ISSN: 2755-9866

Journal of Health Statistics Reports

Research Article

Open Access

A Study of Reliability of Mid Upper Arm Circumference for Detection of Severe Acute Malnutrition in Infants Between 1-<6months of Age

Ojas Vijayanand Potdar[1]*, Rupali Jain[1], RL Suman[2], Suresh Goel[2] and Varun Agarwal[3]

[1]Grant Medical College and J.J. Group of Hospitals, Mumbai. Institute Where the Work was Carried Out: Department of Pediatrics, R.N.T. Medical College, Udaipur, India

[2]Department of Pediatrics, RNT Medical College, Udaipur, India

[3]Aditya Birla Memorial Hospital, Pune, Maharashtra, India

ABSTRACT

Introduction: Severe Acute Malnutrition (SAM) in children below 6months of age is diagnosed in presence of either of (1) weight for height/length <-3 standard deviations (SD) of median WHO growth reference (in infants >45cm); (2) visible severe wasting; (3) presence of bipedal edema. Simple measuring tape with reorientation of health workers can detect beginning of childhood malnutrition. This study aims to study reliability of mid upper arm circumference (MUAC) for detection of SAM in infants aged 1-6 months of age.

Aims and Objectives

- Assessment of MUAC for identification of SAM in infants between 1-6 months of age.
- Comparison of mid upper arm circumference with presently used anthropometric measurement of weight for height for detection of SAM.
- Identification of definitive cut off value of MUAC which can be used as criterion at community level for detection of SAM in infants between 1-6 months of age.
- To study determinants of SAM in children between 1-6 months of age.

Materials and Methods: A single center hospital based prospective observational study was conducted in department of pediatrics at a tertiary care center in Udaipur in India where total of 501 infants aged between 1-6 months of age satisfying inclusion and exclusion criteria were enrolled after ethical committee approval and after obtaining written informed consent from their parents over a period of 1 year from December 2015 to November 2016.

Results: MUAC of <11.3 cm has sensitivity of 87.29%, specificity of 80.75%, Youden index of 0.68 and area under ROC curve as 0.840 with 95%confidence interval as 0.803-0.877. MUAC of <11.3cm (or ≤11.2cm) can thus be used as cut off at community level to diagnose SAM in infants between 1-6 months of age.

Conclusion: This study thus establishes the reliability of MUAC for detection of severe acute malnutrition in infants between 1-<6months of age.

***Corresponding author**

Ojas Vijayanand Potdar, Grant Medical College and J.J. Group of Hospitals, Mumbai.Institute Where the Work was Carried Out: Department of Pediatrics, R.N.T. Medical College, Udaipur, India.

Received: August 19, 2023; **Accepted:** September 07, 2023; **Published:** September 14, 2023

Introduction

Severe Acute Malnutrition (SAM) in children below 6months of age is diagnosed in the presence of either of (1) weight for height/length <-3 standard deviations (SD) of the median WHO growth reference (in infants >45cm); (2) visible severe wasting; (3) presence of bipedal edema [1].

Globally, hunger and malnutrition are two of the most significant challenges [2]. Malnutrition is a general term. It refers to undernutrition resulting from inadequate consumption, poor absorption or excessive loss of nutrients but the term also encompasses over –nutrition, resulting from excessive intake of specific nutrients. Acute malnutrition is classified into SAM and moderate acute malnutrition (MAM) according to severity of malnutrition [3].

SAM is a major global public health problem responsible for over one million young child deaths each year [4].Over the last 10 years, significant progress has been made improving the management of SAM and scaling up treatment programmes internationally. Efforts have largely focused on children aged over 6 months, whose treatment has been revolutionized through the development of Community Management of Acute Malnutrition (CMAM) using ready-to-use therapeutic foods (RUTFs) [5,6]. In contrast to this success, acute malnutrition among infants aged under 6 months old remains inpatient-based and has often been neglected in terms of directed research.

Several reasons were identified for lack of attention:
1. A common assumption that malnutrition is uncommon in this age group.
2. Treatment of infant <6m SAM is challenging.
3. The evidence base underlying current treatments for infant <6m SAM is sparse.

Treating malnourished infants less than 6 months of age is important to avoid malnutrition-associated mortality in the short term and adverse health and development outcomes in the long term. New guidelines of WHO for management of SAM include this age group for the first time and are also applicable to management of moderate acute malnutrition (MAM). Community-based breastfeeding support is the core, but not the sole, treatment. An urgent priority is to develop better case definitions; criteria based on mid-upper-arm circumference (MUAC) are promising but need further research. To effectively move forward, clinical trials of assessment and treatment are needed to booster the currently sparse evidence base. In the meantime, nutrition surveys and screening at health facilities should routinely include infants under 6 months of age in order to better define the burden and outcomes of acute malnutrition in this age group [7].

Malnutrition thus needs to be detected early in infants<6months of age so that its burden in older children can be reduced. Such early detection and treatment can reduce the long term complications like reduced productivity from impaired cognitive ability, reduced productivity with stunting, excess cost of health because of chronic diseases [8]. Hence in a resource limited country like India, where work of identifying and referring SAM patients from periphery to Malnutrition treatment centers lies in hands of anganwadi workers, auxiliary nurse midwives etc., there is need to have criteria which can be easily be applied at field level. Thus, simple measuring tape with some reorientation of the health workers can detect the beginning of childhood malnutrition. This study aims to study the reliability of mid upper arm circumference for detection of severe acute malnutrition in infants aged 1-6 months of age.

Aims and Objectives
- Assessment of mid upper arm circumference for identification of severe acute malnutrition in infants between 1 to <6 months of age
- Comparison of mid upper arm circumference with presently used anthropometric measurement of weight for height for detection of SAM.
- Identification of a definitive cut off value of MUAC which can be used as a criterion at community level for detection of SAM in infants between 1 to <6 months of age.
- To study determinants of SAM in children between 1-<6 months of age.

Materials and Methods
A single center hospital based prospective observational study was conducted in the department of pediatrics at a tertiary care center in Udaipur in India where a total of 501 infants aged between 1-6 months of age were enrolled into the study after ethical committee approval and after obtaining written informed consent from their parents over a period of 1 year from December 2015 to November 2016.The inclusion and exclusion criteria were as follows:

Inclusion Criteria
- Infants between one to less than six months of age (Term Small/ Appropriate for Gestational Age-data obtained by history or documents).

Exclusion Criteria
- Infants less than one month and six and more than 6months of age
- Infants with other causes of edema (ascites, liver dysfunction, renal pathology, CHF)
- Infants with length <45cm
- Preterm babies
- Infants admitted in PICU
- Parents not wiling for consent

After obtaining a written informed consent from parents of all infants who fulfilled the inclusion criteria, a questionnaire was filled which included all background, household, socio-economic, immunization status and medical information obtained from the mother or caregiver through a personal structured interview. A general examination which included head to toe examination of each child was done in presence of care giver. Various findings were noted which included anthropometric measurements in the form of weight, length and mid upper arm circumference. Then, statistical analysis in the study was done using SPSS Software Version 20.0. All the 501 infants included in the study were divided into two groups: study group and control group based on WFH/L criteria. Infants with their WFH/L <-3SD were included in study group and infants with their WFH/L criteria >-3SD were included in control group. WFH/L criteria was considered as standard gold standard test on the basis of which positives and negatives were decided.

Next, various cut off values of MUAC were taken <12cm, <11.5cm, <11.4cm, <11.3cm, <11.2cm, <11.1cm, <11cm, <10.5cm, <10cm, <9.5cm, <9cm. Considering each of the value as a cut off value for diagnosis of SAM, 2*2 contingency table was made. Various statistical variables were then calculated including: sensitivity, specificity, positive predictive value, negative predictive value. Following this a Receiver operator curve (ROC) was plotted. Area under the curve with 95% confidence limits was defined for each cut off value. Youden index was then calculated using the ROC curve.

Results
The results of the study were as follows:
1. This study consisted of 501 infants between 1-<6 months of age, out of which 236 had WFH/L <-3SD and were included in the study group and 265 had WFH/L >-3SD and were included in the control group.
2. Mean age of study group was 3.42±1.5 months and that of control group was 3.81±1.35 months.
3. Comparing anthropometric variables of both the groups- mean weight of the study group was 3.86±0.98 kg while of control group was 5.62±1.45 kg. Mean height of study group was 58.21±4.51 cm and that of control group was 60.21±4.69 cm. Mean MUAC of study group was 9.87±1.36 cm and was 12.75±2.01 cm of the control group.
4. Study group had 71.2% males and 28.8% females. Similar distribution was present in control group and hence two groups are comparable in this regard with no statistical difference ($p>0.05$).
5. 83.1% of study group was also severely undernourished with significant difference ($p<0.001$) between males and females. While undernourishment in males mostly fell in range of

<-3SD and <-4SD, females showed more severe degree of undernourishment of the order of <-5SD and <-6SD.

6. One third (33.9%) of study population was also found to be severely stunted with no significant (p>0.05) gender variation.
7. The 66.06% males and 64.7% females of the study group had WFH/L <-3SD and <-4SD, although extremes like <-5, <-6, <-7 SD were also noted in 35.0% of population, based on SD z core as per WHO.
8. Illiteracy among mothers of study group was 45.8% and that among control group was 37.7%. Statistically significant difference (p<0.001) between the maternal literacy pattern of the study and control group suggests that development of SAM in infants is directly proportional to their mother's educational status. Infants with mothers educated to primary level had 0.529 times less chances of developing SAM and with mothers who have achieved their graduation had 0.419 times less chance.
9. We observed that, 37.3% of mothers of study group and 26.4% of control group had BMI less than the cut off for normal i.e., 18.5kg/m2. This difference was statistically significant (p<0.01). Infants of these mothers had 1.65 times more chances of being malnourished.
10. Nearly half the infant of study group (44.1%) was of first birth order which was significantly higher (p<0.001) than the control group (37.7%). This indicates that children of first birth order have increased chances of developing malnutrition. Also, infants of third birth order have 1.74 times more chances of developing SAM.
11. Nearly half the study group (47.5%) infants had low birth weight (<2.5kg) while only one fourth of control group (28.3%) infants had so. This difference was statistically significant (p<0.001). Low birth weight babies have 2.28 times more chances of developing SAM.
12. 90% of mothers of both the groups had received 2 doses of antenatal TT as prescribed by Government of India. Although the rest 10% was either partially immunized or unimmunized.
13. Maximum percentage of SAM infants were either born to a primigravida (44.06%) or were born at an interval of more than three years from the previous pregnancy (33.89%). Infants born at an interpregnancy interval of 1-<2yrs had1.92 times less chance and those born 2-<3 yrs. had 0.234 times more chance of being malnourished.
14. MUAC of <11.3 cm has a sensitivity of 87.29%, specificity of 80.75%, Youden index of 0.68 and area under ROC curve as 0.840 with 95%confidence interval as 0.803-0.877. MUAC of <11.3cm (or ≤11.2cm) can thus be used as a cut off at community level to diagnose SAM in infants between 1-<6 months of age.

Limitations of our study include that it was a hospital-based study; it did not include premature babies and still many more determinants and biochemical variables were not considered.

Thus, we conclude that various risk factors for development of SAM in infants below 6 months of age include maternal literacy, paternal literacy, BMI of the mother, birth order, birth weight, feeding practices, immunization status, ANC visits and interpregnancy interval. All these factors in cumulative manner play a role through their variable effect in the development of malnourishment in infants. Increased maternal and paternal literacy, exclusive breast feeding, increase birth weight, increase number of ANC visits have a protective role where as low BMI of mother, first and higher birth orders, LBW, incomplete immunization status and reduced interpregnancy interval have negative role in development of SAM.

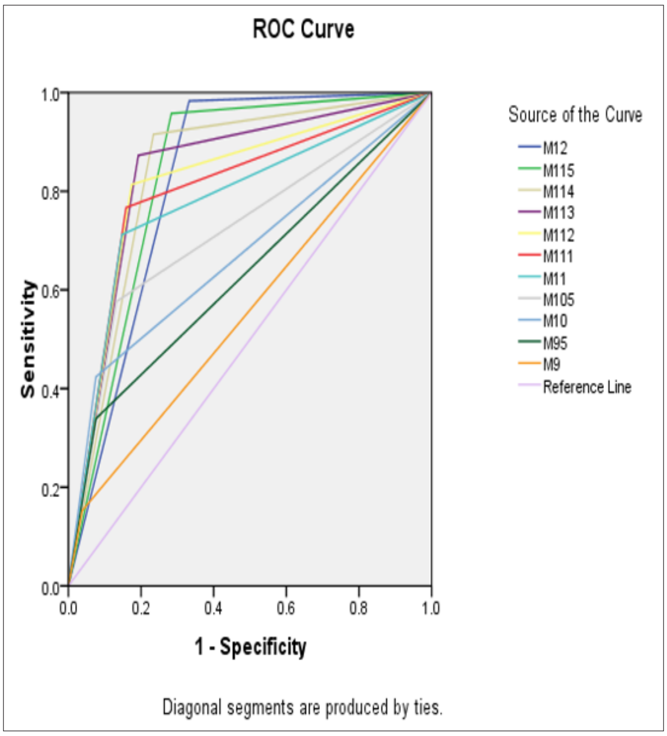
To increase diagnosis of SAM in less than 6 months infants at community level, MUAC with a cut off value of <11.3cm (≤11.2cm) can be used as a screening tool.

Early detection of SAM in these children will help in preventing long term detrimental complications like cognitive impairment, stunting, reduced brain volume, mental retardation and irreversible brain damage. This will also help in reducing the burden of malnourishment in children between 6months to 5 years of age thus improving health status of these children and community as a whole.

These nine determinants had a cumulative effect on development of SAM.

Test for evaluating Mid Upper Arm Circumference

MUAC	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Odd's ratio	Youden index
<12cm	98.31	66.79	72.5	97.79	116.66	0.65
<11.5cm	95.76	71.7	75.08	95	57.25	0.67
<11.4cm	91.53	76.6	77.70	91.03	35.36	0.68
<11.3cm	87.29	80.75	80.16	87.70	28.81	0.68
<11.2cm	81.36	82.64	80.67	83.27	20.77	0.64
<11.1cm	76.69	84.15	81.17	80.22	17.47	0.61
<11cm	71.19	85.28	81.16	76.87	14.32	0.56
<10.5cm	57.63	86.79	79.53	69.70	8.94	0.44
<10cm	42.37	92.45	83.33	64.3	9.01	0.35
<9.5cm	33.90	92.45	80	61.1	6.28	0.26
<9cm	1.25	96.23	78.26	56.04	4.59	0.11



Area under the Curve

Test Result Variable(s)	Area	Std. Error	Asymptotic Sib	95% Confidence Interval	
				Lower Bound	Upper Bound
<12	.825	.019	.000	.788	.863
<11.5	.837	.019	.000	.801	.874
<11.4	.841	.019	.000	.804	.877
<11.3	.840	.019	.000	.803	.877
<11.2	.820	.020	.000	.781	.859
<11.1	.804	.021	.000	.764	.845
<11	.782	.021	.000	.740	.824
<10.5	.722	.023	.000	.676	.768
<10	.674	.025	.000	.626	.722
<9.5	.632	.025	.000	.582	.681
<9	.557	.026	.026	.507	.608

The test Result V ariable(s): M12, M115, M114, M113, M112, M111, M11, M105, M10, M95, M9 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a: Under the nonparametric assumption
b: Null hypothesis: true area = 0.5

Thus, we observe that at MUAC cut off of <11.3cm - sensitivity is 87.29%, specificity is 80.75%, Youden index is 0.68, area under the ROC curve is 0.840 with 95% confidence limits as 0.803-0.877.

Discussion

Childhood wasting (acute malnutrition) is a global public health problem with serious consequences for both individuals and societies. While community-based treatment strategies are making important progress tackling wasting in children aged from 6 to less than 60 months, wasted infants aged less than 6 months are often sidelined. Child malnutrition remains one of many health challenges in developing countries today. The problem of malnutrition has an impact on health, education, and economy of affected country. Malnutrition is a major single and underlying cause of child morbidity and mortality. Also, the level of resistance to infection is lower for malnourished children than other children, causing high levels of morbidity and mortality (UNICEF 2001). Further, poor nutrition also affects cognitive development of children [9].

In our study we have tried to find out cut off MUAC criteria to define SAM in infants less than 6 months, thus making their identification and treatment easier at community level. We have also tried to study their epidemiological, antenatal and birth profile in detail.

In present study 236 SAM children classified by WHO criteria and 265 non-SAM children of age between 1-6 months were included. Mean age of study group was 3.42±1.5months, while 3.81±1.35 months of the control group.

We observed that 71.2% were males in study group and 77.4% in control group compared to 28.8% and 22.6% females respectively. Though this difference is statistically not significant (p>0.05), yet it can be explained by differential health seeking behavior of parents or this can be a normal representation of geographic population. Despite many public awareness programs male child is still preferred in India.

A study conducted by Shah and Chand in 2015 included 302 malnourished children on less than 6 months of age out of which 180 were male, accounting to 59.6% [10]. Comparingbasicanthropometric variables between two groups; mean weight of study group was 3.86±0.98 kg while of control group was 5.62±1.45 kg. Mean height of study group was 58.21±4.51 cm and that of control group was 60.21±4.69 cm. Mean MUAC of the study group was 9.87±1.36 cm and was 12.75±2.01 cm of the control group.

Measuring weight and height of child actually measures much more than a single child, it also measures future of a country. Child health has a prominent role in shaping and defining the structure of a society. It shapes the quality of future human capital, helps population stabilization and furthers future economic growth, among other factors.

Our population was also classified based on their WFA to see for the severity of undernutrition. It was observed that while 42.84% of male study population and 35.29% of the female study population were in <-3SD and <-4SD groups, an equivalent number of male infants 38.09% of the study group but higher number of female infants 53.47% had severe degree of undernutrition with <-5SD, <-6SD and <-7SD scores. The difference was highly statistically significant (p<0.001) indicating that more severe degree of undernutrition is observed in females as compared to males.

Various studies have been done on malnourished children but in most of them children were classified either as wasted or stunted or as Grade l - IV malnutrition as per IAP classification.

In 2012 Vesel et al conducted a study to find that in infants aged < 6 months, severe underweight at the first immunization visit as determined using WHO standards had the highest sensitivity (70.2%) and specificity (85.8%) for predicting mortality in India [11].

It was observed that 35.7% males and 29.4% females in study population were found to be stunted. This difference was not statistically significant (p>0.05).Stunting before age of 3 yr. is associated with poorer motor and cognitive development and altered behavior in later years. The effect is 6-13 DQ (developmental quotient) points [12].

In our study we observed that two-third of the study group had WFH (a measure of wasting) as <-3SD and <-4SD while one-third had more severe degree of wasting with WFH of <-5SD and <-6SD calculated by WHO Anthro Calculator. The difference between males and females was not statistically significant (p>0.05).

In our study we observed that illiteracy rate among mothers was higher in study (45.8%) group as compared to control (37.7%) group. Mothers of infants in control group had higher education standards as compared to mothers in study group. This difference in literacy was highly statistically significant (p<0.001) indicating that increasing maternal literacy can reduce the prevalence of malnutrition in the community.

The importance of mother's education for child health and nutrition has been well demonstrated (Caldwell 1979, Mariara et al. 2009, Ruel et al. 1992). According to Mosley and Chen (1984), maternal education affects children's health and nutritional outcomes through its effect on improving women's socioeconomic status. In turn higher socioeconomic status affects a set of "proximate determinants" of health that directly affect the health and nutritional outcomes of children. The proximate determinants include fertility factors, feeding practices, and the utilization of health services. After controlling for household socioeconomic characteristics, studies have concluded that maternal education is an important determinant of child survival. The various pathways through which maternal education promotes child survival, as suggested by the literature, include the acquisition of health knowledge, adherence to recommended feeding practices for children, and increased command over resources [13].

Gwatkin et al. (2000) found that prevalence of child malnutrition is lower among children of educated mothers. The inverse relationship between maternal education and child malnutrition has also been reported in other studies, such as Mukuria et al. (2005) and Frost et al. (2005) [13].

Comparing paternal literacy rate, we observed that an illiteracy rate in fathers was lower as compared to mother. Fathers of study group (69.5%) had mostly primary and middle school qualification while that of control group had higher qualification standards. This difference was highly statistically significant with a p<0.001.

In 2008, Semba et al collected data from Indonesian families and Bangladeshi families as part of major nutritional surveillance programme and concluded that both maternal and paternal education are strong determinants of child stunting in families in Indonesia and Bangladesh. High levels of maternal and paternal education were both associated with protective care giving behaviors, including vitamin A, complete childhood immunizations, better sanitation, and use of iodized salt (all p<0.0001) [14].

In 2012 Burchi found in a study that one year of mother's education increases their children's height-for-age and weight-for-age z-scores by nearly 0.025 and 0.015. The presence of another literate household member has a significant, though limited, effect on child height while it has no influence on child weight. Lastly, there is no statistically significant difference in the effect of parents' education on the two indicators while our measure of proximate literacy has a significantly larger impact on child height [15].

In 2014, Hanieh et al conducted a study which demonstrated that maternal body mass index, weight gain during pregnancy and maternal ferritin concentration at 32 weeks' gestation were indirectly associated with infant length-for-age z scores at 6 months of age via birth weight. It was hence concluded that maternal nutritional status is an important predictor of early infant growth [16].

In our study it was found that 44.1% of infants in the study group were first-born child of their mother. A spike was also observed at birth order of 3(28.8%) and then reduced. This rise in first birth order is highly significant statistically with p<0.001.Thus, birth order plays an important role in nutritional status of the child and need to be addressed [17].

It was observed in our study that though maximum deliveries were normal vaginal deliveries, 1.7% of study group and 7.5% of control group deliveries were lower segment caesarean sections. This is not statistically significant (p>0.05). Also, though maximum numbers of deliveries were in hospital, 11.9% of deliveries in study group and 9.4% in control group occurred at home.

According to Annual Health Survey (AHS) 2011 conducted by Government of India, Rajasthan state has 70.2% of institutional delivery [18].This is a much lower percentage as compared to our study. This variation may be due the fact that ours is a hospital-based study and the AHS was a field-based study.

To combat problem of home or unskilled deliveries, government of India launched the Janani Shishu Suraksha Karyakram (JSSK) on 1st June 2011 which has provision for both pregnant women and sick new born till 30 days after birth : (1) Free and zero expense treatment, (2) Free drugs and consumables, (3) Free diagnostics & Diet, (4) Free provision of blood, (5) Free transport from home to health institutions, (6) Free transport between facilities in case of referral, (7) Drop back from institutions to home, (8) Exemption from all kinds of user charges. The initiative would further promote institutional delivery by eliminating out of pocket expenses which act as a barrier to seeking institutional care for mothers and sick newborns and facilitate prompt referral through free transport [19]. In our study we observed that nearly half the infants in study group had birth weight of less than 2.5 kg while only one fourth of control group infants had so. This difference was highly statistically significant (p<0.001) indicating that there are higher chances of becoming malnourishsed in babies with low birth weight. Mean wt. in study group was 2.49±0.51 kg and that in control group was 2.66±0.47 kg.

According to NFHS 3, children with low birth weight are much more likely than other children to be malnourished as they grow up. Almost half of children with low birth weight are currently stunted or underweight, compared with about 1/3rd of children with birth weight of 2.5 kg or more [20].

In Sixth report on world nutrition situation by United Nations System Standing Committee on Nutrition (UNSCN) published in 2010, it is stated that increasing birth weight contributes to reducing child growth faltering in first 2 years of life, resulting in less stunting at two years of age, which is eventually reflected in increased adult height. Improved cognitive function and intellectual development across the life-course are associated with an increase in birth weight and reduction in stunting [21].

It was observed in our study that exclusive breast-feeding rates were higher in control group (64.15%) than in study group (47.45%). Complimentary feeding rates were much higher in study group (22.03%) as compared to control group (7.54%). This difference was statistically significant with $p<0.001$ indicating that exclusively breast-fed babies have lower risk of developing malnutrition compared to those who are not exclusively breast fed.According to Annual Health Survey 2011, exclusive breast-feeding rate in Rajasthan is 24.7% in infants less than 6 months of age [22].

Recognizing that exclusive breastfeeding (EBF) is a key to child survival, WHO recommends that "infants should be exclusively breastfed for first 6 months of life to achieve optimal growth, development and health". As a global public health recommendation, infants should be exclusively breastfed for first six months of life to achieve optimal growth, development and health. Thereafter, to meet their evolving nutritional requirements, infants should receive nutritionally adequate and safe complementary foods while breastfeeding continues for up to two years of age or beyond. Exclusive breastfeeding from birth is possible except for few medical conditions, and unrestricted exclusive breastfeeding results in ample milk production [23].

Malnutrition has been responsible, directly or indirectly, for 60% of 10.9 million deaths annually among children under five. Over two-thirds of these deaths, which are often associated with inappropriate feeding practices, occur during first year of life. No more than 35% of infants worldwide are exclusively breastfed during first four months of life; complementary feeding frequently begins too early or too late, and foods are often nutritionally inadequate and unsafe. Malnourished children who survive are more frequently sick and suffer life-long consequences of impaired development.

In 2010 Vesel et al conducted secondary analysis of data on 9424 mother–infant pairs in Ghana, India and Peru. They found out that duration of exclusive breastfeeding was not associated with malnutrition in first 6 months of life [24].

In 2002 Kramer and Kakuma conducted a review of 20 studies and concluded that Infants who are exclusively breastfed for six months experience less morbidity from gastrointestinal infection than those who are partially breastfed as of three or four months, and no deficits have been demonstrated in growth among infants from either developing or developed countries who are exclusively breastfed for six months or longer, the available evidence demonstrates no apparent risks in recommending, as a general policy, exclusive breastfeeding for first six months of life in both developing and developed-country settings [25].

As stated, earlier malnutrition increases the risk and worsens the severity of infections [26].Undernourished children, as well as children with severe malnutrition, have a higher risk of dying than children with an optimal nutritional status [27].SAM increases risk of mortality by 9 times as compared to well-nourished children [28].

In 2009, Irena et al studied 430 children with SAM in Lusaka, Zambia . Among the children, 68.9% (295/428) had edema at admission. The majority of children, 67.3% (261/388), presented with diarrhea; 38.9% (162/420) tested HIV positive; and 40.5% (174/430) of the children died [29].

In a similar study in 2012, Kumar et al. studied co morbidities in 104 hospitalized children with severe acute malnourishment at Gandhi Memorial Hospital, Rewa district, their study showed diarrhea (54.0%) as a leading morbidity followed by acute respiratory tract infections (27.8%) [30].

Regular antenatal and postnatal checkups are beneficial for mother as well as baby. In our study we observed that statistically significant ($p<0.01$) higher percentage of mothers in control group (47.16%) had ANC visits ≥4 compared to the study group (23.72%).

In 2014, Kader and Perera analysed the data of NFHS-3 and found that almost 20% of the infants were born with Low Birth Weight (LBW). They concluded that maternal education, nutritional status and antenatal care received are key determinants that need to be addressed to reduce prevalence of LBW in India [31].

Postnatal check-ups soon after delivery help safeguard the health of mother and baby, particularly for births occurring outside of health care facilities. Almost 6 in 10 women (58 percent) did not receive any postnatal check-up after their most recent birth. About one-quarter of women (27 percent) received a health check-up in the first four hours after delivery, and 37 percent received a health check-up within the critical first two days after delivery. Although the likelihood of a timely postnatal checkup is closely associated with having an institutional delivery, it is notable that 15-24 percent of births even in institutions did not receive a postnatal check-up. Among births delivered at home, only 9-12 percent of births received a postnatal checkup within two days of delivery [32].

In 2007 Zottarelli et al found in their study that children whose mothers had a higher level of education and height>150cm had a low risk of stunting compared to those mothers with no education and height <150cm. Paternal consanguinity, rural residence, high birth order and short birth interval significantly increases the odds of stunting [33].

Short birth intervals are associated with higher levels of stunting and underweight. Undernutrition is substantially higher in rural areas than in urban areas [32].

From our study in an attempt to define the factors for SAM as well as to find out their strength of association, we observe that infants of literate mothers with at least primary education had 0.529 times less chances of developing SAM, also infants of graduate mothers had 0.419 times less chances. Similarly, infants of literate fathers, with primary education had 0.619 times, middle school educated fathers had 1.83 times, high school educated fathers had 2.36 times and graduate fathers had 0.419 times less chances of developing SAM. Infants of mothers with low BMI (<18.5kg/m2) had 1.65 times more chances of becoming malnourished than with normal BMI. Birth order of 3 had 1.74 times more chances of developing malnutrition. Birth weight of <2.5kg had 2.28 times increased risk of developing SAM. Exclusively breast-fed infants had 0.504 times less chances of developing SAM, while those only on complimentary feeding had 3.46 times increased risk of becoming malnourished. Completely immunised child had 0.43 times less chance and a partially immunised one had 2.14 times more chance of being malnourished. Mothers in incomplete number of ANC visits had 0.665 times more chances of having a malnourished infant. Infant born following a narrow inter pregnancy interval of 1-<2yrs had 1.92 times more chances of being malnourished compared to infant with a longer interval of 2-<3yrs who had 0.234 times less chances.

These factors can be considered as determinants of SAM in infants 1-6 months of age. Improved maternal and paternal literacy raises living standards of family, improves hygiene levels, increases health seeking behaviour all of which has a positive effect on nutrition status of child. Increased number of ANC visits and increased duration of interpregnancy interval increases birth preparedness, improves knowledge of mother regarding care of newborn, resulting in improved health outcome of mother and baby. Decreased immunization status makes child more susceptible to diseases and puts him into to vicious cycle of infection and malnutrition. While breast feeding plays a protective role, compliment feeding has a negative effect on nutritional status. This is mainly because of inadequate preparation, infections, inappropriate feeding of complimentary foods.

Mid-upper arm circumference (MUAC) cut-off of 11.5 cm is used as an independent diagnostic criterion to identify severe acute malnutrition (SAM) in children aged between 6 months and 5 years. MUAC is useful for the purpose of mass screening and community-based diagnosis. The mortality due to SAM has also been shown to be higher in infants less than six months of age than in older children. However, role of MUAC in diagnosis of SAM below age of 6 months of age has not been studied adequately [34].

In 2012 Mwangome et al carried out a cross-sectional study and estimated inter-observer variation and accuracy of measurements initially undertaken by an expert anthropometrist, nurses and public health technicians. They found that Mid Upper Arm Circumference was more reliably measured by Community Health Workers than WFH among infants aged <6 months. Further work is needed to define cut-off values based on MUAC's ability to predict mortality among younger infants.

By statistical calculation, we can conclude that MUAC cut off of <11.3 cm can be taken as diagnostic criteria for diagnosing SAM in infants between 1-6 months of age.

Conclusion

This study thus recommends that MUAC of <11.3 cm or <113 mm should be used as a cut off for detection of SAM in infants 1-<6 months of age.

References

1. Ministry of Health and Family Welfare, Government of India, 2013. Facility Based Management of Children with Severe Acute Malnutrition. http://coesamnetwork.org/UploadDocument/FBNSCA-FG-SAM%20(1)%20(1).pdf.
2. Geissler C, Power HJ (2005) Immune function, food allergies and food intolerance. Livingstone C (Editor). Human Nutrition.11thed. Elsevier publisher https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=1509662.
3. Facility based care of Severe Acute Malnutrition (SAM). World Health Organization. National Rural Health Mission. March 2011. https://rajswasthya.nic.in/MTC%20Guideline-%20MOHFW.pdf.
4. A Joint Statement by the World Health Organization, the World Food Programme, the United Nations System Standing Committee on Nutrition and the United Nations Children's Fund. Community-based management of severe acute malnutrition. https://www.unicef.org/documents/who-wfp-scn-and-unicef-joint-statement-community-based-management-severe-acute.
5. Manary MJ, Sandige HL (2008) Management of acute moderate and severe childhood malnutrition. BMJ 337: 2180.
6. Collins S, Nicky Dent, Paul Binns, Paluku Bahwere, Kate Sadler, et al. (2006) Management of severe acute malnutrition in children. Lancet 368: 1992-2000.
7. Kerac M, Mwangome M, McGrath M, Haider R, Berkley KA. Food and Nutrition Bulletin 36: 30-34
8. Ashworth A (2016) Nutrition, Food security and Health. Kliegman KM, Stanton BF, Geme JW, Schor NF (Editor). Nelson text book of paediatrics. 20th ed. Elsevier 1: 295-306.
9. Makoka D (2013) The impact of maternal education on child nutrition: evidence from Malawi, Tanzania, and Zimbabwe. Calverton. MD: ICF International https://dhsprogram.com/pubs/pdf/wp84/wp84.pdf.
10. Chand S, Shah D (2015) Mid-upper Arm Circumference for Detection of Severe Acute Malnutrition in Infants Aged Between One and Six Months. Indian pediatr 52: 528-529.
11. Vesel L, Bhal R, Martines J, Penny M, Bhandari N (2010) Kirkwoodd BR & the WHO Immunization-linked Vitamin A Supplementation Study Group. Use of new World Health Organization child growth standards to assess how infant malnutrition relates to breastfeeding and mortality. Bull 39 World Health Organ 88: 39-48.
12. Ashworth A (2016) Nutrition, Food security and Health. Kliegman KM, Stanton BF, Geme JW, Schor NF (Editor). Nelson text book of paediatrics. 20th ed. Elsevier 1: 295-306.
13. Makoka D (2013) The impact of maternal education on child nutrition: evidence from Malawi, Tanzania, and Zimbabwe. Calverton. MD: ICF International https://dhsprogram.com/publications/publication-wp84-working-papers.cfm.
14. Semba RD, Pee SD, Sun K, Sari M, Akhter N, et al (2008) Effect of parental formal education on risk of child stunting in Indonesia and Bangladesh: a cross-sectional study. Lancet 371: 322-328.
15. Burch F (2012) Whose education affects a child's nutritional status? From parents' to household's education. Demogr Res 27: 681-704.
16. Hanieh S, Ha TT, De Livera AM, Simpson JA, Thuy TT, et al. (2015) Antenatal and early infant predictors of postnatal growth in rural Vietnam: a prospective cohort study. Arch Dis Child 100: 165-173.
17. Ashok NC, Kumar AS, Koppad R, Kumar SD, Dhar M, et al. (2015) PEM in Relation to Birth Order and Birth Interval in Children Aged 1–6 Years in Urban Slums of Mysore City. Indian Journal of Public Health Research and Development 6: 308:313
18. National Health Mission, Ministry Of Health and Family Welfare, India, 2006.
19. Fred A, Sulabha P, Arokiasamy P, Monica K (2005-06) Nutrition in India. National Family Health Survey (NFHS-3). https://dhsprogram.com/pubs/pdf/frind3/frind3-vol1andvol2.pdf.
20. Maternal nutrition and the intergenerational cycle of growth failure. Sixth report on the world nutrition situation. United Nations System. Standing Committee on Nutrition. 2010 https://www.unscn.org/files/Publications/RWNS6/report/chapter3.pdf.
21. Annual Health Survey (ALS) Fact Sheet. Census of India (2011) https://hfw.assam.gov.in/sites/default/files/swf_utility_folder/departments/hfw_lipl_in_oid_3/menu/information_and_services/Assam_Factsheet_2011-12-1-84.pdf.
22. World Health Organization (WHO). Global strategy for infant and young child feeding Geneva.WHO.http://apps.who.int/iris/bitstream/handle/10665/42590/9241562218.

pdf?sequence=1.
23. Vesel L, Bhal R, Martines J, Penny M, Bhandari N (2010) Kirkwoodd BR & the WHO Immunization-linked Vitamin A Supplementation Study Group. Use of new World Health Organization child growth standards to assess how infant malnutrition relates to breastfeeding and mortality. Bull 39 World Health Organ 88: 39-48.
24. Kramer MS, Kakuma R (2012) Optimal duration of exclusive breastfeeding. Cochrane Database of Systematic Reviews 15: CD003517.
25. Müller O, Krawinkel M (2005) Malnutrition and health in developing countries. CMAJ 173: 279-286
26. Caulfield LE, Onis DM, Blössner M, Black RE (2004) Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria and measles. Am J Clin Nutr 80: 193-198.
27. Operational guidelines on Facility Based Management of Children with SAM. Ministry of Health and Family Welfare. Govt. of India, 2011. https://rajswasthya.nic.in/MTC%20 Guideline-%20MOHFW.pdf.
28. Irena AH, Mwambazi M, Mulenga V (2011) Diarrhea is a major killer of children with severe acute malnutrition admitted to inpatient set-up in Lusaka, Zambia. Nutrition J 1: 10:110.
29. Kumar R, Singh J, Joshi K, Singh HP, Bijesh S (2014) Hospitalized Children with Severe Acute Malnutrition in Rewa District. Indian Pediatr 51: 125-127.
30. Kader M, Perera NKPP (2014) Socio-Economic and Nutritional of Low Birth Weight in India. N Am J Med Sc 6: 302-308
31. Fred A, Sulabha P, Arokiasamy P, Monica K (2005-06) Nutrition in India. National Family Health Survey (NFHS-3).Available from: https://dhsprogram.com/pubs/pdf/frind3/frind3-vol1andvol2.pdf.
32. Dereje N (2014) Determinants of Severe Acute Malnutrition among Under Five Children in Shashogo Woreda, Southern Ethiopia: A Community Based Matched Case Control Study. J Nutr Food Sci 4:300.
33. Chand S, Shah D (2015) Mid-upper Arm Circumference for Detection of Severe Acute Malnutrition in Infants Aged Between One and Six Months. Indian pediatr 52: 528-529.
34. Mwangome MK, Fegan G, Mbunya R, Prentice AM, Berkley JA (2012) Reliability and accuracy of anthropometry performed by community health workers among infants under 6 months in rural Kenya. Trop Med Int Health 17: 622-629.