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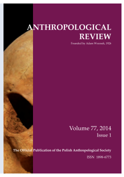

Socio-economic and demographic correlates of stunting among adolescents of Assam, North-east India

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ABSTRACT: The prevalence of stunting (low height-for-age) is a key indicator of long-term chronic undernutrition which reflects an anthropometric failure to reach linear growth potentials due to prolonged food deprivation and/or disease or illness during the early stage of life. The present study assesses the prevalence and socio-economic and demographic correlates of stunting among adolescents of the North-east India. This cross-sectional study was undertaken among 1,818 (830 boys; 988 girls) adolescents (aged 10–18 years) belonging to ethnically heterogeneous populations of Karbi Anglong district of Assam, using stratified random sampling method. Anthropometric measurements of height and weight were recorded using standard procedures. Socio-economic and demographic variables were obtained using pre-structured schedule. The age-sex specific L, M and S reference values were used to calculate height-for-age Z-score (HAZ). According to WHO, HAZ found to be <-2SD was classified as stunting. The data were analysed using descriptive statistics, t-test, ANOVA, chi-square analyses, binary and step-wise multiple logistic regression analysis in SPSS (version, 17.0). The prevalence of stunting was observed to be significantly higher among boys (48.4%) than girls (37.8%) ($p<0.01$). Age-sex specific prevalence was found to be higher among boys than girls aged 14–18 years and contrary were observed among girls aged 10–14 years ($p>0.05$). The binary logistic regression analysis showed that several socio-economic and demographic variables were significantly associated with stunting ($p<0.05$). The step-wise multiple logistic regression analysis showed that sex (boys), age groups (13–15 years and 16–18 years), father's occupation (cultivator) and Rupees ≤5000 household income was significantly associated with stunting ($p<0.05$). Appropriate nutritional intervention programmes and dissemination of knowledge at population level related to undernutrition are necessary to ameliorate their nutritional status.

KEY WORDS: undernutrition; anthropometry, stunting, public health, nutrition assessment, North-east India

Introduction

Undernutrition is a major public-health problem increasing the global health burden of premature mortality and morbidities during childhood. The prevalence of chronic undernutrition and stunting

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remain (<−2SD of low-height-for-age) major public health issues, and a significant proportion of individuals are suffering from moderate or acute malnutrition during early life in many developing countries. The prevalence of stunting is the most commonly used a conventional anthropometric measure/index reflecting long-term chronic undernutrition, linear growth failure and multi-factorial social deprivation and/or a longer-term response to a prolonged food deprivation and/or disease or illness (WHO 1995; Nandy et al. 2005; Prendergast and Humphrey 2014). The adverse ramifications have impaired cognitive and motor development, poor educational achievement, reduced intellectual capacity, human capital formations, decreases offspring birth weight and an elevated risk of metabolic disease into adulthood (Blössner and de Onis 2005; Black et al. 2008; Victora et al. 2008; Prendergast and Humphrey 2014). Socio-economic, demographic, environmental and maternal characteristics were found to have a significant determinant role in the prevalence of stunting in individual and/populations (Mahgoub et al. 2006; Wamani et al. 2007; Abudayya et al. 2009; Mondal and Sen 2010a; Mushtaq et al. 2011; Leal et al. 2012; Sen and Mondal 2012; Herrador et al. 2014; Keino et al. 2014; Zelellw et al. 2014; Tigga et al. 2015). The adverse situation such as poor socio-economic condition, demographic situation, environmental condition, sanitation, poor maternal characteristics and nutrition awareness attributed to developing such linear retardation in physical growth attainments or undernutrition (e.g., stunting) among children and adolescents (Fig. 1). The Commission on Social Determinants of Health has already recommended that the improvement of such living conditions, tackle the inequitable distribution of power, economy and resources and measure and understand the public health problem and assess the impact of the action (WHO 2008). Researchers have already reported that many resource-poor settings, the dietary intakes are consistently inadequate and infectious diseases are found to be widely prevalent, impeding the process of poor catch-up growth attainment and, therefore, potentially increase the prevalence of stunted children and adolescents (Nandy et al. 2005; Keino et al. 2014; Zelellw et al. 2014).

The period ‘adolescence’ is defined by the transition between childhoods to adulthood by age group of 10–19 years, and characterised by an exceptionally rapid physical growth (WHO 1995). It is estimated that adolescents contribute to 1.20 billion of the total world population and India have significantly the largest population cohort of adolescents of 243 million (20.00%) individuals aged 10–19 years (UNICEF 2011). It is generally accepted that the height as a linear anthropometric measurement is influenced by genetic, environmental, socio-economic, demographic and dietary factors (Abudayya et al. 2009; Herrador et al. 2014; Keino et al. 2014). Researchers have reported that the major underlying factor of greater undernutrition was attributed to enormous ethnic differences, poor socio-economic and demographic situations and adverse environment conditions persisting across developing countries (e.g., Wamani et al. 2007; Abudayya et al. 2009; Mushtaq et al. 2011; Leal et al. 2012; Keino et al. 2014). Numerous studies have already reported that the prevalence of stunting is considered to be the major long-term nutritional deprivation and public health

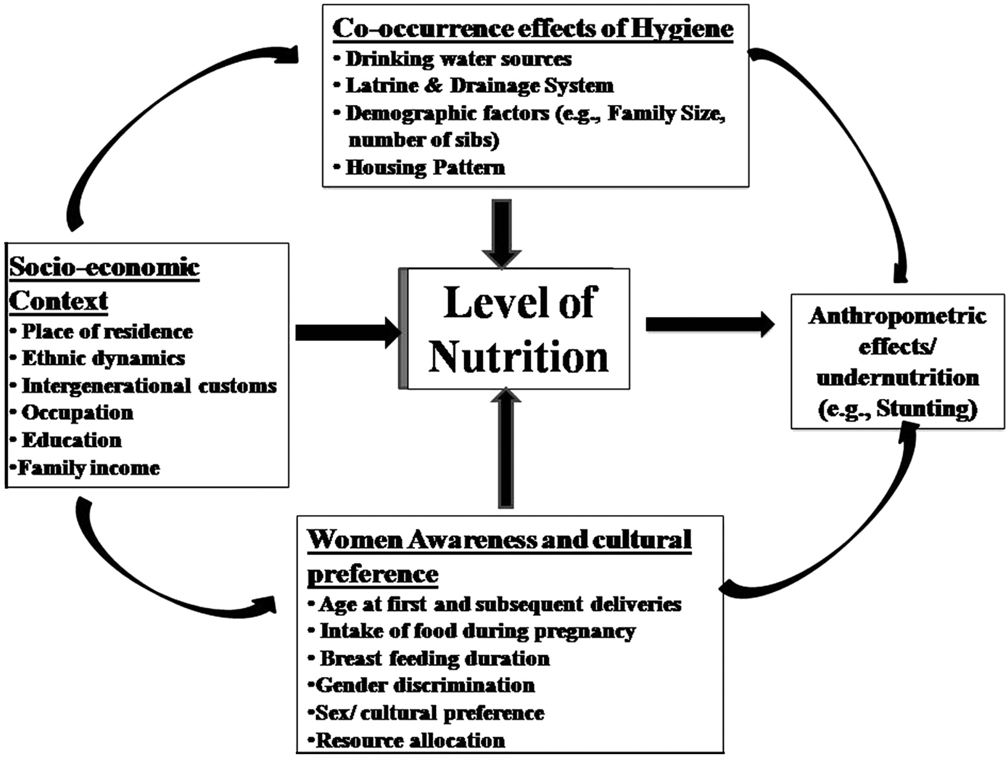

Fig. 1. Socio-economic and demographic determinants model affecting the prevalence of anthropometric failure (e.g., stunting; low height-for-age)

problem among Indian children and adolescents (Anand et al. 1999; Venkaiah et al. 2002; Deshmukh et al. 2006; Rao et al. 2006; Das et al. 2007; Malhotra and Passi 2007; Haboubi and Shaikh 2009; Prashant and Shaw 2009; Mandot et al. 2009; Mondal and Sen 2010a,b; Saxena and Saxena 2011; Shivaramakrishna et al. 2011). Researchers have also reported that a significantly large proportion of growing Indian adolescents were found to be nutritionally vulnerable due to their poor socio-economic status, ignorance, lack of health care and promote facilities that leads to the prolong nutritional deprivation and physical growth retardation during the early stage of life (Venkaiah et al. 2002; Deshmukh et al. 2006; Rao et al. 2006; Medhi et al. 2007; Parasuraman et al. 2009; Mondal and Sen 2010a; Sen et al. 2010; Sen and Mondal 2012).

Therefore, it becomes imperative and a very challenging task for the researchers to identify the major socio-economic and demographic determinants of stunting especially focusing on the population investigation so that preventive measure can be taken to reduce such adverse nutritional manifestation among vulnerable segments of the population. The adolescence period is generally considered to be the most important stage characterised by dynamic physical growth attainments and mental development due to an influence of several determining variables and/or factors. India consists of a large number of ethnic groups and indigenous population having enormous amounts of ethnic and genetic diversity (Indian Genome Variation Consortium 2008). It is a vast country with varied geographical conditions where anthropometric and body composition varies with race, sex and geographical locations. With a population of more than 1.22 billion, the Indian population consists of 4693 communities with several thousand endogamous groups. Geographically, the North-east India, comprises of eight states of Assam, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Manipur and Sikkim. Previous studies have reported that the populations residing in this region are very vulnerable to undernutrition, public health care and medical facilities. A very high prevalence of undernutrition is generally considered to be one of the major public health problems among several tribal and non-tribal children of North-east India (Medhi et al. 2006; 2007; Maiti et al. 2011; Singh and Mondal 2014; Mondal and Terangpi 2014; Islam et al. 2014). Given-above, it is evident that the North-east India is witnessing almost similar prevalence of undernutrition situation reported to be present in the rest of India.

Thus, the objectives of the present study were to assess the prevalence and ascertain the major socio-economic and demographic correlates of stunting among adolescents residing in rural areas of the Karbi Anglong district of Assam, North-east India. Moreover, the information on the stunting prevalence among adolescent of developing countries like India is needed to be generated due to its immense population size, poor healthcare facilities and socio-economic and cultural disparities for the national and international comparisons. The results of the present study will enable the government and non-governmental agencies to formulate appropriate policies and initiate intervention strategies for the well-being of the population.

Materials and methods

Study area and subjects

The North-east India is composed of the eight states of Assam, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Manipur and Sikkim. The present cross-sectional study was carried out among 1,818 adolescents (830 boy and 988 girls) of 10–18 years residing in rural areas under the Nilip Block Chokihola of Bokajan civil sub-division of Karbi Anglong district (25°33’ N to 26°35’ N latitude and 92°10’ E to 93°50’ E longitude), Assam North-east India. The covered study area is situated approximately 180 km from the district town of Diphu, Karbi Anglong. The district has dense tropical forest covered hills and plains and is the largest district amongst the 32 districts of Assam and covers an area of 10,434 km^2. According the National Census of 2011, the district had a population of 9,56, 313 individuals (males: 4,90, 167; females: 4,66, 146) with an average literacy rate of 69.25% (males: 76,14%; females: 62.00%). A total of six higher secondary schools and one junior high school were approached for data collection. The selections of these schools were done based on the numerical strength, dominance and easy road accessibility using purposive random sampling method.

The subjects belonging to heterogeneous population groups, mainly indigenous tribal population, including

Karbi, Rengama Naga, Proto-Australoid tribal groups (Santal, Oraon and Munda), and Nepali and Assamese speaking caste population were identified using stratified random sampling method. The minimum number of subjects required for reliably estimating the prevalence of stunting was calculated following the standard sample size estimation method (Lwanga and Lemeshow, 1991). In this method, the anticipated population proportion of 50%, absolute precision of 5% and confidence interval of 99% are taken into consideration. The minimum sample size estimated for each sex was 662 individuals. The estimated minimum sample size was, therefore, 1,324 (662×2) individuals. Therefore, a total of 1922 adolescents were initially approached for the necessary inclusion in the present study. Those subjects whose dates of birth were either not available in the school records or were not in the age group of 10–18 years were excluded. Of these 1,922 children, 66 were too old and birth records of 38 were not available. So the final study sample was 1818 adolescents (boys: 830; girls: 988). Special care was taken so that each category (sex/age) had at least of 50 subjects (minimum statistical criterion ≥30 subject per sex/age category). Age of the subjects (N=1,818) was ascertained using a birth certificate and relevant official records issued by Government officials. The study was undertaken during October 2013 to August 2014.

A pre-structured schedule was used to obtain that socio-economic and demographic variables include age, sex, family size, number of sibs, parents' occupation, education, monthly household income, number of the earning head in a family, and household pattern. The schedule was completed by both school and house visits, and interviewing parents and the subjects. The modified version of the scale of Kuppuswamy was utilised to ascertain the socio-economic status of the children (Kumar et al. 2007). Relevant data on household income, education and nature of occupation were recorded. Based on the above-mentioned scale, all the adolescents belonged to the low to middle socio-economic group in the present study. The participation of the subjects was completely voluntary in nature and a verbal consent was obtained from the subjects and their parents before collection of data. All the subjects were free from any physical deformities and not suffering from any disease at the time of data collection. To avoid any selection bias, the subjects were examined for any nutritional deficiencies and related disorders. Any previous histories related to medical and surgical episodes were also taken into consideration during the time of examination. All necessary study permissions and consents were obtained from the school authority and village level authorities prior to conducting the study. The study was conducted in accordance ethical guidelines for human experiments as laid down in the Helsinki Declaration of 2000 (Touitou et al. 2004).

Anthropometric measurements

The height and weight recorded using the standard procedure (Hall et al., 2007). The height of the subject was recorded to the nearest 0.10 cm with the help of an anthropometer rod with the head held in the Frankfort horizontal plane. The weight of the subjects, wearing minimum clothing and with bare feet was taken using a portable weighing scale to the nearest 100 gm. The adolescents covered in the course of this study were measured with ample precision to avoid any possible systematic errors (e.g., instrumental and/or definition of landmarks) in the process of anthropometric data collection (Harris and Smith, 2009).

Intra-observer and inter-observer technical errors of the measurements (TEM) were calculated to determine the accuracy of the measurements using the standard procedure of Ulijaszek and Kerr (1999). The TEM was calculated using the following equation:

$$TEM=\sqrt{(\Sigma D^2/2N)}$$

where: D = difference between the measurements, N = number of individuals.

The co-efficient of reliability (R) was subsequently calculated from TEM using the following equation:

$$R=\{1-(TEM)^2/SD^2\}$$

where: SD = standard deviation of the measurements.

For calculating TEM, height and weight were recorded from 50 adolescents by two of the authors (MSR and NM). Very high values of R (>0.985) were obtained for both height and weight and these values were observed to be within the acceptable limits of 0.95 as recommended by Ulijaszek and Kerr (1999). Hence, the measurements recorded by MSR and NM were considered to be reliable and reproducible. Therefore, the TEM values were not incorporated for further statistical consideration and all the measurements in the course of the present study were subsequently recorded by MSR.

Assessment of undernutrition status (stunting)

The age-sex specific Z- score values were calculated using the LMS-method. This method is based on three important curves known as L (lambda), M (mu), and S (sigma) curves. The M-curve is the median or a 50th percentile curve, the S-curve is a measure of the coefficient of variation, and the L-curve is the power of the Box-Cox transformation, which measures the changing skewness of the distribution with age. The age-specific height-for-age Z-score (HAZ) was calculated using the following equation:

$$HAZ = \{(X/M)^*L-1\}/(L^*S)$$

where: X = height, L, M and S are the age-specific values of the appropriate table corresponding reference populations.

The age-sex specific L, M and S reference values of WHO (2007) was used to calculate HAZ. The HAZ was found to be <-2SD is classified as stunting (WHO, 1995, WHO, 2007).

Statistical analysis

The data was statistically analysed 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). Homogeneity of variance was tested using the Levene's test of equality of variance. For all anthropometric variables, the *p*-value was observed to be statistically significant ($p<0.01$). Sex-specific normality was also tested using the Shapiro–Wilk test for each of the anthropometric variables and p-values were observed not to be statistically significant ($p>0.05$). The independent sample t-test was done to assess sex differences in the anthropometric variables. One way analysis of variance (ANOVA) using the Scheffe post- hoc procedure was done to assess age-specific mean differences in the anthropometric variables. Chi-square analysis (χ^2) was used to assess the differences in the overall and age-specific prevalence of stunting between sexes. The binary logistic regression (BLR) analysis was undertaken to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) were used to assess the possible differences and risk factor associated between those with an individual for being stunted (HAZ <−2SD) and normal (HAZ >−2SD). The BLR analysis allows the creation of categorical depended variables and the odds were obtained by comparing with the reference category in the univariate independent model analysis. To create dichotomous dependent variables (stunting vs. normal) normal was coded as '0' and the stunting was coded as '1' in regression models. The 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 univariate BLR analysis were tested to predict the most effective predictor variables in the step-wise multiple logistic regression model analysis. The predictor variables of sex (boys and girls), age (10–12 years, 13–15 years and 16–18 years), family size (≤4 member, 5–6 member and ≥7 member) number of sibs (1–2 sibs, 3 sibs and ≥4 sibs), number of earning heads (1 individual and ≥2 individuals), education (≤8th standard and ≥9th standard), fathers' occupation (cultivator and non-cultivator), mothers' occupation (housewife and working/service), house pattern (non-bricked and bricked) and household income (Rupees ≤5000 and Rupees >5000) were entered as dummy variables into the regression equations and results were obtained by comparing them with the reference categories. A *p*-value of <0.05 considered to be statistically significant.

Results

The age- and sex- specific subject distribution, means and SD of weight, height and HAZ among adolescent boys and girls are shown in Table 1. The boys were

Table 1. Age-sex specific descriptive statistics of weight, height and HAZ of the subjects.

Age (years)	*N*		Weight (kg)				Height (metre)				HAZ			
	Boys	Girls	Boys		Girls		Boys		Girls		Boys		Girls	
			Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
10	52	50	32.72	7.70	27.56	3.86	1.34	0.06	1.34	0.06	−0.64	1.04	−0.88	1.09
11	54	52	32.48	5.54	31.35	4.73	1.39	0.09	1.38	0.06	−0.69	1.26	−1.24	1.05
12	52	53	34.86	6.62	33.50	5.60	1.41	0.06	1.43	0.07	−1.32	0.90	−1.35	1.08
13	88	138	37.65	5.14	37.34	5.95	1.48	0.08	1.47	0.07	−1.35	1.04	−1.45	1.03
14	112	240	43.03	5.57	43.18	5.67	1.53	0.06	1.51	0.07	−1.51	0.89	−1.38	0.94
15	113	179	46.61	5.29	43.66	4.63	1.56	0.07	1.51	0.05	−1.84	0.82	−1.52	0.69
16	133	115	46.80	3.67	43.83	4.00	1.57	0.05	1.52	0.05	−2.14	0.62	−1.64	0.74
17	121	79	48.19	4.02	45.09	4.84	1.57	0.05	1.54	0.05	−2.34	0.67	−1.38	0.82
18	105	82	49.78	4.31	48.02	5.87	1.63	0.07	1.53	0.05	−1.84	0.97	−1.61	0.81
Total	830	988	43.31	7.79	41.15	7.38	1.52	0.11	148.98	0.08	−1.68	1.01	−1.42	0.91

HAZ= height-for-age Z-score, SD= standard deviation.

found to be taller and heavier than girls in almost all age groups, but exceptions were observed among 10 years and 12 years (in height) and 14 years (in weight). The age-specific mean values of weight and height were observed to progressively increase with age among both boys and girls, but decreases in the case of height in 18 years (in girls) only. The age-specific mean height ranged from 1.34 metres (in 10 years) to 1.63 metres (in 18 years) and 1.34 metres (in 10 years) to 1.54 metres (17 years) among boys and girls, respectively. The mean age-sex specific HAZ were decreased with age among boys and girls, but the exception was observed in 18 years (in boys) and 17–18 years (in girls). The mean HAZ values were ranged from −0.64 (in 10 years) to −2.34 (17 years) and −0.88 (in 10 years) to −1.64 (in 16 years) among boys and girls, respectively. Using independent sample *t*-test analysis, statistically significant sex differences were obtained in height (t-value = −7.97; d.f., 1816), weight (*t*-value = −6.07; d.f., 1816) and HAZ (*t*-value = 5.59; d.f., 1816) between the sexes ($p<0.01$). The age-specific mean differences were also found to be statistically significant with respect to height (*F*-value = 149.84, d.f. 8, 829), weight (*F*-value = 138.27, d.f. 8, 829) and HAZ (*F*-value = 34.56, d.f. 8, 829) among boys and also age and height (*F*-value = 90.36, d.f. 8, 987), weight (*F*-value = 127.21 d.f. 8, 987) and HAZ (*F*-value = 4.23, d.f. 8, 829) among girls using ANOVA ($p<0.01$).

Prevalence of stunting (<−2SD of Height-for-Age of WHO, 2007)

The age-specific prevalence of stunting among adolescents is shown in Table 2. The overall prevalence of stunting was found to be significantly higher among boys (48.4%) than girls (37.8%) ($p<0.01$). The age-specific prevalence of stunting was observed to be higher in 17 years (71.1%) and 16 years (47.0%) among boys and girls, respectively. The lower prevalence of stunting was observed among the adolescents of 10 years (23.1% boys; 30.0% girls). The age-specific prevalence of stunting was found to be greater among boys aged 15–18

Table 2. Age-sex specific prevalence of stunting among the subjects.

Age (years)	No of subjects		Prevalence of Stunting			Sex difference	
	Boys	Girls	Boys n (%)	Girls n (%)	Total n (%)	χ^2 value	*p*-value
10	52	50	12 (23.1)	15 (30.0)	27 (26.5)	0.35	NS
11	54	52	17 (31.5)	20 (38.5)	37 (34.9)	0.27	NS
12	52	53	17 (32.7)	24 (45.3)	41 (39.0)	0.77	NS
13	88	138	34 (38.6)	57 (41.3)	91 (40.3)	0.07	NS
14	112	240	46 (41.1)	82 (34.2)	128 (36.4)	0.72	NS
15	113	179	54 (47.8)	60 (33.5)	114 (39.0)	2.54	NS
16	133	115	90 (67.7)	54 (47.0)	144 (58.1)	2.92	NS
17	121	79	86 (71.1)	30 (38.0)	116 (58.0)	6.04	<0.05
18	105	82	46 (43.8)	31 (37.8)	77 (41.2)	0.29	NS
Total	830	988	402 (48.4)	373 (37.8)	775 (42.6)	8.42	<0.01

Values in parentheses indicate percentages; NS- not significant.

years. The prevalence of stunting was observed to be significantly higher among boys than girls aged 14 to 18 years, and contrary was observed among girls aged 10–14 years (p>0.05). The sex difference in the overall prevalence of stunting was found to be statistically significant between boys and girls using chi-square analysis (χ^2- value=8.42, $p<0.01$). However, the age-specific sex difference in the prevalence of stunting was found to be statistically insignificant in most of the age groups (NS), except 17 years (χ^2 – value = 6.04, $p<0.01$) (Table 2).

Binary logistic regression (BLR) analysis and associations of socio-economic and demographic variables with stunting

The results of the BLR analysis and the associations of socio-economic and demographic variables on the prevalence of stunting among adolescents are shown in Table 3. The boys exhibited 1.55 times higher risk of being stunted as compared to girls ($p<0.01$). The results also showed that adolescents aged 13–15 years and 16–18 years exhibited 1.23 times (NS)

Table 3. Binary logistic regression analysis: Association of socio-economic and demographic variables with stunting.

Predictor Variables B		Binary Logistic regression analysis Univariate model†				
		Wald	OR	95%CI	*p*-value	
Sex	Boys	0.44	20.95	1.55	1.28–1.87	<0.001
	Girls®	–	–	1	–	–
Age	10–12 years®	–	–	1	–	–
	13–15 years	0.21	2.21	1.23	0.94–1.62	0.138
	16–18 years	0.81	31.50	2.24	1.69–2.97	<0.001
Family size	≤ 4 members®	–	–	1	–	–
	5–6 members	–0.13	1.18	0.88	0.69–1.11	0.278
	≥7 members	–0.06	0.13	0.95	0.70–1.28	0.717
Number of sibs	1–2 sibs®	–	–	1	–	–
	3 sibs	–0.01	1.56	0.85	0.66–1.10	0.211
	≥4 sibs	–0.01	0.01	1.01	0.79–1.28	0.944
Number of earning head	1 individual®	–	–	1	–	–
	≥ 2 individuals	0.23	3.65	1.26	0.99–1.59	0.056
Education of family head	≤8th standard	0.39	14.45	1.48	1.21–1.81	<0.001
	≥9th standard®	–	–	1	–	–
Fathers occupation	Cultivator	0.87	57.09	2.38	1.90–2.99	<0.001
	Non-cultivator®	–	–	1	–	–
Mothers occupation	Housewife	0.73	13.97	2.07	1.41–3.03	<0.001
	Working/service®	–	–	1	–	–
House type	Non-bricked	0.62	20.26	1.87	1.42–2.45	<0.001
	Bricked®	–	–	1	–	–
Household income	≤Rupees. 5,000	0.45	22.43	1.57	1.30–1.90	<0.001
	>Rupees. 5,000®	–	–	1	–	–

® – reference category; OR- odds ratio; CI – confidence interval; † – binary logistic regression analysis considering effect of one explanatory/predictor variable.

and 2.24 times ($p<0.05$) greater odds of being stunted than their younger counterparts (e.g., 10–12 years). Results of the present study also showed that the adolescents belonging to the 'medium family' (5–6 member) (0.88 times), large family (≥7 member) (0.95 times), 3 sibs (0.85 times) and ≥4 sibs (1.01 times) categories were observed to have statistically in significant association with the prevalence of stunting ($p>0.05$). The results further showed that adolescents belonging to the ≤8th standard parent's education were found to have 1.48 times significantly greater risk of being stunted ($p<0.01$). Similarly, adolescents belonging to the cultivator father's occupation and housewife mother's occupation groups showed 2.38 times and 2.07 times significantly greater odds of being stunted than their reference counterparts, respectively ($p<0.01$). The risk associations were found to be significantly 1.57 times and 1.87 times greater among adolescents belonging to the lowers household income (≤Rupees 5,000) and non-bricked house pattern groups, respectively ($p<0.01$) (Table 3).

Stepwise multiple logistic regression analysis and association of socio-economic and demographic variables with stunting

The results of the step-wise multiple logistic regression (forward conditional model) analysis undertaken to determine the most independent predictor variables for stunting among adolescents are shown in Table 4. The 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 univarite BLR analysis ($p<0.05$). In the first step-wise multiple logistic regression, the adolescents belonging to the 'cultivator' father's

Table 4: Step-wise multiple logistic† regression analysis: The effect of socioeconomic and demographic variables on the prevalence of stunting.

Variables		OR (95%CI) (Step-1)	OR (95%CI) (Step-2)	OR (95%CI) (Step-3)	OR (95%CI) (Step-4)
Sex	Boys				1.33* (1.09–1.62)
	Girls®	–	–	–	–
Age	10–12 years®	–	–	1	1
	13–15 years	–	–	1.34* (1.01–1.77)	1.39* (1.05–1.85)
	16–18 years	–	–	2.52** (1.87–3.38)	2.48** (1.85–3.33)
Fathers occupation	Cultivator	2.38** (1.90–2.99)	3.07** (2.41–3.90)	3.20** (2.50–4.09)	3.09** (2.41–3.95)
	Non–cultivator®	1	1	1	1
Household income	≤Rupees. 5,000		2.09** (1.71–2.56)	2.20** (1.79–2.71)	2.20** (1.79–2.70)
	>Rupees. 5,000®	–	1	1	1

® – reference category; OR- odds ratio; CI – Confidence interval; *$p<0.05$; **$p<0.01$; † – Step-wise multiple logistic regression analyses considering the simultaneous effect of several explanatory/predictor variables. Only those variables which showed ($p<0.05$) association in BLR analysis were considered.

occupation had 2.38 times (95% CI: 1.90–2.99) greater odds of being stunted (p<0.05). In the second step-wise multiple logistic regression, the adolescents belonging to the cultivator father's occupation and ≤Rupees 5,000 household income together were found to have 3.07 times_(95% CI: 2.41–3.90) and 2.09 times (95% CI: 1.71–2.56) significantly (p<0.05) greater risk, respectively, of being stunted. Similarly, in the third step-wise multiple logistic regression, age group 13−15 years, 16−–18 years, cultivator father's occupation and ≤Rupees 5,000 household income had 1.34 times (95% CI: 1.01–1.77), 2.52 times (95% CI: 1.87–3.38), 3.20 times (95% CI: 2.50–4.09) and 2.20 times (95% CI: 1.79–2.71) significantly (p<0.05) greater risks, respectively of being stunted. Finally, the last step-wise multiple logistic regression model showed that sex (i.e., boys) (Odds: 1.33, 95% CI: 1.09–1.64), 13–15 years (Odds: 1.39, 95% CI: 1.05–1.85), 16–18 years (Odds: 2.48, 95% CI: 1.85–3.33), cultivator father's occupation (Odds: 3.09, 95% CI: 2.41–3.95) and ≤Rupees 5,000 household income(Odds: 2.20, 95% CI: 1.790–2.70) had significantly greater risk of stunting (p<0.05).

Discussion

The optimal nutritional status is critical to the attainment of healthy physical growth, human capital and sustainable development. The physical growth is considered to be an important indicator of nutritional status and health of the population. The nutrition assessment of the vulnerable segments of the population should be emphasised, not only for the identification of nutritional risks, but also the improvement of existing health situations. Currently, the nutritional scenario of the developing countries is altering radically during the past two decades experiencing the double burden of malnutrition (both under and over-nutrition) due to changes in socio-economic and demographic transition, dietary habits, lifestyle modification and increasing risks of non-communicable diseases (e.g., Mondal et al. 2015; Rengma et al. 2015). The results showed that the overall prevalence of stunting was observed to be 42.63% (boys 48.4%; girls 37.8%) using the recently proposed WHO reference (WHO 2007). A comparison of the stunting prevalence among Indian adolescents in the present study is depicted in Figure 2. The comparison showed that prevalence of stunting observed to be lower than Indian adolescents of Assam (53.6%) (Medhi et al. 2007), Darjeeling (46.2%) (Mondal and Sen 2010b), Rajasthan (45.17%) (Mandot et al. 2009), Indian adolescents (44.28%) (Rao et al. 2006) and Wardha (50.7%) (Deshmukh et al. 2006). Such variation could be attributed to the large ethnic variation socio-economic disparities, demographic situations, socio-cultural diversity and healthcare practices across the Indian population. However, the present study subjects were drawn from heterogeneous tribal and non-tribal populations residing in rural regions of Assam, North-east India. It is now a generally accepted fact that there is a high prevalence of stunting among rural Indian populations more than 40% of Indian adolescents including from North-east India (Medhi et al. 2006, Medhi et al. 2007; Mandot et al. 2009; Mondal and Sen 2010b; Prashant and Shaw 2009) (Fig. 2). Therefore, the problem of stunting is persistent transversely among Indian adolescents and several researchers have already reported that the undernutrition during adolescence

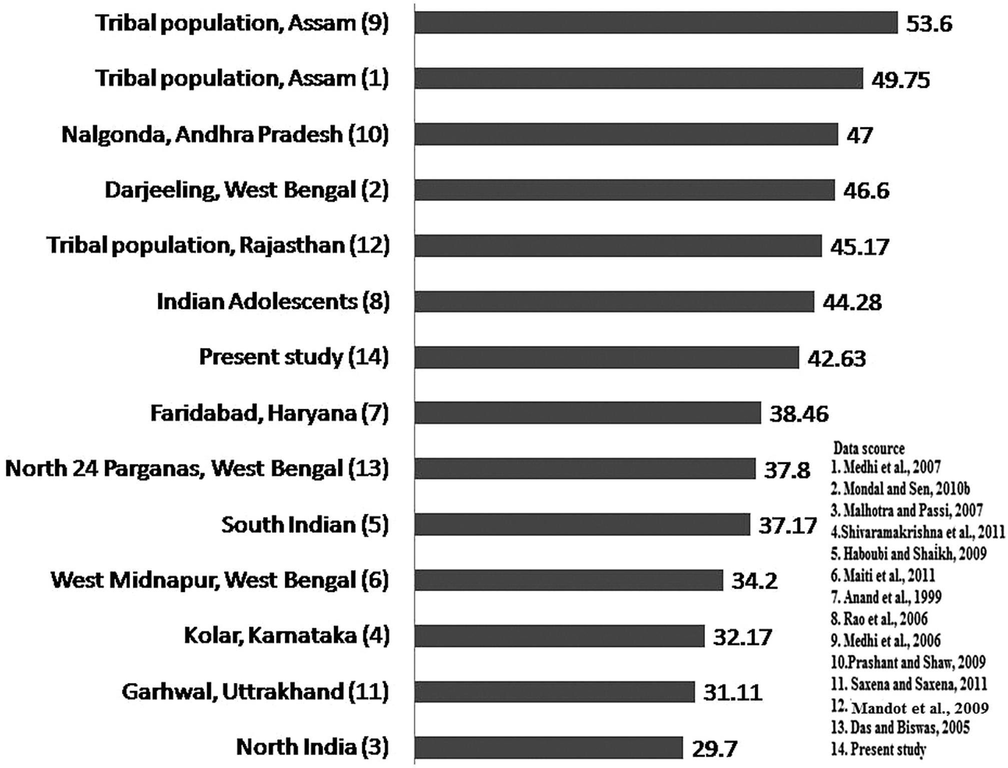

Fig. 2. Prevalence of stunting among Indian adolescents compared with the present study

had not only delayed physical growth, but affected all the linear mechanism of growth processes and poor growth attainments (Rao et al. 2006; Medhi et al. 2007; Mondal and Sen 2010b). The basic reasons behind stunting indicate the long-term cumulative inadequacies of health care services and lack of access and an insufficient intake of food and nutrients during the early stage of childhood (Medhi et al. 2007; Mondal and Sen 2010a; Tigga et al. 2015). Early marriage and confinement among adolescents are long established customs in Indian society, with poverty and ignorance magnifying such problems in populations (Venkaiah et al. 2002; Deshmukh et al. 2006; Parasuramanet al. 2009; Mondal and Sen 2010b). Although, the present study did not consider all these above-discussed factors responsible for the prevalence of stunting in the population, but these variables could have a significant role to play in the prevalence of stunting observed among adolescents (Fig. 1).

Researchers have reported that girls were mostly found to be more nutritionally vulnerable using recommended conventional anthropometric indices than boys in several developing countries (Bose et al. 2007; Mondal and Sen 2010a), but several studies have indicated that male children are more likely to be stunted than their female counterparts in adolescents (Medhi et al. 2007; Wamani et al. 2007; Mondal and Sen 2010b; Keino et al. 2014). The results of the BLR analyses showed that the risk of stunting was observed to be significantly higher among boys than girls ($p<0.01$) (Table 3). Several studies have reported that the odds of stunting are found to be significantly higher among adolescent boys than the girls ($p<0.05$) (Wamani et al. 2007; Abudayya et al. 2009; Herrador et al. 2014; Keino et al. 2014). The basic reason behind the high prevalence of stunting indicates the long term cumulative inadequacies of health and nutrition and an insufficient intake of nutrients during the early stage of childhood. A meta-analysis of 16 Demographic and Health Surveys in Sub-Saharan Africa reported that male children are likely to be more stunted and attributed to the biological vulnerability than their female counterparts (Wamani et al. 2007). In the present study, adolescents aged 13–15 years and 16–18 years exhibited significantly greater odds for being stunted in step-wise multiple logistic regression ($p<0.05$) (Table 4). Similar studies had shown the significant risk factor of being stunted with the advancement of ages among adolescents (Medhi et al. 2007; Mondal and Sen 2010a; Herrador et al. 2014). Zelellw et al. (2014) reported that adolescents of higher ages of 13–15 years had 2.53 times significantly greater risk of stunting with increasing rate as significant as compared to younger age groups (e.g., 7–8 years) among Ethiopian school-going children ($p<0.01$). The results had shown a significantly greater risk of stunting among the adolescents belonging to the lower household income group (<Rupees. 5,000) in both BLR and step-wise multiple logistic regression analyses ($p<0.05$) (Tables 3 and 4). Similar studies have already reported that the children and adolescents belonging to a lower income household observed to have a greater risk for stunting (Abudayya et al. 2009; Mondal and Sen 2010a; Leal et al. 2012; Sen and Mondal 2012; Keino et al. 2014).

Several studies have reported that parents occupations and education have a significant inverse association with undernutrition (Sen and Mondal 2012; Keino et al. 2014; Tigga et al. 2015). The results of the present study showed that adolescents belonging to parents' lower education (e.g., ≤8th standard) had a significantly greater odds of being stunted ($p<0.01$). A similar study had reported that poor educational attainments of parents were shown significantly higher odds of stunting among adolescents (Abudayya et al. 2009; Keino et al. 2014; Zelellw et al. 2014). The present study showed that adolescents belonging to the 'cultivator' fathers and 'housewife' mothers occupation groups had significantly greater odds of being stunted ($p<0.01$) (Table 3). Furthermore, the results of step-wise multiple logistic regression analysis demonstrated that risks have increased by 3-folds among adolescents belonging to the category of cultivator father's occupation (Table 4). Studies have already advocated that the outdoor economic engagement of the parents could lead to giving less attention to the children and protecting the latter from undernutrition (Mahgoub et al. 2006; Tigga et al. 2015). Similar studies have also reported that the adolescents belonging to the parents' service and/or employment categories had significantly lower odds of being undernourished (Abudayya et al. 2009; Zelellw et al. 2014; Tigga et al. 2015). The results of the BLR analysis showed that adolescents belonging to non-bricked categories had a significantly greater risk factor for being stunted than 'bricked house' patterns ($p<0.01$). Several studies had already reported a significant association between environment, sanitation and household pattern with undernutrition (Herrador et al. 2014; Keino et al. 2014; Tigga et al. 2015). In the present study, family size and the 'number of sibs' have shown a statistically insignificant association with stunting ($p>0.01$). Several researchers have reported that family size and the 'number of sibs' had strongly explanatory powers of stunting among children and adolescents (Mondal and Sen 2010a; Sen and Mondal 2012).

The adolescents suffering due to stunting are more likely to develop overweight and obesity in adulthood (Keino et al. 2014; Savanur and Ghugre 2016). Thus, it is imperative to identify the magnitude of stunting at early stages in life. Several studies have confirmed that poor height attainment due to undernutrition among women of childbearing age groups has a greater risk factor for adverse pregnancy outcomes or intrauterine growth retardation (Blössner and de Onis 2005; Victora et al. 2008; Sen et al. 2010). Moreover, the prevalence of stunting has generally been considered as irreversible and difficult to reduce a cyclical process because women who were themselves stunted in childhood tend to have stunted offspring, creating an inter-generational cycle of poverty and reduced human capital (Prendergast and Humphrey 2014). Finally, it must be mentioned here that due to the cross-sectional design of the present study, lack of information on dietary history, resource allocation, cultural practices and disease prevalence, it is difficult to draw a major conclusion and/or identify the actual cause(s) of stunting. It reflects a longstanding process, which adversely affecting the physical growth attainment and most of the considered socio-economic and demographic variables (such as sex, age, fathers occupation and household income) were significantly affecting the growth process, which could have the immediate priority to set up an immediate intervention programme such includes comprehensive dietary supplement, balance diet, micronutrient-rich or protective foods, regularly follow-up investigation, utilization of healthcare services and nutritional awareness should be introduced to ameliorate the nutritional status and factors which need long withstanding interventions such as socio-economic condition, demographic situation, father's occupation, age, sex and household income.

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Authors' contributions

MSR designed the study and collected data; KB undertook statistical analyses, prepared and edited the manuscript; NM designed the study, undertook statistical analyses, prepared and edited the manuscript.

Conflict of interest

Authors do not have any conflict of interest.

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