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Original Research Article

Study of risk factors of severe acute malnutrition (SAM) in children 6 months to 5 years of age and evaluation of effect of micronutrient supplementation (WHO protocol) on serum zinc and magnesium levels: a case control study

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ABSTRACT

Background: Although risk factors for malnutrition have been identified earlier, individual factors potentially change in specific areas over time and a current characterization of risk factors provide the basis for preventative intervention strategies. No guidelines in relation to duration of micronutrient supplementation for treatment of SAM are available. Thus, the study was done to know the adequacy of dose of micronutrients that are presently being supplemented (WHO Protocols) for treating SAM.
Methods: It is a case-control study involving 100 cases with severe acute malnutrition and 100 controls having normal nutrition status 6 months to 5 years of age. Detailed clinical data (using a predesigned questionnaire) and anthropometric measurements were recorded for analysis. Blood assay of Zinc, Magnesium and serum Proteins were done on the day of admission (day 1) and again after 2 weeks of treatment with nutritional supplementation (WHO protocols).
Results: Out of 100 SAM Cases, 42% were from rural area whereas 76% of controls belonged to urban region (p value 0.03). Twenty-four (24%) mothers of SAM cases were Illiterate, whereas only 6 % of mothers in controls were illiterate. 57 % SAM cases were given breast feeding after 4 hours of life, where as 61% controls were given their first feed within 1 hour of birth with p value <0.01. Eighty-eight controls (88%) were given colostrum, whereas only 62 % SAM cases were given colostrum feeds with p value <0.01. Seventy controls (70%) were given exclusive breast feeding for 6 months whereas only 40% of cases (SAM) was given exclusive breast feeding till 6months of age (p value of <0.01). 57% of top fed cases were given over diluted feeds, only 27% of top fed controls were given over diluted feeds (p value 0.02). 53% of cases were bottle fed and 14% of controls were bottle fed with p value <0.01. Mean value of magnesium and zinc before supplementation was 2.4 mg/dl and 117 mcg/dl respectively with no significant rise after supplementation.
Conclusions: Here is a correlation of severe acute malnutrition with rural area, maternal Illiteracy and low socioeconomic status, deprivation of colostrums feeding, lack of exclusive breast feeding for 6 months, over dilution of top feeds and use of bottle feeding. There is no correlation between SAM and immunization status and demographic parameters like age, sex and religion. SAM is inversely related to duration of exclusive breast feeding. 23% of severely malnourished children had delay of developmental milestones. No significant rise of serum levels was seen with WHO recommended doses of micronutrient supplementation

Keywords: Breast feeding, Illiteracy, Immunization, Magnesium, Severe acute malnutrition, Zinc

INTRODUCTION

The National Family Health Survey-3 revealed that 7.9 percent of all children under-five years of age are severely wasted.[1] Under nutrition is the result of many causes not solely related to food and it reflects inadequacies in education of the parents, family income, and infant and young child feeding practices. Besides increasing the risk of death and disease, under nutrition also leads to growth retardation and impaired psychosocial and cognitive development with appropriate nutritional and clinical management, many of the deaths due to severe wasting can be prevented.[2-5]

Protein-energy malnutrition usually manifests early, in children between 6 months and 2 years of age and is associated with early weaning, delayed introduction of complementary foods, a low-protein diet and severe or frequent infections (Rice et al, Kwena et al, and Müller).[4,7,8]

Although risk factors for malnutrition have been identified earlier, individual factors potentially change in specific areas over time and a current characterization of risk factors provides the basis for preventative intervention strategies. This will ensure that the best use is made of available resources.

No guidelines in relation to duration of micronutrient supplementation for treatment of SAM are available. Thus, the study was done to identify the risk factors of SAM and to know the adequacy of dose of micronutrients that are presently being supplemented in the WHO management Protocols.

METHODS

A prospective Case Control Study was conducted in the Department of Pediatrics, Gandhi Medical College, Secunderabad, Telangana from January 2014 to August 2015.The study population included children between 6 months to 59 months of age. 100 subjects were included as cases who were admitted in Nutrition Rehabilitation Centre (NRC) of National Health Mission/UNICEF at Gandhi hospital, Secunderabad, Telangana with Severe Acute Malnutrition (SAM) as per WHO definition-Weight/Height ratio below-3 Z scores of the median using WHO Growth standards, or mid arm circumference <11.5cm, or visible severe wasting or nutritional edema. 100 'controls' with normal nutrition status were selected from general pediatric wards. The study was approved by the institutional ethics committee. Detailed clinical history including child's Personal data (age, sex, religion, area, birth weight); Immunization history, developmental history, nutritional history including feeding practices was obtained using a predesigned questionnaire. Modified Kuppuswamy scale was used for scoring socioeconomic class. Detailed clinical examination and anthropometric measurements-weight, height and mid arm circumference was recorded. Blood samples were collected from all the Cases for estimation of Proteins, Magnesium and Zinc. Assay was done on the day of admission (day 1) and again after 2 weeks of nutritional supplementation at National Institute of Nutrition (NIN), Hyderabad. Samples were stored at -20°C to avoid loss of bioactivity and contamination. Atomic absorption spectrophotometric method was used for estimation of Magnesium and Zinc. Reference normal values were as follows: Serum proteins: 5.6-8mg/dl, serum Magnesium: 1.5-2.3 mg/dl, serum Zinc: 70-150mcg/dl. All the Cases were treated as per NRC guidelines and they were supplemented with Magnesium (0.3 ml/kg of 50% $MgSO_4$), Zinc (2 mg/kg/day) and other micronutrients following WHO recommendations. The sample size in case of 1:1 ratio of case to control was found to be 89:89 (Fleiss, 1981). EPI-INFO statistical package version 3.5.1, August (2008) was used. Simple distribution of the study variables and the cross tabulation were applied. Student t-test was applied to compare the means of variables. Chi-square (χ^2) was done for statistical significance. Data was analyzed using Open Epi Version 3.01. p-value of <0.05 was considered as significant.

RESULTS

Mean age of Cases and Controls was 25.5±15.6 and 27±15.1 months respectively. Out of 100 SAM Cases, 42% were from rural area whereas 76% of controls belonged to urban region. Twenty-four (24%) mothers of Cases were Illiterate, whereas only 6 % of mothers in Controls were illiterate. 69% of mothers in cases were belonging to higher education and 84 % of controls had higher education. Seventy-nine (79%) Cases belonged to Upper lower (UL IV), whereas 70% controls belong to Lower middle (LM III) class. The time of breast feed initiation was categorized into 3 groups like <1 hour, 1-4 hours, >4 hours. 57% SAM cases were given breast feeding after 4 hours of life, where as 61% controls were given their first feed within 1 hour of birth with p value <0.01. Eighty-eight controls (88%) were given colostrum feeds, whereas only 62% SAM cases were given colostrum feeds. Seventy controls (70%) were given exclusive breast feeding for 6 months whereas only 40% of Cases (SAM) was given exclusive breast feeding till 6months of age with p value of <0.01. Among 60 cases who were given exclusive breast feeding for <6months, 38 (63%) were given top feeds and 22 (37%) were given early complementary feeds. Among 30 controls of incomplete exclusive breastfeeding, 18 (60%) were top fed and 12 (40%) were given early complementary feeds with no significant difference in both groups. 57% of top fed cases were given over diluted feeds, only 27% of top fed controls were given over diluted feeds with p value 0.02. The study showed 53% of cases were bottle fed and 14% of controls were bottle fed with p value <0.01. Seventy cases (70%) were completely immunized up to age and 30 % were partially immunized.

Among controls 72% were completely immunized and 28% were partially immunized. Among controls, 7% had

delay in attainment of milestones whereas 23% of Cases had delay in the development showing significant association between SAM and Developmental delay with P Value <0.01. The results of the study showing demographic and other variable associated with Cases and Controls are shown in the Table 1.

Table 1: Statistical analysis: different variables of malnutrition in cases and controls.

		Cases (n=100)	Controls (n=100)	Chi square value	P-value
Age (in months)	6-12	27	28	0.4	0.8
	12-24	28	24		
	25-59	45	48		
Sex	Male	49	56	11	0.163
	Female	51	44		
Area	Rural	42	24	7.3	0.03
	Urban	58	76		
Religion	Hindu	80	74	1.6	0.44
	Muslim	17	24		
	Christian	3	2		
Education	Illiterate	24	6	12	0.01
	Primary	7	10		
	Higher	69	84		
Socio- economic status	Upper lower	79	20	71	< 0.01
	Lower middle	21	70		
	Upper middle	0	10		
Birth weight	<2.5kg	71	62	1.8	0.09
	≥ 2.5kg	29	38		
Time of initiation of feeds	< 1 hour	22	61	54	0.01
	1-4 hours	21	30		
	> 4 hours	57	9		
Pre-lacteal feeds	Given	34	24	2.4	0.06
	Not given	66	76		
Colostrum	Given	62	88	1.8	<0.01
	Not given	38	12		
Exclusive breast feeding	<6 months	60	30	16	<0.01
	6 months	40	70		
nature of feeding in incomplete breast feeding	Top feeds	38 (63%)	18 (60%)		0.09
	Complementary feeds	22 (37%)	12 (40%)		
Top feeds dilution	Over dilution	22 (57%)	5 (27%)	4.4	0.02
	Appropriate	16 (43%)	13 (73%)		
Duration of breast feeding	< 2 years	49	25	11	0.09
	2 years	51	75		
Bottle feeding	Given	53	14	33	<0.01
	Not given	47	86		
Immunisation	Complete	70	72	0.09	0.3
	Partial	30	28		
Developmental delay	No delay	77	93	10	<0.01
	Delay	23	7		

Out of total 100 blood samples collected for the estimation of Proteins, Magnesium and Zinc, 9 were hemolysed. Assay was done in 91 samples. Out of these, 6 samples showed low serum proteins, 3 samples showed low magnesium and 11 had low zinc levels. Repeat estimation was done after nutritional supplementation in only 59 cases as 32 cases were lost to follow up. Mean value of serum proteins before supplementation was 6.8 with a standard deviation of 0.9. Mean value in follow up samples after supplementation was 7 with a standard deviation of 0.8. Comparison of both means by t-test showed p value of 0.3. Mean value of magnesium before supplementation was 2.4mg/dl and after supplementation in follow up was 2.6mg/dl (P value 0.06). Mean value of

serum Zinc before supplementation was 117mcg/dl with a standard deviation 49. Mean value after supplementation was 125 mcg/dl with a standard deviation of 39. Comparison of both means showed p value 0.06. Out of 6 children with low proteins, 3 were lost to follow up and 3 children showed normal proteins in the second sample. All the 3 children with low magnesium were lost to follow up. Out of 11 children with low zinc, 9 improved with supplementation and 2 were lost to follow up.

DISCUSSION

Personal profile of the study population

Association of SAM with age

Mean age of cases and controls were 25.5±15.6 and 27±15.1 months respectively. No significant difference was observed in age distribution among both the groups (p-value 0.8).

Association with gender

49% among cases were male and 51% were female. There was no significant association between gender and SAM with p- value of 0.163. Similar observations were made by Iqbal et al., in their study done in Bangladesh (240 males and 239 females) and Abate et al, study done in Nairobi, Ethiopia (51.2% were male and 48.8% were female).[9,10]

Association with religion

Among cases, 80% were Hindus, 17% were Muslims and 3% were Christians whereas among control group 74% were Hindus, 24% were Muslims and 2% were Christians. The study showed no significant difference in the distribution of religion among both groups. There is no significant association between religion and SAM with p-value 0.44.

Association with region

42% of Cases were from rural region whereas only 24% of controls belong to rural region. There was a significant association between SAM and rural region with p value 0.03. In rural areas inadequacies in nutrition and health education, nutritional surveillance, nutritional rehabilitation, primary health care, early diagnosis and prompt treatment etc. contribute to and perpetuate malnutrition.

Association with maternal education

The study showed 24% of mothers among cases were illiterates, whereas only 6% of mothers in controls were illiterates and 69% of mothers in cases had higher education and 84% of controls had higher education. Significant association was observed with maternal Illiteracy and severe malnutrition (p value <0.01 and chi square 12). Similarly, Amsalu S et al in their study found that maternal illiteracy is one of the important risk factors associated with child malnutrition.[11] Studies done by Dhatrak PP et al.[12] at NKP Salve institute of medical Sciences, Nagpur in and Paramita and Senugupta et al done in Urban slum of Ludhiana have identified maternal education as a significant determinant of child nutrition with illiterate mothers having more underweight children (p=0.004).[12]

Jamro B et al in Pakistan found that 80% mothers and 67% fathers of SAM were illiterate.[13] In South Africa, the NFCS showed higher levels of maternal education were associated with lower levels of stunting, underweight and wasting in all age groups (NFCS,1999).[14]

Association with socioeconomic status

This study showed statistically significant association between low socioeconomic class and severe acute malnutrition (p-value <0.01 and chi square 71) .79% of Cases belong to Upper lower class (UL IV), whereas 70% controls belong to Lower middle class (LM III). There were 10 controls belonging to UM II, whereas no subjects were seen in Cases in this class.

Goyal S et al in their study at Madhya pradesh, found that poor socioeconomic status is a risk factor for SAM.[15] In a similar study done by Solomon Amsalu et al found that the socioeconomic risk factors for severe acute malnutrition were maternal illiteracy (OR=3.83, 95% CI 1.93-7.67), paternal illiteracy (OR=2.04, 95% CI 1.13-3.71), monthly family income of less than 50 USD (OR =3.44, 95% CI 1.66-7.20) and large family size with the number of children greater than 3 (OR=1.96, 95% CI 1.04-3.73).[11] Sapkota and Gurung et al in found that the risk of being underweight in the children from the poor socioeconomic status is almost four times as much as in the children from the rich socioeconomic status (OR= 4.336 (1.719 <OR<10.936)).[23] In a study done at NKP Salve institute of medical sciences at Nagpur, low socioeconomic status was associated with malnutrition in 74.44%.[12]

The prevalence of underweight and of wasting (59.1 % for both) was the highest in children of unskilled laborer's and the differences were statistically significant (p=0.004 and 0.029 respectively).

Families with higher monthly per capita income had significantly lower prevalence of underweight children (p=0.005).

Benjamin and Zachariah also found poor family income as a risk factor for severe malnutrition.[16] Factors like poverty, ignorance, illiteracy, lack of knowledge regarding nutritive value of food, unhygienic environment, large family size, lack of spacing,

overcrowding, and unemployment influences the quality of life and health status of children.[2]

Association of low birth weight with SAM

71% of SAM children were belonging to birth Weight <2.5 kg group and 29% of cases belonged to birth weight ≥2.5 kg group. Among controls 62% belonged to low birth weight and 38 % were in ≥2.5 kg group. There was no significant statistical association between low birth weight and SAM with p value 0.09

Whereas in a study done at NKP Salve institute of medical sciences at Nagpur in 2013, the risk factors associated with malnutrition were low birth weight (85%).[12] Similarly, Paramita Senugupta et al found significantly higher (p=0.024) prevalence of underweight in the LBW children.[12] In a study done in Limpopo, South Africa most children twelve to 24 months old that had a birth weight of less than 2.5kg, were more likely to develop stunting. About 25% of the stunted children weighed less than 2.5kg at birth (Kleynhans et al).[17]

Feeding practices in the Study Population

Time of initiation of breastfeed vs. SAM

57 % Cases were given breast feeding after 4 hrs of life, where as 61% controls were given their first feed within one hour showing statistically significant association between SAM and time of initiation of first feed p value <0.001, chi square 54.

In study by Kumar et al, Initiation of breast-feeding after six hours of birth, deprivation from colustrum and improper complementary feeding were found significant (P <0.05) risk factors for underweight.[18]

Soon after birth the baby is awake, alert and biologically ready to breast feed and initiation is very easy. Later on, the baby goes to a prolonged sleep and therefore initiation maybe difficult leading to feeding problems and malnutrition.[2]

Prelacteal feed and SAM

In the present study, 34% Cases were given prelacteal feeds and 24% of controls gave prelacteal feeds. Association showed p value of 0.06 chi square 2.4 OR 1.6. This study did not show any association between prelacteal feeds and malnutrition. Whereas Solomon amsalu et al identified administration of prelacteal feeds was associated with severe malnutrition (OR=2.31, 95% CI 1.025.27).[11]

Colostrum feeding and SAM

88% controls were given colostrum feeds, whereas only 62% Cases were given colostrum feeds showing statistically significant association between SAM and colostrum feeds (p value <0.01.chi square 1.8 OR 1.5). Similar observations were made by Kumar et al in their study showing deprivation from colostrum was associated with malnutrition (p value <0.05).[18]

Exclusive breast feeding and SAM

In this study 70% of controls were given exclusive breast feeding for 6 months whereas only 40% Cases were given exclusive breast feeding till 6months of age with p-value of <0.01. Similar results were seen in other studies. Solomon amsalu found that lack of exclusive breastfeeding in the first six months of age was associated with severe malnutrition (OR=3.00, 95% CI 1.58-5.73).[11] In study done in Pakistan by Bahawaluddin Jamro et al, lack of exclusive breast feeding was identified as a risk factor for SAM.[13] Paramita et al in their study found that those exclusively breast-fed for >6 months or <4 months have risk for malnutrition (p value <0.01).[6] A study in Delhi found a significant relationship (p<0.05) between those who were not exclusively breast-fed for the first 4 months of life and the malnourished.[19]

Dilution of top feeds and SAM

Present study showed 57% of top fed Cases were given over diluted feeds; only 27% of top fed controls were given over diluted feeds. Significant difference was observed with dilution of feeds in both groups with p value 0.02 chi square 4.4. There was a significant association between dilution of feeds and severe malnutrition. In diluted cow's milk, the net nitrogen and calories will be very low and the child is likely to develop malnutrition.[2]

Duration of breast feeding and SAM

In this study, 51% of cases were given breastfeeding for complete 2 years. whereas 75% of Controls were given 2 years of breastfeeding with p value of 0.09. Breast feeding should be continued well into the second year of life which is the period of maximum brain growth and myelination whereas supplementary feeding improves nutrition.[2]

Bottle feeding vs. SAM

The study showed 53% of Cases were bottle fed and only 14% of controls were bottle fed. The association between bottle feed and malnutrition was significant (p-value <0.01 chi square 33 OR 6.9). Use of bottle was associated with malnutrition in this study. This is also observed in other studies like Solomon amsalu et al which showed bottle-feeding was associated with SAM (OR=3.01, 95% CI 1.24-7.49).[11]

Malnutrition due to dilution and infection due to contamination are the most important side effects of all types of artificial feeding.[2]

Immunization status and SAM

Present study found 70% cases were completely immunized up to age and 30% were partially immunized. Among controls 72% were completely immunized and 28% were partially immunized. No significant difference was observed in the immunization status among both groups (p value 0.3, chi square 0.09). Whereas, the study done at NKP Salve institute of medical sciences at Nagpur in 2013, incomplete immunization was associated with malnutrition in 76% children.[12] Paramita et al in Ludhiana found that incomplete vaccination was higher in undernourished children with p value of 0.02.[12]

Developmental milestones vs. SAM

In our study, 77% Cases had no developmental delay and 23% had delay in the development. Among controls 93% had no delay and 7% had delay in attainment of milestones. There is a significant association between malnutrition and delayed development (p value <0.01 chi square 10).

Table 2: Results of various studies showing risk factors which are associated with severe acute malnutrition with significant p-value.

Study done by	Variables- associated with SAM with significant p-value				
	Poor SES*	**Parental/ maternal illiteracy**	**Non-exclusive breastfeed**	**LBW$**	**Incomplete immunization**
Goyal S et al	Yes	Yes	-	-	Yes
Amsalu S et al	Yes	Yes	Yes	-	-
Jamro B et al	Yes	Yes	Yes	-	-
Nkp salve institute of medical sciences, nagpur	Yes	Yes	Yes	Yes	Yes
Paramita et al	-	Yes	Yes	Yes	Yes
Present study	Yes	Yes	Yes	-	-

*SES: Socio economic status., $ LBW: Low birth weight

Serum zinc levels in children with severe acute malnutrition

In this study, the serum levels of zinc were low in only 11 cases of SAM before supplementation. Mean zinc value before supplementation was 117mcg/dl with standard deviation of 49 and after supplementation mean value was 125 with standard deviation of 39 with p value of 0.06. Not shown any significant rise in mean value of Zinc after supplementation for 2 weeks. Whereas, Hadian and Soleymani, in their study Zinc deficiency was seen in 89.3% of children who had mild malnutrition and in all of children who had moderate or severe malnutrition.[21] Ugwuja et al in Tanzania reported lower serum zinc levels (mean zinc 47 mcg/dL) in 74% of PEM children than in well-nourished children (p <0.05).[21] Which has increased after supplementation.

Table 3: Mean values of zinc in malnourished children in different studies.

	Mean zinc value
Mushi et al	47mcg/dl
Vasudevan et al	98.4 mcg/dl
Present study	117 mcg/dl

Similar to our results, Vasudevan et al has reported normal mean zinc values in malnourished children (98.4 ±26.1 µg/dl). These results could probably because of increasing rate of routine prescription of Zinc drops/syrup by large number of pediatricians/general practitioners to their patients attending the health facilities. This might also be due to failure of estimation of intracellular zinc deficiency in malnourished children with clinical zinc deficiency with normal serum levels.

Serum magnesium levels in severe acute malnutrition

Mean value of magnesium before supplementation was 2.4 in 91 cases and after supplementation in follow up were 2.6 with standard deviations 0.5 and 0.4 respectively. P-value was 0.06 with no significant difference in the means before and after supplementation.

Zafar et al in their study showed that cases with malnutrition showed decreased S. Magnesium level (1.11±0.24 mg/dl) as compared to controls (2.01±0.78 mg/dl).[22]

Table 4: Mean magnesium levels in different studies.

Study	Magnesium levels Mean(mg/dl)
Zafar et al	1.11
Khali et al	1.46
Karle et al	1.92
Present study	2.4

Khali et al reported the mean serum magnesium value as 1.46±0.25 mgdl in group 1 and 1.36±0.25 mg/dl in group 2 on day 1 before starting treatment. These levels were below the normal reference value of 1.56 mg/dl. After treatment on day 12 these were 1.63±0.26 mg/dl and 2.06±0.35 mg/dl in group 1 and 2 respectively.[5] Whereas Karle et al reported serum magnesium values as 1.92 mg/dl before supplementation and 2.23 mg/dl after supplementation of magnesium.[23]

Limitations of the study was to lose to follow up samples were more. Sample wastage was more due to hemolysis.

CONCLUSION

There is a statistical correlation of Severe Acute Malnutrition with rural area, maternal Illiteracy and low socioeconomic status, Deprivation of colostrums feeding, failure of exclusive breast feeding for 6 months, over dilution of top feeds and use of bottle feeding. There is no correlation between SAM and immunization status and other demographic parameters like age, sex and religion. 23% of severely malnourished children had delay of developmental milestones. SAM is inversely related to duration of exclusive breast feeding. Type of feed given in those children with incomplete exclusive breast feeding is not associated with SAM. Serum Proteins, Zinc and Magnesium were normal in SAM children even before supplementation and the rise in levels after supplementation was not significant with WHO prescribed doses.

Recommendations

Targeted approach to educate the mothers in respect of early initiation, duration and importance of exclusive breast feeding and complementary feeding. Further studies with estimation of intracellular magnesium and zinc are needed to know the incidence of actual deficiency. Larger studies are needed to establish the requirement of dose and duration of micronutrient supplements especially Zinc and Magnesium in children with SAM.

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