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Socio-economic and Demographic Correlates of Stunting and Thinness among Rural School-going Children (Aged 5-12 Years) of North Bengal, Eastern India

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ABSTRACT Prevalence of stunting and thinness and their associations with socio-economic and demographic variables were assessed among 619 boys and 643 girls aged 5-12 years residing in Phansidewa block of Darjeeling district, West Bengal, India. Age-gender specific z-scores were calculated to assess stunting and thinness using Anthro Plus. Statistical analyses (descriptive statistics, t-test, ANOVA, Chi-square analysis and binary logistic regression, step-wise multiple logistic regression) were done using SPSS. Overall prevalence of stunting and thinness were 31.8 percent and 27.7 percent, respectively. Prevalence of stunting was lower among boys (31.3%) than girls (32.2%). Thinness was significantly higher among boys (31.0%) than girls (24.4%). Binary logistic regression analysis showed that age, number of sibs and mothers' occupation were significantly associated with stunting. Gender (boys), age, number of sibs, birth order, mothers' occupation and number of income heads of the family had shown a significant association with thinness. Step-wise multiple logistic regression analysis also showed significant association with age, number of sibs and mothers' occupation (in stunting) and gender and age (in thinness) ($p<0.05$).

INTRODUCTION

Nutritional issues have been greatly elevated on the global development agenda and have been committed in reducing prevalence of undernutrition especially among the vulnerable segments of a population (that is, children and women). Undernutrition undoubtedly is a serious public health challenge in many of the developing countries including India (Nandy et al. 2005; Bhargava et al. 2015; Kromeyer-Hauschild et al. 2016; Madrid and Traisci-Marandola 2016). Child undernutrition is acknowledged to play a major role in premature mortality and morbidity of millions of children in the developing countries. Even if it does not cause death, it accounts for several vulnerable infections and diseases, blighting the lives of millions of children (Nandy and Miranda 2008; Black et al. 2013). Child undernutrition is estimated to be the largest contributor to global burden of disease, killing millions of children in the developing countries and causing heavy health expenditures (Black et al. 2003; Lenoir-Wijnkoop et al. 2013). The prevalence of undernutrition was estimated to be implicated in 45.0 percent of all deaths among children <5 years (Black et al. 2013) and India accounted for 38.0 percent of the global burden due to stunting (low height-for-age) (nearly 62 million children) (UNICEF 2013). It has been estimated that approximately two-thirds of the world's malnourished children live in Asia, giving that region the highest concentration of worldwide childhood undernutrition (Ramachandran 2014; UNICEF/WHO 2016). India continues to have unacceptably high rates of undernutrition (Ramachandran 2014) and has the highest occurrence of childhood undernutrition in the world with more than half of Indian children remaining undernourished. The prevalence of childhood undernutrition remains persistently high in India (Khor 2008; Ramachandran 2014; Corsi et al. 2015; Smith and Haddad 2015; Aguayo et al. 2016; Ali et al. 2016; Dhok and Thakre 2016; Saxton et al. 2016; Mandal 2017; Patil et al. 2017).

Significant economic developments have taken place in India but child undernutrition

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(>40.0%) still remains a major public health problem in the country (Ramachandran 2014). Widespread poverty and poor socio-economic conditions are considered to be the two main underlying causes for the high rate of child undernutrition (Antony and Laxmaiah 2008; Khor 2008; Ahmed et al. 2012; Ramachandran 2014). It has been estimated that more than half of the children in the country remain undernourished and also that the country has shown the highest occurrence of global child undernutrition (Khor 2008; Antony and Laxmaiah 2008; Ahmed et al. 2012). Moreover, studies have reported gender discrimination against the female child, that is, that they were more nutritionally more vulnerable than boys (Bose et al. 2007; Mondal and Sen 2010; Sen and Mondal 2012; Tigga et al. 2015a,b; Aurino 2017; Pal and Bose 2017). Child undernutrition is also influenced by several socio-economic and demographic variables such as age, gender, birth order, family size, number of siblings, mother's age at childbirth, residence, family income and sanitation (Mahgoub et al. 2006; Som et al. 2007; Mondal and Sen 2010; Ahmed et al. 2012; Sen and Mondal 2012; Mondal et al. 2015a; Tigga et al. 2015a; Zhang et al. 2015; Rengma et al. 2016; Huda et al. 2017; Meshram et al. 2017; Sinha et al. 2017). Studies have also revealed wide socio-economic differences in rates of morbidity and mortality among children (Nandy et al. 2005; Kismul et al. 2015; Goudet et al. 2016; Mohsena et al. 2016; Kumar et al. 2017).

Anthropometric measures are still considered to be the reliable non-invasive, inexpensive and widely accepted technique to assess child undernutrition. The measures mostly comprise of height, weight and skin-fold thickness measurements (WHO 1995; Hall et al. 2007). The most commonly used conventional anthropometric measures are stunting, underweight, wasting (low weight-for-height) and thinness {low body mass index (BMI)-for-age}(WHO 1995, 2007; Nandy et al. 2005; Mondal and Sen 2010; Sen and Mondal 2012)**.** When a vast segment of the population remains undernourished and underprivileged, studies on prevalence of child undernutrition remain important for both international and national comparisons. The effects of different socio-economic, demographic and lifestyle factors on undernutrition also need to be reported. Special attentions are required on inequalities in health status during the early years of life as these are likely to perpetuate inequality among these future adults.

Objectives

With these above-mentioned issues in mind, the present investigation was carried out with the following objectives:

1. To determine prevalence of stunting and thinness among rural school-going children aged between 5-12 years of Darjeeling district of West Bengal, India.
2. To ascertain possible associations of certain socio-economic, demographic and lifestyle variables on the prevalence of stunting and thinness.

METHODOLOGY

The present cross-sectional investigation was carried out among 1262 school going children (boys: 619; girls: 643) aged 5-12 years residing in rural areas of Phansidewa Block of the district of Darjeeling, West Bengal, located in the eastern part of India. This region is popularly known as North Bengal and constitutes the districts of Darjeeling, Jalpaiguri, Koch Behar, Kalimpong, Alipurduar, North Dinajpur, South Dinajpur and Malda. The Phansidewa Block (Latitude 26º34´59´´ N, Longitude 88º22´00´´ E) is situated near the Indo-Bangladesh border and ~35–40 km from the sub-divisional town of Siliguri. It covers an area of 308.65 km^2. According to the National Census of 2011, the block has a total population of 1,71,508 individuals (males: 87,945; females: 83,563) with the literacy rate of 41.6 percent (males: 51.9%; females: 30.8%). The residents of Phansidewa block have access to all the basic amenities, such as hospitals, schools, markets, post office and government offices (Mondal and Sen 2010; Sen and Mondal 2013). Children who participated in this investigation were enrolled in 12 primary schools located under three Gram Panchayats (a village level local governing authority) viz., Phansidewa Gram Panchayat, Liusipakuri Gram Panchayat and Chathat Gram Panchayat.

The schools were identified based on the following two criteria:

1. Student strength of at least 120 students per class so that the minimum sample size could be covered

2. The schools were based on convenience and easy road accessibility from the block level town of Phansidewa

To avoid possible sampling bias, schools having poor students' strength, low school attendance and located in very remote locations were excluded. Finally, twelve primary schools were selected and data for the present investigation was recorded from students studying in those schools. The children were selected using a stratified random sampling method. The dates of birth of the children were collected from their birth certificates issued by the Government. A total of 1312 children (boys: 650; girls: 660) aged 5-12 years were identified and approached. Of these, 50 children (boys: 31; girls: 19) were excluded because their dates of birth were either not available in the school records and/or were not in the age group selected. Parents of the children were informed about the objectives of the present investigation and a verbal consent was obtained prior to data collection. Participation was purely voluntary. The fieldwork was conducted in accordance with the ethical guidelines for human experiments, as laid down the Helsinki Declaration of 2000 (Touitou et al. 2004).The children were free from any physical deformities, previous histories of medical and surgical episodes and not suffering from any disease at the time of data collection. The data were collected during the period from September 2014 to September 2015.

Socio-economic, Demographic and Lifestyle Variables

Data on age, gender, parents' occupation and nature of occupation, parents' education, monthly family income, family size, family types, house-conditions, electricity facility, sanitary toilet condition and drinking water facilities were collected using a pre-structured schedule. The schedule was filled up by interviewing the parents of the children. The interviews were conducted by both school and households visits. Ample care was taken while briefing the questions to the respondents for valid responses at the time of data collection. A modified version of Kuppuswamy's socio-economic scale was used to evaluate the socio-economic status (SES) of the children. This scale is based on a score calculated from education, occupation and monthly income (Kumar et al. 2007). The SES determination showed that all the children belonged to lower-middle SES.

Anthropometric Measurements Recorded

Anthropometric measurements of height and weight were recorded using standard procedures (Hall et al. 2007). The children were measured with ample precision for avoiding any possible systematic errors of anthropometric data collection (that is, instrumental or landmarks) (Harris and Smith 2009). Intra-observer and inter-observer technical errors of the measurements (TEM) were calculated to determine the accuracy of the anthropometric measurement using the standard procedure (Ulijaszek and Kerr 1999). For calculating TEM, height and weight were recorded from a different data set of 50 children other than those selected for the anthropometric data collection by two of the authors (SD and NM). The coefficient of reliability (R) of the measurements was calculated for testing the reliability of the measurements. Very high values of R (>0.97) were obtained for height and weight and these values were observed to be within the recommended cut-off of 0.95 (Ulijaszek and Kerr 1999). Hence, the measurements recorded by SD and NM were considered to be reliable and reproducible. All the measurements in this present investigation were subsequently recorded by SD.

Assessment of Nutritional Status

The body mass index (BMI) of the children was calculated using the following standard equation (WHO 1995):

$$BMI\ (kg/m^2) = Weight\ (kg)/Height^2\ (m^2)$$

The assessment of nutritional status was determined based on the anthropometric indices of stunting and thinness. To determine the nutritional status of children, the WHO has recommended use of z-score indicators. The severity of undernutrition has been subsequently assessed by utilizing the z-scores according to the classification proposed by the WHO (1995, 2007). The WHO recommended AnthroPlus (version 1.0.4) was used to calculate age-gender specific height-for-age (HAZ) and BMI-for-age (BMIAZ) z-score values for the assessment of nutritional status (WHO 2007). A child with a z-score value between <–2 to –3 SD and <–3 SD for any indices are considered to be moderately and severely undernourished, respectively (Bose et al. 2007; Chowdhury et al. 2008; Mondal and Sen 2010). Thus, boys and girls with z-score values of <–2 to –3 SD have been classified as suffering from moderately stunting and thinness. Those having a Z-score value of < –3 SD have been classified as suffering from severe stunting and thinness (WHO 1995).

Statistical Analysis

The data were statistically analyzed using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL; version 17.0). The descriptive statistical analysis of the data obtained was depicted in terms of mean and standard deviation (SD). One way ANOVA has been performed to test the age-specific mean differences in anthropometric variables of the groups. Independent sample t-test was done to assess gender difference in mean values of anthropometric variables. Two-way ANOVA was performed to determine effects of age and gender on the anthropometric variables, HAZ and BMIAZ. Chi-square (χ^2) analysis was used to assess age and gender specific differences in prevalence of undernutrition. The c^2-analysis was also applied to assess differences in the nutritional indices between different socio-economic and demographic variables. A binary logistic regression (BLR) model was fitted to estimate the crude odds ratios (ORs) and 95 percent confidence intervals (CIs) associated with stunting and thinness, separately. A step-wise multiple logistic regression analysis (forward conditional model) analysis was also undertaken to determine the most effective predictor variables amongst variables considered in BLR analysis. Those variables which showed a significant association in the BLR analysis were tested to predict the most effective predictor variables in the step-wise multiple logistic regression analysis. The predictor variables of gender, age, family size, number of sibs, child birth order fathers occupation, mothers occupation (working and housewife), number of income heads, monthly income, house condition, water supply, number of living rooms, ethnic group were entered as dummy variables and results were obtained by comparing with reference categories, separately. The p-value of <0.05 was considered to be statistically significant.

RESULTS

Descriptive Statistics

Age and gender-specific subject distribution, means and standard deviation of the height, weight, BMI, HAZ and BMIAZ among boys and girls are depicted in Table 1. The age and gender specific mean values showed that boys were significantly heavier and slightly taller than girls. Using independent sample t-test, age specific mean differences of all the anthropometric variables were observed to be highly statistically significant ($p<0.01$). Age-gender specific mean values of height and weight were observed to progressively increases with age among children, except among 12 years boys (in weight) and girls (in height and weight). Age-gender specific comparisons of overall mean values of height and weight of the children have been showed in Figure 1. The age-specific mean values did not showing any age-specific general trend. Age-specific mean BMI values were observed to be slightly higher among boys than girls, especially in early ages (that is, 5-8 years), but observed to be slightly higher among girls in older ages (that is, 9-10 years and 12 years). The mean age and gender specific BMI values ranged from 14.00 kg/m^2 (in 8 years) to 15.31 kg/m^2 (in 11 years) and 13.57 kg/m^2 (in 6 years) to 15.36 kg/m^2 (in 10 years) among boys and girls, respectively. The overall mean HAZ value was observed to be higher among boys (-1.34±1.19) than girls (-1.33±1.05), but on the contrary the value was observed to be slightly higher among girls (-1.51±1.09) than boys (-1.49±1.11) in BMIAZ. The age-gender specific mean HAZ and BMIAZ values did not show any age-specific trend. Gender-specific mean differences in anthropometric variables of height (F-value= 1.729, d.f.,1,1261), weight (F-value= 2.317, d.f.,1,1261), BMI (F-value= 1.037, d.f.,1,1261), HAZ (F-value=0.107, d.f.,1,1261) and BMIAZ (F-value= 0.051, d.f.,1,1261) were observed to be statistically not significant among both gender using ANOVA. Two way ANOVA showed that there were statistically insignificant mean differences between the groups with respect to age and gender in case of height (F-value=1.305), weight (F-value=0.344) and BMI (F-value=0.412). The age-specific mean difference observed to be statistically significant using ANOVA in cases of height,

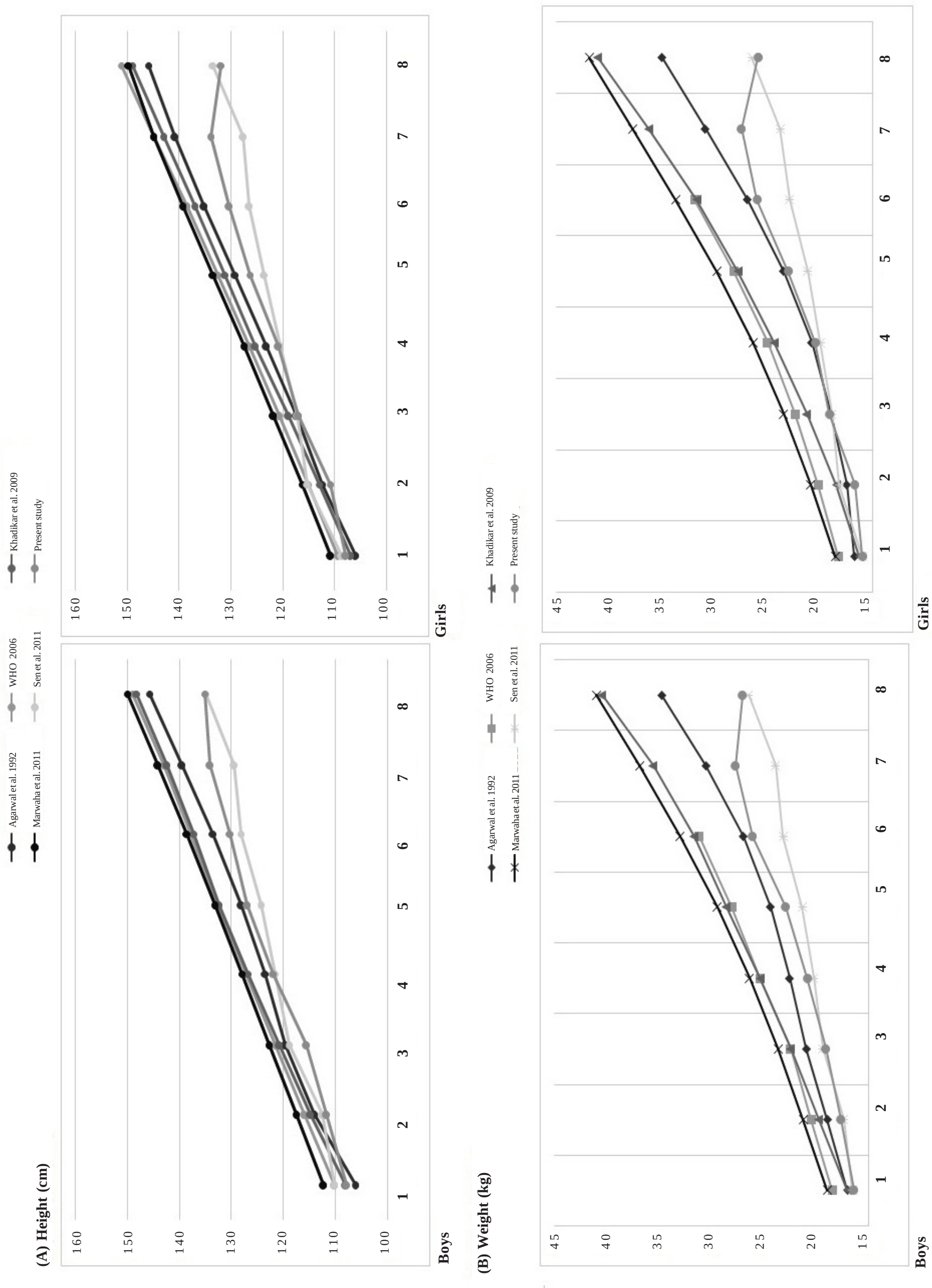

Fig. 1. Age and gender-specific mean comparison of height and weight with Indian children

weight, BMI, HAZ and BMIAZ among boys and girls (Table 1).

Prevalence of Stunting and Thinness among the Children

The age-gender specific prevalence of stunting and thinness among the children is depicted in Table 2. Overall prevalence of stunting and thinness were observed to be 31.8 percent (boys: 31.3%; girls: 32.2%) and 27.7 percent (boys: 31.0%; girls: 24.4%) respectively. Age and gender specific prevalence of overall stunting prevalence was observed to be higher (66.7 % in boys and 68.8% in girls) aged 12 years and whereas, lower prevalence (25.0% in boys and 14.8% in girls) was observed among aged 10 years and 5 years, respectively. Similarly, age-gender specific prevalence of thinness was higher (55.6% in boys and 50.0% in girls) among those aged 12 years. A lower prevalence of thinness was observed (22.7% in boys and 19.8% in girls) aged 10 years and 7 years, respectively. The overall prevalence of moderate stunting and thinness was observed to be higher among boys (25.0% and 24.6%) than girls (24.6% and 19.6%), but severe stunting was higher among girls (7.6%) as compared to boys (6.3%). The overall prevalence of severe grades of thinness was higher among boys (6.5%) than girls (4.8%). The age/gender-specific moderate and severe grades of stunting and thinness did not show any age-specific trends. The age and gender specific prevalence of moderate grade of stunting was observed to be higher in 12 years (41.7%) among boys and in 11years (31.9%) among girls. Prevalence of severe grade of stunting ranged from 2.8 percent (in 6 years) to 25.0 percent (in 12 years) among boys, and from 2.0 percent (in 7 years) to 40.6 percent (in 12 years) among girls. The age-specific prevalence of moderate thinness was higher among boys (36.1%) and girls (28.1%) of 12 years. The age-specific prevalence of severe grades of thinness was also higher among boys (19.4%) and girls (21.9%) aged 12 years. The prevalence of moderate and severe grades of thinness ranged from 20.3 percent (in 11 years) to 36.1 percent (in 12 years) and 1.4 percent (6 years) to 19.4 percent (12 years) among boys respectively. Using χ^2-analysis, gender differences in the prevalence of overall stunting was statistically not significant but observed to be significant in thinness. Gender differences in

Table 1: Age and gender specific mean and standard deviation of anthropometric variables among the children

Age Group	Sample size		Height (cm)				Weight (kg)				BMI (kg/m^2)				HAZ				BMIAZ			
	Boys	Girls	Boys		Girls		Boys		Girls		Boys		Girls		Boys		Girls		Boys		Girls	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
5 years	54	54	107.91	6.66	107.96	5.55	16.47	2.79	16.01	1.85	14.13	1.76	13.73	1.09	-1.05	1.41	-0.83	1.05	-1.07	1.45	-1.18	0.87
6 years	72	90	111.77	6.00	110.95	5.97	17.71	2.54	16.73	2.32	14.14	1.31	13.57	1.39	-1.39	1.02	-1.27	1.16	-1.09	1.10	-1.32	1.11
7 years	96	101	115.68	6.66	117.07	4.91	19.14	2.84	19.15	2.19	14.26	1.44	13.97	1.35	-1.58	1.17	-1.28	0.87	-1.21	1.12	-1.13	0.99
8 years	91	102	122.04	6.79	120.89	5.37	20.90	2.98	20.51	2.78	14.00	1.22	13.99	1.30	-1.34	1.10	-1.42	0.91	-1.52	1.07	-1.29	0.91
9 years	113	101	126.97	5.58	126.44	4.73	22.98	3.10	23.05	3.47	14.23	1.59	14.37	1.58	-1.33	0.92	-1.48	0.75	-1.53	1.23	-1.29	1.00
10 years	88	94	130.26	6.18	130.38	7.03	26.12	5.43	26.02	5.22	15.30	2.25	15.36	7.15	-1.51	0.98	-1.71	1.08	-1.09	1.25	-1.42	1.01
11 years	69	69	134.15	6.74	133.98	6.33	27.74	5.48	27.50	4.99	15.31	1.90	15.23	1.90	-1.69	0.95	-2.11	1.01	-1.39	1.04	-1.35	1.16
12 years	36	32	135.24	7.45	131.95	10.01	27.06	4.43	25.89	5.23	14.70	1.23	14.73	1.61	-2.45	1.18	-2.52	1.73	-2.12	1.02	-2.21	1.44
Total	619	643	122.81	10.80	122.03	10.34	22.11	5.32	21.61	6.24	14.50	1.70	14.34	3.10	-1.34	1.19	-1.33	1.05	-1.49	1.11	-1.51	1.09

Values are parenthesis indicates percentage; $^{**}p<0.01$

Table 2: Age-gender specific prevalence of undernutrition among the children

Age group	Sample size		Stunting (Low height-for-age)						Thinness (Low BMI-for-age)					
			Overall (<-2 SD)		Moderate (<-2 SD to -3 SD)		Severe (<-3SD)		Overall (<-2 SD)		Moderate (-2 SD to-3 SD)		Severe (<-3SD)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
5 years	54	54	15 (27.8)	8 (14.8)	13 (24.1)	8 (14.8)	2 (3.7)	0 (0)	15 (27.8)	13 (24.1)	11 (20.4)	12 (22.2)	4 (7.4)	1 (1.9)
6 years	72	90	27 (37.5)	23 (25.6)	25 (34.7)	20 (22.2)	2 (2.8)	3 (3.3)	17 (23.6)	19 (21.1)	16 (22.2)	16 (17.8)	1 (1.4)	3 (3.3)
7 years	96	101	35 (36.5)	25 (24.8)	25 (26.0)	23 (22.8)	10^{*} (10.4)	2^{*} (2.0)	28 (29.2)	20 (19.8)	24 (25.0)	17 (16.8)	4 (4.2)	3 (3.0)
8 years	91	102	24 (26.4)	26 (25.5)	19 (20.9)	23 (22.6)	5 (5.5)	3 (2.9)	31 (34.1)	23 (22.6)	22 (24.2)	22 (21.6)	9^{*} (9.9)	1^{*} (1.0)
9 years	113	101	21 (18.6)	28 (27.7)	17 (15.0)	26 (25.7)	4 (3.5)	2 (2.0)	43 (38.1)	26 (25.7)	34 (30.1)	22 (21.8)	9 (8.0)	4 (4.0)
10 years	88	94	22 (25.0)	37 (39.4)	18 (20.5)	27 (28.7)	4^{**} (4.6)	10^{**} (10.6)	20 (22.7)	23 (24.5)	18 (20.5)	16 (17.0)	2 (2.3)	7 (7.5)
11 years	69	69	26 (37.7)	38 (55.1)	23 (33.3)	22 (31.9)	3 (4.4)	16 (23.2)	18 (26.1)	17 (24.6)	14 (20.3)	12 (17.4)	4 (5.8)	5 (7.3)
12 years	36	32	24 (66.7)	22 (68.8)	15 (41.7)	9 (28.1)	9 (25.0)	13 (40.6)	20 (55.6)	16 (50.0)	13 (36.1)	9 (28.1)	7 (19.4)	7 (21.9)
Total	619	643	194 (31.3)	207 (32.2)	155 (25.0)	158 (24.5)	39 (6.3)	49 (7.6)	192^{*} (31.0)	157^{*} (24.4)	152 (24.6)	126 (19.6)	40 (6.5)	31 (4.8)

Values in parenthesis indicates percentage; $^{*}p<0.05$; $^{**}p<0.01$

prevalence of age-gender specific moderate and severe grades of stunting and thinness were statistically not significant, but significant differences were observed in case of 7 years (χ^2-value=4.12) and 11 years (χ^2-value= 6.56) (in severe stunting) and 8 years (χ^2-value= 5.38) (in severe thinness), using χ^2 analysis.

Effect of Socio-economic, Demographic and Lifestyle Variables on Prevalence of Stunting and Thinness

Results of the BLR model fitted to estimate the odds ratio of being affected by overall thinness and stunting with certain socio-economic, demographic and lifestyle variables are depicted in Table 3. The results showed that higher risks of being stunted have been observed in cases of higher age groups (9-12 years) (odds ratio: 1.54 times), 2 number of sibs (odds ratio: 2.26 times) and >3 number of siblings (odds ratio: 2.02). The results also showed that children belonging to the working mothers' category exhibited significantly higher risks for stunting (odds ratio: 2.82 times). In case of thinness, boys were in higher risks was observed to exhibit greater odds (odds ratio: 1.38 times) than girls. The odds ratio are significantly higher (odds: 1.29 times) among children belonging to higher ages of 9-12 years. Similarly, children having <1 number of sibs (odds ratio: 2.37 times) and '2 sibs' (odds ratio: 1.51 times) had significantly higher risks for being thin. The children of housewife mothers have significantly higher risk of thinness (odds ratio: 5.93 times) than the working mothers. The presence of more than two income heads in the family showed higher risk (odds ratio: 5.29 times) of thinness.

Step-Wise Multiple Logistic Regression Analysis and Effect of Socio-economic, Demographic and Lifestyle Variables on Prevalence of Stunting and Thinness

Results of the step-wise multiple logistic regression (forward conditional model) analysis undertaken to determine the most independent predictor variables for stunting among children are shown in Table 4. Inclusion of the predictor variables was done based on the criterion that those socio-economic and demographic variables were included which showed a significant association in the BLR analysis ($p<0.05$). In the first step-wise multiple logistic regression, children belonging to the 9-12 years of age group had 1.48 times (95% CI: 1.17-1.88) greater odds ratio of being stunted ($p<0.01$). In the second step-wise multiple logistic regression, the children having 2 and >3 sibs were observed to have 2.40 times (95% CI: 1.42-4.07) and 2.35 times (95% CI: 1.39-3.97), (p<0.01) greater risk, respectively, of being stunted. Similarly, the third step showed that the children having 2 and greater than or equals to 3 sibs were having 2.45 times (95% CI: 1.44-4.17) and 2.41 times (95% CI: 1.42-4.09) greater risk of being stunted. Children of working mothers' had 1.82 times higher risk of being stunted (95% CI: 1.12-2.96). In case of thinness the first step and second step of logistic regression showed that boys had 1.39 times (95% CI: 1.09-1.78) and 1.38 times (95% CI: 1.08-1.77) greater odds ratios respectively and had higher risk of thinness than boys. The second step

Table 4: Step-wise multiple logistic regression analysis and effect of socio-economic, demographic and lifestyle variables on the prevalence of stunting and thinness

Undernutrition	*Variables*		*OR (95%CI) (Step-1)*	*OR (95%CI) (Step-2)*	*OR (95%CI) (Step-3)*
Stunting	Age	5-8 years	1	1	1
		9-12 years	1.48** (1.17-1.88)	1.49** (1.17-1.88)	1.53** (2.21-1.95)
	No. of sibs	<1	-	-	1
		2	-	2.40** (1.42-4.07)	2.45** (1.44-4.17)
		> 3	-	2.35** (1.39-3.97)	2.41** (1.42-4.09)
	Mothers occupation	Housewife	-	-	1
		Working	-	-	1.82** (1.12-2.96)
Thinness	Gender	Boys	1.39** (1.09-1.78)	1.38** (1.08-1.77)	
		Girls	1	1	
	Age	5-8 years	-		
		9-12 years	1	1.29* (1.01-1.65)	

*p<0.05; **p<0.01

Table 3: Binary logistic regression analysis and socio-economic, demographic and lifestyle variables association with stunting and thinness

Variables		*Stunting (N=401)*					*Thinness (N=349)*				
		Prevalence	*χ^2-analysis*	*Crude odds ratio (95% C.I.)*	*Wald*	*S.E.*	*Prevalence*	*χ^2-analysis*	*Crude odds ratio (95% C.I.)*	*Wald*	*S.E.*
Gender	Boys	194 (31.3)	1.01	0.93 (0.73-1.18)	-	-	192 (31.0)	6.87**	1.38** (1.07-1.78)	6.33	0.13
	Girls	207 (32.2)		1	0.35	0.12	157 (24.4)		1		
Age	5-8 years	183 (45.6)	10.46**	1			166 (47.6)	4.33*	1		
	9-12 years	218 (54.4)		1.54** (1.21-1.96)	12.03	0.12	183 (52.4)		1.29* (0.99-1.65)	3.67	0.13
Family Size	< 4	153 (38.2)	0.47	1.09 (0.72-1.65)	0.17	0.21	135(38.7)	0.12	1.03 (0.67-1.59)	0.02	0.21
(No. of individuals)	5-6	204 (50.9)		0.96 (0.64-1.44)	0.04	0.21	175(50.1)		1.00 (0.66-1.52)	0.00	0.21
	>7	44 (11.0)		1	-	-	39 (11.2)		1	-	-
No. of Sibs	<1	32 (8.0)	11.14**	1	-	-	14 (4.01)	1.83	2.37* (1.15-4.86)	5.52	0.37
	2	172 (42.9)		2.26**(1.40-4.00)	8.21	0.12	151(43.3)		1.51* (1.09-2.10)	6.12	0.17
	> 3	197 (49.1)		2.02*(1.36-3.85)	4.94	0.32	184 (52.7)		1	-	-
Birth Order	1	149 (37.2)	5.16*	1	-	-	119 (34.1)	1.29	1	-	-
	2	150 (37.4)		1.25 (0.91-1.73)	1.90	0.12	145 (41.6)		1.25 (0.89-1.74)	1.70	0.17
	> 3	102 (25.4)		1.24 (0.80-1.90)	2.64	0.16	85(24.4)		1.74* (1.11-2.70)	5.99	0.23
Fathers Occupation	Non-cultivator	242 (60.4)	0.78	1.14(0.89-1.47)	1.13	0.13	149(42.7)	0.31	1	-	-
	Cultivator	159 (39.7)		1	-	-	200 (57.3)		1.07 (0.83-1.39)	0.28	0.13
Mothers Occupation	Housewife	378 (94.3)	4.36*	1	-	-	316 (90.5)	1.22	5.93** (1.87-18.93)	9.02	0.59
	Working	23 (5.7)		2.82** (1.14-6.91)	4.28	0.245	33 (9.5)		1	-	-
Income Head	<1	370 (92.3)	1.50	1.56 (0.86-1.83)	1.50	0.22	319(91.4)	0.21	1	-	-
	> 2	31 (7.7)		1	-	-	30(8.6)		5.29** (1.64-17.02)	7.81	0.60
Monthly Income	<3000	93 (23.2)	1.08	1.25 (0.86-1.83)	1.38	0.19	83(23.8)	0.81	0.97 (0.71-1.32)	0.04	0.16
(Rupees)	3001 to 3500	228 (56.9)		1.12 (0.78-1.46)	0.45	0.16	195(55.9)		0.84 (0.57-1.25)	0.73	0.20
	> 3501	80 (20.0)		1	-	-	71(20.3)		1	-	-
House Condition	Bricked	157 (39.2)	0.00	1	-	-	135(38.7)	0.06	1	-	-
	Non bricked	244 (60.9)		0.99 (0.79-1.28)	0.01	0.12	214(61.3)		0.99 (0.76-1.29)	0.09	0.13
Water Supply	Tube well	332 (82.8)	2.36	1	-	-	277(79.4)	0.25	1	-	-
	Dig well and others	69 (17.2)		1.29 (0.94-1.75)	2.46	0.16	72(20.6)		0.97 (0.71- 1.34)	0.02	0.16
No. of Living Rooms	<2	209 (52.1)	1.02	0.98 (0.68-1.51)	0.01	0.21	182(52.2)	1.00	1.12 (0.73-1.71)	0.27	0.22
	3	150 (37.4)		1.01 (0.74-1.37)	0.53	0.21	127(36.4)		1.21 (0.79-1.87)	0.76	0.22
	> 4	42 (10.5)		1	-	-	40 (11.5)		1	-	-
Ethnic Group	General caste	317 (79.1)	0.00	1	-	-	278(79.7)	0.10	1	-	-
	Scheduled caste and tribes	84 (21.0)		1.01 (0.73-1.36)	0.00	0.15	71(20.3)		1.02 (0.74-1.40)	0.01	0.16

Values are parenthesis indicates percentage; *$p<0.05$; **$p<0.01$

showed that children belonging to5-8 years of age group had 1.29 times (95% CI: 1.01-1.65) greater odds ratio and higher risk of thinness.

DISCUSSION

India's majority of individuals are undernourished and underprivileged due to it's large population size and widespread poverty (Ramachandran 2007, 2014; Mondal and Sen 2010; Thakur and Gautam 2015; Tigga et al. 2015a; Aurino 2017; Seshadri and Ramakrishna 2018). Poverty is considered to be a major underlying cause of such widespread undernutrition (Ramachandran 2007; Gopalan 2013; Varadharajan et al. 2013).The present investigation has highlighted prevalence of stunting and thinness among rural children of Darjeeling district of West Bengal, India. The overall prevalence of stunting was (31.8%) higher than that of thinness (27.7%) (Table 2). Several studies had already reported significant associations between parents' service and/or employment categories, monthly family income (Abudayya et al. 2009; Zelellw et al. 2014; Tigga et al. 2015a; Matariya et al. 2016; Roy et al. 2016; Meshram et al. 2017), environment, sanitation and household pattern with undernutrition (Herrador et al. 2014; Tigga et al. 2015a; Zhang et al. 2016; Meshram et al. 2017). Age group of the children showed significant association with both stunting and thinness. Mothers' occupation showed significant association with stunting but not with thinness. Studies have reported that family size and the 'number of sibs' had strongly explanatory powers of stunting among children and adolescents (Mondal and Sen 2010; Sen and Mondal 2012; Meshram et al. 2017).

A comparison showed lower values of age-gender specific mean of height and weight in most of the age groups of the children in present investigation than the reported by Agarwal et al. (1992), WHO (2006), Khadilkar et al. (2009) and Marwaha et al. (2011) (Fig. 1). A comparative evaluation of prevalence of stunting among different Indian ethnic populations with that obtained in the present investigation is depicted in Table 5. The comparison suggested that children and adolescents of the country were more vulnerable in terms of stunting and the magnitudes showed very high (>40%) prevalence of undernourishment (Rao et al. 2005; Medhi et al. 2007; Mitra et al. 2007; Prashant and

Table 5: Comparison of the prevalence of stunting among Indian children with present investigation

Population	*Sample size*	*Region*	*Prevalence of stunting (%)*	*Reference*
Tribal pre-school children (Gond)	1022	Madhya Pradesh, India	51.6	Rao et al. 2005
School children	606	Assam, India	50.5	Medhi et al. 2006
Tea garden workers	605	Assam, India	49.8	Medhi et al. 2007
Kamar tribal children	309	Chhattisgarh, India	63.4	Mitra et al. 2007
Santal children	442	West Bengal, India	17.9	Chowdhury et al. 2008
ICDS children	1012	West Bengal, India	30.7	Mandal et al. 2009
Girls from urban slum area	223	Andhra Pradesh, India	47.0	Prashant and Shaw 2009
Shabar Tribe	577	Orissa, India	45.6	Chakrabarty and Bharati 2010
Rural adolescents	1870	West Bengal, India	45.6	Mondal and Sen 2010
Rural children	1870	West Bengal, India	41.7	Mondal and Sen 2010
Rajbanshi	1870	West Bengal, India	35.9	Mondal and Sen 2010
Bengalee Muslim	1870	West Bengal, India	33.7	Mondal and Sen 2010
Early adolescent school girls	2545	West Bengal, India	32.5	Maiti et al. 2011
Slum children	194	Maharashtra, India	57.2	Bhavsar et al. 2012
Santal pre-school children	299	West Bengal, India	54.2	Bisai 2014
Lodha pre-school children	119	West Bengal, India	29.8	Bisai et al. 2014
Karbi-Anglong adolescents	864	Assam, India	51.2	Mondal and Terangpi 2014
School children	561	Uttar Pradesh, India	23.3	Singh et al. 2014
School children	350	Aligarh, India	68	Sultan 2014
Pre-school children	6183	Meghalaya, India	35.5	Duwarah et al. 2015
Children	3654	West Bengal, India	24.5	Mondal et al. 2015b
Children	2561	Maharashtra	22.7	Aguayo et al. 2016
Slum children	256	Central India	34.8	Dhok and Thakre 2016
Rajbanshi girls	500	West Bengal, India	39.6	Roy et al. 2016
Rural indigenous communities	1227	Eastern India	55.7	Saxton et al. 2016
Anganwadi school children (rural)	100	Central India	37.0	Patil et al. 2017
School going children of North Bengal	1262	West Bengal, India	31.8	Present Study

Shaw 2009; Chakrabarty and Bharati 2010; Mondal and Sen 2010; Bhavsar et al. 2012; Ghosh and Sarkar 2013; Bisai 2014; Mondal and Terangpi 2014; Sultan 2014; Saxton et al. 2016) (Table 5). The comparison showed that prevalence of stunting in the present investigation was significantly lower than these reported among Santal children of West Bengal (54.2%) (Bisai 2014), school children of Aligarh, Uttar Pradesh (68.0%) (Sultan 2014), Oraon tribal children (54.0%) (Mittal and Srivastava 2006), and school children of Assam (50.5%) (Medhi et al. 2006). The prevalence was lower than that has been reported among children belonging to Rajbanshi (35.9%), Bengali Muslim (33.7%) and Tea-labourer (41.7%) populations of Darjeeling, North Bengal (Mondal and Sen 2010). The prevalence of stunting was also lower than those reported among tribal children of Madhya Pradesh (51.6%) (Rao et al. 2005), Kamar children of Chhattisgarh (50.0%) (Mitra et al. 2007), slum children of Central India (34.8%) (Dhok and Thakre 2016), Rajbanshi girls of West Bengal (39.6%) (Roy et al. 2016), indigenous communities of Jharkhand and Odisha (55.7%) (Saxton et al. 2016) and *anganwadi* school children of rural central India (37.0%) (Patil et al. 2017). The present investigation showed higher prevalence of stunting than the children of Maharashtra (22.7%) (Aguayo et al. 2016).

The results of the present investigation also showed that prevalence of stunting was slightly higher among boys than girls (Table 2). The proposed public health assessment classification suggestions that these above-mentioned populations (prevalence=>20%) require to have an implementation of nutritional interventions for necessary betterment of nutritional status (WHO 1995). The present investigation also showed that girls were slightly more nutritionally vulnerable (that is, affected with stunting) than boys, especially when they approached the higher ages (that is, 9-12 years). Several investigations from India have showed gender related trends in undernutrition, where girls were more affected than boys (Bose et al. 2007; Medhi et al. 2007; Mitra et al. 2007; Chowdhury et al. 2008; Dutta et al. 2009; Mondal and Sen 2010; Pal and Bose 2017; Sinha et al. 2017; Seshadri and Ramakrishna 2018). Women, and by extension, girls, customarily eat last and when supplies are insufficient, eat least and this practice is one of the major factors and underlying cause of female malnutrition and low birth-weight infants in the country, given the fact that most rural households face several months of food distress on a recurring seasonal basis (Ramachandran 2014). Several researchers have confirmed that sharp gender disparities prevailed in intra-household access to food is widespread in India, as in most South Asian countries (Ramachandran 2014). It is generally attributed to the fact that boys have a better access to food and basic amenities than girls and there was a pronounced preference for the male child in Indian societies (Ananthakrishnan and Nalini 2002; Kugler and Kumar 2015; Trent et al. 2015; Aurino 2017; Sinha et al. 2017). Several papers have also reported discriminations in diet and basic amenities, education and health-care seeking against the girl child (Ananthakrishnan and Nalini 2002; Bhan et al. 2005; Mukhopadhyay 2015; Kaur and Kumari 2017).

The available data suggested that issue of thinness is persistent transversely among different Indian populations with consistent proportions especially among children. Several papers have reported that high prevalence of thinness was a major public health issue among Indian children (Medhi et al. 2007; Biswas et al. 2009; Das and Bose 2009; Bisai et al. 2010; Sultan 2014). Comparisons with the present investigation showed a significantly lower prevalence of thinness than those reported among rural adolescents of West Bengal (42.4%) (Mondal and Sen 2010), pre-school children of West Bengal (50.7%) (Biswas et al. 2009), Kora-Mudi children (Bisai et al. 2010), school children of West Bengal (Bose and Bisai 2008) and school going adolescent girls of Kashmir (35.7%) (Ali et al. 2016) (Table 6). Very high prevalence of thinness was observed among rural primary school children of West Bengal (82.36%) (Mandal 2017). An almost similar prevalence of thinness as in the present paper was reported among school children of West Bengal (20.2%) (Maiti et al. 2011), from rural children of Assam (19.1%) (Sharma and Mondal 2014) and also from Rajbanshi girls of West Bengal (26.0%) (Roy et al. 2016). Such variations in prevalence of thinness can be attributed to the large ethnic variations, socio-economic disparity and diverse socio-cultural and health-care practices across Indian populations. It is now well accepted that here is a high prevalence of thinness among rural Indian populations (Medhi et al. 2006; Medhi et al.

Table 6: Comparison of the prevalence of thinness among Indian population with present investigation

Population	*Sample size*	*Region*	*Prevalence of stunting (%)*	*Reference*
Tribal School children	606	Assam, India	53.9	Medhi et al. 2006
Children	605	Assam, India	50.2	Medhi et al. 2007
Children	292	Orissa, India	48	Mishra and Mishra 2007
Pre-school children	2016	West Bengal, India	50.7	Biswas et al. 2009
School children	1094	West Bengal, India	23.1	Bose and Bisai 2008
School children	596	West Bengal, India	62.2	Chakraborty and Bose 2009
Bauri children	219	West Bengal, India	65.3	Das and Bose 2009
ICDS children	1012	West Bengal, India	85.2	Mandal et al. 2009
Kora-Mudi children	119	West Bengal, India	67.2	Bisai et al. 2010
Pre-school children	798	West Bengal, India	47	Bisai and Manna 2010
Santal children and adolescents	251	West Bengal, India	41.3	Das and Bose 2010
Rural adolescents	1870	West Bengal, India	42.4	Mondal and Sen 2010
Early adolescent school girls	2545	West Bengal, India	20.2	Maiti et al. 2011
Sunni Muslim girls	370	Delhi, India	38.4	Bansal and Joshi 2013
Santal children	203	West Bengal, India	29.6	Ghosh and Sarkar 2013
Rural adolescents	1165	West Bengal, India	49.1	Mondal 2014
Karbi-Anglong adolescents	864	Assam, India	13.4	Mondal and Terangpi 2014
Rural adolescent girls	1228	Assam, India	19.1	Sharma and Mondal. 2014
School children	561	Uttar Pradesh, India	36.2	Singh et al. 2014
School children	350	Aligarh, India	79.4	Sultan 2014
Children	3654	West Bengal, India	65.3	Mondal et al. 2015b
School going adolescent girls	428	Kashmir, India	35.7	Ali et al. 2016
Rajbanshi	500	West Bengal, India	26.0	Roy et al. 2016
Rural primary school children	618	West Bengal, India	82.4	Mandal 2017
School going children of North Bengal	1262	West Bengal, India	27.7	Present Study

2007; Biswas et al. 2009; Chakraborty and Bose 2009; Das and Bose 2009; Mandal et al. 2009; Bisai et al. 2010; Sultan 2014; Mondal et al. 2015a; Mandal 2017) (Table 6). It is evident that prevalence of thinness was higher among boys (31.2%) than girls (28.5%). Researchers have reported a similar trend of prevalence among children (Medhi et al. 2007; Mondal and Sen 2010). The children and adolescents affected by thinness were more likely to develop into thin adults with a lower BMI (that is, chronic energy deficiency or CED) that would have an impact on reduced physical work productivity (Strickland 2002; Moench-Pfanner et al. 2016; Candler et al. 2017) and poor reproductive performances, greater morbidity and mortality (Sen et al. 2011; Agostoni and Fattore 2013). Introduction of physical training could substantially improve the work capacity, but inactivity leads to rapid and substantial reductions in the ability to sustain heavy work. Therefore, the high (>20%) prevalence undernutrition among these children could be the major attribute to such manifestation that indicate nutritional deprivation reported in Indian children.

Low SES is a determinant of higher risk of stunting and thinness and poverty highly affects the linear growth than body weight of the children (Black et al. 2008; Janevic et al. 2010; Agostoni and Fattore 2013; Meshram et al. 2016). A number of studies have showed that poor children tend to be at higher risk of being undernourished and having restricted growth therefore, economic inequality is an independent determinant for childhood undernutrition (Zere and McIntyre 2003; Janevic et al. 2010; Meshram et al. 2016; Roy et al. 2016) with other determinants like poor socio-economic status and adverse environments, including low income (Choudhury et al. 2000; Mahgoub et al. 2006; Tigga et al. 2015a,b; Mtariya et al. 2016; Roy et al. 2016) and the present study showed similar trends. The health and nutritional benefits from economic growth tend to be concentrated only among the economically advantaged population groups (Mushtaq et al. 2011; Meshram et al. 2016). Moreover, the developing countries remain vulnerable to food insecurity, poor access to health services, undernutrition and increased morbidity and mortality (Zere and McIntyre 2003; Nandy et al. 2005; Nandy et al. 2008; Smith and Haddad 2015; Akseer et al. 2017).The major factors affecting the prevalence of undernutrition in the developing countries are poor socio-economic and environmental conditions, ethnic, socio-economic and socio-demographic disparities (Mahgoub et al. 2006; Mondal and Sen 2010; Ahmed et al. 2012; Tigga et al. 2015a; Huda et al. 2017). The consequences of such undernourishment are poor growth is associated with greater risk of morbidity and mortality from infectious diseases, adverse long-term consequences of delayed linear growth (Black et al. 2013). Most of the studies documenting nutritional status in India have observed that girls were more affected by undernutrition than boys (Bose et al. 2007; Mondal and Sen 2010; Sen and Mondal 2012; Tigga et al. 2015a; Pal and Bose 2017; Sinha et al. 2017; Seshadri and Ramakrishna 2018). The present paper has also reported that girls were more affected by stunting than boys. Many studies have reported that rural girls were more likely to be severely undernourished than rural boys (Choudhury et al. 2000; Mondal and Sen 2010; Bhargava et al. 2015; Pal and Bose 2017; Sinha et al. 2017; Seshadri and Ramakrishna 2018). Boys are more affected by thinness than girls with significantly greater odds ratio ($p<0.01$). In the present paper the results of BLR and stepwise multiple logistic regression analysis showed that children belonging to higher ages (that is, 9-12 years) had greater risk of stunting with greater odds ratio (odds ratio: 1.54 times) than in lower age groups (5-8 years). Moreover, the higher age groups showed greater odds ratio (odds ratio: 1.29 times) in case of thinness than the lower age groups thus agreeing with the studies reported among Indian population (Biswas et al. 2009; Mandal et al. 2009; Tigga et al. 2015a; Mondal et al. 2015a).

A number of studies have found a significant relationship between bigger household sizes and childhood undernutrition. A large household size suggests increased competition for scarce resources (Greene and Merrick 2005; Cleland et al. 2006; Engebretsen et al. 2008; Darteh et al. 2014; Melaku et al. 2015; Liu and Raine 2016). Some household hygienic practices such as access to safe water, hand washing using soap, and other sanitation practices have major role on morbidity related risks, which have a considerable effect on child growth (Checkley et al. 2004; Fink et al. 2011; García et al. 2017). The significant effects of some other socio-economic and demographic correlates (that is, birth order, no. of sibs, mothers' occupation) on prevalence of stunting and thinness among the children can be attributed to the fact that better access to food and amenities may have significant effect on the nutritional status of the children of growing ages. In the present investigation, no such significant effects of other socio economic variables (that is, fathers' occupation and ethnicity) on the prevalence of stunting and thinness have been observed. A few studies have showed the effect of ethnicity on nutritional status (Som et al. 2007; Mondal and Sen 2010; Sen and Mondal 2012; Tigga et al. 2015a; Poh et al. 2016; Venkatraman et al. 2017). Researchers have pointed out that the nutrition levels are not only dependent on the access of nutritious foods, but several other factors are responsible for poor nutritional status (that is, scarcity of clean drinking water and absence of proper sanitation) (Ramachandran 2014; Tigga et al. 2015a,b; Venkatraman et al. 2017). Therefore, the proper dissemination of knowledge and awareness related to nutritional requirement, improvement of economic conditions, use of nutrient rich food, improvement of feeding practices among nutritionally vulnerable segments would be helpful to reduced such prevalence.

CONCLUSION

The ultimate goal of such nutritional studies is to improve the community health and nutrition intervention becomes a priority for these children. In the present paper the prevalence of stunting and thinness and their association with the socio-economic factors providing an insight in the present condition of nutritional status in the study area as well as representing child nutritional status in the rural areas of India. The present paper does not provide the account on the effect of each and every socio-economic variables (that is, age, sex, number of sibs and mothers occupation) although there effect on child undernutrition have been observed in some studies.The findings of the present paper are important in providing more insight for future investigations in the field and propose a major opportunity to improve through proper intervention programmes.

RECOMMENDATIONS

The following recommendations are suggested based on the present investigation for overall improvement of the nutritional status of the children:

1. Proper intervention and policies for improvement of overall nutritional status of the rural school-going children of North Bengal, Indian. The intervention must include high caloric and micronutrient rich supplement to improve the existing undernutrition condition.
2. Dissemination of knowledge and awareness related to nutritional requirements of the children in rural India. Creating nutritional and health-related awareness will certainly helpful to improve the quality of life among the children.
3. More extensive studies for community specific measures to control and monitor the inadequate nutritional conditions of the children.
4. Multi-disciplinary health camps or monitoring offering varied medical service to the children should be organized at regular intervals in the schools. These camps should include doctors, dieticians and nutritionists, and be able to provide free medical diagnosis and medicines.

LIMITATIONS

Due to cross-sectional design of the present study is difficult to draw a major conclusion regarding the high prevalence of undernutrition in children. It is important to mention here that lack of information related to food habits and dietary intake, resource allocations and cultural practices, intra-household resource allocation, gender related issues and eating behaviour among the children which may have important influence of their nutritional status and also the lack of the results related to some other socio-economic variables it was difficult to draw major conclusions and/or identify the actual cause(s) of such higher prevalence of stunting thinness among the children.

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REFERENCES

Abudayya AH, Stigum H, Shi Z, Abed Y, Holmboe-Ottesen G. 2009. Sociodemographic correlates of food habits among school adolescents (12–15 year) in North Gaza Strip. *BMC Pub Health,* 9(1): 185.

Agarwal DK, Agarwal KN, Upadhyay SK, Mittal R, Prakash R, Rai S 1992. Physical and sexual growth pattern of affluent Indian children from 5 to 18 years of age. *Ind Pediatr,* 29(10): 1203-1282.

Agostoni C, Fattore G 2013. Growth outcome: Nutritionist perspective. *World Rev Nutr Diet,* 106: 12-18.

Aguayo VM, Nair R, Badgaiyan N, Krishna V 2016. Determinants of stunting and poor linear growth in children under 2 years of age in India: An in-depth analysis of Maharashtra's comprehensive nutrition survey. *Mat Child Nutr,* 12(S1): 121-140.

Ahmed T, Hossain M, Sanin KI 2012. Global burden of maternal and child under-nutrition and micronutrient deficiencies. *Ann Nutr Metab,* 61(1): 8-17.

Akseer N, Al -Gashm S, Mehta S, Mokdad A, Bhutta ZA 2016. Global and regional trends in the nutritional status of young people: A critical and neglected age group. *Ann New York Acad Sci,* 1393(1): 3-20.

Ali D, Shah RJ, Fazili AB, Rafiq MM, Mushtaq B, Iqbal QM, Dar SY 2016. A study on the prevalence of thinness and obesity in school going adolescent girls of Kashmir Valley. *Int J Comm Med Pub Health,* 3(7): 1884-1893.

Ananthakrishnan S, Nalini P 2002. Social status of the rural girl child in Tamil Nadu. *Indian J Pediatr,* 69(7): 579-583.

Antony GM, Laxmaiah A 2008.Human development, poverty, health and nutrition situation in India. *Indian J Med Res,* 128(2): 198.

Aurino E 2017. Do boys eat better than girls in India? Longitudinal evidence on dietary diversity and food consumption disparities among children and adolescents. *Eco Hum Biol,* 25: 99-111.

Bansal A, Joshi PC 2013. Physical health of Sunni Muslim school girls of Delhi (6–12 years). *Asian Man Int J,* 7(1 and 2): 91-94.

Bhan G, Bhandari N, Taneja S, Mazumder S, Bahl R, Zinc Study Group 2005. The effect of maternal education on gender bias in care-seeking for common childhood illnesses. *Soc Sci Med,* 60(4): 715-724.

Bhargava M, Aggarwal P, Kandpal SD, Semwal J 2015. Magnitude of undernutrition in urban and rural school-going children of district Dehradun using who reference standards. *National J Comm Med,* 6(4): 452-457.

Bhavsar S, Hemant M, Kulkarni R 2012. Maternal and environmental factors affecting the nutritional status of children in Mumbai urban slum. *Int J Sci and Res Pub,* 2(11): 1-9.

Bisai S 2014. Prevalence of undernutrition among Santal tribal preschool children of Paschim Medinipur

District, West Bengal, India. *Int J Pediatr,* 2(4.3): 347-354.

Bisai S, Ghosh T, De GK, Bose K 2010. Very high prevalence of thinness among Kora-Mudi tribal children of Paschim Medinipur District of West Bengal, India. *EJ Biol Sci,* 3(1): 43-49.

Biswas S, Bose K, Bisai S, Chakraborty R 2009. Prevalence of thinness among rural Bengalee pre-school children in Chapra, Nadia district, West Bengal, India. *Malay J Nutr,* 15(2): 155-164.

Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, Uauy R, Maternal and Child Nutrition Study Group 2013. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet,* 382(9890): 427-451.

Black R, Morris S, Bryce J 2003. Where and why are 10 million children dying every year? *Lancet,* 361(9376): 2226-2234.

Black RE, Allen LH, Bhutta ZA, Caulfield LE, De Onis M, Ezzati M, Mathers C, Rivera J, Maternal and Child Undernutrition Study Group 2008. Maternal and child undernutrition: Global and regional exposures and health consequences. *Lancet,* 371(9608): 243-260.

Bose K, Bisai S 2008. Nutritional status of rural adolescent school children in Paschim Medinipur, West Bengal. *Ind Pedtr,* 45(6): 515.

Bose K, Biswas S, Bisai S, Ganguli S, Khatun A, Mukhopadhyay A, Bhadra M 2007. Stunting, underweight and wasting among Integrated Child Development Services (ICDS) scheme children aged 3-5 years of Chapra, Nadia District, West Bengal, India. *Matern Child Nutr*, 3(3): 216-221.

Candler T, Costa S, Heys M, Costello A, Viner RM 2017. Prevalence of thinness in adolescent girls in low-and middle-income countries and associations with wealth, food security, and inequality. *J Adolescent Health,* 60(4): 447-454.

Chakrabarty S, Bharati P 2010. Nutritional status among the Shabar tribal children living in urban, rural and forest habitats of Orissa, India. *Italian J Pub Health,* 7(3): 303-310.

Chakraborty R, Bose K 2009. Very high prevalence of thinness using new international body mass index cut off points among 5-10 year old school children of Nandigram, west Bengal, India. *J Research Med Sci,* 14(2): 129.

Checkley W, Gilman RH, Black RE, Epstein LD, Cabrera L, Sterling CR, Moulton LH 2004. Effect of water and sanitation on childhood health in a poor Peruvian peri-urban community. *Lancet,* 363(9403): 112-148.

Choudhury KK, Hanifi MA, Rasheed S, Bhuiya A 2000. Gender inequality and severe malnutrition among children in a remote rural area of Bangladesh. *J Health Popul Nutr,* 18: 123-130. ISSN 1606-0997.

Chowdhury SD, Chakraborty T, Ghosh TK 2008. Prevalence of undernutrition in Santal children of Puruliya District, West Bengal, India. *Ind Pediatr,* 45(1): 43-46.

Cleland J, Bernstein S, Ezeh A, Faundes A, Glasier A, Innis J 2006. Family planning: The unfinished agenda. *Lancet,* 368(9549): 1810-1827.

Corsi DJ, Mejía-Guevara I, Subramanian SV 2015. Risk factors for chronic undernutrition among children in India: Estimating relative importance, population attributable risk and fractions. *Soc Sci Med,* 30: 1e-21.

Darteh EKM, Acquah E, Kumi-Kyereme A 2014. Correlates of stunting among children in Ghana. *BMC Pub Health,* 14(1): 504.

Das S, Bose K 2009. Undernutrition among Bauri Pre-School Children Of Nituria Block, Purulia District, West Bengal, India. *J Life Sci,* 1(2): 85-89.

Das S, Bose K 2010. Prevalence of thinness among Santal preschool children using new body mass index cut-off points. *J Anthropol,* 2011 (1-4). http://dx.doi.org/10.1155/2011/602782

Dhok RS, Thakre SB 2017. Chronic undernutrition amongst under-five in an urban slum of Central India. *Int J Comm Med Pub Health,* 3(3): 700-704.

Dutta A, Pant K, Puthia R, Sah A 2009. Prevalence of undernutrition among children in the Garhwal Himalayas. *Food Nutr Bull,* 30(1): 77-81.

Duwarah S, Bisai S, Barman H 2015. Prevalence of undernutrition among preschool children under five attending pediatric OPD in a tertiary care hospital of north-eastern India. *Int J Pediatr,* 3(2.2): 527-533.

Engebretsen I, Tylleskär T, Wamani H, Karamagi C, Tumwine JK 2008. Determinants of infant growth in Eastern Uganda: A community-based cross-sectional study. *BMC Pub Health,* 8(1): 418.

Fink G, Gunther I, Hill K 2011. The effect of water and sanitation on child health: Evidence from the demographic and health surveys 1986–2007. *Int J Epidemiol*, 40(5): 1196-1204.

García Cruz LM, González Azpeitia G, Reyes Súarez D, Santana Rodríguez A, Loro Ferrer JF, Serra-Majem L 2017. Factors associated with stunting among children aged 0 to 59 months from the Central Region of Mozambique. *Nutrients,* 9(5): 491.

Ghosh J, Sarkar A 2013. Prevalence of undernutrition among Santal children of Birbhum District, West Bengal, India. *Sri Lanka J Child Health*, 42: 147-150.

Gopalan C 2013. The changing nutrition scenario. *Indian J Med Res*,138(3): 392-397.

Goudet SM, Kimani-Murage EW, Wekesah F, Wanjohi M, Griffiths PL, Bogin B, Madise NJ 2016. How does poverty affect children's nutritional status in Nairobi slums? A qualitative study of the root causes of undernutrition. *Pub Health Nutr,* 20(4): 608-619.

Greene ME, Merrick T 2005. Poverty Reduction: Does Reproductive Health Matter? *Health, Nutrition and Population (HNP) Discussion Paper.* Washington, DC: The World Bank.

Hall JG, Allanson JE, Gripp KW, Slavotinek A 2007. *Handbook of Physical Measurements*. New York: Oxford University Press.

Harris EF, Smith RN 2009. Accounting for measurement error: A critical but often overlooked process. *Arch Oral Biol,* 54: S107-S117.doi:10.1016/j.archoralbio.2008.04.010

Herrador Z, Sordo L, Gadisa E, Moreno J, Nieto J, Benito A, Aseffa A, Cañavate C, Custodio E 2014. Cross-sectional study of malnutrition and associated factors among school aged children in rural and urban settings of Fogera and LiboKemkem districts, Ethiopia. *PloS One,* 9(9): e105880.

Huda TM, Hayes A, El Arifeen S, Dibley MJ 2017. Social determinants of inequalities in child undernutrition in Bangladesh: A decomposition analysis. *Mat Child Nutr,* 12440. DOI: 10.1111/mcn.12440

Janevic T, Petrovic O, Bjelic I, Kubera A 2010. Risk factors for childhood malnutrition in Roma settlements in Serbia. *BMC Pub Health,* 10(1): 509.

Kaur K, Kumari V 2017. Sociocultural factors affecting sex ratio and health deprivation of girl child in India: A review. *Ind J Health and Wellbeing,* 8(4): 310.

Khadilkar VV, Khadilkar AV, Cole TJ, Sayyad MJ. 2009. Cross-sectional growth curves for height, weight and body mass index for affluent Indian children, 2007. *Ind Pediatr,* 46: 477–489.

Khor GL 2008. Food-based approaches to combat the double burden among the poor: Challenges in the Asian context. *Asia Pac J Clin Nutr,* 17(S1): 111.

Kismul H, Hatløy A, Andersen P, Mapatano M, Van den Broeck J, Moland KM 2015. The social context of severe child malnutrition: A qualitative household case study from a rural area of the Democratic Republic of Congo. *Int J for Equity in Health,* 14(1): 1.

Kromeyer-Hauschild K, Moss A, Wabitsch M 2016. *Global BMI Trends. The Oxford Handbook of Economics and Human Biology.* USA: Oxford University Press.

Kugler AD, Kumar S 2015. Preference for boys, family size and educational attainment in India. *National Bureau of Economic Research,* 54(3): 835-859.

Kumar N, Shekhar C, Kumar P, Kundu AS 2007. Kuppuswamy's socioeconomic status scale - Updating for 2007. *Ind J Pediatr,* 74(12): 1131-1132.

Kumar K, Srivastava R, Mishra SK 2017. Socio-demographic determinants of under-five mortality in rural Agra. *Int J Comm Med Pub Health,* 4(9): 3108-3112.

Lenoir-Wijnkoop I, Jones PJ, Uauy R, Segal L, Milner J 2013. Nutrition economics- food as an ally of public health. *Brit J Nutr,* 109(5): 777-784.

Liu J, Raine A 2017. Nutritional status and social behavior in preschool children: The mediating effects of neurocognitive functioning. *Mat Child Nutr*, 13(2). doi: 10.1111/mcn.12321

Madrid BJ, Traisci-Marandola D 2016. Child's right to health, education, and freedom from hunger. In: S Deb (Ed.): *Child Safety, Welfare and Well-being.* Springer India, pp. 117-140.

Mahgoub SEO, Nnyepi M, Bandeke T 2006. Factors affecting prevalence of malnutrition among children under three years of age in Botswana. *Afr J Food Agric Nutr Dev,* 6(1): 1.

Maiti S, Ali KM, De D, Bera TK, Ghosh D, Paul S 2011. A comparative study on nutritional status of urban and rural early adolescent school girls of West Bengal, India. *J Nepal Paediatr Soc,* 31(3): 169-174.

Mandal G, Bose K, Bisai S 2009.Thinness among rural children in Bengal. *Ind J Pediatr,* 76(8): 817-819.

Mandal GC 2017. Thinness among the Rural Primary School Children of Bali Gram Panchayat, Arambag, Hooghly District, West Bengal, India. *J Nutr Therap,* 6(1): 38-42.

Marwaha RK, Tandon N, Ganie MA, Kanwar R, Shivaprasad C, Sabharwal A, Bhadra K, Narang A 2011. Nationwide reference data for height, weight and body mass index of Indian school children. *Nat Med J Ind,* 24(5): 269-277.

Matariya ZR, Lodhiya KK, Mahajan RG 2016. Environmental correlates of undernutrition among children of 3–6 years of age, Rajkot, Gujarat, India. *J Family Med Pri Care,* 5(4): 834.

Medhi GK, Barua A, Mahanta J 2006. Growth and nutritional status of school age children (6-14 years) of tea garden worker of Assam. *J Hum Ecol,* 19(2): 83-85.

Medhi GK, Hazarika NC, Mahanta J 2007.Nutritional status of adolescents among tea garden workers. *Int J Pediatr,* 74(4): 343-347.

Melaku YA, Zello GA, Gill TK, Adams RJ, Shi Z 2015. Prevalence and factors associated with stunting and thinness among adolescent students in Northern Ethiopia: A comparison to World Health Organization standards. *Arch Pub Health,* 73(1): 44.

Meshram II, Balakrishna N, Sreeramakrishna K, Rao KM, Kumar RH, Arlappa N, Manohar G, Reddy CG, Ravindranath M, Kumar SS, Brahmam GN 2016. Trends in nutritional status and nutrient intakes and correlates of overweight/obesity among rural adult women (> 18–60 years) in India: National Nutrition Monitoring Bureau (NNMB) national surveys. *Publ Health Nutr*, 19(5): 767-776.

Meshram II, Kodavanti MR, Rachkulla HK, Nagalla B, Kakani SR 2017. National Nutrition Monitoring Bureau Study Group, 2017. Trends in nutrient intakes, nutritional status, and correlates of undernutrition among rural children below 5 years of age: The National Nutrition Monitoring Bureau Survey 2012. *J Postgrad Med,* 63(2): 84.

Mishra B, Mishra S 2007. Nutritional anthropometry and preschool child feeding practice in working mothers of central Orissa. *Stud Home Comm Sci,* 1: 139-144.

Mitra M, Kumar PV, Chakrabarty S, Bharati, P 2007. Nutritional status of Kamar tribal children in Chhattisgarh. *Int J Pediatr,* 74(4): 381-384.

Mittal PC, Srivastava S 2006. Diet, nutritional status and food related traditions of Oraon tribes of New Mal (West Bengal), India. *Rural Remote Health,* 6(1): 385-395.

Moench-Pfanner R, Silo S, Laillou A, Wieringa F, Hong R, Hong R, Poirot E, Bagriansky J 2016. The economic burden of malnutrition in pregnant women and children under 5 years of age in Cambodia. *Nutr,* 8(5): 292.

Mohsena M, Goto R, Mascie-Taylor CN 2016. Socioeconomic and demographic variation in nutritional status of under-five Bangladeshi children and trend over the twelve-year period 1996-2007. *J Biosocial Sci,* 49(2): 222-238.

Mondal N 2014. Thinness as major underlying problem among adolescents of Northeast India. *J Nepal Paediatr Soc,* 34(1): 39-47.

Mondal N, Sen J 2010. Prevalence of undernutrition among children (5– 12 years) belonging to three communities residing in a similar habitat in North Bengal, India. *Ann Hum Biol,* 37(2): 198-216.

Mondal N, Terangpi M 2014. Prevalence of undernutrition among tribal adolescents of KarbiAnglong district of Assam, Northeast India. *Sri Lanka J Child Health,* 43(3): 154-157.

Mondal N, Basumatary B, Kropi J, Bose K 2015a. Prevalence of double burden of malnutrition among urban school going Bodo children aged 5-11 years of

Assam, Northeast India. *Epidemiol Biostat Pub Health,* 12(4): e11497(1-10).
Mondal T, Mondal S, Biswas M 2015b. An assessment of nutritional status of children of government aided primary school of West Bengal. *Int J Elem Edu* 4(3): 41-45.
Mukhopadhyay S 2015. The intersection of gender, caste and class inequalities in child nutrition in rural India. *Asian Pop Stud,* 11(1): 17-31.
Mushtaq MU, Gull S, Khurshid U, Shahid U, Shad MA, Siddiqui AM 2011. Prevalence and socio-demographic correlates of stunting and thinness among Pakistani primary school children. *BMC Pub Health,* 11(1): 1.
Nandy S, Irving M, Gordon D, Subramanian SV, Smith GD 2005. Poverty, child undernutrition and morbidity: New evidence from India. *Bull World Health Organ,* 83(3): 210-216.
Nandy S, Miranda JJ 2008. Overlooking undernutrition? Using a composite index of anthropometric failure to assess how underweight misses and misleads the assessment of undernutrition in young children. *Soc Sci Med,* 66(9): 1963-1966.
Pal S, Bose K 2017. Anthropometric characteristics of rural primary school children of Hooghly District. *Hum Biol Rev,* 6(1): 30-46.
Patil CR, Thakre SS, Khamgaonkar MB, Thakre S 2017. Prevalence of stunting and wasting among *Anganwadi* school children of rural and urban area of Central India: A cross-sectional study. *Int J,* 6(2): 413.
Poh BK, Wong JE, Norimah AK, Deurenberg P 2016. Differences in body build in children of different ethnic groups and their impact on the prevalence of stunting, thinness, overweight, and obesity. *Food Nutr Bull,* 37(1): 3-13.
Prashant K, Shaw C 2009. Nutritional status of adolescent girls from an urban slum area in South India. *Indian J Pediatr,* 76(5): 501-504.
Ramachandran N 2014. *Persisting Undernutrition in India: Causes, Consequences and Possible Solutions*. ISBN 978-81-322-1832-6 (eBook).
Ramachandran P 2007. Poverty nutrition linkages. *Indian J Med Res,* 126(4): 249-261.
Rao VG, Yadav R, Dolla CK, Kumar S 2005. Undernutrition and childhood morbidities among tribal preschool Children. *Indian J Med Res,* 122(1): 43-47.
Rengma MS, Bose K, Mondal N 2016. Socio-economic and demographic correlates of stunting among adolescents of Assam, North-east India. *Anthropol Rev,* 79(4): 409-425.
Roy S, Barman S, Mondal N, Sen J 2016. Prevalence of stunting and thinness among adolescent girls belonging to the Rajbanshi Population of West Bengal, India. *J Nepal Paediatr Soc,* 36(2): 147-155.
Saxton J, Rath S, Nair N, Gope R, Mahapatra R, Tripathy P, Prost A 2016. Handwashing, sanitation and family planning practices are the strongest underlying determinants of child stunting in rural indigenous communities of Jharkhand and Odisha, Eastern India: A cross-sectional study. *Mat Child Nutr,* 12(4): 869-884.
Sen J, Mondal N 2012. Socio-economic and demographic factors affecting the Composite Index of Anthropometric Failure (CIAF). *Ann Hum Biol,* 39(2): 129-136.
Sen J, Mondal N 2013. Fat mass and fat-free mass as indicators of body composition among Bengalee Muslim children. *Ann Hum Biol,* 40(3): 286-293.
Sen J, Mondal N, Dey S 2011. Assessment of the nutritional status of children aged 5- 12 years using upper arm composition. *Ann Hum Biol,* 38(6): 752-759.
Seshadri SR, Ramakrishna J 2018. Measuring child malnutrition: A review of assessment methods of the nutritional status of school-going children in India. In: SR Seshadri, J Ramakrishna (Eds.): *Nutritional Adequacy, Diversity and Choice among Primary School Children.* Singapore: Springer, pp.15-45.
Sharma J, Mondal N 2014. Prevalence of double nutrition burden among adolescent girls of Assam, Northeast India. *J Nepal Paediatr Soc,* 34(2): 132-137.
Singh JP, Kariwal P, Gupta SB, Singh AK, Imtiaz D 2014. Nutritional status and morbidity among school going children: A scenario from a rural India. *Sch J App Med Sci,* 2(1D): 379-383.
Sinha A, McRoy RG, Berkman B, Sutherland M 2017. Drivers of change: Examining the effects of gender equality on child nutrition. *Children Youth Serv Rev,* 76: 203-312.
Smith LC, Haddad L 2015. Reducing child undernutrition: Past drivers and priorities for the post-MDG era. *World Development,* 68:180-204. doi.10.1016/j.worlddev.2014.11.014.
Som S, Pal M, Bharati P 2007. Role of individual and household level factors on stunting: A comparative study in three Indian states. *Ann Hum Biol,* 34(6): 632-646.
Strickland SS 2002. Functional consequences of adult malnutrition in developing countries: A review. *J Physiol Anthropol,* 21(1): 1-9.
Sultan S 2014. Nutritional status of school age children in selected villages of Jawan Block, Aligarh district. *J Comm Nutr Health,* 3(1): 26-33.
Thakur R, Gautam RK 2015.Assessment of nutritional status among girls of 5-18 years of age of a Central Indian City (Sagar). *Hum Biol Rev,* 4(4): 325-336.
Tigga PL, Sen J, Mondal N 2015a. Association of some socio-economic and socio-Demographic variables with wasting among pre-school children of north Bengal, India. *Ethiopian J Health Sci,* 25(1): 63-72.
Tigga PL, Sen J, Mondal N 2015b. Effects of some socio-economic, demographic and life style factors on the prevalence of thinness among pre-school children. *Epidemiol Biostat Pub Health,* 12(1): 1.
Touitou Y, Portaluppi F, Smolensky MH, Rensing L 2004. Ethical principles and standards for the conduct of human and animal biological rhythm research. *Chronobiol Int,* 21(1): 161-170.
Trent K, South SJ, Bose S 2015.The consequences of India's male surplus for women's partnering and sexual experiences. *J Family Issues,* 36(8): 1062-1068.
Ulijaszek SJ, Kerr DA 1999. Anthropometric measurement error and the assessment of nutritional status. *Br J Nutr,* 82(3): 165-177.
UNICEF 2013. *Improving Child Nutrition: The Achievable Imperative for Global Progress*. United Nations Children's Fund (UNICEF), New York.

UNICEF, WHO, World Bank Group 2016. *Levels and Trends in Child Malnutrition in UNICEF/WHO/World Bank Group Joint Child Malnutrition Estimates Key Findings of the 2016 Edition.* New York: UNICEF; Geneva: WHO; Washington DC: World Bank.

Varadharajan KS, Thomas T, Kurpad AV 2013. Poverty and the state of nutrition in India. *Asia Pac J Clin Nutr,* 22(3): 326-339.

Venkatraman S, Marquis GS, Haas JD 2017. Ethnicity and socioeconomic factors are associated with poor nutritional status in female tea plantation workers from rural India. *FASEB J,* 31(1 Supplement): 637-639.

World Health Organization 1995. Physical Status: The Use and Interpretation of Anthropometry. *Technical Report Series No. 854.* Geneva: World Health Organization.

World Health Organization 2007. Growth Reference Data for Children from 5 to 19 Years, 2007. Geneva: WHO. From <www.who.int/growthref/en/> (Retrieved on 6 April 2017).

Zelellw DA, Gebreigziabher BG, Alene KA, Negatie A, Kasahune TA 2014. Prevalence and associated factors of stunting among schoolchildren, in Debre-Markos Town and GozamenWoreda, East Gojjam Zone, Amhara Regional State, Ethiopia, 2013. *J Nutr Food Sci.* Doi:10.4172/2155-9600.S8-007.

Zere E, McIntyre D 2003. Inequities in under-five child malnutrition in South Africa. *Int J Equity Health,* 2(1): 7.

Zhang N, Bécares L, Chandola T 2016. Patterns and determinants of double-burden of malnutrition among rural children: Evidence from China. *PloS one,* 11(7): e0158119.

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