Human Biology Review (ISSN 22774424) 9(4) 2020
Human Biology Review
Original scientific paper (Khanra et al., 309-327)
www.humanbiologyjournal.com
Modified and Accepted on August 30, 2020

Factors affecting anthropometric failure in urban Bengalee children of Purba Medinipur, West Bengal, India

P. Khanra[1], R. Chakraborty[2] and K. Bose[3]

Citation: Khanra P, Chakraborty R and Bose K. 2020.Factors affecting anthropometric failure in urban Bengalee children of Purba Medinipur, West Bengal, India. Human Biology Review, 9(4), 309-327.

[1]Pikli Khanra, Department of Anthropology, Vidyasagar University, Midnapore, West Bengal, India. Email: pikli2011@gmail.com
[2]Raja Chakraborty, Department of Anthropology, Dinabandhu Mahavidyalaya, Bongaon, West Bengal, India. Email: rajanth2003@yahoo.co.uk.
[3]Kaushik Bose, Department of Anthropology, Vidyasagar University, Midnapore, West Bengal, India. Email: kaushikbose@cantab.net
Corresponding author: Dr. Raja Chakraborty, Associate Professor of Anthropology, Dinabandhu Mahavidyalaya, Bongaon, West Bengal, India. E-mail: rajanth2003@yahoo.co.uk. Ph: 9831608607

ABSTRACT

The Composite Index of Anthropometric Failure (CIAF) is an overall indicator of undernutrition composed of stunting, underweight and wasting. A cross sectional study was conducted in an urban area (Haldia) of Purba Medinipur District, West Bengal, India, to assess the effect of socio-economic factors on CIAF among 621 (307 boys; 314 girls) children aged 3-12 years. Body height (cm) and weight (kg) were recorded using standard procedure. Selected socio-economic and demographic information were recorded using pre-structured schedule. The NCHS reference values were used to calculate Z (< -2SD) scores for the three conventional indices namely underweight, stunting and wasting, and finally, to derive CIAF. Data were analyzed using chi-square test and binary as well as stepwise multiple logistic regression analysis. The CIAF showed a high prevalence of 47.66%. Sex specific prevalence was higher among girls. Low monthly per capita income (Odds ratio, OR = 2.1; p< 0.001) and households having two or less number of rooms (OR = 1.55, p < 0.001) were independently associated with higher risk of anthropometric failure (AF). Factors having a direct impact on earnings which provide basic infrastructure for a healthy livelihood seemed to be the major predictor of AF among children.

Key words: *India; Bengalee; Undernutrition; Composite Index of Anthropometric Failure, children; Socio-economic.*

INTRODUCTION

Undernutrition among children has been a major barrier to human development in India. It remains one of the principal causes of mortality and morbidity in children (ISDBIMC 2019) and ultimately, failure of child health care policies. Chronic undernutrition in children is closely related with their physical, mental, social and intellectual growth and development. Suffering from undernutrition in childhood also reduces the quality of life and economic productivity in the later period of life (Scrimshaw 1996). Childhood undernutrition is commonly defined by stunting, through height-for-age Z-score (HAZ); wasting, through weight-for-age Z-score (WAZ); and underweight, through weight-for-height Z-scores (WHZ) (WHO, 2006), in spite of recent claim that stunting should not be equated with malnutrition (Scheffler et al. 2020). Numerous previous studies have already reported the prevalence of undernutrition among children using these three conventional measures (Sen et al. 2011; Abbasi et al. 2018; Giri et al. 2017). However, these three conventional measures indicate distinct conditions and thus, do not provide the overall prevalence of multiple anthropometric failures (AF), although these conditions may overlap to a great extent (Nandy et al. 2005). Moreover, while a certain category is identified, another condition could be missed in an effort to find out undernourished children in a population (Berger et al. 2008). Development economist Peter Svedberg in the year 2000 (Svedberg 2000;) formulated the composite index of anthropometric failure (CIAF) for detecting total malnourished children in developing countries. Thus, the CIAF was proposed as a single estimate to determine one or multiple AF among stunting, wasting underweight (Svedberg 2000; Nandy et al. 2005). Many studies from India have already reported the prevalence of undernutrition using CIAF (Sen et al. 2011; Ramesh et al. 2017; Roy et al. 2018; Khanra et al. 2019).

Poor socio-economic conditions and other demographic situations play a significant role in determining prevalence of undernutrition in a population (Ramesh et al. 2017, Chakraborty and Bose 2014; Rengma et al. 2016; Pal et al. 2017). Nutritional status of children is significantly affected by socioeconomic factors, such as, parental occupations and level of education, the socioeconomic status of family, the number of family members, the location of household, and whether the residence is in urban or rural area (Eminaet al. 2011; Sunil et al. 2009).Previous studies from India have already reported that undernourishment was significantly associated with poor socio-economic status in a large proportion of children (Chakraborty and Bose 2014; Rengma et al. 2016; Pal et al. 2017; Ramesh et al. 2017).

Hitherto, the socioeconomic, demographic and other factors in relation to nutritional status have been mostly studied using conventional parameters of undernourishment, viz., stunting, wasting, underweight and thinness, which represented different states of undernutrition. However in India, an estimate of undernourishment that might give an overall nutritional condition of children, such as CIAF, has not been much studied so far in relation to the socioeconomic and demographic factors (Sen and Mondal 2012; Endris et al. 2017). It has been also proposed that CIAF might provide more precision in identifying the nutritionally vulnerable segment of the population and the disaggregation of CIAF has adequate potential to enhance the efficacy of a nutritional intervention programme by identifying double or multiple failures(Sen et al. 2011; Sen and Mondal 2012;Kuiti and Bose 2018).Studies that reported such effects on CIAF, especially, in India are scanty(Nandy et al. 2005; Sen and Mondal 2012; Khan and Raza 2014; Shafiq et al. 2019).With this backdrop, the present study aimed to assess the prevalence of undernutrition by using the more accommodative index of CIAF and also to determine the impact of socio-economic and demographic characteristics on anthropometric failure among urban Indian children.

METHODS

Study area and participants

The present cross-sectional study was conducted in Haldia town in Purba Medinipur District of West Bengal, India, during December 2014 to April 2016. Haldia Township is situated in the midst of an industrial belt. Some of the prominent industries are the Indian Oil Corporation Ltd. (IOCL), Calcutta Port Trust (CPT), Haldia Petrochemicals Ltd. (HPL), etc. Mostly, the employees of these organizations live in several colonies in this township area. Participants of the present study were selected from three such colonies and from Rairarchak. All these areas were under municipal ward numbers 18, 21, 25 and 26, which were selected at random from several in the area. The purpose was explained to officials of Haldia municipality to obtain appropriate permission before the commencement of this study. The participant children were aged between 3 and 12 years and belonged to Bengalee community, in particular, the Bengali speaking Hindu caste groups of West Bengal state. The study followed ethical guidelines for studies on human participants as laid down in Helsinki Declaration, 2000 (Touitou et al. 2004) and all the extant laws and acts of the Republic of India as regards the child rights and protection.

Participant children were enrolled for the study through door to door visit by combining opportunity and snowball sampling strategies. The houses from one end of the area were visited sequentially, and children (of the targeted age range) present at home at the time of such visit were enrolled for the study after obtaining informed consent from their parents/legal guardians. As the study period continued and new households were approached, the sample size increased. In a number of cases, repeated visits were made to households to accomplish the remaining work of the previous visit. The response rate was approximately 85%. Age was confirmed from birth certificate and/or vaccination card. All were free from any kind of physical deformity and were not suffering from any disease at the time of study. Finally, 621(307 boys; 314 girls) children between ages 3-12were included in this study.

Socio-economic and demographic information

A pre-structured schedule was used to record socio-economic and demographic characteristics including parents' education (the highest level they passed from school, college or university), parents' occupation (recorded as exact name), monthly family income and expenditure (in INR), house ownership (owned vs. rental), number of living rooms (exact number), total number of family members, cooking fuel types (smoky fuel vs. gas) and sources of drinking water (tube well vs. tap water). All information was obtained by interviewing parents at their home.

Anthropometry and assessment of nutritional status

The anthropometric measurements namely weight and height were taken for each child at one time. Height (cm) and weight (kg) were recorded to nearest 0.1 cm and 0.5 kg respectively with standard procedures (Lohman et al. 1988). A trained investigator (PK) recorded anthropometric measurements. Technical errors of measurements (TEM) were computed and they were found to be within reference values and thus not incorporated in analyses (Ulijaszek and Kerr1999). Nutritional status was assessed using internationally accepted growth reference values of the National Centers for Health Statistics, 1983. Three types of Z scores were calculated: Height-for-age Z-score (stunting), Weight-for-age Z-score (underweight) and Weight-for-height (wasting). Internationally accepted WHO child growth standard (2006) of age and sex specific < -2 Z scores were followed to define underweight, stunting and wasting.

Composite Index of Anthropometric Failure (CIAF)

The same z-score data were used to calculate CIAF to get a single estimate of the overall prevalence of undernutrition. Svedberg (2000) initially constructed six sub-groups of anthropometric failure (A to F). Nandy et al. (2005)further added another sub-group (Table 1), that is children who are only underweight but are not stunted and wasted, known as 'Group-Y'. The CIAF excludes those children who are not in anthropometric failure that is group 'A'. Children in groups 'B' through 'Y' had included all those who are underweight, stunted and wasted. Thus, CIAF was calculated as the sum of prevalence in group B to group Y.

Statistical analysis

Chi-square (x^2) analysis was used to assess differences in the overall prevalence of undernutrition between sexes as well as to study the association between socio-economic parameters and nutritional status (CIAF).A p-value of <0.05 was considered to be statistically significant.

Those variables which showed a significant association in the χ^2 test were employed to determine effective predictor variables using binary logistic regression analysis (BLR), separately for each predictor. The BLR (univariate) analysis was used to determine relationship between anthropometric failure with each socio-economic and demographic factor, viz., fathers'- and mothers' education (above secondary and up to secondary), fathers' occupation (non-manual vs manual), house ownership (own vs rental), number of living rooms (>2 rooms vs ≤2 rooms), monthly family income per capita (≤2500 Rs. Vs >2500 Rs.) and monthly family expenditure per capita (≤2500 Rs. vs>2500Rs.). The odds ratios (ORs) along with 95% confidence intervals (CIs), derived from BLR analyses, were used to assess the relative risks of AF. Finally, the variables which showed a significant association in BLR analysis were further tested to study the most effective predictor factors using forward stepwise multiple logistic regression (FSMLR) analysis. For all these regression analyses, the outcome/dependent variable (CIAF) was categorized into '0' (indicating 'No AF') and '1' (indicating 'AF'). Level of significance for all statistical analyses was set at p <0.05. All analyses were performed using SPSS-16 Software.

RESULTS

Table 1 describes the frequencies of different groups of single and combined nutritional conditions among the children. **Table 2**shows the prevalence of undernutrition and sex differences with respect to the indicators of undernutrition. Higher prevalence of undernutrition was found in girls in all indicators, except stunting. The overall sex combined prevalence (47.66%) of CIAF was higher than the three conventional indices, viz., stunting (23%), wasting (21.9%), underweight (32.8%).

The results of x^2 analyses are shown in **Table 3**. Significant association was found between nutritional status (CIAF) and parental education ($x^2 = 11.17$, $p<0.001$for father, $x^2 = 15.94$, $p<0.001$for mother) as well as monthly income and expenditure ($x^2 =20.88$ $p<0.001$ and $x^2 = 17.84$, $p<0.001$). Fathers' occupation ($x^2 = 11.80$, $p<0.001$) was also significantly associated with CIAF. House ownership status ($x^2 = 4.19$, $p<0.05$) and number of living rooms were also significantly associated ($x^2 = 15.85$, $p<0.001$).

The BLR analysis showed that higher odds of undernutrition were associated with lower education level of fathers' (1.72 times, $p<0.001$) and mothers' (1.98 times, $p<0.001$). Low income (2.10 times, $p<0.001$) and low expenditure (1.99 times, $p<0.001$) also showed a greater risk for being undernourished in children. The odds were significantly higher (2.07 times, $p<0.001$) in undernourished children living in a house having less than two rooms. Engagement of fathers in manual occupations was also significantly associated with higher odds (1.75 times, $p<0.001$) of child undernutrition. Significantly lower risk (0.72 times, $p<0.05$) was found in rental house for being undernourished children than own house **(Table 4).**

Those variables which showed a significant association in BLR analysis were further tested to determine the most effective factors predicting CIAF using stepwise multiple forward logistic regression analysis (**Table 5**). It revealed significantly greater odds (2.10 times, $p< 0.001$) for low monthly income (per capita) to be associated with AF compared to higher monthly income. Having less number of living rooms (<2) in household also showed significantly higher odds (1.55 times, $p < 0.001$) for AF. No other variable, however, qualified to remain in the final model and thus were automatically excluded from the equation.

DISCUSSION

Our study investigated association of selected socio-economic and demographic factors with CIAF, which is relatively newer, non-conventional, but more inclusive overall indicator of undernutrition in children. The overall sex combined prevalence (47.66%) of CIAF was higher than the three conventional indices, viz., stunting (23%), wasting (21.9%), and underweight (32.8%). It is not unusual as CIAF includes all those conventional indicators and somewhat summarizes the overall condition of anthropometric deficiency. Some previous studies in urban areas of different states of India had reported higher prevalence of CIAF, viz: Ahmedabad city (60.5%, Solanki et al. 2014), Nagpur city (58.59%, Dhok and Thakre 2016), Raipur (62.1%, Boregowda et al. 2015) and Assam (51.1%, Kramsapi et al. 2018) in comparison to (47.66%) the present study. Similar prevalence of CIAF was observed in Mumbai city (47.8%, Savanur and Ghugre 2015) while lower prevalence of CIAF was found in Chennai (37%, Ramesh et al. 2017). The girls in the present study showed a higher rate (49.7%) than the boys (45.6%). Higher prevalence among girls than in boys was also reported by some studies (Sen and Mondal 2012; Roy et al. 2018; Khanra et al. 2019). However, the prevalence of stunting was higher among the boys.

The present study revealed significant associations between AF and parental education, monthly income and expenditure, Fathers' occupation, house ownership status (owned vs. rental) and the number of living rooms in household. Prevalence of undernutrition was significantly high in children whose parents were educated up to secondary level compared with children whose parents were educated above secondary level. Previous studies also showed the association of undernourished state in children with the lower parental education level (Biswas and Bose 2010; Headey and Hoddinott 2015). Several studies also emphasized that improving socio-economic condition along with parental education might help to improve the nutritional status of children (Owoaje et al.2014; Cruz et al. 2017; Kavosi et al. 2014; Pal et al. 2017; Vollmer et al. 2017).Another recent study on Indonesian school children revealed that growth in Indonesian children depended directly on parental education and not even via nutrition mediated pathways(Groth et al.2019).We also found that low family income and expenditure were associated with a greater risk of having undernourished (AF) children. Lower income level was determinant of child undernutrition in several o studies(Kirk et al. 2018; Katoch and Sharma 2016; Owoaje et al. 2014; Mondal et al. 2015; Tigga et al. 2015; Rengma et al. 2016; Pal et al. 2017). We also found significant association of fathers'-, but not mothers' occupation with AF.

This was probably because mothers of most of these children were home makers (89.2%) and did not have any cash income, whereas, the source of income in most of the families was fathers' occupation. The fathers engaged in manual job had lower income and perhaps thus associated with higher odds of AF among their children. It was clearly observed in the present study that children whose fathers were mainly engaged with manual occupation attended inferior schools and lived in houses with unhygienic living standards, unsafe drinking water. A previous study had reported that children having healthy weight had fathers who were non-manual workers (Rahman et al. 2009). Findings similar to our study have been observed also by other previous investigations (Tigga et al. 2015; Owoaje et al. 2014; Rengma et al. 2016; Pal et al. 2017).

In low-income countries, especially, adverse living conditions of urban areas have negative impact on health of any individual or population. Nandy et al. (2005) reported that undernourished children had lower mean SLI (Standard of Living Index) scores compared to normal children. Use of smoky cooking fuel was shown by several studies to be linked with higher prevalence of child undernutrition relative to smoky fuel (Mishra and Retherford 2007; Bhagowalia and Gupta 2011). Nevertheless, the variables that represented standard of living conditions in this study however did not show any significant impact on AF. For instance, using smokeless fuel for cooking and tap water for drinking, although indicated better and healthy livelihood, did not show any association with better anthropometric state. This was probably because these variables did not discriminate significantly between better off families and poorer ones. For example, a large number of the families under study used smokeless fuel (87.8%) and tap water was mostly collected from common municipal lines. Besides, cooking gas is also subsidized by the government for the poorer families and smoky hearth is not accepted in urban areas. Study by Sen and Mondal (2012) in northern part of West Bengal also showed that demographic factors of family size and number of siblings were associated with CIAF. Having higher number of family members did not show association with AF in this study. However, it was observed that there was higher prevalence of AF among children who lived in houses with 2 or lesser number of rooms. Similar findings were reported by other studies (Owoaje et al. 2014) including in the same state of India (Biswas et al. 2013). This perhaps indicated that better housing conditions, such as having larger space, were related to better income, and thus linked with lower prevalence of AF. However, on the other hand, although it was assumed that having own house, instead of a rented one, was indicative of better economic status, and thus associated with AF, the opposite was reflected in the results. Living in a rental house, as opposed to owning a house, was associated with lower prevalence of AF in children. This could be explained by the fact that a large proportion (about 46%) of the children, although living in houses owned by their parents, had only 2 or less rooms to live. As mentioned earlier, families having 2 or lesser number of rooms had a higher occurrence of AF. This finding perhaps also pointed out that in urban areas populated mostly by middle- or lower middle class families, owning a house may not indicate better living conditions than living in a rental one, at least with reference to the burden of child undernutrition.

Finally, a more intensive investigation using FSMLR analysis revealed that a low monthly family income and less number of rooms in household were the most important determining factors of the prevalence of AF. No other factor came up to be statistically important relative to these two factors. Low monthly income is closely associated with poor living status with unhygienic living standards, poor sanitary conditions, unsafe drinking water and low calorie diet (Rahaman et al. 2009).Income, a major determinant of socioeconomic condition, has the potential to benefit child nutrition, and household consumption choices depend on production outcomes only via total earnings; income from any source will be equally beneficial (Svedberg 2000; Kirk et al. 2018). Under basic household models, income only have an effect on these nutrition-inducing consumption choices by setting the budget constraint, with no other characteristic of income having influence (Skoufias 2012; Black et al. 2013). A large collection of microeconomic studies attempting to determine the income links to nutrition through specific mechanisms provide mixed and often conflicting results (Black et al. 2013; Kirk et al. 2018). Poor living conditions play a role in the association between income inequality and child health (Marmot 2005; Harker 2006; Sengoelge et al. 2014).

Results indicated that the effect of number of rooms in household on the prevalence of AF was through the pathways of better family income. However, further stepwise regression analysis showed that this factor was linked with AF independent of family income. Therefore, it seems that living space in household in suburban area might determine some important aspects of living conditions that might be, in turn, linked with child nutritional status. The distribution of households in India by size and number of rooms during the year 2001 and 2011 showed that a large number of families lived in single roomed houses (35.1% in 2001; 32.1% in 2011). Onethird of population has been using two-rooms for living purpose in 2001-11(GOI 2019). Several studies highlighted that environment and number of living rooms during early life is an important source of exposure to chemical, biological, and physical agents. Poor living conditions have been reported to be associated with respiratory infections, asthma, and mental health in children (Krieger and Higgins 2002; Harker 2006; Oudin et al. 2017). Some previous studies have already reported that number of living rooms was significantly associated with undernutrition of the children (Biswas et al. 2011; Mondal et al. 2012; Biswas et al. 2013).

To conclude, a high proportion of Indian children (aged 3-12 years), particularly, girls, is suffering from at least any one form of undernutrition, in urban regions bordering rural belts. Monthly income and number of rooms were strong independent predictors of AF relative to other socioeconomic and demographic parameters. Increase of income and living space in the household may decrease the prevalence significantly. The factors that have direct impact on earnings which provide basic infrastructure for a healthy livelihood seemed to be the major predictor of AF among these children, and thus become decisive in child health care. Appropriate corrective and intervention measures are required to ameliorate their nutritional status.

Acknowledgements

All participants and their parents are sincerely acknowledged for their kind cooperation during data collection. Chairperson of Haldia municipality and Child Development Programme Officer of Haldia are also gratefully acknowledged.

REFERENCES

Abbasi S, Mahmood H, Zaman AFarooq B, Malik A, Saga Z. 2018. Indicators of Malnutrition in Under 5 Pakistani Children: A DHS Data Secondary Analysis. *J Med Res Health Education* 2(3):1-10.

Berger MR, Fields-Gardner C, Wagle A, Hollenbeck CB. 2008. Prevalence of malnutrition in human immunodeficiency virus/acquired immunodeficiency syndrome orphans in the Nyanza province of Kenya: a comparison of conventional indexes with a composite index of anthropometric failure. *J American Diet Assoc* 108:1014–1017.

Biswas S and Bose K. 2010.Sex differences in effect of birth and parents' educational status on stunting: a study on Bengalee preschool children from eastern India. *HOMO-J Comp Hum Biol* 61(4):271-276

Biswas S, Bose K, and Koziel S. 2011. Effect of social factors on nutritional status among rural Bengalee preschool children from Eastern India. *Int J Hum Sci* 8(1):289-300.

Biswas S, Koziel S, Chakraboty R and Bose K. 2013. Sibling Composition and Household Room Sharing are Associated with Menarcheal Status among Rural Bengalee girls of West Bengal India. *Hum Biol* 85(4):607-618

Boregowda GS, Soni GP, Jain K, Agarwal, S.2015. Assessment of under nutrition using composite index of anthropometric failure (CIAF) amongst toddlers residing in urban slums of Raipur city, Chhattisgarh, India. *J Clin Diag Res* 9(7): 4-6,

Chakraborty R and Bose K. 2014. Defining malnutrition in India: how much is too little, how much is too much? *Curr Sci* 106 (5):670-672

Cruz LPG, Azpeitia GG, Súarez DR, Rodríguez AS, Ferrer JL, Serra-Majem L. 2017. Factors Associated with Stunting among Children Aged 0 to 59 Months from the Central Region of Mozambique. *Nutrients* 9(491):1-16.

Dhok R and Thakre S. 2016.Measuring undernutrition by composite index of anthropometric failure (CIAF): a community-based study in a slum of Nagpur city. *IntJ Med Sci Pub Health* 5(10):2013-2018.

Emina JB, Kandal N, IninguJYazoume YE. 2011. Maternal education and child nutritional status in the Democratic Republic of Congo. *J Pub Health Epidemiol* 3(12):576-592.

Endris N, Henok A andDube L. 2017. Prevalence of Malnutrition and Associated Factors among Children in Rural Ethiopia. *Bio Med Res Int* 6587853. doi: 10.1155/2017/6587853

Fullerton DG, Bruce N and Gordon SB. 2008. Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. *Transaction of the Roy Soc Trop Med Hygiene*102(9): 843–851.

Giri SP, Biswas S and Bose K. 2017.Prevalence of undernutrition among Bengalee pre-school children of Sundarban, South 24 Parganas, West Bengal, India. *Hum Biol Rev* 6(4):284-300.

GOI (Government of India), Ministry of Housing and Urban Affairs. 2019. Handbook of Urban Statistics. Govt. of India Press: New Delhi.

Groth D, Scheffler C and Hermanussen M. 2019. Body height in stunted Indonesian children depends directly on parental education and not via a nutrition mediated pathway – Evidence from tracing association chains by St. Nicolas House Analysis. *Anthropol Anz* 76(5):445-451.

Harker L. 2006. Chance of a lifetime: the impact of bad housing on children's lives. Shelter: London.

Headey DD and Hoddinott J. 2015. Understanding the rapid reduction of undernutrition in Nepal, 2001–2011.*PLoS One*12:e0145738.

ISDBIMC (India State-Level Disease Burden Initiative Malnutrition Collaborators). 2019. The burden of child and maternal malnutrition and trends in its indicators in the states of India: the Global Burden of Disease Study 1990–2017. *Lancet Child Adolesc Health* 3:855–70.

Katoch OR and Sharma A. 2016. Prevalence and determinants of underweight: a study on school-going children of farming households in rural areas of district Doda, Jammu & Kashmir, India. *Int J Recent Sci Res* 8(6):17360-17363.

Kavosi E, Hassanzadeh R, Rostami Z, Nasihatkon A, Moghadami M, Heidari M. 2014.Prevalence and determinants of under-nutrition among children under six: a cross-sectional survey in Fars Province, Iran. *Int J Health Policy Management* 3(2):71-76.

Khan REA and Raza MA. 2014 Child malnutrition in developing economies: a case study of Bangladesh. *Qual Quant* 48(3):1389-1408.

Khanra P, Biswas S and Bose K. 2019. Nutritional assessment by composite anthropometric failure among school going children of Purba Medinipur, West Bengal, India. *Hum Biol Rev* 8(1):66-75

Kirk A, Kilic T and Carletto C. 2018. Composition of Household income and child nutrition outcomes evidence from Uganda. *World Dev* 109:452-469.

Kramsapi R, Singh KN and Mondal N. 2018. Composite index of anthropometric failure (CIAF) among preschool(2-5 years) tribal children of Assam (India). *Hum Biol Rev* 7(1):1-18

Krieger J and Higgins DL. 2002. Housing and health: time again for public health action. *Am J of Pub Health* 92(5):758-768.

Kuiti B and Bose K. 2018. The Concept of Composite Index of Anthropometric Failure (CIAF): Revisited and Revised. *Anthropol Open J* 3(1): 32-35

Lohman TG, Roche AF and Martorell R. 1988.Anthropometric standardization referencemanual. Human Kinetics Books: Chicago, IL.

Marmot, M. 2005. Social determinants of health inequalities. *Lancet*365(9464):1099-1104.

Mondal N, Basumatary B, Kropi J, Bose K. 2015. 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

Mondal PR, Biswas S and Bose K. 2012. Gender discrimination in undernutrition with mediating factors among Bengalee school children from Eastern India. *Homo-J Comp Hum Biol*63(2):126-135

Mishra V and Ratherford R. 2007. Does biofuel smoke contribute to anaemia and stunting in early childhood? *Int J Epidemiol* 36(1):117-129.

Nandy S, Irving M, Gordon D, Subramanian SV, Smith GD.2005. Poverty, child undernutrition and morbidity: new evidence from India. *Bull WHO* 83(3):210-216.

Oudin A. 2017. Air pollution and dementia. *J Pub Health Emerg*1(49):1-4.

Owoaje E, Onifade O and Desmennu A. 2014. Family and socioeconomic risk factors for undernutrition among children aged 6 to 23 Months in Ibadan, Nigeria. *Pan Afr Med J*17(161):1-7.

Pal A, Pari AK, Sinha A, Dhara PC. 2017. Prevalence of undernutrition and factors: A cross-sectional study among rural adolescents in West Bengal, India. *Int J Pediatr Adolesc Med* 4(1):9-18.

Rahman M, Mostofa G and Nasrin SO. 2009. Nutritional status among children aged 24-59 months in rural Bangladesh: an assessment measured by BMI index. *Internet J Biol Anthropol* 3(1):1-7.

Ramesh S, Sundari S and Ramesh J. 2017. Assessment of Nutritional Status by Composite Index of Anthropometric Failure (CIAF): A Study among under-5 Children in Chennai, Tamil Nadu, India. *Res J Pharmaceut Biol Chem Sci* 8(3):1495-1499.

Rengma MS, Bose K and Mondal N. 2016. Socio-economic and demographic correlates of stunting among adolescents of Assam, North- east India. *Anthropol Rev* 2016;79(4):409425

Roy, K, Dasgupta A, Roychoudhury N, Bandyopadhyay L, Mandal S, Paul B. 2018. Assessment of under nutrition with composite index of anthropometric failure (CIAF) among under-five children in a rural area of West Bengal, India. *Int J Contemp Ped* 5(4):1651-1656.

Savanur MS and Ghugre PS. 2015. Magnitude of undernutrition in children aged 2 to4 years using CIAF and conventional indices in the slums of Mumbai city. *J Health Pop Nutr* 33(3):1-7

Scheffler C, Hermanussen M, Bogin B, Liana DS, Taolin F, Cempaka PMVP, Irawan M, Ibbiba LF, Mappapa NK, Payong MKE et al. 2020. Stunting is not a synonym of malnutrition. *Eur J Clin Nutr*74:377-386

Scrimshaw NS. 1996. Nutrition and health from womb to tomb. *Nutr Today*2:55-67

Sen J, Dey S and Mondal N. 2011. Conventional nutritional indices and Composite Index of Anthropometric Failure: which seems more appropriate for assessing under-nutrition among children? A cross-sectional study among school children of the Bengalee Muslim Population of North Bengal, India. *Italian J Pub Health* 8(2):172-185.

Sen J and Mondal N. 2012. Socio-economic and demographic factors affecting the Composite Index of Anthropometric Failure (CIAF). *Ann Hum Biol*39(2):129 136.
doi: 10.3109/03014460.2012.655777

Sengoelge M, Elling B, Laflamme L, Hasselberg M..2014. Country-level economic disparity and child mortality related to housing and injuries: a study in 26 European countries. *Inj Prev*5:311-315

Shafiq A, Hussain A, Asif M, Hwang J, Jameel A, Kanwel S. 2012. The effect of "women's empowerment" on child nutritional status in Pakistan. *IntJEnviron Res Public Health* 16:4499.
doi: 10.3390/ijerph16224499

Skoufias E, Tiwari S and Zaman H. 2012. Crises, Food Prices, and the Income Elasticity of Micronutrients: Estimates from Indonesia. *World Bank Econ Rev* 26(3):415- 442

Solanki R, Patel T, Shah H, Singh S.2014.Measuring undernutrition through z-scores and composite index of anthropometric failure (CIAF): a study among slum children in Ahmedabad City, Gujarat. *Nat J Comm Med* 5(4):434–439.

Sunil TS. 2009. Effects of socioeconomic and behavioral factors on childhood malnutrition in Yemen. *Matern Child Nutr* 5:251– 259.

Svedberg P. 2000.Poverty and undernutrition: theory, measurement, and policy: a study prepared for the World Institute for Development Economics Research of the United Nations. Oxford University Press: Oxford.

Tigga PL, Sen J and Mondal N. 2015. Association of some socio-economic and socio demographic variables with wasting among pre-school children of North Bengal, India. *Ethiop J Health Sci* 25(1):63-72.

Touitou Y, Portaluppi F, Smolensky MH, Rensing L. 2004. Ethical principles And standards for the conduct of human and animal biological rhythm research. *J Biol Med Rhythm Res* 21(1):161-170

Ulijaszek SJ and Kerr DA. 1999. Anthropometric measurements error and the assessment of nutritional status. *Br J Nutr* 82:165-177

Vollmer S, Harttgen K, Kupka R, Subramanian SV.2017. Levels and trends of childhood undernutrition by wealth and education according to a Composite Index of Anthropometric

Failure: evidence from 146 Demographic and Health Surveys from 39 countries. *BMJ Global Health* 2 (2):p.e000206.

WHO(2006) Child Growth Standards. Length/Height for age, Weight for Age, Weight for Length, Weight for Height and Body Mass Index for Age. Methods and Development. World Health Organization: Geneva.

Table 1. Classification of undernutrition with anthropometric failure (CIAF)

Group	Description	Wasting	Stunting	Under-weight	Number	%
A	No Failure	No	No	No	325	52.33
B	Wasting Only	Yes	No	No	71	11.43
C	Wasting & Underweight	Yes	No	Yes	49	7.89
D	Wasting, Stunting & Underweight	Yes	Yes	Yes	15	2.42
E	Stunting & Underweight	No	Yes	Yes	105	16.91
F	Stunting Only	No	Yes	No	23	3.70
Y	Underweight Only	No	No	Yes	33	5.31
	CIAF (B to Y)				296	47.67
Total					621	100.0

This classification is followingNandy et al., 2005.

Table 2. Prevalence of undernutrition among the children

Sex	N	Underweigh t	Not Underweigh t	Stunted	Not Stunted	Wasted	Not Wasted	Anthropo-metric Failure	No Anthropometric Failure
Boys	307(49.44)	95(30.90)	212(69.10)	72(23.50)	235(76.50)	67(21.80)	240(78.20)	140(45.60)	167(54.40)
Girls	314(50.56)	106(33.80)	208(66.20)	71(22.60)	243(77.40)	69(22.00)	245(78.00)	156(49.68)	158(50.32)
x^2	0.13	0.56		0.06		0.01		1.21	
Sex Combined	621(100.00)	201(32.37)	420(67.63)	143(23.03)	478(76.97)	136(21.90)	485(78.10)	296(47.66)	325(52.34)

Table 3. Association of socio-economic, demographic characteristics with nutritional status

Variables	Categories	No Anthropometric Failure		Anthropometric Failure		
		N	%	N	%	x^2
Fathers' education	Upto secondary level	153	46.08	179	53.92	
	Above secondary level	172	59.52	117	40.48	11.17**
Mothers' education	Upto secondary level	185	46.37	214	53.63	
	Above secondary level	140	63.06	82	36.94	15.94**
Monthly Family income (Per capita)	>2500 INR	138	43.40	180	56.60	
	≤2500 INR	187	61.72	116	38.28	20.88**
Monthly Family expenditure (Per capita)	>2500 INR	147	44.41	184	55.59	
	≤2500 INR	178	61.38	112	38.62	17.84**
Mothers' occupation	Home maker	294	53.07	260	46.93	
	Working mother	31	46.27	36	53.73	1.11
Fathers' occupation	Manual	116	44.27	146	55.73	
	Non-Manual	209	58.22	150	41.78	11.80**
Number of family members	Up to 5vmembers	196	54.44	164	45.55	1.53
	Above 5 members	129	49.42	132	50.57	
House ownership	Owned	179	48.91	187	51.09	
	Rental	146	57.25	109	42.75	4.19*
Number of living rooms	≤2Rooms	210	47.30	234	52.70	
	>2Rooms	115	64.97	62	35.03	15.85**
Fuel types	Smokeless fuel	288	52.84	257	47.16	
	Smoky fuel	37	48.68	39	51.32	0.46
Sources of drinking water	Tube well	170	50.60	166	49.40	
	Tap water	155	54.39	130	45.61	0.89

**p<0.001; *p<0.05

Table 4. Results of univariate binary logistic regression) analysis on factors associated with undernutrition

Variables	Categories	Total	Prevalence of CIAF		B	S.E.	Wald	p	ORs	95.0% CI	
			N	%						Lower	Upper
Father's education	Above secondary level*	289	117	40.84	-	-	-	-	1	-	-
	Up to secondary level	332	179	53.96	0.54	0.16	11.1	0.001	1.72	1.25	2.37
Mother's education	Above secondary level*	222	82	36.94	-	-	-	-	1	-	-
	Up to secondary level	399	214	53.63	0.68	0.17	15.74	0.001	1.98	1.41	2.76
Monthly income (per capita)	>2500 INR*	303	116	38.28	-	-	-	-	1	-	-
	≤2500 INR	318	180	56.60	0.74	0.16	20.63	0.001	2.10	1.53	2.90
Monthly expenditure (per capita)	>2500 INR*	290	112	38.62	-	-	-	-	1	-	-
	≤2500 INR	331	184	55.59	0.69	0.16	17.66	0.001	1.99	1.44	2.74
Father's occupation	Non-manual*	359	150	41.78	-	-	-	-	1	-	-
	Manual	262	146	55.73	0.56	0.16	11.72	0.001	1.75	1.27	2.42
Number of living rooms	>2 Rooms*	177	62	35.03	-	-	-	-	1	-	-
	≤2 Rooms	444	234	52.70	0.73	0.18	15.57	0.001	2.07	1.44	2.96
House ownership	Own*	366	187	51.09	-	-	-	-	1	-	-
	Rental	255	109	42.75	-0.30	0.16	4.19	0.041	0.72	0.52	0.99

OR = odds ratio;CI = confidence intervals (CIs), *reference category

Table 5. Results of forward stepwise logistic regression analysis

Steps	Variables	B	SE	Wald	p	OR (95% CI)
Step 1	Monthly family income per capita	.743	.164	20.634	.000	2.103 (1.526-2.898)
	Constant	-.478	.118	16.324	.000	.620
Step 2	Monthly family income per capita	.565	.183	9.552	.002	1.759 (1.230-2.517)
	Number of living rooms	.443	.206	4.631	.031	1.558 (1.040-2.333)
	Constant	-.706	.161	19.188	.000	.494