

Risk factors for severe acute malnutrition among children aged 6–59 months: A community-based case-control study from Vellore, Southern India

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ABSTRACT

Background: Malnutrition plays an important role in the economic burden of society as well as the country. This study aimed to identify the various risk factors and determinants of severe acute malnutrition (SAM) as defined by WHO growth reference standards in children aged 6 months to 59 months living in Vellore. **Methods:** A community-based case-control study matched for age (± 2 months), gender and location was done among the children of the age group 6–59 months residing in both rural and urban Vellore. Children of age group 6–59 months with SAM according to WHO definition, i.e., weight for height of less than -3 SD with or without nutritional oedema were classified as cases. Children with weight-for-height z-score more than -1 SD and MUAC ≥ 13.5 cms were classified as controls. With 2 controls per case, the required sample size was 54 cases and 108 controls. A questionnaire used to identify the risk factors including dietary intake. Uni-variate and multivariate analysis was done to generate an odds ratio and 95% confidence interval for the risk factors. **Results:** Majority of the cases 64.8% and 50% of the controls belonged to low SES. After adjusting all confounders, Severe Acute Malnutrition was significantly associated with birth weight < 2.499 kg [AOR- 8.95 (95% CI: 2.98–26.85)], not exclusively breastfed for 6 months [AOR 4.67 (95% CI: 1.72–12.65)], inadequate calorie intake [AOR 8.09 (95% CI: 3.15–20.82)] and mother being underweight [AOR 6.87 (95% CI: 1.92–24.55)]. **Conclusion:** Programs should be implemented to reduce the poor nutritional status of young girls and women in the reproductive age group. The importance of exclusive breastfeeding for the first six months, the time of weaning and appropriate feeding practice for the child should be emphasized to postnatal mothers during their hospital visits.

Keywords: Children, Malnutrition, risk factors, severe acute malnutrition

Background

Malnutrition, in all its forms, is a public health problem of epidemic proportions.^[1] Globally, every year, nearly 3 million

malnutrition associated deaths are reported in the under-5 age group.^[2] In addition to direct causes such as inadequate dietary intake, lack of exclusive breastfeeding, respiratory and gastrointestinal infections, indirect factors such as food insecurity, presence of morbidity among parents, and poor environmental conditions especially overcrowding, lack of sanitation and poor purchasing power are detrimental to the healthy growth of the child thereby predisposing them to chronic morbidity and at times culminating in mortality.^[3–8] Despite the marked improvement in

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health and living conditions, India is still way behind in achieving the target for child mortality; the failure to address malnutrition being negatively conducive to the same.^[9]

Combating child malnutrition is of great public health importance to the future economic development and social well-being of countries. It is essential to know the causes and risk factors of child malnutrition to deal with the problem of child malnutrition adequately. The prevalence of malnutrition in India and various parts of India is relatively well documented, but there is very minimal information for risk factors of severe acute malnutrition (SAM). So far, there have been many hospital-based studies conducted to determine the risk factors for SAM. The present study was designed to identify risk factors and determinants of SAM among children aged between 6 and 59 months living in both rural and urban slum areas of Vellore district, Tamil Nadu.

Material and Methods

A community-based case-control study was carried out in urban and rural areas of Vellore, Tamil Nadu, Southern India among children aged between 6 and 59 months. According to the 2011 census, the population of children with under-5 years of age was 10,742 in Vellore city (urban) and 11,555 in Kaniyambadi block (rural). The cases and controls were defined as per the World Health Organization (WHO) Multicentric Growth Reference Study (MGRS) Criteria 2006.^[10] Children with SAM, that is, weight for height z-score of less than $-3SD$ with or without nutritional edema were considered as cases. Children with weight-for-height z-score more than $-1SD$ and mid-upper arm circumference (MUAC) ≥ 13.5 cm were considered as controls.

Assuming an odds ratio of 3 for SAM among children who were not exclusively breastfed from birth to 6 months of age^[11] and proportion of exclusive breastfeeding among under-5 children of 40%,^[12] the sample size was estimated as 54 cases and 108 controls.

A baseline survey was undertaken by the Department of Community Health, Christian Medical College, Vellore as part of a clinical trial to evaluate the efficacy of three feeding regimens (locally prepared ready-to-use therapeutic food [RUTF-L], commercially available RUTF [RUTF-C], and augmented home-prepared foods [AHPF]), on the recovery of children from uncomplicated SAM, in Vellore.^[13] Briefly, children with MUAC < 13 cm in the age group 6–59 months were identified in the community and were referred to the study clinic for anthropometric measurements and further screening. The Z scores of weight for height were calculated using the WHO Anthro software.^[14] Children with Z score less than $-3SD$ were classified as cases of SAM, following which a home visit was done by a medical officer and trained field workers on the same day, to document existing risk factors, before the initiation of feeding interventions.

Selection of controls

For each identified case, two controls matched for age (± 2 months), gender and locality, were recruited within the following 2 weeks.

The independent variables assessed were gender and age-specific anthropometric z-scores of weight-for-height (WHZ). Based on the literature review, this study incorporated five domains affecting a child's nutritional status, namely demography, child's birth details, morbidity, diet, and parental related risk factors.

A semi-structured interviewer-administered questionnaire was used to assess the various demography and parental related risk factors. Review of hospital records and road to health cards were done to collect information on birth-related characteristics such as birth weight, gestational age, past medical history and associated morbidity, and history of hospitalization in the last six months for any reason.

The dietary intake of the child was assessed using a 24-h dietary recall questionnaire. Standard cups, glasses, ladles, spoons, and paper disks were used to determine the amount of food consumed by the children. Then the nutrients present in the raw ingredients were calculated using the database of "Nutritive Value of Indian Foods" had given by the National Institute of Nutrition (NIN).^[15] The nutrients from the ready-made foods like biscuits and other packaged food items were calculated from the information given by the manufacturers.

The mother's nutritional knowledge was assessed by seven simple questions (scored out of 10) that involved three domains, namely breastfeeding, weaning, and nutrition. History of chronic illnesses such as tuberculosis, HIV, and cancer of the parents were also documented.

Electronic weighing scales were used to measure the weight. Children were weighed twice wearing vests and bloomers. The average of the two readings was taken. Heights were measured using the stadiometer/height board, whereas children younger than 2 years were measured using infant-o-meter. MUAC was measured using the inch tape. Weight was measured to the nearest 0.1 kg, height to the nearest 0.1 cm, and MUAC measured to 2 mm precision.

The questionnaire was translated to Tamil (local language) and then translated back into English to ensure accuracy. Signed informed consent was obtained from the mother/primary caregiver of the child. Confidentiality of the information collected from the respondents strictly adhered. During the period of data collection, a child (cases and controls) who was found to be suffering from an acute illness was referred to the secondary-level hospital (CHAD hospital, Vellore) for further management.

Statistical analyses were performed using the IBM Statistical Program for Social Sciences (SPSS) version 20. The z-score value of

WHZ was computed using the WHO Anthro (version 3.2.2, 2011). Descriptive analyses were done to compare the socioeconomic characteristics, child's dietary intake, and caregiver variables between cases and controls. Mean, and the standard deviation was reported for normally distributed continuous variables. Categorical variables were reported as proportions. A Chi-square test was performed to elicit associations between SAM and risk factors. Crude and adjusted odds ratios (OR) with 95% confidence intervals (CI) were determined for potential risk factors. *P* values less than 0.05 were considered statistically significant.

Ethical standards disclosure

Ethical clearance was obtained from the IRB and ethics committee (IRB min no.: 8153), Christian Medical College, Vellore, India. Written informed consent was obtained from mothers in the local language (Tamil) or in the language in which they are comfortable (English/Hindi) before administering the questionnaire.

Results

A total of 160 participants were recruited into the study, including 54 cases and 106 controls. The sociodemographic characteristics of the study population were described in Table 1. Of the 54 cases and 106 controls, 39% of children were between the age group of 12–23 months in both cases and controls, and 27.8% of cases and 22.6% of controls were in the age group of 24–35 months. The mean age was 24 months in both cases and controls (cases: 24.35 ± 12.9 , control: 24.24 ± 12.7). There was no difference in the mother's age at the time of the birth of the index child among both the cases and controls ($P = 0.105$).

The mean birth weight among cases and controls was 2.37 kg (± 0.548) and 3.02 kg (± 0.537), respectively. Institutional delivery was documented among the majority of the cases (96.3%) and controls (99.1%). With respect to gestational age at birth, 16.7% of cases and 6.6% of control children were born preterm ($P < 0.05$).

Table 1: Demographic characteristics of the study population

Category		Cases n=54 (%)	Controls n=106 (%)
Gender	Male	26 (48.1%)	51 (48.1%)
	Female	28 (51.9%)	55 (51.9%)
Residence	Urban	39 (72.2%)	81 (76.4%)
	Rural	15 (27.8%)	25 (23.6%)
Type of house	Huts	7 (13%)	6 (5.6%)
	Mixed	7 (13%)	47 (44.3%)
	Pucca	36 (66.7%)	51 (48.1%)
Type of family	Mansion	4 (7.4%)	2 (1.9%)
	Nuclear	25 (46.3%)	61 (57.5%)
	Joint	14 (25.9%)	39 (36.8%)
Religion	Extended	15 (27.8%)	6 (5.7%)
	Hindu	37 (68.5%)	90 (84.9%)
	Christian	8 (14.8%)	0
SES* (BG Prasad's)	Muslims	9 (16.7%)	15 (15.1%)
	I (high)	1 (1.9%)	5 (4.7%)
	II	3 (5.6%)	11 (10.4%)
	III	15 (27.8%)	37 (34.9%)
	IV	23 (42.6%)	45 (42.5%)
Fathers occupation	V (low)	12 (22.2%)	8 (7.5%)
	Unemployed	1 (1.9%)	0
	Unskilled/semi-skilled	25 (46.3%)	54 (51%)
	Skilled	14 (25.9%)	27 (25.5%)
	Clerical/shop owners	10 (18.5%)	13 (12.3%)
Mothers' occupation	Semi-professionals/Professionals	4 (7.4%)	12 (11.3%)
	House wife	46 (85.2%)	96 (90.6%)
	Working mothers	8 (14.8%)	10 (9.4%)
Fathers' education	Illiterate/Primary	16 (29.7%)	23 (21.7%)
	Middle	12 (22.2%)	28 (26.4%)
	High school	18 (33.3%)	28 (26.4%)
	High secondary and more	8 (14.9%)	27 (25.4%)
Mothers' education	Illiterate/Primary	16 (29.7%)	28 (26.4%)
	Middle	14 (25.9%)	24 (22.6%)
	High school	13 (24.1%)	30 (28.3%)
Family size	High secondary and more	11 (20.5%)	24 (22.7%)
	4 and more	4 (7.4%)	6 (5.7%)

*SES: Socioeconomic Status

Exclusive breastfeeding for six months was practiced by 55.6% of cases and 88.7% of the controls ($P < 0.05$). The mean duration of breastfeeding among the cases and controls was $12(\pm 7.2)$ and $15.23(\pm 7.6)$ months, respectively. Routine immunization was documented in 81.5% of cases and 94.3% of controls.

Among the 160 children studied, 50% of cases and 66% of controls were in the normal height for age cutoff points, that is, HAZ > -2 to 3 SD. Among cases, 27.8% were stunted, and 18.5% were severely stunted (HAZ < -3). Among controls, 13.2% were stunted, and another 13.2% were severely stunted. As per the case definition, all children in the cases had WHZ scores below -3 SD. Among controls, 81.1% of the children had WHZ ≥ 1 SD. Few children in the control group (14.2%) had a "possible risk of being overweight" (WHZ > 1 to ≤ 2 SD), 4.7% of controls were overweight (WHZ > 2 to ≤ 3 SD), and none were obese (WHZ > 3 SD).

Table 2 describes the various risk factors for SAM. In the demographic domain, only religion showed a statistically significant association with SAM. With regard to birth and infancy related factors, low birth weight, incomplete immunization, presence of congenital anomalies, and parents' having more than one child emerged as significant risk factors for SAM. The presence of current medical illness and hospitalization were also contributory risk factors for SAM. SAM was found to be more prevalent among those who were not exclusively breastfed and those with inadequate calorie and protein intake. In the domain of family health and dynamics, SAM was found to be associated with the presence of chronic illness in the mother, underweight mothers (BMI < 18.5), poor knowledge of nutrition among mothers, history of smoking tobacco, and history of alcohol consumption among fathers, and history of child's contact with tuberculosis.

Multiple logistic regression was performed, and the adjusted OR with the P value was calculated. Birth weight less than 2.5 kg,

Table 2: Risk factors associated with SAM

Category		Case n=54 n (%)	Control n=106 n (%)	OR (95% CI)	AOR (95% CI)	P
Demography-related risk factors:						
Religion-	Hindu	37 (68.5%)	90 (84.9%)	0.39 (0.18-0.85)	0.54 (0.14-2.1)	0.374
	Others	17 (31.5%)	16 (15.1%)			
SES (BG Prasad)	Low	35 (64.8%)	53 (50%)	1.84 (0.94-3.62)	1.31 (0.48-3.58)	0.603
	High	19 (35.2%)	53 (50%)			
Child's birth-related risk factors:						
Birth weight	<2.5 Kg	27 (50%)	9 (8.5%)	10.8 (4.53-25.64)	8.95 (2.98-26.85)	<0.001*
	≥ 2.5 Kg	27 (50%)	97 (1.5%)			
Congenital disorder	Present	7 (13%)	2 (1.9%)	7.75 (1.55-38.7)	0.89 (0.08-10.07)	0.928
	Absent	47 (87%)	104 (98.1%)			
Being single child	yes	11 (20.4%)	46 (43.4%)	0.33 (0.16-0.72)	0.58 (0.18-1.81)	0.347
	No	43 (79.6%)	60 (56.6%)			
Child's morbidity-related risk factors:						
Current Medical illnesses	Present	11 (20.4%)	4 (3.8%)	6.52 (1.97-21.6)	3.70 (0.57-23.94)	0.169
	Absent	43 (79.6%)	102 (96.2%)			
Hospitalization in last 1 year	Present	11 (20.4%)	7 (6.6%)	3.62 (1.31-9.96)	0.84 (0.16-4.56)	0.841
	Absent	43 (79.6%)	99 (93.4%)			
Immunization	Incomplete	10 (18.5%)	6 (5.7%)	3.79 (1.3-11.07)	1.32 (0.24-7.2)	0.747
	Complete	44 (81.5%)	100 (94.3%)			
Child's diet-related risk factors						
Exclusively breastfed	No	24 (44.4%)	12 (11.3%)	6.27 (2.8-14.02)	4.67 (1.72-12.65)	0.002*
	Yes	30 (55.6%)	94 (88.7%)			
Calorie intake	Inadequate	38 (70.4%)	26 (24.5%)	7.31 (3.51-15.21)	8.093 (3.15-0.82)	<0.001*
	Adequate	16 (29.6%)	80 (75.5%)			
Parental-related risk factors:						
Household TB contact	Present	7 (13%)	2 (1.9%)	7.75 (1.55-38.7)	1.01 (0.13-7.66)	0.995
	Absent	47 (87%)	104 (98.1%)			
Mother's BMI in kg/m ²	Underweight (<18.5)	13 (24.1%)	8 (7.5%)	3.88 (1.5-10.08)	6.87 (1.92-24.55)	0.003*
	Others	41 (75.9%)	98 (92.5%)			
Mother's nutritional knowledge	Poor	47 (92.2%)	74 (74.7)	3.97 (1.3-12.13)	1.8 (0.47-6.93)	0.393
	Good	7 (12.97%)	32 (30.2%)			
Father smokes	Yes	27 (50%)	35 (33%)	2.03 (1.04-3.96)	1.02 (0.33-3.12)	0.979
	No	27 (50%)	71 (67%)			
Father Alcohol Consumption	Present	30 (55.6%)	41 (38.7%)	1.98 (1.02-3.85)	1.3 (0.41-4.13)	0.659
	Absent	24 (44.4%)	65 (61.3%)			

*Statistically significant. OR: odds ratio; AOR: adjusted odds ratio; SES: socioeconomic status; TB: tuberculosis; BMI: body mass index

absence of exclusive breastfeeding for six months, inadequate calorie intake and mother's BMI less than 18.5 kg/m² were identified as risk factors for SAM. Those variables which were found to be significant in the bivariate analysis, such as religion, inadequate protein intake, fathers' habit of smoking tobacco and alcohol consumption, presence of chronic illness among mothers, mothers' poor knowledge on nutrition (score ≤ 4), and history of contact with tuberculosis were found to be statistically nonsignificant when the model was adjusted for confounders.

Discussion

According to National Family Health Survey (NFHS) III data on chronic childhood malnutrition,^[16] low birth weight (LBW) was found to be a major determinant of SAM, as was also observed in this study. The birth weight is affected by many socioeconomic factors such as being rural or urban, wealth, caste, religion, education, and tobacco use by mother.^[16] Similar studies conducted in different countries also showed a strong association between malnutrition and LBW.^[17-20] A study done in Ghana showed that preterm babies were prone to develop malnutrition in later life.^[19] This study did not find any significant association between prematurity and the child's nutritional status. This might be due to high early neonatal death among preterm babies^[21] or improvement of nursery care over the years after the introduction of the National Rural Health Mission (NRHM) Programme in India.^[22]

Nutritional experts advise exclusive breastfeeding for the first 6 months of life.^[23] According to the Hungama survey, in India, only 40% of the children were exclusively breastfed for the first 6 months of age.^[12] The current study has pointed out the absence of exclusive breastfeeding until six months of age as a risk factor for SAM. The odds of being malnourished were four times higher among those who were not exclusively breastfed until 6 months of age. Similar findings were noted in the study done in the Democratic Republic of Congo (DRC)^[20] and many parts of rural India.^[24-26] The dietary calorie intake of cases was inadequate as compared to controls based on the recommended daily allowance (RDA). Poor calorie intake has emerged as a significant risk factor for child malnutrition in this study. This may be primarily due to the non-availability of food and faulty feeding practices among the cases. However, no statistically significant association was noted between protein intake and child malnutrition. Our study findings were similar to the results observed in a study done in DRC.^[20] According to a survey done in Somalia, Mothers of malnourished children had poor knowledge regarding breastfeeding and complementary feeds.^[27] However, in our study, we did not find any statistical association between SAM and mothers' nutritional knowledge.

Malnourished women tend to give birth to an LBW child who will probably develop protein-energy malnutrition.^[28] The current study has shown a statistically significant association low BMI of the mothers' (<18.5) and SAM. This has been corroborated by the findings from NFHS III^[29] and a study done in Mao, Chad.^[30]

The association between mothers' chronic disease status, fathers' habits like smoking tobacco and alcohol consumption) and SAM was not statistically significant. However, studies done elsewhere have shown a significant association between the presence of smoking among fathers and child malnutrition.^[31]

The literacy status of the parents did not emerge as a significant risk factor for malnutrition in this study. Other studies in different parts of India showed a strong association between maternal education and poor nutrition among children.^[12,32] No statistically significant association was noted between the mother's occupation and child malnutrition. A study done by Miler *et al.* showed that the absence of a mother's care interferes with the child's nutritional status, but these findings were based on children whose mothers were doing irregular shift duties.^[33] The absence of association in the present study could be due to fewer mothers who had an occupation (11% in both cases and controls).

Immunization against childhood diseases such as tuberculosis, diphtheria, measles, and whooping cough, reduce childhood mortality, and morbidity. Children who develop these diseases suffer from malnutrition as well as impaired cognitive, emotional and social skills.^[34] In a study done in Ethiopia, fully vaccinated children had a higher chance of getting recovered from SAM compared to partially or not vaccinated children.^[35] The current study showed an increase in SAM among those who were partially immunized. This, however, was not statistically significant after adjusting for confounders.

Parents' having more than one child was shown as a risk factor for SAM in bivariate analysis. This might probably be due to incomplete and divided parental and nutritional support from the parents. In contrast, the single child enjoys undivided parental as well as nutritional support from the entire family. This observation was similar to the findings of the study done in Bangladesh.^[36] In this study, 13% of the cases and only 1.9% of the controls had congenital disorders ($P = 0.004$). This again was not statistically significant after adjusting for confounders.

According to a study done in Bangladesh, illness in the last 2 weeks increases the odds of children developing Malnutrition.^[36] Similarly, in this study, the frequency of SAM was found to be higher among those who were suffering from medical illnesses such as diarrhea, acute respiratory infection (ARI), measles, and chickenpox at the time of the interview. However, the findings were not statistically significant in the logistic regression model. This could be possibly attributed to the practice of reducing oral intake during acute illness. According to the literature, malnourished children were prone to develop common communicable diseases, and therefore, increased hospitalization. Inadequate nutritional supplementation during hospital admission would further worsen the preexisting malnourishment and weight loss.^[37] In this study, the history of hospitalization in the past 6 months was significantly associated with malnutrition in the bivariate analysis but not on multivariate analysis.

Though belonging to the Hindu religion was a protective factor in the bivariate analysis, it was not so in the multiple logistic models. Surprisingly, no statistically significant association was noted between low SES and SAM. This finding was contrary to the conclusions of a study done in Rajasthan, which showed that 82% of underweight children belonged to the low SES group.^[38] This could be due to the public distribution system (PDS) in Tamil Nadu. The Tamil Nadu PDS follows the distribution of staple foods to every household, irrespective of whether they fall below or above the official poverty line.

In Summary, results from the present study confirm that LBW, absence of exclusive breastfeeding, inadequate calorie intake by children, and low BMI of mothers as significant risk factors for the development of SAM among children aged 6–59 months.

Limitation

Finding appropriate controls in the community was a major limitation of the study. Apart from that, there may be interviewer bias in the data collection as the interviewer was aware of the nutritional status of the cases and controls before the interview. The majority of the mothers, both cases and controls, had difficulty in recollecting the duration of breastfeeding and the time of initiation of complementary feeds. This could have raised a recall bias in the study. Also, the calorie intake was based on a single 24-h dietary recall and may have subsequently resulted in over-estimation or under-estimation of the actual calorie intake of the children.

Conclusion

Having the knowledge of various risk factors of SAM would benefit the primary care physicians and the community health workers to identify the “at-risk” children in the community through screening (based on the risk factor) and help them to address the problem early. Also, various new programs should be implemented to reduce the poor nutritional status of young girls and women in the reproductive age group. The importance of exclusive breastfeeding for the first 6 months, the time of weaning and appropriate feeding practice for the child should be told to the antenatal and postnatal mothers during their hospital visits by the health care provider.

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Conflicts of interest

There are no conflicts of interest.

Bibliography

- Collins S. Treating severe acute malnutrition seriously. *Arch Dis Child* 2007;92:453-61.
- Malnutrition in Children. UNICEF DATA. Available from: <https://data.unicef.org/topic/nutrition/malnutrition/>. [Last accessed on 2018 Dec 13].
- Wong HJ, Moy FM, Nair S. Risk factors of malnutrition among preschool children in Terengganu, Malaysia: A case control study. *BMC Public Health* 2014;3;14:785.
- Saloojee H, De Maayer T, Garenne ML, Kahn K. What's new? Investigating risk factors for severe childhood malnutrition in a high HIV prevalence South African setting. *Scand J Public Health Suppl* 2007;69:96-106.
- Rodríguez L, Cervantes E, Ortiz R. Malnutrition and gastrointestinal and respiratory infections in children: A public health problem. *Int J Environ Res Public Health* 2011;8:1174-205.
- Jamro B, Junejo AA, Lal S, Bouk GR, Jamro S. Risk factors for severe acute malnutrition in children under the age of five years in Sukkur. *PAK J Med Res* 2012;51.
- Victora CG, Vaughan JP, Kirkwood BR, Martines JC, Barcelos LB. Risk factors for malnutrition in Brazilian children: The role of social and environmental variables. *Bull World Health Organ* 1986;64:299-309.
- Ministry of Health and Family Welfare Government of India. Operational Guidelines on Facility Based Management of Children with Severe Acute Malnutrition-2011. Available from: <http://rajswasthya.nic.in/MTC%20Guideline-%20MOHFW.pdf>. [Last accessed on 2019 Dec 24].
- Nath A. India's progress toward achieving the millennium development goals. *Indian J Community Med* 2011;36:85-92.
- World Health Organization and UNICEF. WHO child growth standards and the identification of severe acute malnutrition in infants and children. 2009. Available from: https://apps.who.int/iris/bitstream/handle/10665/44129/9789241598163_eng.pdf?sequence=1. [Last accessed on 2020 Jan 7].
- Amsalu S, Tigabu Z. Risk factors for severe acute malnutrition in children under the age of five: A case-control study. *J Health Dev* 2008;22:21-5.
- The HUNGaMa survey report. HUNGaMa fighting hunger and malnutrition, the HUNGaMa survey report (2011). Available from: <http://www.naandi.org/wp-content/uploads/2013/12/HUNGaMa-Survey-2011-The-Report.pdf>. [Last accessed on 2019 Jul 3].
- Bhandari N, Mohan SB, Bose A, Iyengar SD, Taneja S, Mazumder S, *et al.* Efficacy of three feeding regimens for home-based management of children with uncomplicated severe acute malnutrition: A randomised trial in India. *BMJ Global Health* 2016;1:e000144.
- WHO|WHO Anthro Survey Analyser and other tools [Internet]. WHO. [Last accessed on 2018 Jan 26]. Available from: <http://www.who.int/childgrowth/software/en/>.
- Gopalan C, Sastri BVR, Balasubramanian SC. Nutritive Value of Indian Foods. National Institute of Nutrition, Indian Council of Medical Research; 1989. p. 174.
- Ashtekar SV, Kulkarni MB, Sadavarte VS, Ashtekar RS. Analysis of birth weights of a rural hospital. *Indian J Community Med* 2010;35:252-5.
- Ranchi Low Birth Weight Project - Study Protocol. Available from: <http://hetv.org/pdf/ranchi-lbw-protocol.pdf>. [Last

- accessed on 2014 Sep 5].
18. Bomela NJ. Social, economic, health and environmental determinants of child nutritional status in three Central Asian Republics. *Public Health Nutr* 2009;12:1871-7.
 19. Enweronu-Laryea CC, Aryee INA, Adei EAP. Severe acute malnutrition in very low birth weight preterm infants. *J Parenter Enter Nutr* 2012;36:354-7.
 20. Mukuku O, Mutombo AM, Kamona LK, Lubala TK, Mawaw PM, Aloni MN, *et al.* Predictive Model for the Risk of Severe Acute Malnutrition in Children. Huerta JM, editor. *J Nutr Metab* 2019;2019:4740825.
 21. D'Onofrio BM, Class QA, Rickert ME, Larsson H, Långström N, Lichtenstein P. Preterm birth and mortality and morbidity: A population-based quasi-experimental study. *JAMA Psychiatry* 2013;70:1231-40.
 22. Sankar MJ, Neogi SB, Sharma J, Chauhan M, Srivastava R, Prabhakar PK, State of newborn health in India. *J Perinatol* 2016;36(Suppl 3):S3-8.
 23. WHO | Exclusive breastfeeding. Available from: http://www.who.int/nutrition/topics/exclusive_breastfeeding/en/. [Last accessed on 2019 Jul 3].
 24. Ambadekar NN, Zodpey SP. Risk factors for severe acute malnutrition in under-five children: A case-control study in a rural part of India. *Public Health* 2017;142:136-43.
 25. Mishra K, Kumar P, Basu S, Rai K, Aneja S. Risk factors for severe acute malnutrition in children below 5 y of age in India: A case-control study. *Indian J Pediatr* 2014;81:762-5.
 26. Prashanth MR, Savitha MR, Prashantha B. Risk factors for severe acute malnutrition in under-five children attending nutritional rehabilitation centre of tertiary teaching hospital in Karnataka: A case control study. *Int J Contemp Pediatr* 2017;4:1721-6.
 27. Kalid M, Osman F, Sulaiman M, Dykes F, Erlandsson K. Infant and young child nutritional status and their caregivers' feeding knowledge and hygiene practices in internally displaced person camps, Somalia. *BMC Nutr* 2019;5:59.
 28. Ramakrishnan U. Nutrition and low birth weight: From research to practice. *Am J Clin Nutr* 2004;79:17-21.
 29. Subramanian SV, Ackerson LK, Smith GD. Parental BMI and childhood undernutrition in India: An assessment of intrauterine influence. *Am Acad Pediatr* 2010;126:e663-71.
 30. Dodos J, Altare C, Bechir M., *et al.* Individual and household risk factors of severe acute malnutrition among under-five children in Mao, Chad: A matched case-control study. *Arch Public Health* 2018;76:35.
 31. Semba RD, de Pee S, Sun K, Best CM, Sari M, Bloem MW, *et al.* Paternal smoking and increased risk of infant and under-5 child mortality in Indonesia. *Am J Public Health* 2008;98:1824-6.
 32. Gupta MC, Mehrotra M, Arora S, Saran M. Relation of childhood malnutrition to parental education and mothers' nutrition related KAP. *Indian J Pediatr* 1991;58:269-74.
 33. Vaida N. Impact of maternal occupation on health and nutritional status of P reschoolers in Srinagar city. *OSR J Humanit Soc Sci* 2013;7:9-12.
 34. Shuaib F, Kimbrough D, Rooffe M, McGwin Jr G, Jolly P. Factors associated with incomplete childhood immunisation among residents of St. Mary Parish of Jamaica. *West Indian Med J* 2010;59:549-54.
 35. Adimasu M, Sebsibie G, Abebe F, Baye G, Abere K. Recovery time from severe acute malnutrition and associated factors among under-5 children in Yekatit 12 Hospital, Addis Ababa, Ethiopia: A retrospective cohort study. *Epidemiol Health* 2020;42:e2020003.
 36. Hoq M, Ali M, Islam A, Banerjee C. Risk factors of acute malnutrition among children aged 6-59 months enrolled in a community-based programme in Kurigram, Bangladesh: A mixed-method matched case-control study. *J Health Popul Nutr* 2019;38:36.
 37. Rocha GA, Rocha EJM, Martins CV. The effects of hospitalisation on the nutritional status of children. *J Pediatr (Rio J)* 2006;82:70-4.
 38. Soni AL, Singh RN, Gupta BD. Nutritional disorders in rural Rajasthan. *Indian J Pediatr* 1980;47:199-202.