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Prevalence of Thinness and Associated Factors among 3 to 12 Year Old Boys of Purba Medinipur District, West Bengal, India

Pikli Khanra[1], Raja Chakraborty[2] and Kaushik Bose[1*]

[1]Department of Anthropology, Vidyadagar University, Midnapore -721102, West Bengal, India

[2]Department of Anthropology, Dinabandhu Mahavidyala, Bongaon, West Bengal, India

[*]Correspondence should be addressed to Kaushik Bose
(Email: kaushikbose@cantab.net)

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Abstract

Maternal and child undernutrition is highly prevalent in developing countries, resulting in substantial mortality and increased overall disease burden. In general, Body Mass Index (BMI) is the most appropriate, inexpensive and non-invasive tool to determine the nutritional status. The WHO cut-offs are provided for -1, -2 and -3 standard deviations (SD) for BMI-for-age and <-2 SD is classified as "thinness". A cross-sectional study was conducted in two areas (Haldia municipality and Desopran block) of Purba Medinipur of West Bengal, India. A total of 576 boys aged 3-12 years participated in this study. A pre structured schedule was prepared for data collection. Height (cm) and weight (kg) of the participants were measured. SPSS version 16 was used for data screening and analysis. WHO Anthro Plus 1.0.4. and WHO Anthro 3.2.2. software programmes were utilized for assessment of nutritional status. Overall, 220 (38.19%) participants were nutritionally thin. Bivariate and multivariate logistic regression were used to determine probable risk factors for thin boys. Multiple logistic regression showed that under nourished mother (Wald $\chi^2 = 8.75$, $p<0.01$) and low birth weight (Wald $\chi^2 = 16.02$, $p<0.001$) were very important risk factors for thinness.

Keywords: India; Body mass index; Bengalee; Boys.

AMS Subject Classification: 91D20.

1. Introduction

Prevalence of overweight is increasing worldwide, although underweight remains a major public health problem in developing countries (Black et al., 2013). Malnutrition is the most important risk factor for the burden of disease being directly and indirectly responsible for more than half of child death (Mazengia and Biks, 2018). Undernutrion continues to be the principal cause of ill-health condition and premature mortality and morbidity in developing countries (Nandy et al., 2005). In India, one of the important aims of nutritional research is to improve the undernutrion status and its related consequences among most nutritionally vulnerable segments especially children, adolescents and women. Anthropometry has been a reliable, non-invasive, inexpensive and easiest measurable method to assess nutritional status in adults and children (Kuczmarski et al., 2002). The body mass index (BMI) is an anthropometric measure that has been extensively used to assess nutritional status in terms of thinness (low BMI-for-age) or chronic energy deficiency (Cole et al., 2007). It has been suggested that BMI-for-age is a better indicator than weight-for-age (wasting) to assess the risk of infections associated with undernutrition (Cole et al., 2007 and WHO, 2007). Recently, BMI in relation to age (BMI- for- age) has been recommended to be the best surrogate anthropometric measure of thinness among children and adolescents aged between 2-18 years (Cole et al., 2007). International age-sex specific reference cut-offs have also been proposed to assess the prevalence of thinness (Cole et al., 2007). The WHO cut-offs are provided for -1, -2 and -3 standard deviations (SD) for BMI-for-age, of which <-2 SD defines “thinness” and <-3 SD “severe thinness”(WHO, 2007). Recently a number of studies have utilized these cut-offs to report the magnitude of thinness among Indian children (*Singh et al., 2014)* especially West Bengal (Bose and Bisai, 2008, Chakraborty and Bose, 2009, Mandal et al., 2009, *Mondal and Sen, 2010,* Das and Bose, 2011, Das et al., 2012, Guedes et al., 2013, Mandal et al., 2014, Mandal, 2014, Debnath et al., 2018) .

Several studies have consistently reported that the prevalence of child undernutrition is influenced by different types of socio-economic and socio-demographic variables (Guedes et al., 2013, Pearcea et al., 2016, Rengma et al., 2016, Sarkar, 2016, Yadav et al., 2016, Ramesh et al., 2017, Pal et al., 2017, Titaley et al., 2019, Mazengia and Biks, 2018). Chronic energy deficiency (CED) in women of reproductive age, common in India, is a manifestation of long-

standing malnutrition. It increases the risk of preterm births and infants with low birth weight (Black et al., 2013, Bharati et al., 2007, Deaton and Dreze, 2009) Low birth weight (LBW) was the largest contributor to child malnutrition DALYs (disability-adjusted life-years) in India, its slow decline should be considered as a priority. South Asia, with India as its largest component, is estimated to have the highest prevalence of LBW for any region in the world (Blencowe et al., 2019). A major issue with tracking LBW is the poor quality of birth weight data in many low-income and middle-income countries, including India (Blencowe et al., 2019). LBW adversely affects not only child health but also increases the risk of chronic diseases later in life. (Blencowe et al., 2012, Christian et al., 2013, Katz et al., 2013). Weight at birth is an intergenerational issue dependent on interplay of various factors, including maternal undernutrition, intrauterine growth, gestation at birth, birth spacing and order, and maternal age. The higher proportion of underweight women in the reproductive age group in India compared with sub-Saharan Africa has been suggested to contribute to a higher prevalence of LBW in India, even though sub-Saharan Africa is poorer. The findings in this report indicate that, if the trends up to 2017 continue, the NNM 2022 and the WHO and UNICEF 2030 targets will not be achieved in most states of India. Even working together with a common goal such as Global Every Newborn Action Plan, the India Newborn Action Plan launched in 2014, aims to reduce LBW through improved preconception and antenatal care, adolescent-specific health services, nutritional counseling, and micronutrient supplementation. (Lawn et al., 2014). India has been trying to address child undernutrition for many decades through various policy initiatives, such as the Integrated Child Development Scheme (ICDS) launched in 1975, the National Nutrition Policy (NNP) 1993, the Mid Day Meal Scheme (MDMS) for school children 1995, and the National Food Security Act 2013, (NNP, 1993, NFSA, 2015) but the prevalence of stunting, wasting and underweight remains high. Chronic undernutrition, caused by a variety of social, environmental, and economic risk factors, is unsurprisingly highest in the less developed states (Sen et al., 2011, Bovet et al., 2011, Rana et al., 2012, Schonbeck et al., 2014, Mohamed and Hussein, 2015, Selvaraj et al., 2016). Therefore the objectives of the present study were to assess the prevalence of thinness and its association with socio-economic, demographic and maternal and child heath factors.

2. Methodology

The present cross-sectional study was conducted in Haldia municipality and Deshopran block of Purba Medinipur and the data was collected during the period December 2014 to April 2016. The study was conducted among 576 boys aged 3-12 years old. A detailed description of the sampling procedure has been described elsewhere (Khanra et al., 2020; 2021). No strict statistical sampling of individuals could be applied to collect data due to operational difficulties in the field, as mentioned in other studies (Chakraborty et al., 2011, Das et al., 2018). Data were collected from two separate areas (one rural and one urban) of Purba Medinipur district. The rural children included in the present study belonged to three villages of Amtalia gram pancahyat namely Kultalia, Sikdarchak and Uttar Amtalia, under Contai - II Desopran block near Rasulpur river. Urban participants were selected from three colonies (CPT, IOC and HREL) and Rairarchak of Haldia municipality near Haldi River. Participants were selected by door to door visits. A structured questionnaire was used to collect data on socio demographic and economic (place of residence, categories of caste, fathers' education, mothers' education, fathers' occupation, mothers' occupation, family size, employed person, house ownership, number of living rooms, use of latrine, cooking fuel type, drinking water, monthly income per capita and monthly expenditure per capita), mother health issues (pregnancy status, maternal age at child birth and nutrition status of the mother) and child health related issues (weight at birth, number of elder sisters and/or brothers, number of younger sisters and/or brothers, parity, place of delivery, time period of breast feeding and supplementary food). All information were collected from parents by face to face interviews. Ethical guidelines, as laid down by the Helsinki Declaration of 2000, was adhered to (Touitou et al., 2004). Pregnancy status and place of delivery were collected from polio card as well as date of birth also. Participants were also classified into two categories based on caste, namely, general and reserved, following Government of India Guidelines. The latter group included individuals belonging to Schedule (SC) and Other Backward Caste (OBC). Information on family size, employed persons, living rooms, younger and elder sisters and brothers, time period of breast feeding and parity were collected from parents. Information about birth weight and time period of supplementary food were collected from polio card and classified following WHO (2007) guideline. Mother's nutritional status was determined using BMI. The BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2).

Based on their BMI, mothers were classified as undernourished (BMI <18.5 kg/m^2) or normal (>18.5 kg/m^2).

All anthropometric measurements were made by the first author. Weight (kg) and height (cm) were measured for each child to the nearest 1 mm and 500 g respectively, following standard procedures (Lohman et al., 1988). Technical error of measurements (TEM) were computed and they were found to be within reference values as given by Ulijaszek and Kerr (1999). The BMI for age Z Scores were computed to assess nutritional status. The Z Scores for these nutritional indicators were determined using the WHO Anthro 3.2.2. and Anthro Plus 1.0.4. software programs. Thinness was defined as BAZ less than -2 Z score (Cole et al., 2007). The data were statistical analysed using the Statistical Package for Social Sciences (SPSS: 16). A binary logistic regression model was fitted to identify factors associated with thinness. Variables which demonstrated significant association in the bivariate analysis were fitted into multivariable logistic regression analysis. Odds Ratios (OR) with the corresponding 95% confidence interval (CI) were calculated to show the significant level of associations in stepwise multiple logistic regression analysis. A *p*- value of <0.05 was considered to be statistically significant. The dependent variable thinness (thinness vs. normal) was coded as '0' = thinness; '1' = normal in the regression model. The stepwise multiple logistic regression analysis (Enter method) was undertaken to determine the most effective predictor variables. Predictor variables entered into regression analysis were: place of residence (urban vs. rural area), categories of caste (general vs. reserved), fathers' education (above secondary vs. upto secondary), mothers' education (above secondary vs. up to secondary), fathers' occupation (non manual vs. manual), mothers' occupation (house wife and working mother), family size (one to 5 members vs. above 6 members), employed person (above 2 persons vs. one person), house ownership (own vs. rental), number of living rooms (above 2 rooms vs. up to 2 rooms), use of latrine (sanitary latrine vs. open and others), cooking fuel type (smokeless vs. smoky fuel), dirking water (tube well vs. tap), monthly income per capita (Rs.≥2001 vs. Rs.≤2000), monthly expenditure per capita (Rs.≥1751 vs. Rs.≤1750), pregnancy status (1^{st} vs. 2^{nd} and above), maternal age at child birth (>20 years vs. ≤20years), nutrition status of the mother (normal vs. underweight), weight at birth (≥2500gm vs. <2500gm), number of elder sisters & brothers (no elder sisters and brothers vs. elder sisters and brothers), number of younger sisters & brothers (no younger

brothers and sisters vs. younger brothers and sisters), parity (1st parity vs. others), place of delivery (institutional vs. home), times period of breast feeding (2 years and above vs. less than 2 years) and supplementary food (around 6 months vs. above 6 months).

3. Results

A total of 615 (Rural = 308; Urban = 307) boys, aged 3 to 12 years, were included in this study. Complete response was obtained from 576 (93.66%) individuals. Overall, 291(50.52%) participants were urban residents while 285 (49.47%) were from rural areas. In total, 220 (38.19%) participants were nutritionally thin. Overall, 67.5% boys belonged to general categories of caste. The majority of parents were educated up to secondary educational level. Around 57.1% fathers were manual workers and 88.2% mothers were house wife. Out of the total respondents, 72.6% of households had less than six members and 73.6% households had one employed person. We observed that 79.5% families had their own house and 77.8% families were living in house having two rooms or less than two rooms. It was found that 83.8% children used sanitary latrine and 47.4 % families used smokeless fuel for cooking purpose. Around 48 families had above Rs. 2000 income (per capita) and also above Rs. 1750 expenditure (per capita) per month (table 1).

Most of the respondents (60%) had institutional delivery. The majority (89.9%) of the participants were born with normal (≥2500gm) birth weight. It was observed that 53.1% boys depended on breastfeeding practice above two years but 20.8% participants did not start supplementary feeding at around six months. Moreover, 37.2% boys were born to mothers aged below 20 years old. Out of total respondents, 9.7% mothers were nutritionally underweight. In total, 59.4% participants had no younger sisters and brothers while 41.5% participants had elder sisters and/or brothers. Lastly, 35.2% participants had younger brothers and/or sisters (table 2).

As presented in tables 3 and 4, predictors were assessed through binary logistic regression analysis. A total of 11 variables had significant effects on thinness. Boys from rural areas were more likely to be thin (OR = 1.66, CI = 1.18 - 2.33) than those from urban areas. Boys with poorly educated mothers were likely to be thin than those with moderately educated mothers (OR = 1.50, CI = 0.98 - 2.27).

Fathers' occupation was significantly (OR = 1.49, CI = 1.06 – 2.11) associated with thinness. Significantly (OR = 1.62, CI = 1.06 - 2.47) greater risk for thinness was found among those who lived in house having two rooms or less. The smoky fuel type in household also showed (OR = 1.52, CI = 1.08 - 2.14) greater risk for thinness among the boys (table 3).

Significantly higher odds (OR = 1.45, CI = 1.03 - 2.05) for thinness were found among those who were born at the time period of 2nd and above pregnancy period. There existed higher odds (OR = 2.26, CI = 1.30 - 3.93) of thinness in LBW boys. At the household level, the odds (OR = 1.51, CI = 1.05 - 2.16) of thinness increased significantly among those having younger sisters, brothers and/or both. Parity was also significantly (OR = 1.46, CI = 1.04 - 2.06) associated with prevalence of thinness. Those who did not undertake supplementary food at around six month were significantly more likely (OR = 1.55, CI = 1.03 - 2.33) to be thin. Higher odds (OR = 4.29, CI = 2.36 - 7.81) were observed among boys whose mother were nutritionally undernourished (table 4).

The result multivariate logistic regression showed that boys with undernourished mother were more likely to be thin (Wald $\chi^2 = 8.75$, $p<0.01$). The odds (Wald $\chi^2 = 16.02$, $p<0.001$) for thinness in boys were significantly high among those who weighed <2500gm at birth. Those boys who had younger sisters and brothers were more likely to be thin (Wald $\chi^2 = 5.75$, $p = 0.01$) than the other boys. Boys from rural areas were significantly more likely to be thin (Wald = 5.13, $p<0.05$) (table 5).

4. Discussion

The prevalence of thinness in the current study was 38.19%. This prevalence was higher than those observed in Sudan (23.1%) (Mohamed and Hussein, 2015). It was much higher than those observed in Netherlands (9.8%) (Schonbeck et al., 2014), Southern Nigeria (13.0%) (Ene-Obong et al., 2012), Southern Australia (5%) (Pearcea et al., 2016) and Brazil (4%) (Guedes et al., 2013). However, it was lower than those observed (53.69%) in of some other parts of rural India by Singh et al. (2014) (53.69%). It was also lower than those repoted (71.1%) by Mondal and Sen (2010) from another rural Indian region. Some other cross-sectional regional studies have also reported higher prevalence (Bose and Bisai, 2008, Chakraborty and Bose, 2009, Das and Bose, 2011, Das et al., 2012) than the current study.

We observed higher odds for thinness among those living in rural area. Many previous studies have reported similar findings of higher prevalence of undernutrition is rural areas (Mazengia and Biks, 2018, Titaley et al., 2019, Ray and Chandra, 2013, Pal et al., 2016, Abbasi et al., 2018). Prevalence of thinness was significantly higher in children whose parents were educated up to secondary level compared with those who were educated above secondary level. Mother's education is very often considered the most significant predictor of children's undernutrition (Stamenkovic et al., 2016). Children whose mothers have higher education are more likely to be better nourished (Mazengia and Biks, 2018, Nguyen et al., 2013, Keino et al., 2014, Mohammad et al., 2014, Tigga et al., 2015, Getaneh et al., 2019). Fathers' occupation also plays an important part in child nutrition because household income and asset mainly depend on it (Rahman et al., 2009). We also found higher odds for thinness in boys whose fathers were working in manual occupational group. Similar findings had been reported earlier (Rengma et al., 2016, Pal et al., 2017, Tigga et al., 2015, Getaneh et al., 2019, Owoaje et al., 2014). The environment and number of living rooms during early life is an important source of exposure to chemical, biological, and physical agents (Krieger and Higgins, 2002, Harker, 2006, Oudin. 2017). 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. 2017). Some previous studies have already reported that number of living rooms was significantly associated with undernutrition among the children (Biswas et al., 2011, Mondal et al., 2012, Biswas et al., 2013, Khan and Raza, 2014). Higher prevalence of undernutrition was found among those belonging to families using smokey fuel type for cooking. Women and children, who spend most of the time indoors and in the vicinity of cooking areas (Duflo et al., 2008, Mishra et al., 2002) could be affected to acute respiratory infection (ARI), anemia, blindness and other disorders (WHO, 2000), which may lead to a growth retardation. Some previous studies had also similar results (Bhagowalia and Gupta, 2011, Sharma et al., 2011, Smith, 2000, Yeasmin and Islam, 2016, Cruz et al., 2017).

Birth order and number of elder sisters and brothers were significantly associated with prevalence of thinness. Some previous studies have reported that these factors were closely associated with child health (Debnath et al., 2018, Pal et al., 2016, Abbasi et al., 2018, Mondal et al., 2012, Biswas et al., 2013, Degarege et al., 2015, Roy et al., 2018). We observed that higher odds existed for thinness among those who did not receive supplementary food at six months. Exclusive

breastfeeding for the first 6 months and continued breast feeding together with appropriate foods can have a major impact child's survival, growth and development (Scherbaum and Srour, 2016). Exclusive breast feeding and supplementary food need to start at appropriate time periods for improved child health (Swaminathan et al., 2019). Some previous studies reported similar findings (Mazengia and Biks, 2018, Titaley et al., 2019, Roy et al., 2018, Scherbaum and Srour, 2016, Khan and Islam, 2017). It was observed that LBW was significantly associated with thinness. Higher prevalence of thinness was found among boys whose mothers were nutritionally undernourished. Malnutrition in women at reproductive age is a manifestation of log-standing nutritional stress because it increases the risk of preterm births and infants with LBW (Mazengia and Biks, 2018, Titaley et al., 2019, Swaminathan et al., 2019, Tette et al., 2015, Rahman et al., 2016).

Multiple logistic regression analysis showed that rural area, LBW, presence of elder sisters and brothers and undernourished mothers were significantly associated with prevalence of thinness. The present study reported higher odds in boys whose mothers were undernourished and those born with low weight at birth than the other two predictors. During reproductive time, CED in women is a vital issue because it increases the risk of preterm births and infants with LBW. We found that LBW boys had an increased likelihood of being undernourished as found in previous literature [Mazengia and Biks, 2018, Titaley et al., 2019, Swaminathan et al., 2019, Ntenda, 2019). LBW individuals tended to remain underweight until early childhood (Swaminathan et al., 2019). The child's sub-optimal growth during the prenatal period is often the result of maternal nutrition. During the postnatal period sufficient feeding practices can reduce the effects of poor intellectual growth (Rahman et al., 2016, Akombi et al., 2017). Improving the nutritional status of girls in general and that of women in the preconception period and during pregnancy and provision of quality antenatal care, including the treatment of pregnancy complications, would positively affect LBW and extend the benefits to the next generation (Blencowe et al., 2019). After LBW baby delivery, if dietary intake is inadequate and there is an effect of unhealthy environmental conditions, children will have increased chances of different types of infections that continuously lead to poor growth (Akombi et al., 2017).

One main limitation of our work is that the sample size of this study was not statistically determined. Moreover, detailed information on daily food intake, diet

composition and activity patterns were not available. However, the principal strength of this paper is that it investigates rural/urban differences in the prevalence of thinness and associated risk factors among pre-adolescent boys. Hitherto, very few studies from India have done this.

5. Conclusion

Our study reported that a large number (38.9%) of boys were thin. Low birth weight and poor maternal nutritional status were important predictor variables of thinness.

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References

[1] Abbasi S, Mahmood H, Zaman A, Farooq ZD, Mallk A, Saga Z. (2018). Indicators of Malnutrition in Under 5 Pakistani Children: A DHS Data Secondary Analysis. Journal of Medical Research and Health Education, 2(3), 1-10.

[2] Akombi, B., Agho, K., Hall, J., Wali, N., Renzaho, A. and Merom, D. (2017). Stunting, Wasting and Underweight in Sub-Saharan Africa: A Systematic Review. International Journal of Environmental Research and Public Health, 14(8), 863–881.

[3] Bhagowalia, Priya and Gupta, Parul, (2011). "Nutritional status and access to clean fuels: Evidence from South Asia," 2011 Annual Meeting, July 24-26, 2011, Pittsburgh, Pennsylvania 103728, Agricultural and Applied Economics Association.

[4] Bharati, S., Pal, M., Bhattacharya, B. N. and Bharati, P. (2007). Prevalence and Causes of Chronic Energy Deficiency and Obesity in Women of India. Human Biology, 79(4), 395–412.

[5] Biswas S, Bose K, Koziel S. (2011). Effect of social factors on nutritional status among rural Bengalee preschool children from Eastern India.

International Journal of Human Science, 8(1), 289-300.

[6] Biswas S., Koziel S., Chakraborty R. and Bose K. (2013). Sibling Composition and Household Room Sharing Are Associated with Menarcheal Status among Rural Bengalee Girls of West Bengal, India. Human Biology, 85(4), 607–618.

[7] Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R. and Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. The Lancet, 382(9890), 427–451.

[8] Blencowe, H., Cousens, S., Oestergaard, M. Z., Chou, D., Moller, A.-B., Narwal, R., Adler, A., Vera Garcia, C., Rohde, S., Say, L. and Lawn, J. E. (2012). National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. The Lancet, 379(9832), 2162–2172.

[9] Blencowe, H., Krasevec, J., de Onis, M., Black, R. E., An, X., Stevens, G. A., Borghi, E., Hayashi, C., Estevez, D., Cegolon, L., Shiekh, S., Ponce Hardy, V., Lawn, J.E. and Cousens, S. (2019). National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. The Lancet Global Health, 7(7), e849–e860.

[10] Bose, K. and Bisai, S. (2008). Prevalence of undernutrition among rural adolescents of West Bengal, India. Journal of Tropical Pediatrics, 54(6), 422–423.

[11] Bovet, P., Kizirian, N., Madeleine, G., Blössner, M. and Chiolero, A. (2011). Prevalence of thinness in children and adolescents in the Seychelles: comparison of two international growth references. Nutrition Journal, 10(65), 1–6.

[12] Chakraborty, R. and 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. Journal of Research in Medical Sciences: The Official Journal of Isfahan University of Medical Sciences, 14(2), 129–133.

[13] Chakraborty, R., Bose, K. and Koziel, S. (2011). Use of mid-upper arm circumference in determining undernutrition and illness in rural adult Oraon men of Gumla District, Jharkhand, India. Rural and Remote Health, 11(3), 1–12.

[14] Christian, P., Lee, S. E., Donahue Angel, M., Adair, L.S., Arifeen, S. E., Ashorn, P., Barros, F. C., Fall, C. H., Fawzi, W. W., Hao, W., Hu, G., Humphrey, J. H., Huybregts, L., Joglekar, C. V., Kariuki, S. K., Kolsteren, P., Krishnaveni, G. V., Liu, E., Martorell, R. and Osrin, D. (2013). Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries. International Journal of Epidemiology, 42(5), 1340–1355.

[15] Cole, T. J., Flegal, K. M., Nicholls, D. and Jackson, A. A. (2007). Body mass index cut offs to define thinness in children and adolescents: international survey. British Medical Journal, 335(7612), 194–201.

[16] Cruz, L. G., Azpeitia, G. G, Súarez, D. R, Rodríguez, A. S, Ferrer, J. L and Serra-Majem, L. (2017). Factors Associated with Stunting among Children Aged 0 to 59 Months from the Central Region of Mozambique. Nutrients, 9(5), 491–507.

[17] Das, P., Khatun, A., Bose, K. and Chakraborty, R. (2018). The validity of mid-upper arm circumference as an indicator of low BMI in population screening for undernutrition: a study among adult slum dwellers in eastern India. Public Health Nutrition, 21(14), 2575–2583.

[18] Das, S. and Bose, K. (2011). Prevalence of Thinness among Santal Preschool Children Using New Body Mass Index Cut-Off Points. Journal of Anthropology, 2011, 1–4.

[19] Das, S., Mahata, M. and Bose, K. (2012). Age-trend in thinness among Birhor children and adolescents of Purulia: a primitive tribe of West Bengal, India. Asian Journal of Biological and Life Sciences 1(1), 58–60.

[20] Deaton A, Dreze J. Food and nutrition in India: facts and interpretations. Economic and Political Weekly 2009; XLIV: 42–65.

[21] Debnath, S., Mondal, N. and Sen, J. (2018). Prevalence of thinness among rural children of West Bengal, India. Human Biology Review, 7 (4), 362-385.

[22] Degarege, D., Degarege, A. and Animut, A. (2015). Undernutrition and associated risk factors among school age children in Addis Ababa, Ethiopia. BMC Public Health, 15(1), 1–9.

[23] Duflo, E., Kremer, M. and Robinson, J. (2008). How High Are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya. American Economic Review, 98(2), 482–488.

[24] Ene-Obong, H., Ibeanu, V., Onuoha, N. and Ejekwu, A. (2012). Prevalence of Overweight, Obesity, and Thinness among Urban School-Aged Children and Adolescents in Southern Nigeria. Food and Nutrition Bulletin, 33(4), 242–250.

[25] Getaneh, Z., Melku, M., Geta, M., Melak, T. and Hunegnaw, M. T. (2019). Prevalence and determinants of stunting and wasting among public primary school children in Gondar town, northwest, Ethiopia. BMC Pediatrics, 19(1), 3–11.

[26] Guedes, D. P., Almeida, F. N., M. Neto, J. T., Maia, M. de F. de M. and Tolentino, T. M. (2013). Low body weight/thinness, overweight and obesity of children and adolescents from a Brazilian region of low economic status. Revista Paulista de Pediatria, 31(4), 437–443.

[27] Harker, L. (2006). Chance of a lifetime : the impact of bad housing on children's lives. London: Shelter Uk.

[28] Katz, J., Lee, A. C., Kozuki, N., Lawn, J. E., Cousens, S., Blencowe, H., Ezzati, M., Bhutta, Z. A., Marchant, T., Willey, B. A., Adair, L., Barros, F., Baqui, A. H., Christian, P., Fawzi, W., Gonzalez, R., Humphrey, J., Huybregts, L.,

[29] Kolsteren, P. and Mongkolchati, A. (2013). Mortality risk in preterm and small-for-gestational-age infants in low-income and middle-income countries: a pooled country analysis. The Lancet, 382(9890), 417–425.

[30] Keino, S., Plasqui, G., Ettyang, G. and van den Borne, B. (2014). Determinants of stunting and overweight among young children and adolescents in sub-Saharan Africa. Food and Nutrition Bulletin, 35(2), 167–78.

[31] Khan, Md. N. and Islam, M. M. (2017). Effect of exclusive breastfeeding on selected adverse health and nutritional outcomes: a nationally representative study. BMC Public Health, 17(1), 1–7.

[32] Khan, R. E. A. and Raza, M. A. (2014). Child malnutrition in developing economies: a case study of Bangladesh. Quality and Quantity, 48(3), 1389–1408.

[33] 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.

[34] Khanra, P., Bose, K. and Chakraborty, R. (2021). Mother's education level is

associated with anthropometric failure among 3- to 12-year-old rural children in Purba Medinipur, West Bengal, India. Journal of Biosocial Science, 53(6), 856–867.

[35] Krieger, J. and Higgins, D. L. (2002). Housing and health: time again for public health action. American Journal of Public Health, 92(5), 758–768.

[36] Kuczmarski R. J, Ogden C. L, Guo S. S, et al. (2002). 2000 CDC growth charts for the United States: Methods and development. National Center for Health Statistics. Vital Health Statistics, 11(246), 1–190.

[37] Lawn, J.E., Blencowe, H., Oza, S., You, D., Lee, A.C., Waiswa, P., Lalli, M., Bhutta, Z., Barros, A.J., Christian, P., Mathers, C. and Cousens, S.N. (2014). Every Newborn: progress, priorities, and potential beyond survival. The Lancet, 384(9938), 189–205.

[38] Lohman, T. G. (1988). Anthropometric standardization reference manual. Champaign, Ill.: Human Kinetics Books.

[39] Mandal, G. C., Bose, K. and Bisai, S. (2009). Thinness among rural children in Bengal. The Indian Journal of Pediatrics, 76(8), 817–819.

[40] Mandal, S., Prabhakar, Vr., Pal, J., Parthasarathi, R. and Biswas, R. (2014). An assessment of nutritional status of children aged 0-14 years in a slum area of Kolkata. International Journal of Medicine and Public Health, 4(2), 159–162.

[41] Mazengia, A. and Biks, G. (2018). Predictors of Stunting among School-Age Children in Northwestern Ethiopia. Journal of Nutrition and Metabolism, 2018(10), 1–7.

[42] Mishra V. K, Retherford R. D, Smith K. R. (2002). Indoor air pollution: the quiet killer, Asia Pacific. Hawaii.edu,Analysis from the East-West. Center No. 63, 1–8

[43] Mohamed, S. and Hussein, M. D. (2015). Prevalence of Thinness, Stunting and Anemia Among Rural School-aged Sudanese Children: A Cross-sectional Study. Journal of Tropical Pediatrics, 61(4), 260–265.

[44] Mohammad, K., Kassab, M., Gamble, J., Creedy, D. K. and Foster, J. (2014). [45] Factors associated with birth weight inequalities in Jordan. International Nursing Review, 61(3), 435–440.

[46] Mondal, N. (2014). Thinness as Major Underlying Problem Among Adolescents of Northeast India. Journal of Nepal Paediatric Society, 34(1), 39–47.

[47] Mondal, N. and Sen, J. (2010). Prevalence of undernutrition among children (5–12 years) belonging to three communities residing in a similar habitat in North Bengal, India. Annals of Human Biology, 37(2), 199–217.

[48] Mondal, P.R., Biswas, S. and Bose, K. (2012). Gender discrimination in undernutrition with mediating factors among Bengalee school children from Eastern India. HOMO, 63(2), 126–135.

[49] Nandy, S., Irving, M., Gordon, D., Subramanian, S. V. and Smith, G. D. (2005). Poverty, child undernutrition and morbidity: new evidence from India. Bulletin of the World Health Organization, 83(3), 210–216.

[50] NFSA (2015). Ministry of Consumer Affairs, Food & Public Distribution, Government of India. National Food Security Act 9NFSA), 2013. Food and Public Distribution.

[51] Nguyen, H. T., Eriksson, B., Petzold, M., Bondjers, G., Tran, T. K., Nguyen, L.T. and Ascher, H. (2013). Factors associated with physical growth of children during the first two years of life in rural and urban areas of Vietnam. BMC Pediatrics, 13(149), 1–10.

[52] NNP (1993). Department of Women and Child Development, Ministry of Human Resource Development, Government of India. National Nutrition Policy. Government of India.

[53] Ntenda, P. A. M. (2019). Association of low birth weight with undernutrition in preschool-aged children in Malawi. Nutrition Journal, 18(51), 1–15.

[54] Oudin, A. (2017). Air pollution and dementia. Journal of Public Health and Emergency, 1(49), 1–4.

[55] 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 African Medical Journal, 17, 1–7.

[56] Pal, A., Pari, A. K., Sinha, A. and Dhara, P. C. (2017). Prevalence of undernutrition and associated factors: A cross-sectional study among rural adolescents in West Bengal, India. International Journal of Pediatrics and Adolescent Medicine, 4(1), 9–18.

[57] Pal, D., Kanungo, S., Bal, B., Bhowmik, K., Mahapatra, T. and Sarkar, K. (2016). Malnutrition Scenario among School Children in Eastern-India-an Epidemiological Study. Epidemiology: Open Access, 06(02), 1–9.

[58] Pearce, A., Scalzi, D., Lynch, J. and Smithers, L. G. (2016). Do thin, overweight and obese children have poorer development than their

healthy-weight peers at the start of school? Findings from a South Australian data linkage study. Early Childhood Research Quarterly, 35, 85–94.

[59] Rahman, M., Mostofa, G. and Nasrin, S. (2009). Nutritional status among children aged 24-59 months in rural Bangladesh: An assessment measured by BMI index. The Internet Journal of Biological Anthropology, 3(1), 1–7.

[60] Rahman, M. S., Howlader, T., Masud, M. S. and Rahman, M. L. (2016). Association of Low-Birth Weight with Malnutrition in Children under Five Years in Bangladesh: Do Mother's Education, Socio-Economic Status, and Birth Interval Matter? PLOS ONE, 11(6), e0157814.

[61] Ramesh S, Sundari S, 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. Research Journal of Pharmaceutical, Biological and Chemical Science, 8(3): 1495-1499.

[62] Rana M. Md., Fredoushi A, Tamanna S, Sabrin F, Afroz N. N. (2012). Assessment of nutritional status of 5-10 years Garo children in Sherpur District, Bangladesh. International Journal of Bioscience, 2(11), 66-73.

[63] Ray I, Chandra A. K. (2013). An anthropometric study on the children of Tripura: Nutritional and health coverage and redefining WHO percentile cut-off points. International Journal of Science and Research, 3(5):1-8.

[64] Rengma, M., Bose, K. and Mondal, N. (2016). Socio-economic and demographic correlates of stunting among adolescents of Assam, North-east India. Anthropological Review, 79(4), pp.409–425.

[65] Roy, K., Dasgupta, A., Roychoudhury, N., Bandyopadhyay, L., Mandal, S. and 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. International Journal of Contemporary Pediatrics, 5(4), pp.1651–1656.

[66] Yeasmin S. and Islam K. (2016). Prevalence and Determinants of Undernutrition among School Age Slum Children in Dhaka City, Bangladesh. Journal of Nutrition and Health Sciences, 3(2), 1–8.

[67] Sarkar, S. (2016). Cross-sectional study of child malnutrition and associated risk factors among children aged under five in West Bengal, India. International Journal of Population Studies, 2(1), 89–102.

[68] Scherbaum V, Srour M. L. (2016).The Rloe of Breastfeeding in the

Prevention of Childhood Malnutrition. World Review of Nutrition and Dietetics, 115:82-97

[69] Schonbeck, Y., van Dommelen, P., Hira Sing, R. A. and van Buuren, S. (2014). Thinness in the era of obesity: trends in children and adolescents in The Netherlands since 1980. The European Journal of Public Health, 25(2), 268–273.

[70] Selvaraj, V., Sangareddi, S., Velmurugan, L., Muniyappan, U. and Anitha, F. (2016). Nutritional status of adolescent school children in a semi-urban area based on anthropometry. International Journal of Contemporary Pediatrics, 3(2), 468–472.

[71] Sen J, Dey S, 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 Journal of Public Health. 8(2): 172-85.

[72] Sharma M. K, Kumar D, Mittal P. C, Goel N. (2011). Status of Child Undernutrition: Some Socio-Demographic Concerns in Allahabad, Uttar Pradesh Indian. Journal of Epidemiology and Community Health, 42(1): 38-43.

[73] Singh, J., Kariwal, P., Gupta, S., Singh, A. and Imtiaz, D. (2014). Nutritional status and morbidity among school going children: A scenario from a rural India. Scholars Journal of Applied Medical Sciences, 2(1D), 379–383.

[74] Smith, K. R. (2000). National burden of disease in India from indoor air pollution. Proceedings of the National Academy of Sciences, 97(24), 13286–13293.

[75] Stamenkovic, Z., Djikanovic, B., Laaser, U. and Bjegovic-Mikanovic, V. (2016). The role of mother's education in the nutritional status of children in Serbia. Public Health Nutrition, 19(15), 2734–2742.

[76] Swaminathan, S., Hemalatha, R., Pandey, A., Kassebaum, N. J., Laxmaiah, A., Longvah, T., Lodha, R., Ramji, S., Kumar, G.A., Afshin, A., Gupta, S. S., Kar, A., Khera, A. K., Mathai, M., Awasthi, S., Rasaily, R., Varghese, C. M., Millear,

[77] A.I., Manguerra, H. and Gardner, W. M. (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. The Lancet Child and

Adolescent Health, 3(12), pp.855–870.

[78] Tette, E. M. A., Sifah, E. K. and Nartey, E. T. (2015). Factors affecting malnutrition in children and the uptake of interventions to prevent the condition. BMC Pediatrics, 15(189), 1–11.

[79] Tigga, P. L., 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. Ethiopian Journal of Health Sciences, 25(1), 63–72.

[80] Titaley, C. R., Ariawan, I., Hapsari, D., Muasyaroh, A. and Dibley, M.J. (2019). Determinants of the Stunting of Children Under Two Years Old in Indonesia: A Multilevel Analysis of the 2013 Indonesia Basic Health Survey. Nutrients, 11(5), 1106–1118.

[81] Touitou, Y., Portaluppi, F., Smolensky, M. H. and Rensing, L. (2004). Ethical Principles and Standards for the Conduct of Human and Animal Biological Rhythm Research. Chronobiology International, 21(1), 161–170.

[82] Ulijaszek, S. J. and Kerr, D. A. (1999). Anthropometric measurement error and the assessment of nutritional status. British Journal of Nutrition, 82(3), 165–177.

[83] WHO, (2000). Global strategy for health for all by the year 2000. Geneva: World Health Organization.

[84] World Health Organization (2007). WHO child growth standards: head circumference-for-age, arm circumference-for-age, triceps skinfold-for-age and subscapular skinfold-for-age : methods and development.

[85] Yadav, A., Kotwal, A., Vaidya, R. and Yadav, J. (2016). Anthropometric indices and its socio-demographic determinants among primary school children of an urban school in Pune, India. International Journal of Medicine and Public Health, 6(4), 160–164.

Table 1: Socio-economic and demographic characteristics of the families of the participants.

Variables	Categories	Frequency	Percent
Place of residence	Urban area	291	50.5
	Rural area	285	49.5
Categories of caste	General	389	67.5
	Reserved	187	32.5
Fathers' education	Above secondary	184	31.9
	Upto secondary	392	68.1
Mothers' education	Above secondary	129	22.4
	Upto secondary	447	77.6
Fathers' occupation	Non manual	247	42.9
	Manual	329	57.1
Mothers' occupation	House wife	508	88.2
	Working mother	68	11.8
Family size	1-5 members	418	72.6
	Above 6 members	158	27.4
Employed person	Above 2 persons	152	26.4
	One person	424	73.6
House ownership	Own	458	79.5
	Rental	118	20.5
Number of living rooms	Above 2	128	22.2
	Upto 2	448	77.8
Use of latrine	Sanitary latrine	483	83.8
	Open and others	93	16.1
Cooking fuel type	Smokeless	273	47.4
	Smoky fuel	303	52.6
Dirking water	Tube well	425	73.8
	Tap	151	26.2
Monthly income (per capita)	Rs.≥2001	279	48.4
	Rs. ≤2000	297	51.6
Monthly expenditure (per capita)	Rs.≥1751	280	48.6
	Rs.≤1750	296	51.4

Table 2: Demographic, nutritional and birth related factors among the participants.

Variables	Categories	Frequency	Percent
Weight at birth	≥2500gm	518	89.9
	<2500gm	58	10.1
Pregnancy status	1St	359	62.3
	2nd and above	217	37.7
Number of elder sisters & brothers	No elder sisters and brothers	337	58.5
	Elder sisters and brothers	239	41.5
Number of younger sisters& brothers	No younger brothers and sisters	373	64.8
	Younger brothers and sisters	203	35.2
Birth order	1st	342	59.4
	2^{nd} and above	234	40.6
Maternal age at child birth	> 20 years	362	62.8
	≤ 20 years	214	37.2
Place of delivery	Institutional	346	60.1
	Home	230	39.9
Nutrition status of the mother	Normal	520	90.3
	Underweight	56	9.7
Times period of breast feeding	2 years and above	306	53.1
	less than 2 years	270	46.9
Supplementary food	Around 6 months	456	79.2
	Above 6 months	120	20.8

Table 3: Frequency distribution of the boys by different socio-economic and demographic characteristics and the results of binary logistic regressions.

Variables	Categories	Total	Prevalence of thinness		B	Wald	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
			n	%					Lower	Upper
Place of residence	Urban	291	94	32.3	-	-	-	-	-	-
	Rural	285	126	44.2	0.507	8.595	0.001	1.661	1.183	2.331
Categories of caste	General	389	148	38	-	-	-	-	-	-
	Reserved	187	72	38.5	0.019	0.011	0.91	1.02	0.712	1.459
Fathers' education	Above secondary	184	62	33.7	-	-	-	-	-	-
	Upto secondary	392	158	40.3	0.284	2.312	0.128	1.329	0.921	1.916
Mothers' education	Above secondary	129	40	31	-	-	-	-	-	-
	Upto secondary	447	180	40.3	0.405	3.61	0.05	1.5	0.987	2.279
Fathers' occupation	Non manual	247	81	32.8	-	-	-	-	-	-
	Manual	329	139	42.2	0.405	5.32	0.021	1.499	1.063	2.115
Mothers' occupation	House wife	508	194	38.2	-	-	-	-	-	-
	Working mother	68	26	38.2	0.002	0	0.99	1	0.595	1.687
Number of family members	Upto 5 members	418	164	39.2	-	-	-	-	-	-
	Above 6 & members	158	56	35.4	-0.16	0.698	0.404	0.85	0.581	1.244
Employed persons	Above 2 persons	152	57	37.5	-	-	-	-	-	-
	One person	424	163	38.4	0.042	0.045	0.831	1.042	0.711	1.528
House ownership	Own	458	179	39.1	-	-	-	-	-	-
	Rental	118	41	34.7	-0.19	0.746	0.388	0.83	0.544	1.267
Number of living rooms	Above 2 Rooms	128	83	64.8	-	-	-	-	-	-
	Upto 2 Rooms	448	182	40.6	0.483	4.992	0.025	1.62	1.061	2.475
Use of latrine	Sanitary latrine	483	177	36.6	-	-	-	-	-	-
	Open and others	93	43	46.2	0.397	3.015	0.082	1.487	0.95	2.326
Cooking fuel type	Smokeless	273	90	33	-	-	-	-	-	-
	Smoky fuel	303	130	42.9	0.424	5.981	0.014	1.528	1.088	2.146
Drinking water	Tube well	425	171	40.2	-	-	-	-	-	-
	Tap	151	49	32.5	-0.34	2.848	0.092	0.714	0.482	1.056
Per capita income	Rs.≥ 2001	279	113	40.5	-	-	-	-	-	-
	Rs.≤ 2000	297	107	36	-0.19	1.219	0.27	0.827	0.591	1.158
Per capita expenditure	Rs.≥ 1751	280	103	36.8	-	-	-	-	-	-
	Rs.≤1750	296	117	39.5	0.116	0.458	0.499	1.123	0.802	1.573

Table 4: Frequency distribution of the boys by different child and maternal characteristics and the results of binary logistic regressions.

Variables	Categories	Total	Prevalence of thinness		B	Wald	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
			n	%					Lower	Upper
Pregnancy status	1 st	359	125	34.8	-	-	-	-	-	-
	2nd and above	217	95	43.7	0.377	4.582	0.032	1.458	1.032	2.058
Weight at birth	≥2500gm	518	187	36.1	-	-	-	-	-	-
	<2500gm	58	33	56.8	0.818	8.401	0.004	2.266	1.303	3.939
Elder sisters & brothers	No elder sisters & brothers	337	118	35	-	-	-	-	-	-
	Elder sisters or brothers or both present	239	102	42.7	0.323	3.469	0.063	1.382	0.983	1.942
Younger sisters & brothers	No younger sisters & brothers	373	155	41.6	-	-	-	-	-	-
	Younger sisters or brothers or both present	203	65	32	0.412	5.036	0.025	1.51	1.054	2.163
Birth order	1 st	342	118	34.5	-	-	-	-	-	-
	2nd and above	234	102	43.6	0.383	4.842	0.028	1.467	1.043	2.064
Mother age at child birth	>20 years	362	136	37.6	-	-	-	-	-	-
	≤20 years	214	84	39.3	0.071	0.161	0.688	1.074	0.759	1.519
Place of delivery	Institutional	346	137	39.6	-	-	-	-	-	-
	Home	230	83	36.1	-0.15	0.72	0.396	0.861	0.61	1.216
Nutritional status of the mother	Normal	520	181	34.8	-	-	-	-	-	-
	Undernourished	56	39	69.6	1.458	22.868	0.001	4.297	2.364	7.81
Breast feeding	2 years and above	306	110	35.9	-	-	-	-	-	-
	Less than 2 years	270	110	40.7	0.203	1.395	0.238	1.225	0.875	1.716
Supplementary food	Within 6 months	456	164	36	-	-	-	-	-	-
	Above 6 months	120	56	46.7	0.443	4.571	0.033	1.558	1.038	2.339

Table 5: Results of multivariate logistic regression model to predict thinness

Variables	B	Wald	OR(95.0% CI)	Sig.
Place of residence	0.412	5.137	1.509(1.05-2.15)	0.023
Younger sisters & brothers	0.465	5.759	1.592(1.08-2.32)	0.016
Mother nutrition	1.256	16.029	3.512(1.89-6.49)	0.001
Weight at birth	0.879	8.755	2.409(1.34-4.31)	0.003