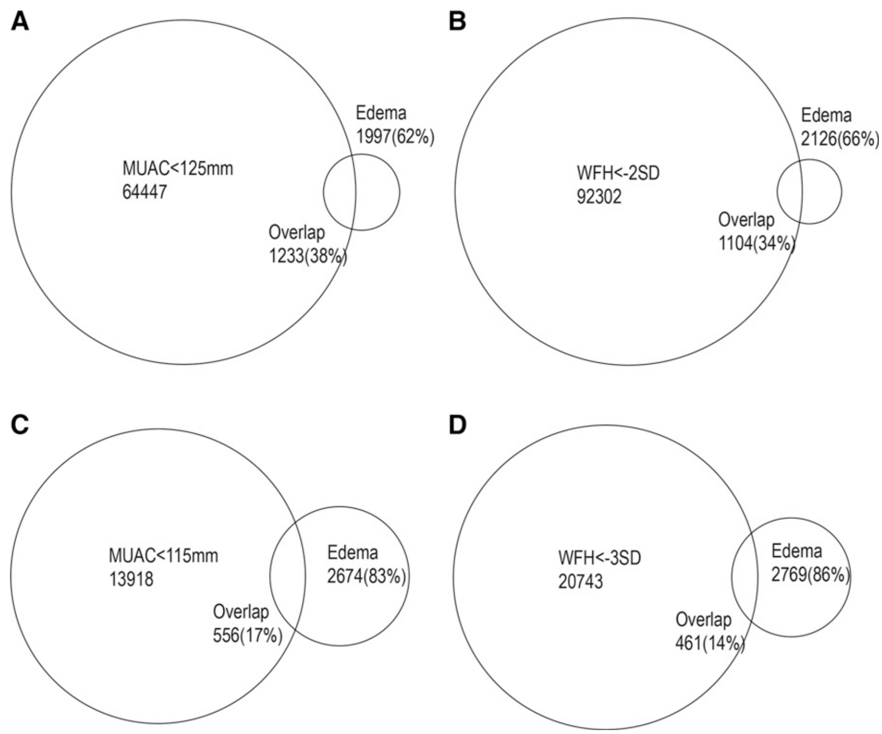

FIGURE 1 Overall overlap between bilateral edema and wasting based on MUAC (A) and WFH (B) and between edema bilateral and severe wasting based on MUAC (C) and WFH (D) (n = 852). MUAC, midupper arm circumference; WFH, weight-for-height.

At the nutrition program level, the implications are considerable. Using wasting indexes only in any context of screening for potential admission to a treatment program will capture a minority of edema cases, thereby excluding a numerically rare but highly lethal form of malnutrition from the possibility of treatment. Furthermore, nutrition programs treating SAM rely on caseload estimates for program planning, supply chain management, and human resource requirements. The annual burden of SAM is calculated as follows: burden = population 6–59 mo × prevalence × 2.6, where the population refers to the population of children aged 6–59 mo in the program area, prevalence is the prevalence of SAM for children aged 6–59 mo, and 2.6 is a factor to convert prevalence into incidence based on the expected duration of SAM episodes (33). Whether the prevalence of SAM used includes edematous malnutrition has an important impact on the burden calculation in countries with a higher proportion of edema cases (i.e., in Central and South Africa). Currently, many national burden estimates are based on Multiple Indicator Cluster Surveys and Demographic and Health Surveys that do not include edematous malnutrition and therefore underestimate the burden of SAM in certain countries, which has a detrimental impact on programs.

At the population level, the implications are less marked. When looking at trends of global prevalence over time to predict whether a situation is getting worse or is worse than the previous year at the same time, including or not including edema makes relatively little difference. The differences between wasting and GAM are very small overall. Using MUAC for the estimation of wasting included more edema cases than WFH overall. Surveys used as an early warning system or to confirm the severity of a situation could help classify a situation based on wasting alone, particularly if using MUAC. In Central and South Africa, where the largest number and prevalence of edema cases were observed, the differences between estimates were higher, which indicates this may not be applicable to all countries.

There are 2 main limitations to this study. One is the selection of surveys. The database was built based on available small-scale surveys that were mainly conducted in areas where there was suspicion of a problem compared with national Demographic and Health Surveys and Multiple Indicator Cluster Surveys that are conducted every 3–5 y and show long-term trends. This explains the greater number of African surveys in the sample compared with other parts of the world: our data are thus not representative of global epidemiology. This may skew the burden of edematous malnutrition observed in our data set. The second is the fact that edematous malnutrition should be assessed by using incidence rather than prevalence measures. This study uses prevalence, which is not an optimal basis to measure the impact of the inclusion of edema cases on the measure of acute malnutrition. The use of incidence is likely to show bigger differences between the estimates of acute malnutrition and wasting because the duration of kwashiorkor episodes is very short, and kwashiorkor cases are less likely to be picked up by a cross-sectional survey (26, 33, 34).

Other limitations include the small number of surveys (13) from the Caribbean and the fact that they were all from Haiti. Also important to take account of in future work is the seasonality of SAM: the timing of the surveys might affect the prevalence of edema cases. Measurement errors might also influence survey results. There is no reason to believe that it affects our findings where hundreds of surveys are pooled, but in a single survey, different final prevalence results might arise if observers are not well trained or supervised and there is different intraobserver/interobserver variability assessing different anthropometric measures. Finally, the extent to which to results presented here

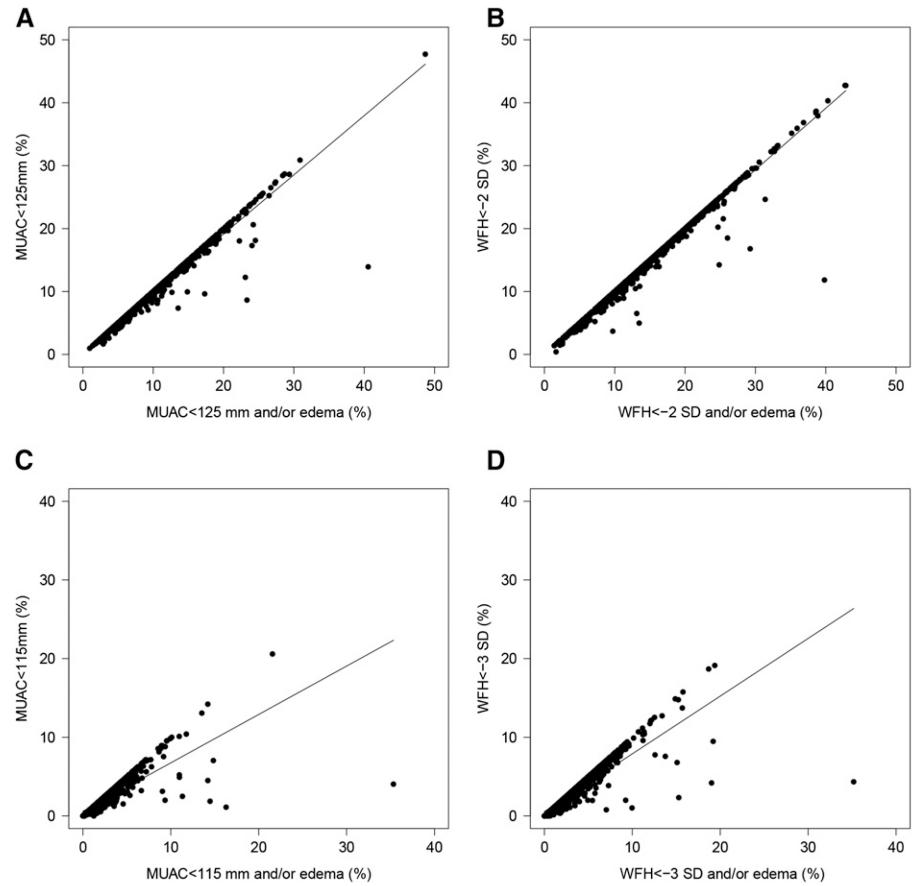

FIGURE 2 Overall wasting vs. acute malnutrition on MUAC (A) and WFH (B) and severe wasting vs. severe acute malnutrition with MUAC (C) and WFH (D) (n = 852). MUAC, midupper arm circumference; WFH, weight-for-height.

reflect the national program is unclear, and it would thus be interesting to look at the proportion of admissions based on bilateral edema per country.

In conclusion, although *wasting* is often used as a substitute for *acute malnutrition*, the 2 terms are not interchangeable. Using wasting alone instead of acute malnutrition can have important repercussions, particularly at the nutrition program level. Although wasting alone can be used to classify the severity of a situation based on global estimates in countries with a low burden of edema cases, edematous malnutrition should be included in nutrition surveys. The measurement of bilateral edema does not imply heavy time or cost implications. Furthermore, wasting and edematous malnutrition have common causes (24), are both detected at the community level and in health centers, and are managed in the same programs with the same treatments. We thus recommend that both should be systematically included in nutrition surveillance.

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The authors' responsibilities were as follows—SF: wrote the first draft of the article and had the primary responsibility for the final content; SF, FC, and MK: were involved in conception and design, data acquisition, analysis, and interpretation; FC and MK: critically revised different draft versions; and all authors: approved the final version of the article. The authors reported no conflicts of interest related to this study.

TABLE 4
Summary statistics of the differences between estimates of wasting and GAM and severe wasting and SAM using MUAC or WFH overall (n = 852)[1]

	Minimum	Lower quartile	Median	Mean	Upper quartile	Maximum
GAM–wasting (MUAC)	0.0	0.0	0.0	0.3	0.3	26.7
GAM–wasting (WFH)	0.0	0.0	0.0	0.3	0.3	28.0
SAM–severe wasting (MUAC)	0.0	0.0	0.1	0.4	0.4	31.3
SAM–severe wasting (WFH)	0.0	0.0	0.1	0.4	0.4	30.8

[1]Values are percentages. GAM, global acute malnutrition; MUAC, midupper arm circumference; SAM, severe acute malnutrition; WFH, weight-for-height.

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