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Mid-upper arm circumference for age and undernutrition among 2 to 6 year old Bauri and Santal children of Purulia, West Bengal, India

Subal Das[1], Sudip Datta Banik[2] and Kaushik Bose[3]

[1]Dept. of Anthropology and Tribal Development, Guru Ghasidas Vishwavidyalaya, Koni, Bilaspur, Chhatisgarh. Email: das_vu@rediffmail.com & dsubalvu@gmail.com

[2]Department of Human Ecology. Centro de Investigación y de Estudios Avanzados (Cinvestav) del IPN- Merida. Yucatan, Mexico. Email: sdbanik@hotmail.com

[3]Associate Professor and Head, Dept. of Anthropology, Vidyasagar University, West Bengal. Email: banda@vsnl.net

Corresponding Author: Subal Das, Assistant Professor, Dept. of Anthropology and Tribal Development, Guru Ghasidas Vishwavidyalaya, Koni, Bilaspur, Chhatisgarh - PIN: 495009
Email: das_vu@rediffmail.com & dsubalvu@gmail.com

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ABSTRACT

Background: *Mid-upper arm circumference (MUAC) is one of the simplest and easiest measures for large-scale screening programme for assessing undernutrition, especially among children. MUAC-based nutritional survey is easy to implement at the community level by the health workers or volunteers after minimum training.*

Methods: *The present cross sectional study was done among Bauri and Santal children of Purulia, West Bengal, India. A total of 1013 children (Bauri = 499 and Santal = 514) aged 2-6 years were measured for MUAC. The normalized MUAC for age by z-scores were calculated using LMS method.*

Results: *The age, sex and community specific sample distributions were prepared. Mean MUAC increased with age (except among Santal boys at the age of 6 years). The girls had higher median MUAC than boys at all ages except at 2 years. Prevalence of MUAC-based undernutrition (following WHO) was highest at the age of 3 years for boys (61.7 %) and girls (36.5 %). Similarly, prevalence of undernutrition was highest (48.6 % and 47.4 %) among Santal boys and girls at the age of 6 and 3 years, respectively. Significant sex difference (age combined) in prevalence of undernutrition was observed among Bauris (χ^2= 20.54, df= 8, p< 0.001) and Santals (χ^2= 6.71, p< 0.05).*

Conclusion: *High rate of undernutrition was observed among these children.. Our study clearly revealed that the median MUAC of children were lower than two standard references at all ages.*

Key words: *Tribe; Caste; Undernutrition; MUAC; LMS*

INTRODUCTION

Children are the future of society and mothers are the guardians of that future (WHO, 2005). Hence, to ensure sound foundation and secure future of any society, health and nutrition of their children need protection. In South and South-East Asia, India ranks first in the prevalence of undernutrition with 43 % and 48 % children <5 years of age being underweight and stunted, respectively in rural areas (Pasricha & Biggs, 2010), while the figures are much higher in tribal children (underweight: 55%, stunting: 54% and wasting: 28%) (IIPS, 2007). Malnutrition is more common in India than in Sub-Saharan Africa. Malnutrition however, varies in different states of India ranging between 13 % and 55 % representing Meghalaya and Madhya Pradesh respectively (UNICEF, 2013).

Nutritional status is a major, modifiable and powerful element in promoting health, preventing and treating diseases and improving the quality of life (WHO, 1978). Nutritional status of a community is the sum of the nutritional status of individuals who form that community. The main objective of a "comprehensive" nutritional survey is to obtain precise information on the prevalence and geographic distribution of nutritional status of a given community, and the identification of individuals or groups "at risk" or in need of nutritional intervention. Undernutrition remains a widespread problem in developing countries, in particular among the poorest and most vulnerable segments of the population.

Anthropometry is an essential method of child health supervision and the epidemiological assessment of the nutritional status of a defined population of children. In tribal areas of India, reports on nutritional status using mid-upper arm circumference (MUAC) of preschool children of tribal communities and Hindu castes, are very scanty.

Therefore, in view of high prevalence of malnutrition among tribal and caste preschool children as well as necessity of spatial and temporal community specific data, a cross-sectional study was done among the Santal (tribal) and Bauri (Hindu caste) children (2-6 years) to assess their nutritional status using MUAC and thereby estimating the rates of undernutrition based on MUAC. The present study also compared the data of MUAC after normalization through LMS (Cole & Green, 1992), with other available data of standard references (de Onis et al., 1997; WHO, 2007).

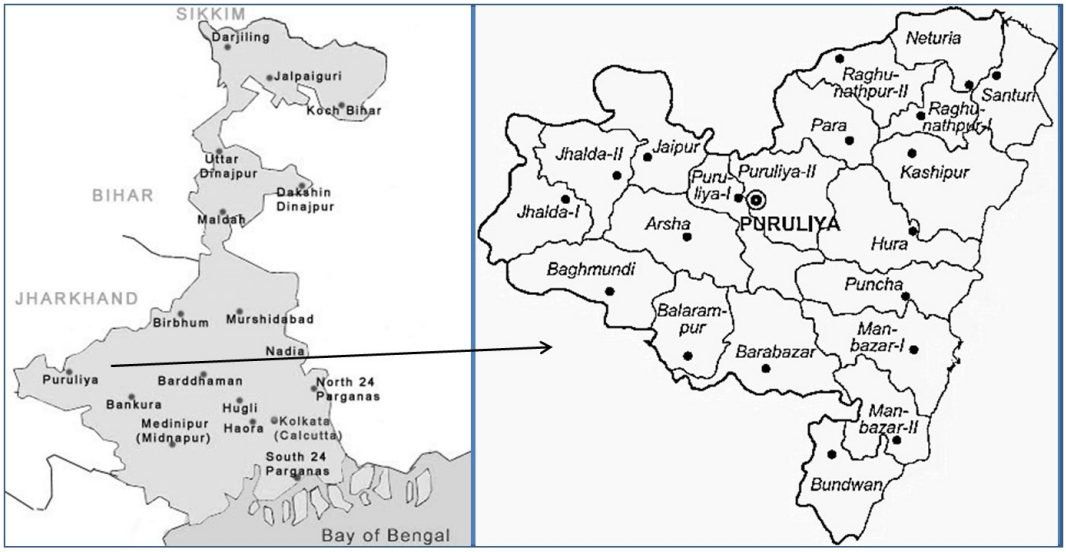
MATERIALS AND METHODS

Subjects: The present study was cross-sectional, conducted among the Santal and Bauri children in more than 30 villages of Purulia district (Figure 1) in West Bengal, India. The study was conducted during 2009-2011 on a sample size of 1013 children (Bauri = 499 and Santal = 514) aged 2–6 years. The sampling design was probabilistic in nature.

Table 1: Distribution of sample size by age, sex and community

Age (years)	Bauri			Santal			Overall
	Boys (n)	Girls (n)	Total (n)	Boys (n)	Girls (n)	Total (n)	(n)
2	37	35	72	63	47	110	182
3	47	52	99	41	57	98	197
4	59	35	94	57	47	104	198
5	83	71	154	61	76	137	291
6	48	32	80	37	28	65	145
Total	274	225	499	259	255	514	1013

Table 1 shows the sample size of the studied children by age, sex and community. It is clear from this table that maximum distribution (sex and community combined) was observed at age of 5 years (291) of the total sample. Maximum distribution of Bauri boys and girls were observed at age of 5 years i.e., (83 and 71). Similarly, maximum distribution of Santal boys was at age 2 years (63) and girls at age of 5 years (137) respectively.



Note: In many other references (available online), the name of the district Purulia is often found as Puruliya. However, they are synonymous.

Figure 1: A map of the Purulia district West Bengal

The Bauris are a comparatively well known sizeable endogamous Hindu caste in West Bengal. The total Bauri population in West Bengal is 1,091,022, constituting 5.9% of the total scheduled caste (low social status) population of the state. In Purulia district, the Bauri population is 209,080, constituting 8.2% of the total scheduled caste population of the district (Census (Puruliya), 2011). Primary occupation of the Bauris is agriculture and daily-labour. Some of them are also engaged in selling various items of merchandise in trains and buses. Their other traditional occupation is palanquin-bearing, that has become relatively rare now-a-days. Socio-economic status and literacy rate of Bauris are very low (Risley, 1981).

The Santals belong to the Proto-Australoid group with dark skin colour, sunken nose and lower forehead. Out of the total population of Purulia district, 19.22% belongs to Scheduled Tribes. Santals comprise 62.66 % of the total tribal population of Purulia, West Bengal. Purulia district has the second highest percentage of tribal population (18.3%) after Jalpaiguri district (18.9%) in West Bengal (Census (West Bengal), 2011).

Parents, villagers and block (an administrative jurisdiction) authorities were informed about the plans and objectives of present study in advance. Anthropometric measurements and other socio-economic data were collected from the community through household visits. Mid-upper arm circumferences (MUAC) were recorded to its nearest 0.1 cm. using a non-stretchable measuring tape. The WHO (1995) recommended cut-off points of MUAC (cm) by age and sex were utilized to determine nutritional status. The estimated sample size for each age and sex was calculated to be 32 by the formula: $n = (z^2pq)/d^2$ (Cochran, 1977), where $z = 1.96$, p is the prevalence of malnutrition (30.0 %) in preschool children from age 2 to 6 years, $q = 1 – p$ and d is the desired precision (5.0 %). The samples were adequate by age and sex as per estimated sample size calculation except for age 6 years among Santal girls. Age of the children was documented from the birth certificates provided by nearest Public Health Center (PHC), immunization card, and the information provided by the volunteer-teachers of *Anganwadi* (a social service unit of the local Government) and was also subsequently confirmed from their parents. Age of the subjects was considered to the nearest whole number. Thus, the appropriate (to the nearest whole age) cut-off values were utilized.

Descriptive statistics of mean and standard deviations of MUAC by age and sex were computed. Student's t- test was performed to test the sex difference in MUAC. Analysis of

variance (ANOVA) was done to test the differences in the mean values of MUAC by age. Chi-square (χ^2) test was also performed to see the significant difference in the prevalence of undernutrition by age and sex.

Normalized MUAC-for-age of the Santal and Bauri children by sex was computed through LMS method (Cole & Green, 1992), using the software LMS ChartMaker Pro (version 2.4). Decimal age was used and the LMS method was performed through Box-Cox (Box & Cox, 1964) power transformation (with power L) and thereby normalized the data (MUAC) at any given age (between 2 and 6 years). The distribution of MUAC by age was characterized by L (Lambda), M (the generalized mean/median) and S (the generalized coefficient of variation). The effective degrees of freedom (e=3, d=5 and f=3) values for L, M and S respectively were selected to reach significant P-deviance value (-6.0 for boys and -7.4 for girls) and the LMS splines with rescaled age were used for smoothing the MUAC values across different ages. The estimated z-scores was generated ranging between–2 and +2 standard deviation (SD) for MUAC by age (in years), sex and also both sex combined and the results were exported to Microsoft Excel spreadsheet. The normalized MUAC scores and graphs were used to compare with corresponding standard age-sex references (de Onis et al., 1997; WHO, 2007).

All statistical analyses were performed using the Statistical Package for Social Science (SPSS/PC- Version 16) and Microsoft office excel. Statistical significance was set to a value of $p < 0.05$. Ethical approval was obtained from the Ethical Committee of Vidyasagar University, before the commencement of the study.

RESULTS

Age of the children was ranging between 1.97 years (23.64 months) and 6.59 years (79.08 months). Mean age of Bauri boys (4.21 years ± 1.25 standard deviation or SD) was significantly different ($t=2.87$, $p< 0.01$) from that noted in Santal boys (3.89 years ± 1.34 SD). However, mean age among Santal girls (3.95 years ± 1.27 SD) did not vary from that recorded among Bauri girls (4.06 years ± 1.27 SD) (Table 2).

Table 3 presents the mean, standard deviation (SD), and the results of t-test and F-test (ANOVA) of the children. There was a gradual rise of mean MUAC except for age 6 years

among Santal boys and girls. Negatively significant ($p< 0.05$) differences in MUAC were observed at age 3 and 5 years among Bauris. It showed that girls of age 3 and 5 years had higher

Table 2: Distribution of age among children in years and corresponding months

Community	Gender	Age	Minimum	Maximum	Mean	SD
Bauri	Boys	years	1.97	6.51	4.21	1.25
		months	23.64	78.12	50.50	15.03
	Girls	years	1.95	6.47	4.06	1.27
		months	23.40	77.64	48.66	15.28
Santal	Boys	years	1.95	6.57	3.89	1.34
		months	23.40	78.84	46.63	16.09
	Girls	years	1.95	6.59	3.95	1.29
		months	23.40	79.08	47.34	15.44

Table 3: Distribution of mean mid-upper arm circumference (MUAC) by age, sex and community

Age	Bauri			Santal		
(years)	Boys	Girls	t	Boys	Girls	T
2	13.12 (0.92)	13.42 (1.01)	-1.31	13.50 (1.00)	13.27 (0.84)	1.24
3	13.25 (0.79)	13.71 (0.93)	-2.66**	13.53 (0.91)	13.55 (0.85)	-0.13
4	13.89 (0.98)	14.17 (0.81)	-1.43	14.11 (0.80)	14.04 (0.78)	0.46
5	14.15 (0.95)	14.73 (0.88)	-3.88***	14.33 (1.06)	14.48 (0.87)	-0.93
6	14.65 (0.87)	14.84 (0.99)	-0.91	13.96 (0.96)	14.36 (0.76)	-1.83
	F= 22.25***	F= 19.66***		8.18***	20.49***	

Standard deviations are presented in parentheses.
Significance at *=p<0.05, **=p<0.01, ***=p<0.001

mean MUAC than boys. Significant age difference in mean MUAC was clearly evident among in both Bauri boys (F= 22.25, p < 0.001) and girls (F= 19.66; p < 0.001). Similarly, significant age difference was also observed among Santal boys (F= 8.18; p< 0.001) and girls (F= 20.49; p< 0.001).

Table 4: Prevalence of undernutrition of the studied children based on MUAC cut-off points (WHO, 1995)

Age (years)	Bauri			Santal		
	Boys (%)	Girls (%)	Chi-square (df= 2)	Boys (%)	Girls (%)	Chi-square (df= 2)
2	45.90	28.60	2.39	33.30	27.60	2.47
3	61.70	36.50	8.20*	48.00	47.40	0.74
4	37.30	31.40	4.56	33.40	36.20	2.61
5	39.70	12.70	15.18***	36.10	17.20	6.70*
6	22.90	3.10	5.90*	48.60	3.60	15.67***
Overall (Age combined)	40.90	22.30	20.54***	38.60	27.80	6.71*

Significance at *=p<0.05, **=p<0.01, ***=p<0.001.

The prevalence of undernutrition using MUAC of the studied children is presented in Table 4. The prevalence of undernutrition in Bauri boys was highest (61.7 %) at age 3 years and highest in girls (36.5 %) at age 3 years. Similarly, prevalence of undernutrition was highest among Santal boys (48.6 %) and girls (47.4 %) at age 6 and 3 years. Positively significant (p< 0.05) sex difference in the prevalence of undernutrition was observed at age 3, 5, 6 years and overall age combined among Bauri children. Similarly, positively significant sex difference (p< 0.05) was also observed at the age of 5 and 6 years and also at overall age combined among Santals. Significant sex difference (age combined) in prevalence of undernutrition was observed among Bauris (χ^2= 20.54; p< 0.001) and Santals (χ^2= 6.71; p< 0.05). Table 5 shows the sex-specific and sex-combined MUAC-for-age reference growth values for children aged 2- 6 years. Median MUAC of girls was higher than boys at all ages except for the age at 2 years.

Table 5: LMS z-scores of MUAC-for-age among the studied preschool children

	Z-scores				
Age (Years)	-2 SD	-1SD	Median	+1 SD	+2 SD
		Both Sex			
2	11.86	12.48	13.23	13.99	14.60
3	12.12	12.73	13.50	14.31	15.00
4	12.53	13.20	14.03	14.89	15.60
5	12.84	13.56	14.42	15.26	15.93
6	13.02	13.75	14.62	15.45	16.10
		Boys			
2	11.87	12.50	13.27	14.04	14.66
3	11.98	12.59	13.36	14.16	14.82
4	12.54	13.16	13.98	14.87	15.65
5	12.77	13.43	14.27	15.18	15.95
6	13.00	13.70	14.56	15.43	16.13
		Girls			
2	11.89	12.40	13.04	13.69	14.24
3	12.49	12.97	13.62	14.38	15.09
4	13.07	13.54	14.20	14.96	15.66
5	13.56	14.04	14.67	15.36	15.98
6	13.80	14.27	14.89	15.56	16.14

DISCUSSION

High proportion of children in developing countries is already nutritionally deprived when they are preschoolers. Many are born as preterm, have low birth weight; poor maternal micronutrient status during pregnancy contributes to lower nutrient deposition *in utero*; poor maternal micronutrient status during lactation lead to nutritional deficiency in infancy and these deficits act as the "programming factors" for inappropriate growth and development in later phases of life (WHO, 1995).

Normalized scores of MUAC-for-age by sex of the children in the present study have been compared with standard references (de Onis et al., 1997; WHO, 2007) (Table 6). It was evident from the table 6 and figures (2 and 3) that there was difference in subcutaneous fat (beneath skin) of either boys or girls between the samples drawn in 1997 (de Onis et al., 1997) and 2007 (WHO, 2007) MUAC-for-age. The maximum difference of MUAC among boys between the presently studied sample and the reference values (de Onis et al., 1997) was 4.65 cm

Table 6: Comparison between the normalized MUAC by age of the children in present study and the standard references of de Onis et al., (1997) and WHO (2007) growth reference data for corresponding age-group (2-5 years)

Age (Years)	Z-Scores	de Onis et al., 1997	WHO, 2007	Present study	de Onis et al., 1997	WHO, 2007	Present study
		Boys			Girls		
		MUAC-for-age					
2	-2 SD	13.6	13.0	11.87	13.4	12.7	11.89
	-1 SD	14.9	14.0	12.50	14.7	13.7	12.40
	Median	16.2	15.2	13.27	16.0	14.9	13.04
	+1 SD	17.6	16.4	14.04	17.4	16.1	13.69
	+2 SD	18.9	17.7	14.66	18.7	17.5	14.24
3	-2 SD	13.8	13.5	11.98	13.6	13.3	12.49
	-1 SD	15.2	14.5	12.53	15.0	14.4	12.97
	Median	16.6	15.7	13.36	16.4	15.6	13.62
	+1 SD	18.0	17.1	14.16	17.8	17.0	14.38
	+2 SD	19.3	18.3	14.82	19.2	18.5	15.09
4	-2 SD	14.1	13.7	12.54	13.9	13.6	13.07
	-1 SD	15.5	14.9	13.16	15.4	14.9	13.54
	Median	17.0	16.1	13.98	16.8	16.2	14.20
	+1 SD	18.4	17.6	14.87	18.3	17.8	14.96
	+2 SD	19.9	19.1	15.65	19.8	19.4	15.66
5	-2 SD	14.2	14.0	12.77	14.1	14.0	13.56
	-1 SD	15.8	15.2	13.43	15.7	15.4	14.04
	Median	17.4	16.5	14.27	17.3	16.9	14.67
	+1 SD	19.0	18.0	15.18	18.9	18.5	15.36
	+2 SD	20.6	19.8	15.95	20.5	20.4	15.98

at + 1 SD and minimum 1.43 cm at -2 SD at the age of 5 years; and with respect to WHO (WHO, 2007), the maximum difference was 3.85 cm at + 1 SD at the age of 5 years and minimum difference was 1.13 cm at -2 SD at 2 years. Likewise, among the girls of the present study, the maximum difference was 4.52 cm at + 1 SD and minimum difference was 0.54 cm at – 2 SD at the age of 5 years (in comparison with an earlier reference (de Onis et al., 1997). When compared with other reference (WHO, 2007), the maximum difference was 4.42 cm at + 1 SD and minimum difference was 0.44 cm at – 2 SD at the age of 5 years.

Figures (2 and 3) show the median MUAC of the studied children in comparison with de-Onis et al., (1997) and WHO (2007) reference values of median MUAC. It was amply evident that for both boys (Fig. 1) and girls (Fig. 2), there existed an increasing age trend in median MUAC. The boys and girls of the present study consistently had lower median MUAC by age in

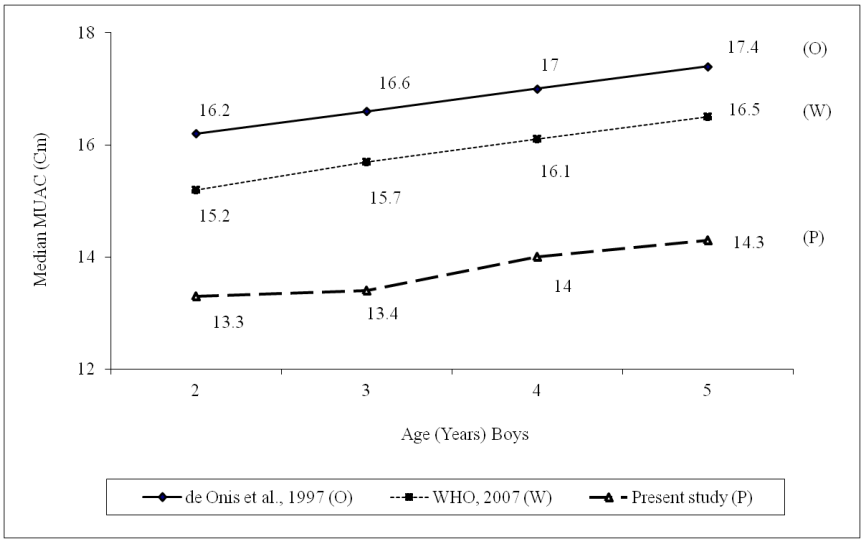


Figure 2: Comparative median values of boys of studied children with reference values aged (2-5) years

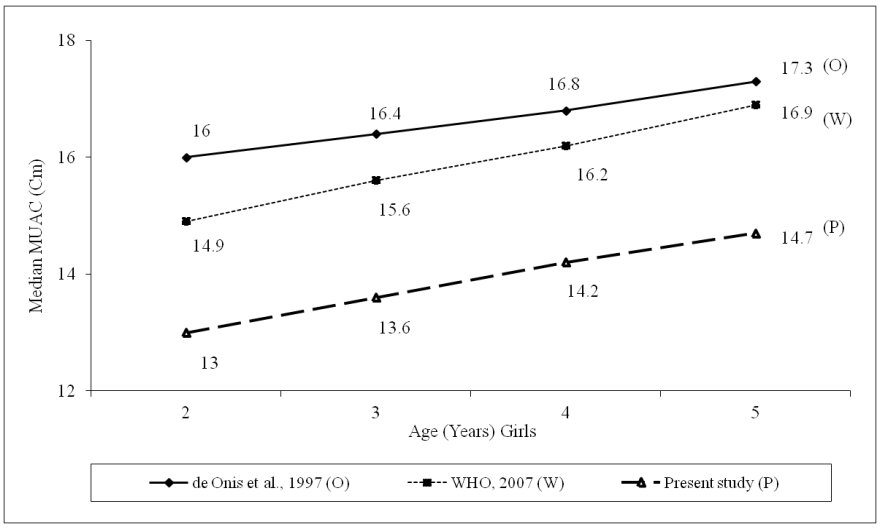


Figure 3: Comparative median values of girls of studied children with reference values aged (2-5) years

comparison with the standard references (de Onis et al., 1997; WHO, 2007). With respect to data of 1997 (de Onis et al., 1997), among boys, differences of median MUAC ranged from 2.93 cm (minimum at 2 years) to 3.24 cm (maximum at 3 years). Similarly, with respect to the data of 2007 (WHO, 2007), the difference of MUAC at the age of 2 years was 1.93 cm (minimum) and

2.34 cm (maximum) at the age of 4 years among boys. Difference of median MUAC among girls was minimum (2.6 cm) at 4 years and maximum (2.96) at 2 years, with respect to the reference (de Onis et al., 1997). Likewise, the girls of the present study had minimum difference (1.86 cm) at 2 years and maximum difference (2.23 cm) at 5 years of age.

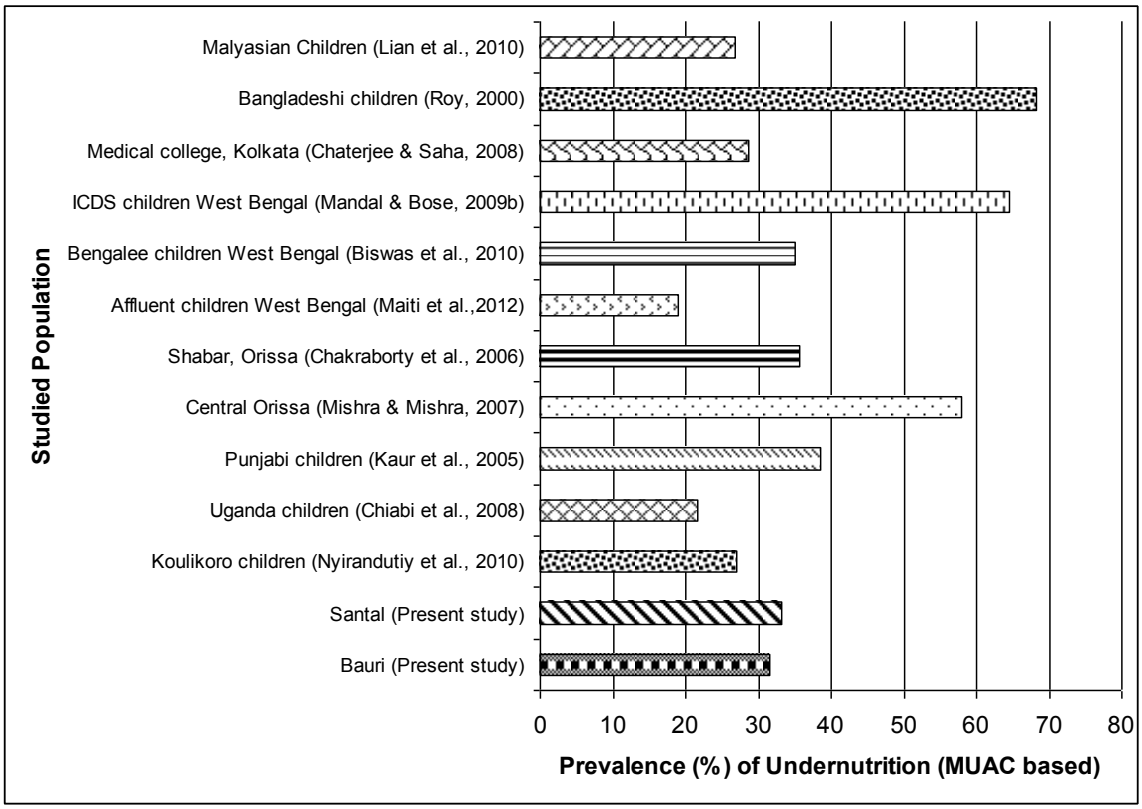


Figure 4: Comparative prevalence of undernutrition (MUAC based) with Regional, National, and International populations

Figure 4 presents the comparative prevalence of undernutrition using MUAC with other international, national and regional studies among children below 6 years of age. It is clear from the figure that the overall highest (68.3 %) prevalence of undernutrition was observed among the Bangladeshi children (Roy, 2000) and the least (18.96 %) prevalence was observed among the affluent Bengalee children of West Bengal (Maiti et al., 2012). It is also clear from the figure that out of the four international studies Bangladeshi children (Roy, 2000) had the highest (68.3 %) and Ugandan children had lowest (21.6 %) prevalence of undernutrition using MUAC. Of the national studies, children of Central Orissa (Mishra & Mishra, 2007) had the highest (58.0 %) and Shabar children of Orissa (Chakraborty et al., 2006) had the lowest (35.6 %) frequency of

undernutrition. Out of four studied regional (in West Bengal) populations, affluent Bengalee Maiti et al., 2012) children had the lowest (18.96 %) prevalence of undernutrition using MUAC.

CONCLUSION

In conclusion, it was clear that the children in the present study showed remarkable differences in MUAC-for–age in comparison with standard references (de Onis et al., 1997; WHO, 2007). It was clear that 39.8 % boys and 25.1 % girls (age and community combined) showed undernutrition as per MUAC-for-age reference (WHO, 1995). Most importantly the median MUAC values of both boys and girls of the studied children were much lower than the other two reference values at all ages (de Onis et al., 1997; WHO, 2007). Further research on development of growth reference data of MUAC, representing communities with larger sample size, and wider geographical regions will be more effective. The present study as a preliminary one, could at least open up that possibility of further research in that direction.

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Ethical approval: Obtained.

Competing interest: No profits in any form have been established or will be established from a profitable party related directly or indirectly.

Contributors: SD conceptualized this study, collected-analyzed data and contributed in preparing this manuscript. SDB undertook statistical analyses and contributed in preparing the paper. KB conceptualized this study, contributed in preparing and finalizing the manuscript.

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