

Prevalence of Malnutrition in Rural Karnataka, South India: A Comparison of Anthropometric Indicators

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ABSTRACT

Malnutrition is a problem at varying proportions in developing countries, and anthropometry is a simple tool to assess its magnitude in children. This study was aimed at identifying the prevalence of malnutrition among 256 children of rural areas of Karnataka in South India, who attended the *aanganwadis*. The value of using various field-based formulae and of various anthropometric indicators used for classification of malnutrition was also studied. The children, aged 12-60 months, came from villages located at the outskirts of Bangalore city. The prevalence of wasting, stunting, and wasting and stunting was 31.2%, 9.4%, and 29.2% respectively. Wasting was more predominant among the younger age groups ($p < 0.01$). To detect wasting (acute malnutrition), the best indicator was a comparison with the reference weight calculated using Weech's formula. However, the age of child had to be rounded off to the nearest quarter of a year. Results of the study showed that indicators, such as mid-upper arm circumference (MUAC), needed to be used with caution since they are not sensitive enough to detect all cases of malnutrition. However, the MUAC-for-height (quac stick) method could be used since it was more sensitive. For detection of stunting, if reference tables are not available, Weech's formula can be used for calculation of expected height taking care to account for age to the nearest quarter, although the sensitivity of this indicator is not very high.

Key words: Infant nutritional status; Child nutritional status; Infant nutrition disorders; Child nutrition disorders; Anthropometry; India

INTRODUCTION

Malnutrition is widely recognized as a major health problem in developing countries. Growing children in particular are most vulnerable to its consequences. The frequency of malnutrition cannot be easily estimated from the prevalence of commonly-recognized clinical syndromes, such as marasmus and kwashiorkor because these constitute syndromes only, the proverbial tip of the iceberg. Cases with mild-to-moderate malnutrition are likely to remain unrecognized because clinical criteria

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for their diagnosis are imprecise and are difficult to interpret accurately.

It is widely accepted that, for practical purposes, anthropometry is the most useful tool for assessing the nutritional status of children.

There are many anthropometric indicators in use, such as mid-upper arm circumference (MUAC), MUAC-for-height, weight-for-age, height-for-age, weight-for-height, and body mass index of Quetlet. Most of these indicators need to be used along with specific reference tables, e.g. National Center for Health Statistics (NCHS) tables, for interpreting data. This might not be possible in over-crowded outpatient departments of common tertiary care hospitals. Therefore, to estimate the expected weight or height of a child rapidly, especially in emergency situations, many field workers and clinicians use formulae first introduced by Weech, using age as a

variable. Paediatricians now widely use these formulae in clinical practice (1).

Each of the above indicators has advantages and disadvantages. Some have a high sensitivity, while others have a high specificity. An ideal anthropometric indicator should have a high sensitivity to detect malnutrition accurately. At the same time, its specificity should be good so that the government resources and facilities meant for malnourished population may reach only those in need of them.

The study was carried out to estimate the prevalence of wasting and stunting among children aged 12-60 months and to compare the commonly-used anthropometric indicators in terms of their sensitivity and specificity.

MATERIALS AND METHODS

This study was carried out in 11 villages in the Singhasandra Primary Health Centre area, at the outskirts of the city of Bangalore in rural Karnataka. A non-government organization (NGO) runs the health centre.

Cases were taken from among those children who visited the hospital along with their mothers during the antenatal clinic—a specialist facility provided for pregnant mothers at the health centre. Cases were also taken from various *aanganwadis* and crèches in the area. The children essentially belonged to one of the 11 villages served by the NGO. Children aged 12-60 months were included in the study. Age of child was recorded using birth/delivery records or *aanganwadi*/school/crèche records. Children whose age could not be accurately known were excluded from the study. No other inclusion or exclusion criteria were applied. Age of child was estimated to the most recently-attained month (2). In total, 295 children were examined, but only 256 were included in the study since the age of 39 children could not be known accurately.

MUAC was measured to the nearest millimetre at the exact midpoint of the left arm using a narrow, flexible, and non-stretchable tape made of plastic (3,4). Weight of children was taken using a stand-on scale, the accuracy of which was established on a daily basis. Height of child was measured to the nearest millimetre using a right-angled head-plate non-stretchable tape fixed to the wall. Recumbent length was taken for children under 85 cm and standing height for children over 85 cm. All measurements were taken thrice and averaged for the final reading.

Each observer (one of the authors) was assigned to take one particular measurement for the whole study to reduce inter-observer bias. Being medical graduates, they did not undergo any special training.

The classification proposed by Waterlow incorporates both the above indicators and was used for the study for presenting data (5). All data and indices were compared with the NCHS tables for weight-for-height and height-for-age. The report of the World Health Organization has recommended the use of the above reference population (4). A value of mean $-2SD$ was taken as the cut-off point for detection of wasting and stunting (4,6-8).

The children were divided into three age groups: 12-35 months, 36-47 months, and 48-60 months (6). This age stratification is very important since the prevalence and distribution of wasting and stunting differ from age to age.

The prevalence of wasting was determined using the following indicators.

- MUAC
- MUAC-for-height
- Weight-for-age indicator using the NCHS tables for weight-for-age
- Field formulae described in Nelson's Textbook of pediatrics (1)

$$2x+8=\text{reference weight (where x is age in years)}$$

We further modified the age to include more accurate age groups, i.e. those with intervals of half year and quarter of a year. In other words:

$$2x+8=\text{reference weight of child (where x is age rounded off to the nearest 6 months, e.g. 1, 1 } \frac{1}{2}, 2, 2 \frac{1}{2}, \text{ etc.) and}$$

$$2x+8=\text{reference weight of child (where x is age rounded off to the nearest quarter of a year, e.g. } 2 \frac{1}{4}, 2 \frac{1}{2}, 2 \frac{3}{4}, 3, \text{ etc.)}$$

The prevalence of wasting as detected by each of the above methods was then compared with the prevalence as estimated using the NCHS tables for weight-for-height which was used as a comparison in our study.

In the same way, the prevalence of stunting was calculated using Weech's formula ($6x+77$ =reference height of child where x is age in years) (1). We also modified this as described above, and the age was rounded off to the nearest quarter of a year. This prevalence was

then compared with the prevalence estimated using the NCHS tables for height-for-age.

Sensitivity, specificity, predictive values, and likelihood ratios were calculated for each indicator of malnutrition comparing these with the NCHS standards.

RESULTS

Prevalence of malnutrition

In our study, about 70% of the children were malnourished (wasting, stunting, or both). Wasting had a high prevalence of 60.4% (Table 1). The prevalence of stunting was 38.6%. Only 30.1% were normal.

The following trends in the distribution of malnutrition were observed in our study (Table 1). Significance was estimated by chi-square test.

The number of children who had only stunting (9.4%) was much fewer than the number who had only wasting (31.2%). The prevalence of malnutrition was slightly

prevalence of stunting (pure and mixed) in females (38.4%) was lower than that in males (38.9%).

Comparison of anthropometric indicators

The anthropometric indicators (Table 2, 3, and 4) we have compared were as follows:

Sensitivity of MUAC: The sensitivity of MUAC was very low, i.e. 24.6%, which means that nearly 75% of the malnourished cases were missed. The specificity of the indicator was very good (94.8%), and, therefore, children diagnosed wrongly as being malnourished would be very rare if this indicator is used.

MUAC-for-height: This indicator compared the MUAC of a child with the MUAC of a reference child of same height. This method, used in field surveys, is better known as the 'quac stick' method. The sensitivity of this test was 47% (twice that of MUAC), and the specificity was 88.5%.

Use of Weech's formula (1) for calculation of reference weight: In clinical practice and field surveys, it might

Table 1. Prevalence of malnutrition in studied population

Group	Normal		Wasted only*		Stunted only*		Wasted and stunted	
	No.	%	No.	%	No.	%	No.	%
Total population	77	30.1	80	31.2	24	9.4	75	29.3
Females	32	27.3	40	34.2	10	8.5	35	29.9
Males	45	32.4	40	28.8	13	10.1	40	28.8
Age 12-35 months	14	22.2	31	49.2	5	7.9	13	20.6
Age 36-47 months	34	30.9	35	31.8	13	11.8	28	25.5
Age 48-60 months	29	34.9	14	16.9	6	7.2	34	41.0

* mean -2SD

more in females (72.7%) than in males (67.6%). The proportion of girls having wasting was 64% compared to that of boys which was 57.6% (not significant). The prevalence of malnutrition was much higher in the lower age groups (77.8% in the age group of 12-35 months), and it decreased in the older age groups (69.1% in the age group of 36-47 months and 65.1% in the age group of 48-60 months). The prevalence of wasting in children varied with increasing age, although this was not significant (69.8%, 57.3%, and 57.9% in the age group of 12-35 months, 36-47 months, and 48-60 months respectively). The prevalence of stunting in children increased with age (28.5%, 37.3%, and 48.2% in the age group of 12-35 months, 36-47 months, and 48-60 months respectively). These differences were significant ($\chi^2=6.14$, $p<0.05$). The number of girls having wasting alone or wasting and stunting was 64.1% which was much higher than that in boys (57.6%). The total

not always be possible to refer to the standard tables for reference weights, e.g. NCHS tables. The use of Weech's formula provides a simple alternative. This indicator compares the weight of a child with that of the reference weight (as calculated by the above formula). Waterlow chooses a cut-off of 80% of the reference weight as an indicator for malnutrition (6,9). The sensitivity of the above indicator was 74%, and the specificity was 87%.

Modified Weech's formula using half-yearly intervals:

The use of age in years was rounded off to the nearest $\frac{1}{2}$ year attained, e.g. 2 years 3 months rounded off to 2 years, while 2 years 7 months rounded off to $2\frac{1}{2}$ years, increased the sensitivity to 80%, and the specificity became 78%.

Modified Weech's formula using quarterly intervals:

The use of the same formula as above ($2x+8$) where x is the age rounded off to the nearest quarter attained,

e.g. $2\frac{1}{4}$ years, $2\frac{1}{2}$ years, and $2\frac{3}{4}$ years, increased the sensitivity to 92.3%, and the specificity reduced to 78%.

of anthropometric indicators depend on its area of application. These indices can be used for assessing the

Table 2. Comparison of presence or absence of malnutrition using different criteria

Indicator	Presence (+)/absence (-) of malnutrition	Malnourished using weight/height tables (<mean -2SD)	Normal using weight/height tables (>mean -2SD)
Malnourishment using MUAC	+	16	10
	-	49	181
Malnourishment using MUAC/height	+	31	22
	-	34	169
Malnourishment using formula-'age x2 +8' (age rounded to nearest quarter year)	+	60	43
	-	5	148
Malnourishment using formula-'age x2+8' (age rounded to nearest half year)	+	52	42
	-	13	149
Malnourishment using formula-'age x2+8' (age in years)	+	48	25
	-	17	166
Malnourishment using weight/age	+	59	42
	-	6	149

The figures mentioned are indicative of the actual number in each category
Weight/height tables refer to the standards prescribed by the NCHS

Table 3. Comparison of height indicators using different criteria

Indicator	Presence (+)/absence (-) of malnutrition	Malnourished using height/age tables	Normal using height/age tables
Malnourished using formula-'age x6+77' for reference height	+	19	3
	-	20	198

The figures mentioned are indicative of the actual number in each category
Height/age tables refer to the standards prescribed by the NCHS

Weight-for-height compared to weight-for-age (using NCHS tables): The comparison of weights of the children with reference weights obtained using weight-for-age tables (by NCHS) yielded a sensitivity of 90% and a specificity of 78%. These values were similar to the sensitivity and specificity values obtained when Weech's formula was used for calculating the reference weight. However, the age to be used in the formula has to be accurately rounded off to the nearest quarter as demonstrated above.

Height-for-age (NCHS tables) compared to modified Weech's formula for reference height: Heights of the children were compared with the reference heights calculated using modified Weech's formula for height (where x is age rounded off to the nearest quarter). This method yielded a sensitivity of 48.7% and a specificity of 98.5%.

DISCUSSION

The use and interpretation of growth measurements differ significantly according to whether they concern the individual or an entire population. The selection and use

nutritional status of children in a clinical set-up, in emergency situations, such as natural and man-made calamities, and in growth monitoring of children. Deficits in one or more of the anthropometric indicators are often regarded as evidence of malnutrition.

Each indicator has its own merits and demerits, and each indicator is best suited for a particular situation. MUAC, for many years, has been the indicator of choice for use during emergency situations. Indicators, such as weight-for-height or height-for-age, allow malnutrition to be classified into stunting and wasting. Stunting is highly prevalent in most developing countries. In our study, a large proportion of children had acute malnutrition. Stunting, on the other hand, was prevalent when compared with an earlier comprehensive study done in the same region (10).

In our study, stunting was predominant in the children of older age groups, while wasting was more common in the younger age groups. The worldwide prevalence of stunting varies considerably from 5% to 65% in developing countries (11). In many such settings, the prevalence of stunting starts to rise after the age of three

months and reaches a peak at three years. This can be explained by the fact that stunting is a sign of chronic

indicator than MUAC. Whenever possible, MUAC-for-height (quac stick method) should be used.

Table 4. Validity of different anthropometric indicators

Indicator	Sensitivity (%)	Specificity (%)	Predictive value of +ve test	Predictive value of -ve test	Likelihood ratio of +ve test	Likelihood ratio of -ve test
MUAC compared with weight-for-height (NCHS)	24.6	94.8	61.5	78.7	4.7	0.8
MUAC-for-height compared with weight-for-height (NCHS)	47.7	88.5	58.5	83.2	4.1	0.6
Formula $2x+8$ compared with weight-for-height (where x is age in years)	73.8	86.9	66.7	90.2	5.5	0.3
Formula $2x+8$ (x is age rounded off to nearest 6 months) compared to weight-for-height	80	78	55.3	92	3.6	0.2
Formula $2x+8$ (x is age rounded off to nearest 3 months) compared to weight-for-height	92.3	77.5	58.2	96.7	4.1	0.1
Weight-for-age (NCHS) compared to weight-for-height (NCHS)	90.8	78.0	58.1	96.1	4.3	0.1
Formula $6x+77$ for height compared to height-for-age (NCHS)	48.7	98.5	86.4	90.8	32.5	0.5

malnutrition, and, therefore, would take more time to manifest unlike wasting which is a sign of acute malnutrition that usually manifests at a younger age when inadequate weaning practices compromise the nutritional status of child.

MUAC has been proposed as an alternative index for nutritional status for use where the collection of height and weight is difficult, such as in emergency situations of famine or a refugee crisis. In these situations, low MUAC, based on a fixed cut-off point, such as 12.5 cm, has been used as a proxy for low weight-for-height. Comparisons of these two indicators, however, show that these are poorly correlated (12,13). MUAC, however, appears to be a superior predictor of childhood mortality compared to anthropometric indicators based on height-for-weight (14-17). This led to the proposal of MUAC as an additional screening tool in non-emergency situations. Key operational advantages of MUAC include the portability of measuring-tapes, and the fact that a single cut-off value (12.5 cm or 13 cm) can be used for children aged less than five years. Results of our study showed that the indicators, such as MUAC, need to be used with caution, since these are not sensitive enough to detect all cases of malnutrition. MUAC-for-height is more sensitive and superior compared to MUAC, and, therefore, in field surveys, in epidemics or drought, it would be a better

Weight-for-age reflects body mass index relative to chronological age. It is influenced by both height of child (height-for-age) and his/her weight (weight-for-height), and its composite nature makes interpretation complex. However, in the absence of significant wasting in a community, weight-for-age and height-for-age provide similar information in that both reflect the long-term nutritional experience of the individual or the population. Short-term change, especially reduction in weight-for-age, reveals changes in weight-for-height (18) because low weight-for-age reflects low height-for-age or low weight-for-height, or both. The term 'global malnutrition' has been used for describing the indicator, which may encompass chronic malnutrition and/or acute malnutrition. The worldwide variation of low weight-for-age and its age distribution are similar to those of low height-for-age (11).

In our study, the sensitivity of weight-for-age as an indicator was 90.8%. The use of Weech's formula to calculate the reference weight is a common practice in the clinical set-up where many a time reference tables may not be available. Using the formula to calculate the reference weight rather than the NCHS tables yielded a sensitivity of 73.8% and a specificity of 86.9%. However, when the age of child, substituted with the formula was rounded off to the nearest six months, the sensitivity

increased to 80%, while the specificity was 78%. When the age was rounded off to the nearest quarter (3 months), the sensitivity was 92.3%, and the specificity was 77.5%.

Weech's formula, therefore, appears to be a sensitive test to detect malnutrition. Using age rounded off to the nearest quarter in the formula can increase the sensitivity of this test. The sensitivity achieved by doing this was comparable to that of using weight-for-age as an indicator for malnutrition. The ideal method to diagnose malnutrition is to use the reference data provided by the NCHS. Weech's formula can be used as a suitable alternative if the above tables are not available. Degree of malnutrition can also be calculated by comparing the weight of child under study with the reference weight calculated by the above formula, e.g. Grade 1=70-79% of expected weight, etc.

In the presence of natural calamities, the use of Weech's formula as a method to calculate the reference values for comparison is actually superior to using MUAC with a fixed cut-off (12.5 cm) in terms of sensitivity. However, if obtaining the exact age of child is not possible, the age-independent indicators, such as MUAC or MUAC-for-height, would be a better indicator.

For the detection of stunting, the use of reference heights obtained from Weech's formula for height compared to the NCHS reference tables for height yielded a sensitivity of 48.7% and a specificity of 98.5%. Therefore, the ideal method to detect stunting would be to use height-for-age tables supplied by the NCHS, which is more sensitive than using modified Weech's formula for height.

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