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Nutritional Assessment of Children Aged Twelve to Fifty Nine Months with Diarrhoea, Using Mid-upper-arm Circumference (MUAC)

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Authors' contributions

Author OP conceived of the idea for the study, designed the proforma, wrote the protocol, collected and analyzed the data and wrote the first draft of the manuscript, authors OEK and FOA revised the manuscript and made significant intellectual contributions. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Background: Protein energy malnutrition is a significant cause of morbidity and mortality in children between the ages of 12 and 59 months and diarrhoea has been shown to have a bi-directional relationship with malnutrition. Mid upper arm circumference (MUAC) has been shown to be a useful indicator of malnutrition in children aged 12 to 59 months.
Objective: To determine the nutritional status of children aged 12 to 59 months with diarrhoea using mid upper arm circumference (MUAC).
Method: Over a 6 month period, all children aged 12 to 59 months who presented to the Niger Delta University Teaching Hospital (NDUTH) with diarrhoea were consecutively recruited into the study. Information on their ages, diarrhoeal type, duration and frequency as well as parental educational level and occupation were obtained and recorded into a proforma. MUACs were measured and recorded to the nearest 0.1cm.
Results: There were 144 children with a male to female ratio of 1.3:1. The mean MUAC was 14.25 ± 2.46cm with a steady increase with age from13.45 ± 1.99cm at 12 to 23 months to 16.50 ± 0.58cm at 48 to 59 months. Using MUAC measurements, 19 (13.2%) of the children were malnourished, with 7 (4.9%) having severe acute malnutrition and 12 (8.3%) having moderate acute malnutrition (MAM). Seventeen (11.8%) of the children were at risk of malnutrition. Children with chronic diarrhoea and ages ranging from 12 to

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23 months had significantly lower MUACs with χ^2 and p values of 19.58 (0.000) and 7.99 (0.005) respectively.
Conclusion: Under nutrition is an important problem in children aged 12 to 59 months with diarrhoea. There is need to pay extra attention to nutritional status of this age group especially during episodes of diarrhoea.

Keywords: Mid upper arm circumference; children; diarrhea; malnutrition.

1. INTRODUCTION

Protein energy malnutrition is prevalent in Nigeria and is a significant cause of morbidity and mortality in children [1]. Early recognition of severe acute malnutrition in sick children is important as standard management protocols may reduce mortality [2]. Diarrhoea is common in developing countries like Nigeria, with a single child having about 2.6 episodes per year [3]. Studies have demonstrated a strong bi-directional relationship between malnutrition and diarrhoea with malnourished children having a higher incidence of diarrhoea [4-7] as well as a higher case fatality rate when compared to children with normal nutrition [8]. Diarrhoea may lead to malnutrition due to reduced dietary intake, mal-absorption or mal-digestion [9], while malnutrition may cause or worsen diarrhoea as a result of a weakened immune system [10].

Several studies measuring the impact of diarrhoea on child nutrition have been done but these studies used anthropometric measures of weight for age and height for age [11-13]. Another useful anthropometric measure of nutritional status is Mid Upper Arm Circumference (MUAC). McDowell and King [14] in Zambia demonstrated that it is similar in accuracy to weight for age and weight for length as an indicator of clinical nutrition. It has the advantage of being cheap and easy to perform and requires only a measuring tape which is easy to carry [15]. MUAC is particularly useful when the precise age of the child is unknown as it is relatively independent of age with reference medians increasing only slightly (by approximately 1.7cm between the ages of one and five years [16-18]. Vella et al. [19] in West Uganda compared the relative risk of mortality in malnutrition using the various anthropometric indices. They found MUAC to be the most reliable predictor of mortality and therefore recommended its use as the anthropometric indicator of choice in identifying children at high risk of death.

The present study was carried out to measure the effect of diarrhoea and some socioeconomic factors on the nutritional status of children aged twelve to fifty nine months using an easily measurable anthropometric indicator; the mid upper arm circumference.

2. METHODOLOGY

The study was carried out within a six month period (between the months of September 2012 and February 2013) in the Paediatric unit of the Niger Delta University Teaching Hospital (NDUTH). Ethical clearance was sought and obtained from the Research and Ethics Committee of the NDUTH. Informed consent was also obtained from parents and guardians of the children recruited for the study.

2.1 Patient Recruitment

All children aged 12 to 59 months presenting with diarrhoea with an average frequency of three or more times per day or greater than the frequency considered normal for the child were consecutively recruited into the study. Children whose parents did not give consent were excluded from the study. Also those with chronic medical conditions like severe persistent asthma, congenital heart disease and HIV infection which may affect nutritional status were excluded. The investigators administered and filled a questionnaire for each child recruited into the study. Information on the questionnaire included the child's personal data, duration of diarrhoea, presence of blood in stools and number of diarrhoeal episodes in the past one year. Parental socioeconomic stratification was done based on the classification described by Oyedeji [20].

Diarrhoea was classified according to duration [21], with acute diarrhoea being less than two weeks, persistent diarrhoea with duration of greater than or equal to two weeks but less than four weeks and chronic diarrhoea being greater than or equal to four weeks. The children were said to have dysentery when there was presence of visible blood in the diarrhoeal stools.

2.1.1 Measurement of mid upper arm circumference

Mid Upper Arm Circumferences (MUAC) were measured to the nearest 0.1cm at the mid-point between the tips of the left shoulder and elbow using a non-stretchable measuring tape. With the left elbow flexed, the acromium and olecranon processes were identified and marked with a pen. Using the measuring tape, the mid-point between these two landmarks were found and marked. Then with the arm hanging straight down, the tape was strapped around the arm at the mid-point mark and the mid upper arm circumference measured and recorded to the nearest 0.1cm. All MUAC measurements were taken and recorded by only one of the authors to avoid inter-observer error. Children with MUAC < 12.5cm were classified as having malnutrition while those with MUAC between 12.5cm and 13.4cm were classified as being at risk of malnutrition [22]. Children with MUAC measurements < 12.5cm were divided into two categories; those with MUAC measurements less than 11.5cm were classified as having severe acute malnutrition (SAM), while those with MUAC measurements between 11.5cm and 12.4cm were classified as having moderate acute malnutrition (MAM) [22]. Those with MUAC measurements greater than or equal to 13.5cm were classified as having normal nutrition [22].

2.1.1.1Treatment protocol

Each child recruited for the study was assessed for dehydration by the investigators and treated based on the WHO protocol [23]. The patients were assessed for other clinical problems and appropriately treated. They were all given zinc tablets at 20mg daily for 2 weeks. Those with dysentery were given ciprofluoxacin tablets at 15mg/kg/day for 3 days.

2.1.1.1.1Data analysis

The data was analyzed using epi-info version 6.04 and SPSS version 15 statistical packages. Test of significance between proportions was assessed using Chi-square and Fisher's exact test where appropriate. A 95% confidence interval was used and a p value of less than 0.05 was considered significant.

3. RESULTS

3.1 General Characteristics

As shown in Table 1, a total of 144 children between 12 and 59 months who presented with diarrhoea at the NDUTH were recruited for the study. There were 81 (56.3%) males and 63 (43.7%) females, giving a male to female ratio of 1.3:1. The mean MUAC of the study population was 14.25 ± 2.46cm. There was an increase in MUAC measurements with increasing age, from 13.45 ± 1.99cm at 12 – 23 months to 16.50 ± 0.58cm at 48 – 59 months.

Table 1. Age and sex distribution of the 144 children

Age range	Male (%)	Female (%)	Frequency (%)	Mean MUAC (cm)
12 – 23 months	45 (31.2)	40 (27.7)	85 (24.9)	13.45 ± 1.99
24 – 35 months	25 (17.4)	16 (11.1)	41 (12.0)	14.75 ± 1.94
36 – 47 months	9 (6.3)	6 (4.2)	15 (4.3)	15.80 ± 1.72
48 – 59 months	2 (1.4)	1 (0.7)	3 (0.9)	16.50 ± 0.58
Total	81 (56.3)	63 (43.7)	144 (100)	14.25 ± 2.46

3.1.1 Duration, type and frequency of diarrhea

As shown in Table 2, 126 (87.5%) of the children had acute diarrhoea, 8 (5.6%) had persistent diarrhoea and 10 (6.9%) had chronic diarrhoea. Thirty seven (25.7%) of them had dysentery. One hundred and five (72.9%) had less than 3 diarrhoeal episodes in the preceding one year while 39 (27.1%) had 3 or more episodes.

Nineteen children (13.2%) were malnourished with MUAC less than 12.5cm. Seven (4.9%) of them had severe acute malnutrition with MUAC less than 11.5cm, while 12 (8.3%) had moderate acute malnutrition with MUAC ranging from 11.5 to 12.4cm. Seventeen (11.8%) children were at risk of malnutrition with MUAC ranging from 12.5 to 13.4cm.

Significantly more children with chronic diarrhoea were malnourished. There was no significant difference in MUACs of the children with dysentery when compared to those with watery diarrhoea. There was also no significant difference in MUAC measurements of those with three or more diarrhoeal episodes in the preceding one year when compared to those with less than three episodes.

3.1.1.1 MUAC according to age, sex and parental social class

Table 3 shows that all the children with MUAC measurements in the malnutrition range were less than 36 months of age. Thirty six percent of those aged 12 to 23 months were malnourished while 12.2% of those aged 24 to 35 months were malnourished. This difference was statistically significant, $\chi^2 = 7.99$, $p = 0.005$.

A higher percentage 28.6% of the female children were malnourished as compared to 22.2% of the males. This difference was however not statistically significant; $\chi^2 = 0.76$, $p = 0.383$.

Table 3 also shows that a higher percentage (30.6%) of the malnourished children had parents from the lower social class, followed by the middle social class (25.5%). This difference was also not statistically significant; $\chi^2 = 3.82$, $p = 0.147$.

Table 2. MUAC according to duration, type and frequency of diarrhea

	Total (%)	≥13.5cm (%)	12.5 – 13.4cm (%)	11.5 – 12.4cm (%)	<11.5cm (%)	Total malnourished (%)	χ^2 (p value)
MUAC according to duration of diarrhoea							
Acute	126 (100.0)	102 (81.0)	10 (7.9)	10(7.9)	4(3.2)	14 (11.1)	19.58(0.000)
persistent	8 (100.0)	2 (25.0)	4 (50.0)	1(12.5)	1(12.5)	2 (25.0)	
chronic	10 (100.0)	4 (40.0)	3 (30.0)	1(10.0)	2(20.0)	3 (30.0)	
MUAC according to type of diarrhoea							
Blood in stool	37 (100.0)	24 (64.9)	4 (10.8)	4(10.8)	5(13.5)	9 (24.3)	2.73 (0.099)
No blood in stool	107 (100.0)	84 (78.5)	13 (12.1)	8(7.5)	2(1.9)	10 (9.3)	
MUAC according to frequency of diarrhoea							
Less than 3	105 (100.0)	76 (72.4)	12 (11.4)	12(11.4)	5(4.8)	17 (16.2)	1.42 (0.234)
3 or more	39 (100.0)	32 (82.1)	5 (12.8)	0(0.0)	2(5.1)	2 (5.1)	

Table 3. MUAC according to age category, sex and parental social class

Age category (months)	Total number (%)	≥13.5cm (%)	12.5 – 13.4cm (%)	11.5 – 12.4cm (%)	<11.5cm (%)	Total malnourished (%)	χ^2 (p value)
MUAC according to age category							
12 – 23	85 (100.0)	54 (63.5)	13 (15.3)	11 (12.9)	7 (8.2)	18(21.2)	7.99 (0.005)
24 – 35	41 (100.0)	36 (87.8)	4 (9.8)	1 (2.4)	0 (0.0)	1(2.4)	
36 – 47	15 (100.0)	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
48 – 59	3 (100.0)	3 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
MUAC according to sex							
Male	81 (100.0)	63 (77.8)	9 (11.1)	5(6.2)	4(4.9)	9(11.1)	0.76 (0.383)
Female	63 (100.0)	45 (71.4)	8 (12.7)	7(11.1)	3(4.8)	10(15.9)	
MUAC according to parental social class							
Upper class	27 (100.0)	24 (88.9%)	3 (11.1)	0 (0.0)	0 (0.0)	0 (0.0)	3.82 (0.147)
Middle class	55 (100.0)	41 (74.5)	11 (20.0)	2(3.6)	1(1.8)	3(54.5)	
Lower class	62 (100.0)	43 (69.4)	3 (4.8)	10(16.1)	6(9.7)	16(25.8)	

4. DISCUSSION

Mid upper arm circumference is an indicator of a child's body weight and muscle mass and has been endorsed by the World Health Organization (WHO) as a tool for diagnosing acute malnutrition [24]. The WHO recommends that case finding for community based management of acute malnutrition should rely on MUAC as it is simpler, faster to measure and more sensitive for predicting mortality risk [19,25]. It is also useful in clinical settings and as such has also been recommended by the WHO as an independent indicator for admission in outpatient clinics because it requires little equipment and training and a large number of children can be screened within a short time [26]. Myatt et al. [27] in Ethiopia demonstrated that weight for height and MUAC case definitions yielded similar estimates for the prevalence of acute malnutrition. Velzeboer et al. [28] in a comparison of weight for height and MUAC among Guatemalan children found that younger children tended to become upset and agitated during weight and height measurements but no such behavior was observed during the measurement of MUAC.

The mean MUAC of 14.25 ± 2.46cm in the present study is similar to the mean MUAC of 14.26 ± 1.21cm reported by Alam et al. [29] in a nutritional survey of urban slum children below five years. This similarity may be due to the fact that in both studies, the majority of the subjects were from low socioeconomic parents. Dairo et al. [30] in Ibadan Nigeria, reported a comparably higher MUAC of 15.47 ± 1.4 cm. Their higher value may be explained by the fact that their subjects were children living in urban Ibadan whereas the centre where the present study was done is located in a rural area and as such most of the patients who present to the hospital are rural dwellers. As demonstrated by Charturvedi et al. [31] children in urban areas have higher MUAC values compared to those living in rural areas. Also the subjects in the Ibadan study were apparently healthy children in nursery schools whereas those in the present study were children with diarrhoea which has been demonstrated to contribute to malnutrition [32]. In 2006, Bruno S [33], in Dar Es Salaam reported that 45% of patients with protein energy malnutrition at Kilifi District hospital, Dar Es Salaam had co-existing diarrhoea.

The mean MUAC in the present study showed a steady increase with increasing age. This is similar to findings from other authors [30] in Nigeria as well as other African countries [34] and Bangladesh [35]. This raises the question of whether use of single MUAC cut off values are appropriate for children between 12 to 59 months.MUAC cut off values being used, are those developed in the 1960s based on observations from well-nourished Polish under five children [36]. However in recent times, questions have arisen on the fact that MUAC is age and sex independent and it has been suggested that MUAC z-scores which adjust for age and sex are more useful indicators of nutritional status [15,37]. Hop et al. [38] in Hanoi, Vietnam carried out a study aimed at observing the development of MUAC of children on a longitudinal basis. They found that MUAC increased by about 1cm for boys and 1.5cm for girls between one and five years. As a result of their findings, they suggested that single cut off values of MUAC should not be used in screening for malnutrition for under-fives but should be elevated with increasing age. Briend A [39] however, argued in support of the use of single cut off MUAC values as an indicator of risk of death inspite of the increase with age. He explained that when a fixed cut off is used for identifying children with severe acute malnutrition, more young children are selected. As younger children are at a higher risk of mortality, this improves the selection of a higher risk group.

The overall prevalence of under nutrition in the present study was 13.2%.This is lower than the 18.9% reported by Maiti et al. [40] in West Bengal India. The lower prevalence in the

present study may be due to the fact that the ages of the children studied ranged from 12 to 59 months as against the Indian study where comparably younger children aged 6 to 23 months were studied. The present study and other studies [34,35,41] have demonstrated that malnutrition is more prevalent in children within the younger age groups. Chiabi et al. [42] in Cameroon reported a lower prevalence of 2.4% in apparently healthy children attending immunization clinics. Kaur et al. [43] and Chaturvedi et al. [31] however reported much higher prevalences of 38.5% and 53.2% in Punjab and Agra district India. The reason for their higher prevalence is not immediately clear. Further studies need to be carried out to determine the effect of other factors like genetic and geographical differences on the anthropometric measurements of children in these different continents.

The present study provides some evidence that there is a direct relationship between diarrhoea and malnutrition. Though this does not indicate causality, it may imply that addressing the issue of diarrhoea may improve under-five nutritional status.Roy [35] in rural Bangladesh used MUAC for evaluation of high risk groups for childhood malnutrition. He reported that children who had diarrhoea in the last 12 months preceding his study had significantly higher levels of malnutrition.Assis et al. [32] in Serrinha, North East Brazil also demonstrated that diarrhoea is a major determinant of poor growth in children less than 5 years. This is however different from reports byPoskitt et al. [44] who reviewed diarrhoea presentations and nutritional status in young rural Gambian children over a fifteen year period as a test of an earlier hypothesis that reduced diarrhoea prevalence would lead to improved growth and reduced prevalence of malnutrition. They found that even as the number of diarrhoea presentations fell steadily over the years, there was no noticeable change in the nutritional status of the children at one and two years. They concluded that even if reduction in incidence and prevalence of diarrhoea is undoubtedly important for child health, policies to reduce diarrhoea alone cannot be expected to achieve improvements in child nutrition. Their study highlights the importance of adequate dietary intake for optimum growth in children less than five years.A study done by Wierzba et al. [45] in a peri-urban area outside Alexandria, Egypt, showed that diarrhoea alone does not appear to contribute substantially to malnutrition when children have diarrhoea free time for catch up growth.It has been demonstrated that catch up growth can be induced in young children after diarrhoea by ensuring energy intake 50% in excess of recommendations and protein intake 100% more than recommended for a few weeks [44].

The present study also found no significant difference in MUAC of children with dysentery and watery diarrhoea. This is similar to findings by Roy [35] but is in contrast to findings by Alam et al. [46] who examined the role of diarrhoea in the aetiology of growth retardation in young children. They reported that dysentery was associated with significantly lower annual weight and height gain. They explained this association with the fact that dysenteric episodes tend to last longer, are often associated with fever, damage the intestinal structure, impair function with associated greater endogenous protein loss which may have a negative effect on growth. Significantly more children with chronic diarrhoea in the present study had MUAC in the under nutrition range. This is expected as chronic diarrhoea causes malnutrition as a result of mal-absorption in addition to mal-digestion and reduced food intake [4].

In the present study, the prevalence of malnutrition was found to decrease with increasing age. Marshal et al. [47] in Afghanistan, demonstrated that even if older children were more likely to suffer from diarrhoea compared to younger children, they are less likely to be malnourished as a result of the diarrhoea. Roy [35] in Bangladesh found that children less than 2 years had significantly higher levels of severe malnutrition (using MUAC) than those

aged 2 years or older. This has also been demonstrated by researchers in India [48]. This may be explained by the fact that children in the second year of life are especially vulnerable to malnutrition as they are transiting from infant to family diet [49]. This period is characterized by high nutrient need when several meals a day are required for optimum growth, especially for those who have stopped breastfeeding [49]. There was no statistically significant sex difference in the prevalence of under nutrition in the present study. This is similar to findings by Biswas et al. [50] and Mandal and Bose [48] in West Bengal India but in contrast to findings by Chaturvedi et al. [31] who reported a higher prevalence in girls and Maiti et al. [40] with a higher prevalence in boys. Though this was not statistically significant, the prevalence of under nutrition was higher among children with parents from the lower social class. This is similar to findings by Amosu et al. [51] who reported a very high prevalence (85.2%) of wasting among under-five children of low income earners in Ipokia Local Government Area, Ogun State, Nigeria. Roy [35] also reported similar findings in Bangladesh. This is not surprising as child hood under-nutrition is more prevalent in poor households as a result of poor food security, and recurrent infections [52].

A limitation of the present study was that the children were assessed for only acute malnutrition using MUAC values whereas they may also have co-existing chronic malnutrition. Also other possible confounding factors were not ascertained as they may have other causes of malnutrition apart from diarrhoea.

5. CONCLUSION

The mean MUAC was 14.25 ± 2.46cm and 19 (13.2%) of the children were malnourished. Malnutrition is an important problem in children between the ages of twelve and fifty nine months with diarrhoea. There is need to pay extra attention to nutritional status of this age group especially during episodes of diarrheoa. Also diarrhoea prevention and control programmes need to be intensified. Progress in improvement of child nutrition can be made with provision of basic services and support for initiatives that empower families and communities in ensuring adequate nutritional intake and prevention of infections like diarrhoea.

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CONSENT

Informed consent was obtained from parents and guardians of the children recruited for the study.

ETHICAL APPROVAL

Ethical clearance was sought and obtained from the Research and Ethics Committee of the NDUTH.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fatunde OJ, Asekun-Olarinmoye EO, Ogundiran FA. Seasonal prevalence of protein energy malnutrition (PEM). Niger J Paediatr. 1995;22:57–63.
2. Schofield C, Ashworth A. Why have mortality rates for severe malnutrition remained so high? Bull World Hlth Organ. 1996;74:223–229.
3. Bern C, Matines J, de Zoysa I. The magnitude of the global problem of diarrhoeal diseases: a ten year update. Bull World Hlth Organ. 1992;70:705–714.
4. El Samani EFZ, Willert WC, Ware JH. Association of malnutrition and diarrhoeaan children aged under five years. A prospective follow up study in rural Sudanese community. Am J Epidemiol. 1988;128:93–105.
5. Chowdhury MK, Gupta VM, Bairagi R, Bhattacharya BN. Does malnutrition predispose to diarrhoea during childhood? Evidence from a longitudinal study in Matlab, Bangladesh. Eur J ClinNutr. 1990;44:515–525.
6. Gordon JE, Guzman MA, Ascoli W, Scrimshaw NS. Acute diarrhoeal disease in less developed countries – patterns of epidemiological behavior in rural Guatemalan villages. Bull WHO. 1984;31:9–20.
7. Trowbridge FL, Newton LH, Campbell CC. Nutritional status and severity of diarrhoea. Lancet. 1981;1:1375.
8. Black RE, Brown KH, Becker S. Malnutrition is a determining factor in diarrhoeal duration, but not incidence, among young children in a longitudinal study in rural Bangladesh. Am J Clin Nutr. 1984;39:87–94.
9. Njuguna J, Muruka C. Diarrhoea and malnutrition among children in a Kenyan district: a correlational study. J Rural Trop Pub Hlth. 2011;10:35–38.
10. Nel E. Diarrhoea and malnutrition. South Afr J Clin Nutr. 2010;23:15–18.
11. Briend A, Hassan KZ, Aziz KMA, Haque BA. Are diarrhoea control programmes likely to reduce childhood malnutrition? Observation from rural Bangladesh. Int J Epidemiol. 1987;16:477–481.
12. Bairagi R, Chowdhury MK, Kim YJ, Curlin GT, Gray RH. The association between malnutrition and diarrhoea in rural Bangladesh. Int J Epidemiol 1987; 16: 477 – 481.
13. Moy RJD, Booth IW, Choto AB, McNeish AS. Is diarrhoea a major cause of malnutrition in developing countries? Recent trends in diarrhoea and malnutrition. In: proceedings of 2nd commonwealth conference on diarrhoea and malnutrition. New Delhi: Anupam Art Printers. 1991;125–37.
14. McDowell I, King FS. Interpretation of arm circumference as an indicator of nutritional status. Arch Dis Child. 1982;57:292–296.
15. Hall G, Chowdhury S, Bloem M. Use of mid upper arm circumference z-scores in nutritional assessment. Lancet. 1993;341:1481.
16. Burgess HJL, Burgess AP. A modified standard for MUAC in young children. J Trop Pediatr. 1969;15:189–192.
17. Vella V, Tomkins A, Ndiku J, Marshal T, Cortinovis I. Anthropometry as a predictor of mortality among Ugandan children allowing for socio-economic status. Eur J Clin Nutr. 1994;48:189–197.
18. Alam N, Wojtyniak B, Rahaman MM. Anthropometric indicators and risk of death. Am J Clin Nutr. 1989;49:884–888.

19. Vella V, Tomkins A, Borghesi A, Miglion GB, Ndiku J, Adriko BC. Anthropometry and childhood mortality in Northwest and Southwest Uganda. Am J Pub Hlth. 1993;83(11):1616–1618.
20. Oyedeji GA. Socioeconomic and cultural background of hospitalized patients in Ilesha. Niger J Paediatr. 1985;12:111–117.
21. Cutting W. Diarrhoeal diseases. Definition and classification. In: Tanfield P, Brueton M, Chan M, Parkin M, Waterson T (eds). Diseases of children in the subtropics and tropics. 4th ed. 1991;456.
22. WHO/UNICEF/WFP/SCN joint statement. Community based management of severe acute malnutrition. Geneva, New York, Rome, 2007. Accessed 22 February 2011. Available:http://www.who.int/childadolescenthealth/documents/pdfs/severeacutemalnutritionen.pdf
23. WHO programme for control of diarrhoea diseases: assessing the diarrhoea patient. In: readings on diarrhoea – students manual, Geneva. 1990;31–43.
24. Young H, Jaspars S. The meaning and measurement of acute malnutrition in emergencies; a primer for decision makers. In: Humanitarian network practice paper 2006; 56. Publishers: Humanitarian Practice anetwork (HPN), Overseas Development Institute, III Westmininster bridge road, London, SE17JD, United Kingdom. Accessed 22 February 2011. Available at: www.odihpn.org.
25. Berkley J, Mwangi I, Griffiths K, Ahmed I, Mithwani S, English M et al. Assessment of severe malnutrition among hospitalized children in rural Kenya. JAMA. 2005;294(5):591–597.
26. Myatt M. A review of methods to detect cases of severely malnourished children in the community based therapeutic programmes, draft background paper for WHO, UNICEF and SCN informal global consultation on community based management in children. Geneva, 21-23 November 2005.
27. Myatt M, Duffield A, Seal A, Pasteur F. The effect of body shape on weight-for-height and mid-upper-arm circumference based case definitions of acute malnutrition in Ethiopian children. Ann Human Biol. 2009;36(1):5–20.
28. Velzeboer MI, Selwyn BJ, Sargent F, Pottitt E, Delgado H. The use of arm circumference in simplified screening of acute malnutrition by minimally trained health workers. J Trop Pediatr. 1983;29:159–166.
29. Alam MA, Hakin MA, Rouf MA. Haque O, Ali ME, Zaidul ISM. Nutritional status of urban slum children below five years: Assessment by anthropometric measurements with special reference to socio-economic status. J Food Agric Environ 2011; 9(2): 85 – 90.
30. Dairo MD, Fatokun ME, Kuti M. Reliability of the mid upper arm circumference for the assessment of wasting among children aged 12 to 59 months in urban Ibadan, Nigeria. Int J Biomed Sci. 2012;8(2):140–143.
31. Chaturvedi M, Nandan D, Gupta SC. Rapid assessment of nutritional status of children in Agra district. Indian J PrevSoc Med. 2006;37(3&4):165–169.
32. Assis AMO, Barreto ML, santos LMP, Fiaccone R, da Silva Gomes GS. Growth faltering in childhood related to diarrhoea: a longitudinal community based study. Eur J ClinNutr 2005; 59: 1317 – 1323.
33. Bruno S. Effects of infection on severely malnourished children in Kilifi-Mombasa and Dar Es Salaam: a comparative study. Dar Es Salaam Med Stud J. 2006;14(1):27–35.
34. Olwedo MA, Mworozi E, Bachou H, Orach CG. Factors associated with malnutrition among children in internally displaced persons camps, Northern Uganda. Afr Hlth Sci. 2008;8(4):244–252.

35. Roy NC. Use of mid upper arm circumference for evaluation of nutritional status of children and for identification of high risk groups for malnutrition in rural Bangladesh. J Health Popul Nutr. 2000;18(3):171–180.
36. Mei Z, Grm-Strawn LM, de Onis M, Yip R. The development of a MUAC-for-height reference, including a comparison to other nutritional status screening indicators. Bull World Hlth Organ. 1997;75(4):333–341.
37. Van den Broeck J, Eeckels R, Vuylsteke J. Influence of nutritional status on child mortality in rural Zaire. Lancet. 1993;341:1491–1495.
38. Hop LT, Gross R, Sastroamidjojo S, Giay T, Schultink W. Mid-upper-arm circumference development and its validity in assessment of undernutrition. Asia Pacific J Clin Nutr. 1998;7(1):65–69.
39. Briend A. Use of MUAC for severe acute malnutrition. CMAM forum; collaborating to improve the management of acute malnutrition worldwide. FAQ I, June 2012. Available at community-based management of acute malnutrition (CMAM) www.cmamforum.org.
40. Maiti S, De D, Ali KM, Ghosh A, Ghosh D, Paul S. Evaluation of nutritional status by mid upper arm circumference amongst affluent children. J Nepal Paediatr Soc. 2012;32(2):113–116.
41. Teshome B, Kogi-Makau W, Getahun Z, Taye G. Magnitude and determinants of stunting in children under five years of age in food surplus region of Ethiopia: the case of West Gojam Zone. Ethiop J Health Dev. 2009;23(2):98–106.
42. Chiabi A, Tchokoteu PF, Takou V, Fru F, Tchovine F. Anthropometric measurements of children attending a vaccination clinic in Yaounde, Cameroon. Afr Hlth Sci. 2008;8(3):174–179.
43. Kaur G, Kang HS, Singal P, Singh SP. Nutritional status. Anthropometric perspective of preschool children. Anthropologist. 2005;7(2):99–103.
44. Poskitt EME, Poppitt SD, Prentice AM, Weaver LT. Dietary supplementation and rapid catch-up growth after acute diarrhea in childhood. Brit J Nutr. 1996;76:479–490.
45. Wierzba TF, El-Yazeed RA, Savarino SJ, Moural AS, Rao M, Baddour M et al. The interrelationship of malnutrition and diarrhea in a periurban area outside Alexandria Egypt. J Paediatr Gastroenterol Nutr. 2001;32:189–196.
46. Alam DS, Marks GC, Baqui AH, Yunus M, Fuchs GJ. Association between clinical types of diarrhea and growth of children under 5 years in rural Bangladesh. Int J Epidemiol. 2000;29:916–921.
47. Marshal T, Takano T, Nakamura K, Kizuki M, Hemat S, Watanebe M et al. Factors associated with the health and nutritional status of children under 5 years of age in Afghanistan: family behavior related to women and past experience of war related hardships. BMC Pub Health. 2008;8:301.
48. Mandal GC, Bose K. Assessment of under nutrition by mid upper arm circumference among preschool children of Arambag, Hooghly District West Bengal, India: an observational study. Int J Pediatr Neonatol. 2009;11(1). DOI 10.5580/940.
49. Pyke SK. Succeeding generations. In: The effect of investment in children. Russell Sage Foundation (Publishers). 1979;72–81.
50. Biswas S, Bose K, Mukhopadhyay A, Bhadra M. Mid upper arm circumference based under nutrition among Bengalee children of Chapra, West Bengal, India. Iran J Pediatr. 2010;20(1):63-68.
51. Amosu AM, Degun AM, Atulomeh NOS, Olanrewaju MF. A study of the nutritional status of under-5 children of low income earners in a South-Western Nigerian Community. J Biol Sci. 2011;3(6):578–585.

52. United Nations System standing Committee on Nutrition, Task force on assessment, monitoring and evaluation, fact sheet on food and nutrition security indicators: mid upper arm circumference. SCN News update March 2008. Accessed 22 February 2011. Available at www.unsystem.org/scn.

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