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Stunting is Associated with Low Birth Weight Among 3-12 Years Old Boys in Purba Medinipur, West Bengal, India

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Stunting is a serious public health issue. It raises the risk of sickness in infancy and childhood. Low- and middle-income nations, notably India, have been battling for years to overcome this major issue, which is also connected to many socioeconomic and biological issues. However, understanding the interaction pattern of undernutrition with these determinants is critical for efficient policies and execution. Stunting (low height-for-age) in newborns and children is a well-known and simple indicator of undernutrition. The current study sought to determine the relationship among stunting, socioeconomic, demographic, and birth-related variables. The research was conducted in the Haldia municipality and Deshopran block (West Bengal, India). The participants were 291 (50.5%) urban and 285 (49.5%) rural boys aged 3-12 years. Stunting was defined as height-for-age 'Z Score' < -2. Overall, 13.88% boys were stunted. Stunting was significantly associated with low birth weight (LBW), controlling for all other significant variables.

Key Words: India, children, stunting, low birth weight

Introduction

Body height or stature is a linear anthropometric measurement influenced by genetic, socioeconomic, demographic and dietary factors in a population [25, 33]. Stunting, defined as low height for age (HAZ), is a well-recognized indicator of linear growth in children. A child is said to be stunted if the age and sex-specific z-score for height is less than -2 [82]. The state of stunting was suggested to reflect a chronic nutritional deficiency, often connected with socioeconomic and environmental adversities [3]. In 2016, an estimated 144 million children less than five years in low- and middle-income countries (LMIC) were stunted [81]. In India, 38.4% of children were found stunted in the fourth National Family Health Survey (NFHS) 2015-16. In particular, 28% and 34% of children aged less than 5 years in urban and rural areas, respectively, were reportedly stunted in the Indian state of West Bengal [27]. Numerous studies have already reported the prevalence (%) of stunting in India ranging from 10.9 to 55.9 in boys and 18 to 58.4 in girls [1, 12, 17, 46, 62, 71], and in West Bengal [5, 6, 20, 43, 57, 64].

Stunting is considered to be a marker of the underlying processes responsible for poor growth and other adverse outcomes both in early and later life [16]. Stunting at an early stage of development leaves a long-lasting or permanent detrimental effect **on** later life. Stunted children often experience delayed skeletal maturation and usually become short adults and perform sub-optimal functions later in life [45]. Besides, it has long-term consequences **on** cognitive development, learning ability, and productivity during adulthood [16]. It also leads to reduced immune functions and increased susceptibility to infectious diseases. Stunting in childhood was also found to be associated with a higher incidence of non-communicable diseases, such as diabetes, hypertension, heart failure and other cardiovascular diseases during adulthood [10]. Stunted adolescents are often likely to develop overweight and obesity in adulthood [33, 66]. Long-term follow-up studies on children from five low- and middle-income countries, namely Brazil, Guatemala, India, the Philippines, and South Africa, found that childhood stunting was linked to short adult stature, lower lean body mass, less schooling, decreased mental functions, lower-income, and lower birth weight of infants born to women who had been stunted as children [77]. Thus, identifying stunting at an early stage in life could lead to improved population health in the long run.

Mothers' health and nutritional status are closely linked with those of their offspring. Children born to short women were at greater risk of mortality than children having mothers of normal height. Infants born to underweight or stunted women were highly likely to be underweight or stunted. In this way, undernutrition passes from one generation to another like an inherited attribute [55]. Several studies confirmed that poor height attainment due to undernutrition among women of childbearing age had a greater risk of adverse pregnancy outcomes or intrauterine growth retardation in the fetus [8, 77]. Low birth weight (LBW) and preterm birth are associated with short height in mothers [22, 39]. About twenty million infants are born each year with LBW, and many of them are from LMIC [74]. Moreover, the prevalence of stunting has been generally considered irreversible and difficult to reduce in a recurrent process. In childhood, women who were themselves stunted tend to have stunted offspring, creating an inter-generational cycle of poverty and reduced human capital [58]. The associations between poor socioeconomic, demographic and environmental conditions and chronic nutritional deficiencies are currently well known [9, 12, 35, 36, 46, 62, 65, 71]. Increased risk of stunting has been associated with both poor socioeconomic conditions and early exposure to adverse conditions, such as illness and inappropriate feeding practices [36, 70]. The results of a large survey from India revealed that undernutrition (indicated by anthropometry) was associated with birth-order, duration of breastfeeding, place of delivery of the child, wealth index of the household, mother's BMI and mother's education in both urban and rural areas [34].

Apart from all those factors as described above, the phenomenon of undernutrition may also have genetic mechanisms [18]. Stunting is a derivative of height, and the latter also has a strong heritability component [44]. It was recently claimed that stunting might not always be, or in every context, should be equated with undernourishment in children [67], indicating that stunting might have causal factors other than those responsible for undernourishment, in general. With the same dataset used in the present study, it was already recently reported that low levels of mothers' education in rural areas and lower family income with poor housing in urban areas were associated with a higher prevalence of undernourished children [35, 36]. Therefore, the present study aimed to re-assess the roles of socioeconomic and demographic factors, the already known contributors of stunting, maternal nutritional status, and birth-related factors, particularly birth weight. We hypothesized that factors, such as birth weight, shall have a significant effect relative to all other probable factors in predicting the prevalence of stunting among boys aged 3-12 years.

Materials and Methods

Participants and settings

This cross-sectional study was conducted between December 2014 and April 2016 in selected areas under Haldia Municipality and Deshopran Block (rural) areas of Purba Medinipur district of West Bengal state, India. Among the 615 (urban: 307; rural: 308) participants of the study, 576 (93.7%) provided complete information. Out of them, 291 (50.5%) were urban, and 285 (49.5%) were rural boys aged between 3 and 12 years. In the public education system of the state, children begin to attend the care centers to receive a mid-day meal and some pre-nursery type education approximately around 3 years of age. On the other hand, since the study was intended to restrict within the preadolescent stage of the boys, the upper age was restricted to 12 years. A detailed description of the sample recruitment procedure was described elsewhere [35, 36]. Data were collected from one rural and one urban area of Purba Medinipur District (PMD). The rural boys were recruited from three villages, namely Kultalia, Sikdarchak and Uttar Amtalia, under Desopran Block of Contai Subdivision of PMD and the urban boys from three settlement colonies (CPT, IOC and HREL) and Rairarchak area under Haldia Municipality. The study abode by the ethical guidelines as per Helsinki Declaration, 2000 [72].

Demographic, socioeconomic and birth-related information

Demographic, socioeconomic, maternal health and childbirth-related data were collected directly from the parents, in most cases, from mothers, through a structured questionnaire. The information included social category (general- or scheduled caste), place of residence (urban or rural), number of family members, numbers of elder- and/or younger sisters and brothers, number of living rooms, house ownership, family income, parental education, type of cooking fuel and dirking water facility. Information regarding mother's age at child birth, place of delivery, birth weight, duration of breast feeding and infant's age during the introduction of supplementary feeding were also recorded. Information about birth weight and the age of introducing supplementary food was obtained from the mothers. Low birth weight was defined as < 2500g of body weight of newborns [80].

Anthropometry

One researcher (PK) recorded all anthropometric measurements from all children. Height (cm) was measured for each child to the nearest millimeter, following standard procedure [42]. Prior to the commencement of the main survey, one researcher (PK) measured 30 individuals for standardization of protocol. The intra-individual technical errors of measurements were computed [73] and found within the acceptable limits, and thus, not incorporated in analyses of the main data set. Height-for-age 'Z Score' (HAZ) was computed to identify stunting among the children. The Z-Scores were derived using the WHO Anthro 3.2.2 and Anthro Plus 1.0.4 software. Stunting was defined as HAZ less than -2 [82].

Statistics

Percentages were used to report the distribution of the population according to categories of different variables. Mean and standard deviation (SD) statistics were used to describe continuous variables. Binary logistic regression (BLR) analyses (univariate model) were performed for each independent factor to assess whether it is significantly associated with stunting. In each BLR, odds ratio (OR) with 95% confidence interval (CI) was calculated to show the magnitude of association of a particular category of a predictor with stunting relative to the other category of the variables. Factors significantly associated in the bivariate analyses were further included in stepwise multivariate logistic regression analyses (enter method) to estimate their effects relative to each other and to identify the most effective predictor variables, if any. In all regression analyses, the dependent/outcome variable, namely, stunting was coded as 1 for 'stunted' and 0 for 'non-stunted'. The predictor variables in the present study were categorized as follow: social category (general or scheduled castes), place of residence (urban or rural), family size (≤5 or >5 members), Number of elder siblings or younger siblings (Nil vs. either or both present), number of living rooms (≤2 or >2 rooms), house ownership (own or rental), monthly family income per capita (≤2000 or >2000), parental education (both above secondary level or not), type of cooking fuel (smoky or smokeless), dirking water facility (tube well or municipal supply), mother's age at childbirth (≤20- or >20 years), place of delivery (institutional vs. home), birth weight (<2500gm vs. ≥ 2500gm), duration of breastfeeding (≤2 or >2 years) and infant's age on the introduction of supplementary feeding (≤ 6- or > 6 months). For each of these predictors, the superior alternatives (such as, smokeless fuel) or the higher values (such as birth weight ≥ 2500gm), were coded '0', whereas the respective poorer conditions or qualities (such as smoky fuel) or the lower values (such as birth weight ≥ 2500gm), were coded '1', respectively.

Family size, number of living rooms, number of younger and elder sisters and brothers, duration of breastfeeding and parity data were categorized on the basis cut off based on respective 50^{th} percentiles. Mother's age at childbirth, birth weight and place of delivery and date of birth were confirmed from the vaccination record. Duration of breastfeeding, the introduction of supplementary food and birth weight data were classified following appropriate guidelines [80]. Mother's nutritional status was determined using body mass index (BMI) calculated as weight in kilograms divided by height in meters squared (kg/m^2). Based on BMI values, the nutritional status of the mother were classified as undernourished (BMI $<18.5 kg/m^2$) or normal ($>18.5 kg/m^2$). A p-value of <0.05 is considered to be statistically significant. All statistical analyses were performed through SPSS-16 software.

Results

The overall prevalence of stunting among the boys in this study was 13.9%. **Tables 1 and 2** present the percent distribution of the participants according to categories of all independent factors as well as the significance of the association of each of these factors with stunting through the results of univariate BLR analyses. The results of BLR indicated that the risk of stunting was significantly higher (ORs = 2.53, $p<0.05$) among the boys whose parents were less educated. Poor household income was also significantly associated with a higher prevalence of stunting (ORs = 2.02, $p<0.05$). Boys who were very low weight at birth were significantly (ORs= 2.70, $p<0.01$) more likely to be stunted. Boys who had younger sisters and brothers were significantly (ORs=1.61, $p<0.05$) more likely to be stunted. Boys delivered at home were more likely to be stunted than those delivered at health institutions (ORs= 2.03, $p<0.01$). The risk of stunting was also found to be significantly (ORs=1.60, $p<0.05$) higher among boys whose mothers had less than 149.2cm height.

Table 3 presents the results of multivariate BLR analysis to identify independent risk factors predicting stunting. Boys who were low weight at birth were significantly ($p<0.005$) more likely to be stunted than boys who had a normal or healthy weight, independent of all other potential predictors. Other factors that show a significant effect on the prevalence of stunting in univariate BLR analyses did not reveal a significant impact in multivariate BLR analysis.

Discussion

The present study showed a significant association of stunting with parental education and family income when their effects were assessed separately. No other socio-demographic characteristic showed a statistically significant association. In contrast to their higher levels, lower parental income and educational levels were associated with a higher prevalence of stunting, respectively. However, this trend was not very surprising, since the previous studies, based on the same data set showed that mothers' education level in rural children, and the family economic condition in the urban counterpart, were the most important independent determinants of undernutrition among these 3-12 years old children [35, 36]. However, these studies used a composite index of anthropometric failure (CIAF), but not stunting, as the measure of undernourishment. Numerous previous researches showed that various measures of socioeconomic status, such as income, educational level and family assets, were associated with nutritional status in children [50, 52, 77]. The independent importance of both education and

Table 1. Frequency distribution and factors associated (binary logistic regression) with stunting among respondents by different socioeconomic and demographic characteristics

Variables	Categories	Total	(%)	Prevalence of stunting	B	Wald	p	OR	95 % CI for OR	
				N (%)					Lower	Upper
Place of residence	Urban®	291	50.5	45 (15.5)				1		
	Rural	285	49.5	35 (12.3)	-0.27	1.21	0.27	0.76	0.47	1.23
Social category	General®	389	67.5	56 (14.4)				1		
	Reserved	187	32.5	24 (12.8)	-0.13	0.25	0.61	0.87	0.52	1.46
Parental education	Both ≥ secondary*	117	20.3	8 (6.8)				1		
	Both < secondary	459	79.7	72 (15.7)	0.93	5.74	0.01	2.53	1.18	5.42
Family size	≤ 5 members*	418	72.6	61 (15.6)				1		
	> 5 members	158	27.4	19 (12.0)	-0.22	0.63	0.42	0.8	0.46	1.38
House ownership	Own*	458	79.5	62 (13.5)				1		
	Rental	118	20.5	18 (15.2)	0.14	0.23	0.63	1.15	0.65	2.03
Number of living rooms	> 2 rooms*	128	22.2	14 (10.9)				1		
	≤ 2 rooms	448	77.8	66 (14.7)	0.34	1.19	0.27	1.4	0.76	2.59
Cooking fuel type	Smokeless*	273	47.4	40 (14.6)				1		
	Smoky	303	52.6	40 (13.2)	-0.12	0.25	0.61	0.88	0.55	1.42
Drinking water	Tube well*	425	73.8	60 (14.1)				1		
	Tap	151	26.2	20 (13.2)	-0.07	0.07	0.79	0.92	0.54	1.6
Per capita income	Rs.>2000*	279	48.4	27 (9.7)				1		
	Rs. ≤2000	297	51.6	53 (17.8)	0.71	7.8	0.01	2.02	1.23	3.33
Per capita expenditure	Rs.>1750*	280	48.6	28 (10.0)				1		
	Rs.≤1750	296	51.4	52 (17.6)	0.65	6.73	0.01	1.92	1.17	3.13

® – reference category; CI – confidence interval, Binary logistic regression analysis (univariate model) considering effect of one predictor variables

Table 2. Frequency distribution and factors associated (binary logistic regression) with stunting among respondents by child and maternal issues

Variables	Categories	Total	(%)	Prevalence of stunting	B	Wald	p	OR	95.0% CI for OR	
				N (%)					Lower	Upper
Weight at birth	2500 & above*	518	89.9	64 (12.3)				1		
	<2500	58	10.1	16 (27.6)	0.93	9.49	0.01	2.7	1.43	5.08
Elder sisters & brothers	None*	337	58.5	46 (13.6)				1		
	Either or both	239	41.5	34 (14.2)	0.05	0.04	0.84	1.05	0.65	1.69
Younger sisters & brothers	None*	373	64.8	44 (11.8)				1		
	Either or both	203	35.2	36 (17.7)	0.48	3.83	0.05	1.61	0.99	2.6
Birth order	1st*	342	59.4	46 (13.4)				1		
	≥ 2nd	234	40.6	34 (14.5)	0.09	0.13	0.71	1.09	0.67	1.76
Mother age at child birth	≥ 20 years*	362	62.8	43 (11.9)				1		
	<20 years	214	37.2	37 (17.3)	0.44	3.26	0.07	1.55	0.96	2.49
Place of delivery	Institutional*	346	60.1	36 (10.4)				1		
	Home	230	39.9	44 (19.1)	0.71	8.56	0.01	2.03	1.26	3.28
Mothers' nutritional status	Normal*	520	90.3	74 (14.2)				1		
	Undernourished	56	9.7	6 (10.7)	0.32	0.52	0.47	0.72	0.29	1.74
Mothers' height	≥149.2cm*	288	50	32 (11.1)				1		
	<149.2cm	288	50	48 (16.7)	0.47	3.67	0.05	1.6	0.98	2.58
Period of breast feeding	≥ 2 years*	306	53.1	44 (14.4)				1		
	< 2 years	270	46.9	36 (13.3)	0.09	0.13	0.72	0.92	0.57	1.47
Introduction of supplementary food	≤ 6 months*	456	79.2	65 (14.2)				1		
	> 6 months	120	20.8	15 (12.5)	0.15	0.24	0.62	0.86	0.47	1.57

*Reference category; CI – confidence interval; Binary logistic regression analysis (univariate model) considering effect of one predictor variable

Table 3. Results of a multivariate logistic regression model (enter method) to predict stunting

Variables	B	Wald	p	OR	95.0% CI for OR	
					Lower	Upper
Parental education	0.546	1.547	0.21	1.727	0.73	4.08
Per capita income	0.42	1.099	0.294	1.51	0.699	3.263
Younger sisters and brothers	0.84	0.97	0.755	1.087	0.643	1.839
Weight at birth	0.947	7.856	0.005	2.579	1.33	5.003
Place of delivery	0.385	2.045	0.153	1.47	0.867	2.493
Mother height	0.318	1.567	0.211	1.375	0.35	2.262

CI – confidence interval

economic condition of the family for healthy growth of children were revealed in numerous previous studies, especially from low and middle-income countries [13, 32, 54, 57, 78]. There are plenty of evidence showing a positive association between low income and prevalence of stunting [31, 33, 37, 51, 57]. Therefore, improvement of the economic condition along with education seemed to be an effective measure to reduce child undernutrition, including stunting.

Similar to income and parental education, lower birth weight and birth at home, rather than in institutional health facilities, also showed association with higher chances of being stunted among the 3-12 years old boys in the present study. It is, however, worth mentioning that having one or more younger siblings and low mother's height was also very close to be significantly associated with stunting (Wald: 3.83 and 3.67, respectively, both p=0.05). Researchers have reported that the risk of stunting was higher among children born underweight. In this study, the direction of a relationship between birth weight and childhood undernutrition was in line with the results of other studies that showed that low birth weight had a significant higher risk of stunting in childhood [53, 60]. As mentioned above, the present study also revealed a close linkage between stunting and having younger brothers and sisters. This could, however, be the result of relatively increased attention towards the younger children by the parents in a resource-constrained setting, particularly in terms of food distribution and health care. Indeed, previous studies in similar populations in the same Indian state showed that a higher risk of stunting was associated with the presence of younger sisters and brothers [7, 51]. Place of delivery was a significant predictor of stunting in the present study, as also was reported in another study in Malawi [12]. In the present study, the relatively short mothers (<149.2 cm) had more stunted boys, although this association was not statistically significant, although closely to be. Studies identified mother's height to be closely linked with birth weight and length of offspring [84]. Evidence showed that maternal malnutrition was a risk for survival, health, and development among the offspring and may create an intergenerational cycle of malnutrition in the future where a stunted female child would become a stunted mother and would, in turn, deliver another stunted child [19].

However, all the above associations disappeared in the multiple regression analyses, whereas only the birth weight showed a significant independent association with the prevalence of stunting, allowing for all other potential factors. Boys with lower birth weight showed higher chances of being stunted at 3-12 years. Even family income or parental education did not qualify for a significant statistical effect on the stunting prevalence, as shown in our previous studies with the same data set, in rural and urban counterparts, respectively [35, 36]. In a study in Indonesia, LBW was the major predictor of stunting among infants aged 12-23 months. LBW infants showed 1.74 times higher likelihood to be stunted (95% CI 1.38-2.19) compared to those born with normal weight [4]. In the pre-school children in Bangladesh, birth size was one of the important determinants of stunting [59]. Another study from Zimbabwe showed decreased growth in LBW babies than normal-weight babies, and significant length differences appeared at 12 months of age [47]. The major factors responsible for undernutrition in under-five children in Pakistan were size at birth, previous birth interval, mothers' BMI at birth and parental education [61]. In the present study, mothers' nutritional status (BMI) was not associated with stunting.

LBW and stunting together were held responsible for more than two million deaths and ninety million disability-adjusted life years or DALYs [41]. India alone suffered 0.6 million deaths and 24.6 million DALYs from countries across the world due to stunting and IUGR/LBW [41]. LBW can result from preterm delivery or intrauterine growth restriction (IUGR) or a combination of the two. The global prevalence of LBW is 15.5%, which means that about 20.6 million infants with LBW are born each year, 96.5% of them in developing countries [79]. Globally, 14.6 percent of babies were born with low birth weight out of 20.5 million new born in 2015 [75]. India alone, with an estimated 33% of all newborns weighing < 2500g at birth, contributed 40% of the world's LBW population [30]. The prevalence of low birth weight in India was 21.4% in 2017 [29]. As per NFHS-3, the prevalence of LBW in West Bengal was 22% [28]. The causes of LBW are numerous and multifaceted. It depends on complex interactions of numerous factors like genetic, reproductive, socio-demographic, cultural, political and surrounding physical environmental conditions [3] and regional factors [46, 56, 71]. The etiology of LBW is maximally related to maternal [14, 15, 21, 26, 63], and socioeconomic and psychological factors [2, 69, 49]. Stunting is generally regarded as an expression of chronic deprivation from nutritional requirements at the population level. To determine the state of stunting, the importance of birth weight is independent of other important determinants. This indicates that improvement of maternal health and obstetric care, and socioeconomic development might improve the nutritional health of children. It might also have a long-term impression extended to adulthood. The observed correlations and linear associations between birth size and adult height have been consistent in several studies, although from the high-income countries [38, 40, 76].

Undoubtedly, undernourishment occurs from food deprivation or due to a diet deficiency in essential nutrients. Growing children starkly exhibit its consequences. Stunting is widely regarded as one of the efficient proxy measures of chronic undernutrition in children. However, there is adequate debate in recent times over the unquestionable acceptance of short stature, particularly in children, as a perfect proxy to undernourishment [67]. There are also evidence indicating that nutritional interventions did not always improve relative body size in children in terms of stature [22], or if at all, with a small effect size [48]. Even stunting or small stature in children often poorly correlate with other anthropometric measures of nutritional/energy stores in the body [24, 67, 68]. Keeping in view these lines of arguments and recent evidence, including the present one, it appears that stunting (short stature) is not essentially a product of undernutrition. Maternal and prenatal health and nutritional conditions also influence body height in childhood through the size at birth.

The WHO has set a goal of reducing LBW and stunted children aged 5 years by 40% between 2010 to 2025 [83]. However, to fulfil this sacred ambition, further extensive studies, preferably with longitudinal designs in varied ecological contrasts, might assess the appropriateness of stature as a measure of undernourishment in children, especially in India. It was earlier proposed that the small size could adapt to unique mother-child ecology in a chronically resource-constrained situation rather than a clinical condition [11].

The study has some inherent limitations. As this study included only boys, the impact of birth weight in girls, allowing for socioeconomic factors that might have different impacts on two genders, is worth investigating in further studies. The current investigation also lacked detailed information on food intake and the composition of the diet and no information on the physical exercise pattern. However, if supported by some further evidence from similar populations, the results of this study could have direct policy implications in terms of interventions to reduce the burden of undernutrition in Indian children.

Conclusion

In this study, stunting in school going boys aged 3-12 years in Purba Medinipur district of West Bengal was significantly associated with LBW. Among the potential factors, LBW was the most dominant concomitant of stunting. Programmes for the reduction of stunting should focus on the socioeconomic improvement, particularly, on spreading education, and on the health of women, particularly before and during pregnancy.

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*Authors' contributions***:** PK collected and analyzed the data and prepared the draft manuscript. KB designed and supervised the study, analyzed the data and provided intellectual inputs to the manuscript. RC designed the study and prepared the final manuscript.

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