Comparison between Weight-for-Height Z-Score and Mid Upper Arm Circumference to Diagnose Children with Acute Malnutrition in five Districts in India

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Abstract

Background: The World Health Organization recommends weight-for-height Z-score (WHZ) or mid-upper arm circumference (MUAC) and bilateral pitting edema to diagnose acute malnutrition among children aged 6–59 months. WHZ and MUAC identify different sets of children with acute malnutrition, and overlap between their prevalence varies greatly among countries. Objective: The objective of the study was to determine the degree of overlap and agreement between WHZ and MUAC to diagnose children with acute malnutrition in India. Methods: Five nutrition surveys using Standardized Monitoring and Assessment of Relief and Transitions methodology were conducted in four Indian states. A total of 2127 children aged 6–59 months were analyzed. All anthropometric indices were calculated using emergency nutrition assessment software and analyzed in Epi-Info 3.5.4. Results: Of total global acute malnutrition (GAM) cases, 96% and 28.4% cases were diagnosed with WHZ and MUAC, respectively. Similarly, of total severe acute malnutrition (SAM) cases, 95.1% were identified using WHZ and 30% using MUAC. The proportion of overlap between the two criteria for GAM and SAM cases was 24.5% and 25.2%, respectively. The analysis showed that MUAC was comparatively more sensitive to identify acute malnutrition among 6–23-month aged children and females. Conclusion: One-fourth of GAM and SAM cases were identified with both criteria. MUAC identified approximately 30% of the total SAM cases which was lower than other countries. MUAC identified more number of females and younger children, who may have higher mortality risk and would result significantly smaller caseload (68% smaller) that requires intervention compared to when using WHZ.

Keywords: Global acute malnutrition, mid-upper arm circumference, severe acute malnutrition, weight-for-height Z-score

INTRODUCTION

World Health Organization (WHO) recommends that either weight-for-height Z-score (WHZ) or mid-upper arm circumference (MUAC) and bilateral pitting edema to diagnose acute malnutrition among children aged 6–59 months. WHZ and MUAC identify different sets of children with acute malnutrition. Global acute malnutrition (GAM) is defined as the children with WHZ <-2 and/or MUAC <125 mm. For identifying children with severe acute malnutrition (SAM), WHZ <-3SD and/or MUAC <115 mm are used. However, agreement between WHZ and MUAC is poor as both indicators identify different sets of children.[1] In 2009, the WHO and United Nations Children’s Fund (UNICEF) joint statement estimated that about 40% SAM children were identified by both WHZ and MUAC criteria.[2]

Grellety and Golden reported that, in India, among all GAM cases, 54.9% children were diagnosed with WHZ <-2 only, 11.7% with MUAC <125 mm only, and about 33.4% children were identified with both criteria. This overlap of prevalence based on WHZ and MUAC varies between countries and also within countries.[3]

In a community setting, MUAC measurement technique is considered to be simpler, feasible, and cost-effective screening method as compared to screening using WHZ criterion.[4]

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The WHO 2013 Guideline: Updates on the management of SAM in infants and children also recommended using MUAC for identification of acute malnutrition cases by frontline workers within the community.\textsuperscript{[5]} Evidence suggests that MUAC identifies children who are having high mortality risk.\textsuperscript{[6]} National Family Health Survey (NFHS) uses WHZ as a criterion to identify acute malnutrition cases;\textsuperscript{[7]} however, many program implementers advocate for using MUAC criterion in community settings because of the above reasons. Therefore, it would be important to estimate the prevalence using both WHZ and MUAC to understand the total caseload of acute malnutrition. This will help in deciding on which criterion is most suitable in Indian context for screening and identification of acute malnutrition cases depending on their program objectives. With this background, we conducted five cross-sectional surveys in four Indian states to assess percentage cases of acute malnutrition identified independently and jointly using WHZ and MUAC criteria.

**Methods**

This study included primary data analysis of anthropometric datasets from five nutrition surveys conducted in four Indian states between 2015 and 2017. Cross-sectional surveys were conducted in two districts of Odisha – Nabarangpur and Koraput and three blocks – Attappady (Kerala), Khutpani (Jharkhand), and Naraini (Uttar Pradesh) by Kalawati Saran Children Hospital, in collaboration with UNICEF India. These high burden pockets were identified by the state governments for the implementation of the community-based program to address problems of acute malnutrition. These nutrition surveys were conducted using Standardized Monitoring and Assessment of Relief and Transitions methodology which aims to estimate the prevalence of wasting among children aged 6–59 months.\textsuperscript{[8]}

All surveys used two-stage cluster sampling where the probability of being sampled was proportional to the population size. For each survey, the sample size was calculated using emergency nutrition assessment (ENA) software. For survey in Jharkhand, sample size was calculated taking the prevalence of wasting as per rapid survey of children 2013–2014.\textsuperscript{[9]} For survey in other states, respective sample sizes were calculated taking prevalence of wasting as per NFHS-4 data.\textsuperscript{[7]} The sample size was sufficient to estimate the wasting prevalence with a precision of ±5%. Informed consent was taken from all the households that were included in the survey.

Equipment of global standard was used for anthropometric assessment. For measuring height, weight, and MUAC, wooden infanto-cum-stadiometer, SECA 874 digital weighing scales and standardized MUAC tapes were used, respectively. The WHO-recommended standard methods were followed to take anthropometric measurements. Anthropometric indices based on the WHO 2006 ENA software (July 2015), CDC-Atlanta, USA standards were calculated using ENA (July 2015). All analyses were performed in Epi-Info (version 3.5.4), CDC-Atlanta, USA.

Data on weight, height, MUAC, gender, and age for a total of 2368 children <5 years were used in this study. The data cleaning was done by deleting the records of children <6 months, >59 months, and with missing data. At individual survey level, outliers were removed as the ENA flags children who had WHZ score ≤−3SD or ≥+3SD from the survey mean. Survey mean is mean WHZ in each survey. Post dataset cleaning, 2127 children were included for the final analysis. Table 1 shows the states, survey areas, and number of children that were included in the analysis.

The GAM and SAM cases were subdivided into three subgroups, each to understand the actual distribution of cases based on WHZ and MUAC. The WHZ <−2 SD only means those cases who were GAM only by WHZ and their MUAC were ≥125 mm. The MUAC <125 mm only means those cases who were GAM only by MUAC and their WHZ were ≥2 SD. The overlapping GAM cases means those children who were classified as GAM by both criteria, i.e., they had WHZ <−2 SD and MUAC <125 mm.

The WHZ <−3 SD only means those cases who were SAM by WHZ only and their MUAC were >115 mm. The MUAC <115 mm only means those cases who were SAM by MUAC only and their WHZ were ≥3 SD. The overlapping SAM cases were those children who were SAM based on both WHZ <−3 SD and MUAC <115 mm.

**Results**

The analysis shows a nearly equal representation of male and female children. Among 2127 children, 32.5% were identified as GAM and 5.8% were identified as a SAM either by WHZ or MUAC criteria. With WHZ alone criteria, the prevalence of GAM and SAM was 30.8% and 5.4%, respectively, whereas with MUAC alone criteria, the prevalence of GAM and SAM was 9.3% and 1.9%, respectively. We calculated kappa coefficients (k) (If “k” is 1, then it implies perfect agreement between the two criteria to diagnose SAM or GAM, and if “k” is 0, it implies perfect disagreement) to see the level of agreements between WHZ and MUAC in diagnosing GAM or SAM. It was found that kappa coefficient (k) between WHZ and MUAC for diagnosing GAM was 0.29 and for SAM was 0.39. Hence, it can be inferred that, there is a “fair agreement” between the two criteria in diagnosing SAM and GAM.

Among 2127 children, 691 children were identified as a GAM. Among these cases, around 25% cases were identified using both criteria [refer Table 2]. WHZ criteria identified more than 95% of the cases and MUAC identified 28.4% GAM cases. When the data for the GAM cases was further analyzed survey area wise, huge variations were observed in the proportion of overlap cases. In Kerala, only 10.6% children were identified as GAM with both criteria, whereas in Jharkhand, the corresponding figure was 32.9%.

The data in Table 2 indicate that, of total GAM cases, more than 90% were identified using WHZ criteria and MUAC could detect cases ranging from 12% to 36%. Figure 1 shows the
Kumar, et al.: Comparison between WHZ and MUAC to diagnose children with SAM

Among 2127 children, 123 cases were diagnosed as SAM. Among all SAM cases, 70% were identified using WHZ < −3 SD only and little <5% of cases were identified with MUAC <115 mm only. Around 25% of cases were identified using both criteria. When the data were assessed at individual survey level, the proportion of children identified as SAM based on WHZ <−3 SD only varied from 53% (Uttar Pradesh) to 87% (Kerala) whereas, based on MUAC <115 mm only, it ranged from 0% (Kerala) to 6.4% (Jharkhand). The survey from Uttar Pradesh was able to identify maximum overlapping SAM cases (42.3%) using both criteria, whereas, in Kerela, it was only 12.5%.

Table 1: The state, survey area, and number of children analyzed

| State    | Survey area | Number of clusters | Total children | Male | Female | 6-23 months | 24-59 months |
|----------|-------------|--------------------|----------------|------|--------|-------------|--------------|
| Kerala   | Attapady    | 80                 | 332            | 172  | 160    | 111         | 221          |
| Jharkhand| Khutpani    | 56                 | 396            | 203  | 193    | 132         | 264          |
| Odisha   | Nabarangpur | 47                 | 535            | 255  | 280    | 185         | 350          |
| Odisha   | Koraput     | 48                 | 448            | 220  | 228    | 155         | 293          |
| Uttar Pradesh | Naraini | 41                | 416            | 218  | 198    | 144         | 272          |
| India    | Total       | 272                | 2127           | 1068 | 1059   | 728         | 1339         |

Table 2: Identification of global acute malnutrition by weight-for-height Z-score, mid-upper arm circumference, or by both criteria in five different survey areas

| State    | Survey area | GAM subjects | WHZ < -2 only (%) | MUAC <125 mm only (%) | Both criteria (%) | Total WHZ < -2 (%) | Total MUAC <125 mm (%) |
|----------|-------------|--------------|-------------------|-----------------------|------------------|-------------------|------------------------|
| Kerala   | Attapady    | 67           | 87.88             | 1.52                  | 10.60            | 98.48             | 12.12                  |
| Jharkhand| Khutpani    | 137          | 63.5              | 3.65                  | 32.85            | 96.35             | 36.50                  |
| Odisha   | Nabarangpur | 213          | 75.12             | 1.88                  | 23.00            | 98.12             | 24.88                  |
| Odisha   | Koraput     | 137          | 72.26             | 5.84                  | 21.90            | 94.16             | 27.74                  |
| Uttar Pradesh | Naraini | 137          | 65.69             | 6.57                  | 27.74            | 93.43             | 34.31                  |
| India    | Total       | 691          | 71.64             | 3.91                  | 24.46            | 96.09             | 28.36                  |

GAM: Global acute malnutrition, WHZ: Weight-for-height Z-score, MUAC: Mid-upper arm circumference

Figure 1: Proportion of children with global acute malnutrition diagnosis by both MUAC <125 mm and WHZ < -2 SD (yellow-green) or by mid-upper arm circumference only or weight-for-height Z-score only (green)

Table 3 indicates that, of all SAM cases, more than 95% were diagnosed using WHZ criteria and MUAC identified 30.1% of the SAM cases in the sample. Figure 2 graphically exhibits that WHZ <−3 SD only identified around 70% of the cases and MUAC (<115 mm) only identified 4.8%. About 25.2% of the cases were detected with both criteria.

We also attempted to understand gender- and age group-wise difference in SAM and GAM prevalence using different identification criteria. We used t-test method to statistically analyze whether difference in gender- and age group-wise prevalence of GAM and SAM cases were significant for cases identified using WHZ, MUAC, and both criteria.

Among all GAM cases, 54% were male and 46% were female children using WHZ only criteria, 37% were male and 63% were female using MUAC only criteria, and 53% were male and 47% were female using both criteria. The gender differences were statistically significant in GAM cases using WHZ only ($P = 0.018$), MUAC only ($P = 0.0001$), and among all identified GAM cases ($P = 0.071$) using both criteria.

Similarly, among all SAM cases, 54% were male and 46% were female children using WHZ only criteria, 36% were male and 64% were female using MUAC only criteria, and 51% were male and 49% were female using both criteria. The differences were statistically non significant in SAM cases using WHZ only ($P = 0.375$), MUAC only ($P = 0.065$), and both ($P = 0.703$) criteria.

Cases of acute malnutrition based on different criteria were stratified into two age groups; 6–23 months and 24–59 months. The result shows that, when only WHZ was used to identify GAM cases, 54% and 46% cases were found to be of children from the older and younger age group, respectively.
Table 3: Identification of severe acute malnutrition cases by weight-for-height Z-score, mid-upper arm circumference, or both criteria

| State          | Survey area  | SAM subjects | WHZ < -3 only (%) | MUAC < 115 mm only (%) | Both criteria (%) | Total WHZ < -3 (%) | Total MUAC < 115 mm (%) |
|----------------|--------------|--------------|-------------------|------------------------|------------------|-------------------|-------------------------|
| Kerala         | Attappady    | 8            | 87.50             | 0.00                   | 12.50            | 100.00            | 12.50                   |
| Jharkhand      | Khutpani     | 31           | 67.74             | 6.45                   | 25.81            | 93.55             | 32.26                   |
| Odisha         | Nabarangpur  | 39           | 74.36             | 5.13                   | 20.51            | 94.87             | 25.64                   |
| Odisha         | Koraput      | 18           | 77.78             | 5.56                   | 16.67            | 94.44             | 22.22                   |
| Uttar Pradesh  | Naraini      | 26           | 53.85             | 3.85                   | 42.31            | 96.15             | 46.15                   |
| India          | Total        | 123          | 69.92             | 4.88                   | 25.20            | 95.12             | 30.08                   |

GAM: Global acute malnutrition, WHZ: Weight-for-height Z-score, MUAC: Mid-upper arm circumference, SAM: Severe acute malnutrition

Figure 2: Proportion of children with severe acute malnutrition diagnosed by both mid-upper arm circumference <115 mm and WHZ < 3SD (yellow-green) or by mid-upper arm circumference only or weight-for-height Z-score only (green)

For MUAC only, among all GAM cases, 67% and 33% cases were found to be of children from the younger and older age group, respectively. For both WHZ and MUAC criteria, among all GAM cases, 58% and 42% cases were found to be of children from the older and younger age group, respectively. All these differences were statistically significant at $P < 0.001$. Among all SAM cases, the result shows that 59% and 41% were found to be of children from the older and younger age group, respectively, when WHZ only criteria were used. The difference was statistically significant with $P = 0.052$. Similarly, 76% SAM cases identified by MUAC only belonged to younger age group implying every three out of four SAM cases were younger children ($P < 0.001$). For both criteria, among all SAM cases, 51% and 49% cases were found to be of children from the older and younger age group, respectively. The difference was statistically significant at $P < 0.001$.

The above analyses show that using MUAC as the standalone criterion would categorize slightly higher proportion of female children and children from younger age group as acute malnourished.

Discussion

Global evidence indicates that WHZ and MUAC criteria identify children with acute malnutrition in different proportions. Multicountry study conducted by Grellety and Golden (2016) showed that the number of children diagnosed by one criterion or the other varied dramatically across countries. They found that excess of young children in the survey dataset would lead to the diagnosis of more children with MUAC, whereas having an excess of older and taller children would diagnose more children using WHZ. This study also showed that, in India, proportion of total children diagnosed as SAM with WHZ (84.5%) were significantly high as compared to MUAC criterion (38.4%). Table 1 shows that, in each survey area, around 34% of children were from the age group of 6–23 months, and hence there was a possibility that more children would be identified by WHZ than MUAC. The analysis of anthropometric datasets confirms the same that larger proportion of SAM children were identified using WHZ as compared to MUAC. The analysis shows that more than 95% of the children were diagnosed with GAM and SAM based on WHZ criterion and about one-third were identified using MUAC. The proportion of overlap cases with both WHZ and MUAC varied a lot among different states within India.

If MUAC is used as a standalone criterion, then one-third of SAM cases of total caseload will get detected, implying that 70% SAM cases with WHZ < 3SD will remain undetected at community level screening drive. However, global evidence suggests that MUAC identifies children who are at a higher risk of mortality and require immediate care. Berkley et al. also suggested that MUAC is proven to be more sensitive than WHZ in identifying high-risk SAM children and predicting mortality. The decision of preferring either MUAC or WHZ as a standalone criterion for any child nutrition program depends on the objective of the program as well as the feasibility. If the objective is to provide immediate care to the children who are at risk of death, then MUAC could be used as a criterion of detection whereas, if the objective is to manage all the cases with acute malnutrition, then WHZ or both can be used.

Further analysis highlights that the proportion of SAM children detected with MUAC varied considerably across states within India.
states. Of the total children with SAM, cases identified using MUAC in Attappady, Khutpani, Nabarangpur, Koraput, and Naraini were 12.5%, 32.2%, 25.6%, 22.2%, and 46.1% compared to WHZ 100%, 93.6%, 94.9%, 94.4%, and 96.2%, respectively.

No significant differences in the proportion of GAM and SAM cases from different gender or different age groups were found when WHZ was used as an identification criterion. However, the analysis found that MUAC identifies slightly higher proportion of children who were young and females. This was also pointed out by other studies.\[11,12\]

Evidence suggests MUAC as a better predictor of mortality as compared to WHZ; however, assessing the immediate death risk should not be the only purpose of diagnosing acute malnutrition. Acute malnutrition contributes to increased morbidity and impaired physical development.\[13\] Both WHZ and MUAC are known to identify different sets of children and just using MUAC will underestimate the prevalence of SAM at the community level.\[14\] Nonetheless, MUAC tape is a preferred tool as it is feasible to use at community level screening to detect cases of acute malnutrition.

So far in India, no routine national survey captures the burden of acute malnutrition based on MUAC. However, the ongoing Comprehensive National Nutrition Survey by MoHFW that started in 2017 is expected to provide the results in 2018, and for the first time, state-level MUAC data will be provided. Inclusion of MUAC as an indicator in large-scale nutrition surveys will help in estimating the actual prevalence of acute malnutrition based on both WHZ and MUAC to inform the policy and programmatic planning.

**Conclusion**

In Indian context, WHZ and MUAC criteria pick different sets of children as GAM and SAM. Around 25% of GAM and SAM cases were identified by both the criteria. The current analysis tried to present a comparison between WHZ and MUAC criteria for the identification of children with acute malnutrition in a community setting, primarily to inform the policymakers and program implementers toward agreement and difference in case identification. Kappa coefficient shows a fair agreement between WHZ and MUAC for diagnosing acute malnutrition. The policy decision to use WHZ and/or MUAC as criteria for the identification of acute malnutrition depends on the objective of the program and resources. If the objective is to identify all the cases with acute malnutrition, then both criteria can be used together; however, if the program objective is to manage the children at higher mortality risk, then MUAC should be used. Using MUAC would decrease the caseload by about 68% that requires urgent management of SAM.

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**Conflicts of interest**

There are no conflicts of interest.

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