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Determinants of stunting among children under 2 years in urban informal settlements in Mumbai, India: evidence from a household census

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Abstract

Background: There is limited evidence on the determinants of childhood stunting across urban India or specifically in slum settlements. This study aims to assess the extent of stunting among children under 2 years of age and examine its determinants in informal settlements of Mumbai.

Methods: Data were collected in 2014–2015 in a post intervention census of a cluster randomized controlled trial to improve the health of women and children. Census covered 40 slum settlements of around 600 households each. A total of 3578 children were included in the study. Mixed effects logistic regression models were used to identify factors associated with stunting.

Results: The prevalence of stunting among children aged 0–23 months was 38%. In the adjusted model, higher maternal education (AOR 0.59; 95% CI 0.42, 0.82), birth interval of at least 2 years (AOR 0.71; 95% CI 0.58, 0.87) and intended conception of the child (AOR 0.80; 95% CI 0.64, 0.99) were associated with lower odds of stunting. Maternal exposure to physical violence (AOR 1.83; 95% CI 1.21, 2.77) was associated with higher odds of being stunted. A child aged 18–23 months had 5.04 times greater odds (95% CI 3.91, 6.5) of being stunted than a child less than 6 months of age. Male child had higher odds of being stunted (AOR 1.33; 95% CI 1.14, 1.54).

Conclusions: Our findings support a multidimensional aetiology for stunting. The results of the study emphasize the importance of women's status and decision-making power in urban India, along with access to and uptake of family planning and services to provide support for survivors of domestic violence. Ultimately, a multilateral effort is needed to ensure the success of nutrition-specific interventions by focusing on the underlying health and social status of women living in urban slums.

Trial registration: ISRCTN Register: ISRCTN56183183, and Clinical Trials Registry of India: CTRI/2012/09/003004

Keywords: Malnutrition, Stunting, Slum settlements, Mumbai, India

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Background

The last two decades have witnessed encouraging global trends in the reduction of childhood stunting. Between 2000 and 2016, stunting prevalence among children under five declined from 33 to 23% and the global number of stunted children declined from 198.4 million to 154.8 million [1]. India, home to one third of stunted children [2], has shown similar downward trends. The recent National Family Health Survey (NFHS 2015–2016) [3] indicated that child stunting had fallen from 48 to 38% over one decade—nearly doubling the rate of stunting reduction in previous decades [4]. In spite of this remarkable progress, measures are still needed to accelerate reductions further to achieve the global nutrition targets adopted by the World Health Assembly for 2025 [5].

In Mumbai, India's largest metropolis, 42% of the population live in slums [6]. It is estimated that 26% of children in Mumbai are stunted, but data have not been disaggregated for slum areas [7]. Malnutrition rates among children in slums are generally higher than in non-slum areas. Studies conducted in Mumbai's slum settlements have found prevalence of stunting of 34 to 47% among children under five [8–10].

Slum populations rank among the poorest and most underserved communities in India. The census of India defines a slum as "areas unfit for human habitation due to dilapidation, overcrowding, faulty building design, narrow or faulty arrangements of streets, lack of ventilation, light or sanitation facilities, or any combination of these factors detrimental to safety and health" [6]. Inadequate access to safe drinking water and sanitation services puts children at increased risk of illness, malnutrition and death. Evidence suggests that the risks exceed those prevalent in rural areas [11].

Stunting results from chronic suboptimal nutrient intake, thereby restricting a child's growth, and is defined as height-for-age less than two standard deviations below the WHO Child Growth Standards median [12]. Stunting has severe short- and long-term health and functional consequences, including poor cognition and educational performance, low adult wages and lost productivity [13]. The harms are largely irreversible and have negative consequences through to adulthood [14]. A framework developed by UNICEF recognizes that the determinants of stunting are multidimensional due to an interaction of household, environmental, socio-economic and cultural influences [15]. While the factors that contribute to childhood stunting are complex, a window of opportunity exists within the first 1000 days of a child's life when linear growth is most sensitive to environmentally modifiable factors, such as feeding, morbidity treatment and psychosocial care. Growth trajectories are set early in life and 70% of stunting reportedly occurs during this period [16].

There is limited evidence on the determinants of childhood stunting across urban India or specifically in slum settlements. A review of the current literature available for urban India suggests that determinants of malnutrition among children include poor maternal health (including body mass index and nutrition), low parental educational status, compromised household sanitation and hygiene, respiratory and gastrointestinal illnesses, underutilization of health care services, low birth weight and poor child feeding practices [17–19].

Our study drew on a census of families in 40 slum settlements of Mumbai covering a population of 120,000. Its objectives are (1) to document the extent of stunting and (2) to examine the determinants of early childhood stunting among children under 2 years.

Methods

Study design

Data for the study originated from a trial to evaluate the impact of community resource centres on maternal and child health and nutrition outcomes. Data were collected from February 2014 to September 2015, in a census after the trial intervention covering all households with married women aged 15–49 years. We used these cross-sectional data in a secondary analysis to understand the extent and determinants of stunting in children under 2 years of age in the study population. The original trial tested a model that included service provision, outreach and community mobilization activities, cascaded out through the community resource centres. The resource centres targeted women of reproductive age and children under 5 years of age to participate in activities and access health and nutrition services. The results of the trial are presented elsewhere [20].

Setting

The commercial capital of Maharashtra state, Mumbai, is India's most populous city. The existing infrastructure is overburdened and nearly half of the population lives in slum settlements. The Municipal Corporation of Greater Mumbai is the primary local body responsible for civic administration across 24 municipal wards in three zones: city, central and western. The sampling frame of this study included two of Mumbai's most vulnerable municipal wards (M East and L) in the central zone, with the lowest Human Development Indices. The low indices of these wards could be attributed to large migrant populations, low and insecure levels of livelihood activity, large-scale unauthorized housing and poor education and health facilities [21]. The study areas were selected after a systematic vulnerability assessment in both wards using a vulnerability score card [22]. Each area consisted of ~ 600 households; some areas included entire slum clusters, while others were sections of larger geographical settlements. Most of the 40 areas involved in the study were situated on or beside hazardous locations like railway lines, garbage dumps, creeks and open sewers or drains. The primary health services in these areas were provided by municipal health centres and included outreach services for antenatal care and immunization for children. The population also had access to government child care centres, providing health, education and nutrition services, growth monitoring, supplementary nutrition, preschool education, immunization, nutrition, health education and referrals.

All the households in the study population held a ration card, an official document provided to households that are eligible to purchase subsidized food grains from the public distribution system. The majority of participants held orange ration cards given to households with annual income between INR 15,000 and 100,000 (US$ 204–1360).

Sample

The trial covered 24,939 households of which 15,907 households had married women in the reproductive age group. We could interview 16,236 out of 17,568 eligible women in 15,907 households. 4113 (25%) of all women interviewed had a total of 4460 children under 2 years of age. Of all (4460) children under two, 173 had a younger sibling. In the case of two siblings under 2 years of age, we excluded the older sibling from the analysis as the socio-demographic profile of the mother remained same and recall period was longer as compared to the younger child. Twins (19) were also excluded from the analysis as their nutritional status differs from that of singletons [23]. Complete information was not available for 9 children and anthropometric data were missing for 662 children. The final sample included 3578 children under the age of two (Fig. 1).

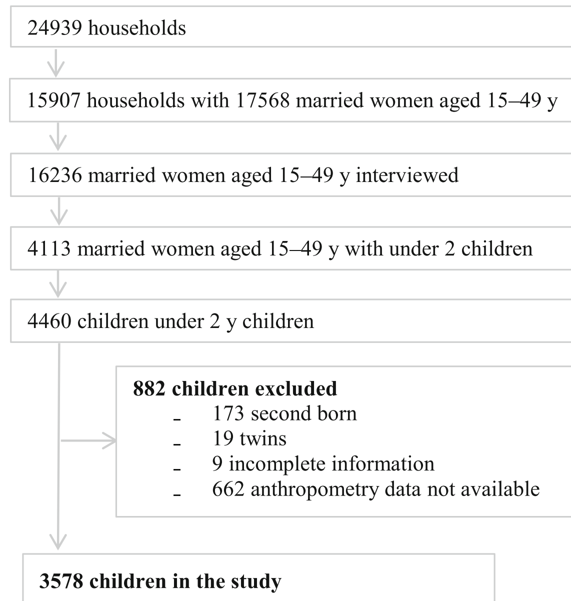

Fig. 1 Study profile of children under 2 years in 40 informal settlements of Mumbai, 2014–2015

Data collection

Two teams of six investigators and one supervisor collected the data for the census. Each team was responsible for data collection in 20 study areas. The primary respondents were mothers of children 0–2 years of age. Investigators visited homes up to three times each to set up interviews with the mothers. The questionnaire was administered in Hindi to eligible women, after which weight and length of all children were measured.

Anthropometric assessment

Anthropometric measurements were used in assessment of nutritional status of all children aged 0–23 months. Weight was measured on Seca 385 electronic scales to a precision of 10 g. Length of children was measured with Harlow rollameters to a precision of 1 mm. All children were measured twice and the mean value was used in the analysis. To minimize intra- and inter-observer errors, relative technical error of measurement (% TEM) was evaluated on two occasions during the data collection period, with representative values of 0.38% and 0.50% for height.

Other variables

At the household level, information was collected on home ownership, housing construction, drinking water source and toilet facility. Parental age, educational attainment and current employment status were also part of the questionnaire. Information on maternal care included intended pregnancy, antenatal care and place of delivery. The module on the child included information on age, sex, birth interval and immunization. Information on Infant and Young Child Feeding (IYCF) was collected according to WHO guidelines [24]. Women also answered an additional set of questions about intimate partner violence in the 2 years preceding the census.

Data were collected on smartphones with an open-source tool from Open Data Kit (Seattle, WA, USA) running in Google Android (versions 3.0–4.4). The system included automatic skips and validation constraints. Five percent of interviews selected at random were observed by a supervisor. Data were checked after download for errors in key fields by a data manager.

Statistical analysis

Outcome variable

The outcome of interest was stunting in children aged 0–23 months, identified by length/height measurement.

Children with height-for-age *z* scores below minus two standard deviations (HAZ < − 2SD) from the median of the WHO growth standards reference population were considered stunted. Children with height-for-age *z* scores below − 6 or above 6 were excluded from the analysis [25].

Independent variables

The primary analysis developed a series of mixed effects logistic regression models, including the variable describing stunting and a random effect for cluster. To explore the determinants of stunting, independent variables were chosen purposefully using the WHO framework for household causes of stunted growth and development [26]. This framework groups causes in four broad categories: household and family factors (maternal factors and home environment), inadequate complementary feeding (poor quality foods, inadequate practices and food and water safety), breastfeeding (inadequate practices) and infection (clinical and subclinical infection) [27].

Based on the available data from the census, regression analysis for household and family factors included drinking water source, toilet facility and socio-economic status, intended pregnancy, antenatal care, institutional delivery and birth interval. A variable describing mothers' experience of physical violence was also included. The analysis also included typical demographic covariates of paternal education, maternal education and occupational status and religion. Demographic characteristics of the child included were age and gender. The components of inadequate complementary feeding and breastfeeding included a proxy variable for "age-appropriate feeding". This variable was constructed by combining IYCF indicators on exclusive breastfeeding for children under 6 months with minimum acceptable diet for children aged 6–23 months. A child was considered to have age-appropriate feeding if she was under 6 months and exclusively breastfed or aged 6–23 months and consumed a minimally acceptable diet [28].

We described the characteristics of households, mothers, fathers and children with frequencies and proportions. We used means and standard deviations (SDs) to describe continuous variables. We developed an index of household wealth from standardized weights for the first component of a principal components analysis of data on household assets and split the resultant factor scores into quartiles [29]. We generated standard deviation (*z*) scores for height for age using the zscore06 module in Stata/IC 13.1 (StataCorp, College Station, TX). We plotted *z* scores against child age and fitted quadratic regression lines with 95% confidence intervals (CI).

Ethical considerations

We identified no risks of harm to women and children participating in the study. However, if investigators identified children as malnourished or women were concerned about access to health facilities for maternal or child care or were survivors of domestic violence, they were supported through the system by the SNEHA health workers who visited the households regularly. Participants were asked for written consent to interview after an explanation of the purpose, benefits and risks of the study. The right of participants to withdraw from the interview or not to participate was respected. Anonymity of informants was ensured and they were assured of the confidentiality of data.

Results

Table 1 summarizes the background characteristics of the children. More than half of families said that they owned their homes, most of which were of robust construction. More than three fourths of families received drinking water from public taps or community tap stands and over 80% of households used public toilets. Most families were of Muslim faith. More than half of mothers had secondary education, as did nearly two thirds of fathers. Most fathers were employed, with 59% engaged in a skilled job. Few mothers were engaged in paid work.

Antenatal care and institutional delivery by mothers of children under two were high: 89% had accessed antenatal care at least four times during pregnancy and 88% had an institutional delivery. Eighteen percent of children under 2 years were born within 2 years of another sibling, shorter than WHO recommendations for spacing [30]. The proportions of boys and girls were similar (Table 2).

Table 3 provides detailed information on Infant and Young Child Feeding practices. Less than half of infants were reported as having been breastfed within 1 h of birth, and almost two thirds of infants under 6 months were exclusively breastfed. Continued breastfeeding at 1 year was high (81%). Fifty-seven percent of infants aged 6–8 months had been introduced to solids and semisolids. For children aged 6–23 months, consumption of iron-rich foods was low at 17%. Composite indicators were similarly poor; only 19% met dietary diversity standards and 12% had a minimally acceptable diet. The proportion of children receiving a minimum number of meals (66%) was comparatively better. Age-appropriate feeding, a combined IYCF indicator to measure diet of all children under 2 years, was low at 24%.

Table 4 summarizes the anthropometric findings. Children's lengths or heights were expressed as height-for-age *z* scores (HAZ), which represent an individual child's stature relative to the WHO reference population

Table 1 Socio-economic and demographic characteristics, for children under 2 years

Households	**3578**				
	n	**%**		***n***	**%**
Home ownership			**Socio-economic status**		
Own home	1877	52	Poorest	911	25
Rented home	1701	48	Quartile 2	881	25
Housing construction			Quartile 3	950	27
Robust (pucca)	2623	73	Least poor	836	23
Temporary (kaccha)	955	27	**Religion**		
Drinking water source			Muslim	2997	84
Public/community tapstand	2777	78	Hindu	575	16
Water tap at home	801	22	Other	6	<1
Toilet facility					
Public/shared	2974	83			
Private	604	17			
Mother			**Father**		
Age (years)			**Age (years)**		
15–19	68	2	≤ 24	237	6
20–24	1194	33	25–29	1142	32
25–29	1360	38	30–34	1094	31
30+	956	27	35+	1047	29
Education			Missing	58	2
No formal schooling	977	27	**Education**		
Primary	171	5	No formal schooling	761	21
Secondary	2101	59	Primary	167	5
Higher	329	9	Secondary	2244	63
Occupation			Higher	345	9
Employed	149	4	Missing	61	2
Not employed	3429	96	**Occupation**		
Parity			Skilled job	2128	59
1 or 2 children	1930	54	Unskilled job	1333	37
3 or more children	1648	46	Not employed	59	2
Marital status			Missing	58	2
Married/cohabitating	3520	98			
Widowed/divorced/separated	58	2			

median. A HAZ score of − 1 implies that the child is one standard deviation shorter than the median. Conventionally, children whose stature is shorter than two standard deviations below the median (HAZ below − 2) are categorized as stunted. We found that 38% of children were stunted and 14% were severely stunted (HAZ below − 3). Mean height for age was − 1.53 *z* scores, but there was a difference between girls (− 1.46 *z* scores) and boys (− 1.59 *z* scores). The proportion of stunting increased from 21% at 0–5 months to 57% at 18–23 months. This variation in the prevalence is explained in Fig. 2 which depicts length/height for age (HAZ) scores for each child by age. It illustrates the steep fall in length/height for age from birth to around 2 years of age.

Given that growth faltering is most critical in infants and children under 2 years of age, determinants were analysed for this age group (Table 5). The results show that prevalence of stunting was higher in households with shared toilet facility and poor wealth status. Stunting increased with low level of parental education, maternal abuse, narrow birth interval, unintended

Table 2 Child characteristics, for children under 2 years

Child	*n*	%
Age (months)		
0–5	861	24
6–11	987	28
12–17	943	26
18–23	787	22
Sex		
Female	1795	50
Male	1783	50
Preceding birth interval with elder sibling		
< 24 months	644	18
≥ 24 months	1986	56
First child	948	26
Mother had antenatal care		
4 or more visits	3196	89
No or less than 4 visits	382	11
Place of birth		
Hospital	3140	88
Home	438	12

pregnancy, inadequate antenatal visits and home births. Boys had higher levels of stunting as compared to girls. Stunting increased with age of the child and inadequate age-appropriate feeding.

Table 6 shows unadjusted and adjusted odds ratios for the association of stunting with parental and household characteristics. In the fully adjusted model, a child was less likely to be stunted if her mother had received higher education above grade 12 (AOR 0.59; 95% CI 0.42, 0.82). For maternal characteristics related to pregnancy, both appropriate spacing of at least 2 years (AOR 0.71; 95% CI 0.58, 0.87), compared with less than 2 years, and intended conception of the child (AOR 0.80; 95% CI 0.64, 0.99) were associated with lower odds of stunting. If a mother had experienced physical violence in the last 2 years, her child had higher odds (AOR 1.83; 95% CI 1.21, 2.77) of being stunted. Males had higher odds of being stunted (AOR 1.33; 95% CI 1.14, 1.54). A child aged 18–23 months had 5.04 times greater odds (95% CI 3.91, 6.5) of being stunted than a child less than 6 months of age.

Discussion

Our analysis of 3578 children under 2 years of age confirms that children living in urban slums experience

Table 3 Infant and Young Child Feeding indicators, overall and by age group, for children under 2 years

	Children	*n*	%
Early initiation of breastfeeding (0–23 months)	3578	1614	45
Exclusive breastfeeding under 6 months (0–5 months)	861	531	62
Continued breastfeeding at 1 year (12–15 months)	587	475	81
Introduction of solids or semi-solids (6–8 months)	441	251	57
Minimum dietary diversity (6–23 months)			
All	2684	514	19
6–11 months	954	81	8
12–23 months	1730	433	25
Minimum meal frequency (6–23 months)			
All	2684	1779	66
6–11 months	954	546	57
12–23 months	1730	1233	71
Minimum acceptable diet (6–23 month)			
All	2684	321	12
6–11 months	954	61	6
12–23 months	1730	260	15
Consumption of iron-rich foods (6–23 month)			
All	2684	460	17
6–11 months	954	155	16
12–23 months	1730	305	18
Age appropriate feeding (All)	3545	852	24

Information on IYCF missing for 33 children. Age appropriate feeding defined as exclusive breastfeeding for children under 6 months and minimum acceptable diet for 6–23 months

Table 4 Standard deviation (*z*) scores for anthropometric indicators, overall and by sex and age group, for children under 2 years

Height for age	Children, *N*	*z* score, Mean	SD	*z* score < 2, *n*	%	*z* score < 3, *n*	%
All	3578	− 1.53	1.50	1345	37.5	508	14.2
Boys	1783	− 1.59	1.56	708	39.7	303	16.9
Girls	1795	− 1.46	1.42	637	35.4	205	11.4
0–5 months	861	− 0.85	1.50	182	21.0	47	5.4
6–11 months	987	− 1.30	1.49	298	30.1	91	9.2
12–17 months	943	− 1.82	1.33	419	44.4	157	16.6
18–23 months	787	− 2.21	1.33	446	56.6	212	26.9

impaired growth. At 38%, the prevalence of stunting was considerably higher than global (23%) [1] and urban estimates for Maharashtra (20%) [17]. This could be attributed to the disadvantaged nature of the population. The prevalence of malnutrition in slums is usually higher than the non-slum population [7] and the findings of our study accord with previous studies conducted in slums [9, 31–33]. Health and nutrition of slum children are often compromised and this is further aggravated by lack of basic amenities like adequate housing, safe drinking water and sanitation. A growing body of evidence suggests that water, sanitation and hygiene (WASH) are important determinants of childhood stunting [34, 35]. Though 27% of houses in our study were of insubstantial construction and high proportions did not have access to individual piped drinking water (78%) or private toilets (83%), we did not find a significant association of these factors with stunting. One of the probable explanations could be that they were defined with minimum benchmarks of piped water supply and basic household sanitation.

Stunting often begins in utero [13, 36]. Studies have demonstrated that average height-for-age *z* scores are already low at birth in deprived populations and decline sharply during the first 24 months of life [37]. Our study had similar results. Stunting was lowest in the first 5 months of life (21%) and showed a nearly threefold increase by the time children reached 18–23 months. The steady increase in stunting until 2 years of age highlights the critical period for growth faltering.

A major component of care in the first 23 months is the set of Infant and Young Child Feeding (IYCF) practices recommended by WHO [38]. Our study showed poor IYCF indicators, particularly in terms of dietary diversity and acceptable diet. The high risk of stunting observed in the study may be linked to lack of appropriate food supplementation during the weaning period. An analysis of Demographic Health Survey data suggests that adherence to child feeding practices was associated with less likelihood of stunting or underweight in children [39]. An analysis of data from multiple countries suggested that improved dietary diversity was associated

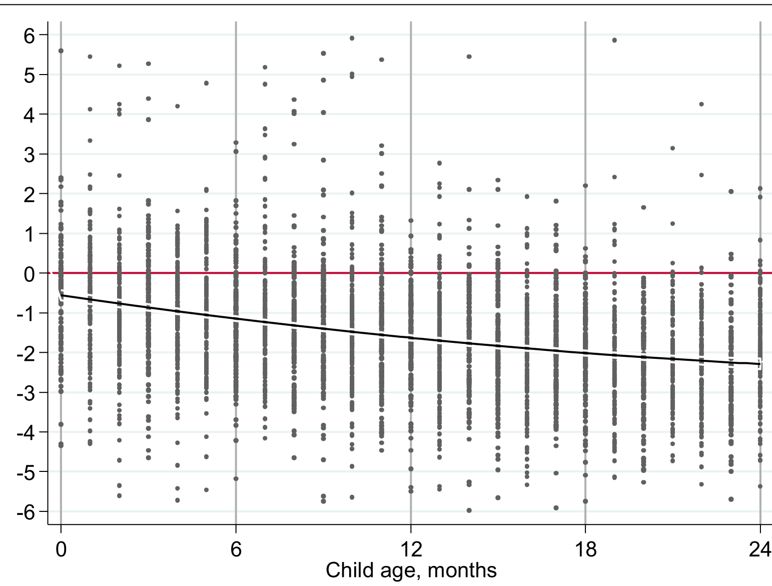

Fig. 2 Standard deviation (*z*) scores for stunting by age, showing quadratic line of fit with 95% confidence intervals, for children under 2 years

Table 5 Prevalence of stunting by household, parental and child characteristics, for children under 2 years

	Stunting		
	n	%	*N*
Drinking water source			
Public/community tapstand	1063	38	2777
Water tap at home	282	35	801
Toilet facility			
Public/shared	1152	39	2974
Private	193	32	604
Socio-economic status			
Poorest	374	41	911
Quartile 2	355	40	881
Quartile 3	339	36	950
Least poor	277	33	836
Religion			
Muslim	1116	37	2997
Hindu	228	40	575
Other	1	-	6
Father's education			
No formal schooling	306	40	761
Primary	71	43	167
Secondary	839	37	2244
Higher	103	30	345
Mother's education			
No formal schooling	420	43	977
Primary	69	40	171
Secondary	766	36	2101
Higher	90	27	329
Mother's occupation			
Working	64	43	149
Not working	1281	37	3429
Mother experienced physical violence			
Yes	67	54	124
No	1254	37	3393
Birth interval			
< 24 months	291	45	644
≥ 24 months	708	36	1986
First child	346	37	948
Intended pregnancy			
Yes	1004	36	2832
No	207	42	499
Antenatal care			
4 or more ANC visits	1171	37	3196
None or less than 4 visits	174	46	382
Place of delivery			
Hospital	1159	37	3140

Table 5 Prevalence of stunting by household, parental and child characteristics, for children under 2 years *(Continued)*

	Stunting		
	n	%	*N*
Home	186	42	438
Gender			
Girl	637	35	1795
Boy	708	40	1783
Child age (months)			
0–5	182	21	861
6–11	298	30	987
12–17	419	44	943
18–23	446	57	787
Age appropriate feeding			
No	1071	40	2693
Yes	262	31	852

negatively with stunting among children aged 6–23 months [40]. Improved age-appropriate feeding was associated with less likelihood of stunting in our univariable logistic model but was not significant in the adjusted model. This lack of clear association between the achievement of IYCF indicators and stunting may be explained by poor dietary quality at an individual level, particularly in our context. Availability as well as accessibility of nutritious food in urban slums is variable. It is also possible that frequent exposure to intestinal infections associated with poor sanitation offsets the beneficial effects of appropriate feeding practices [41–43]. Another possible argument is that the effects of IYCF are not manifest as concurrent somatic growth or may not manifest until children are older [41].

The literature suggests that unintended pregnancy may adversely affect a child's health, perhaps contributing to conscious or unconscious neglect and inadequate nutrition, lack of parental bonding and inattention to health care needs [44–48]. These effects influence the process of stunting, probably beginning in the perinatal period and continuing into childhood [49]. Recent studies suggest that children who had been unwanted at the time of conception had an elevated risk of stunting [50, 51]. Our results were consistent with these studies. In the same vein, shorter birth interval is a risk factor for child undernutrition if the mother's nutrient reserves become depleted, increasing the risk of intrauterine growth retardation and adversely affecting both infant nutrient stores at birth and nutrient delivery via breast milk [52]. A child born within 2 years of the previous child has a 68% higher risk of dying in the neonatal period (days 0–28) and a 99% higher risk of dying in the post-neonatal period (1–12 months), and mothers with short intervals are at higher risk of birth complications [53]. Almost one third of children in India are born after intervals of less than 24 months, risking the survival and undernutrition of both mother and child [54]. Nearly one fifth of children in our study had birth intervals shorter than 24 months and our findings of the positive association of short birth interval with stunting were consistent with other recent studies [14, 55, 56].

Our study revealed that male children had a higher risk of stunting than females. Recent studies have found similar associations between sex and stunting [57–61]. Most studies attribute these sex differences in nutritional status to biological variances in morbidity between boys and girls in early life [62, 63]. A meta-analysis of sixteen Demographic and Health Surveys of ten countries in sub-Saharan Africa found that male children were more likely to become stunted than females, which might suggest that boys are more vulnerable to health inequalities than their female counterparts in the same age groups [63].

Recent studies have identified several maternal risk factors for childhood stunting, such as maternal age and education and poor maternal health seeking behaviour in lower-income countries [56, 60, 64]. An analysis of 180 Demographic and Health Surveys from 62 low- and middle-income countries reported that higher maternal education levels were associated with lower childhood undernutrition [65]. Recent studies in African countries have also suggested that children were significantly less likely to be malnourished when their mothers were more educated [66, 67]. Our findings were in line with these and suggested that higher level of maternal education beyond the tenth grade was a protective factor against stunting. We did not find associations of maternal age, poor antenatal or delivery care with stunting.

Another increasingly evident maternal risk factor is the linkage between high rates of intimate partner

Table 6 Association between household, parental and child level characteristics and stunting in children under 2 years

	Unadjusted OR	I: Home AOR (95% CI)[a]	II: Home and maternal AOR (95% CI)[b]	III: Home, maternal and care practices AOR (95% CI)[c]	IV: Home, maternal, care and feeding practices AOR (95% CI)[d]	V: Full model AOR (95% CI)[e]
N		**3517**	**3270**	**3270**	**3237**	**3234**
β_o (se)		0.76 (.08)	1.05 (0.15)	1.25 (0.23)	1.35 (0.25)	0.47 (0.11)
Water tap at home	0.99 (0.82, 1.21)	1.21 (0.97, 1.51)	1.21 (0.97, 1.52)	1.23 (0.98, 1.54)	1.23 (0.98, 1.55)	1.12 (0.88, 1.42)
Private toilet	0.78 (0.63, 0.96)	0.81 (0.64, 1.03)	0.82 (0.65, 1.05)	0.82 (0.64, 1.05)	0.82 (0.64, 1.05)	0.84 (0.65, 1.09)
Socio-economic Status						
Poorest	1.00	1.00	1.00	1.00	1.00	1.00
Quartile 2	0.93 (0.76, 1.12)	0.96 (0.79, 1.17)	1.00 (0.81, 1.23)	1.02 (0.83, 1.26)	1.04 (0.84, 1.28)	0.97 (0.78, 1.21)
Quartile 3	0.78 (0.64, 0.95)	0.83 (0.68, 1.02)	0.86 (0.69, 1.06)	0.88 (0.71, 1.09)	0.87 (0.70, 1.09)	0.83 (0.66, 1.04)
Least poor	0.73 (0.59, 0.90)	0.81 (0.64, 1.02)	0.85 (0.67, 1.08)	0.87 (0.68, 1.11)	0.90 (0.70, 1.14)	0.87 (0.68, 1.13)
Maternal education						
No formal schooling	1.00	1.00	1.00	1.00	1.00	1.00
Primary	0.92 (0.66, 1.29)	0.92 (0.66, 1.30)	0.95 (0.66, 1.36)	0.97 (0.68, 1.39)	1 (0.69, 1.43)	1.02 (0.7, 1.49)
Secondary	0.76 (0.65, 0.90)	0.79 (0.67, 0.93)	0.8 (0.67, 0.95)	0.81 (0.68, 0.97)	0.83 (0.70, 0.99)	0.84 (0.7, 1.01)
Higher	0.52 (0.40, 0.70)	0.59 (0.44, 0.78)	0.56 (0.41, 0.77)	0.57 (0.42, 0.78)	0.58 (0.42, 0.79)	0.59 (0.42, 0.82)
Experienced physical violence	2.08 (1.44, 3.01)	1.98 (1.36, 2.86)	1.92 (1.3, 2.85)	1.90 (1.28, 2.81)	1.86 (1.25, 2.77)	1.83 (1.21, 2.77)
Birth interval						
< 24 months	1.00		1.00	1.00	1.00	1.00
≥ 24 months	0.67 (0.56, 0.80)		0.69 (0.57, 0.84)	0.7 (0.57, 0.85)	0.68 (0.56, 0.83)	0.71 (0.58, 0.87)
First child	0.70 (0.57, 0.87)		0.78 (0.62, 0.98)	0.79 (0.62, 1.00)	0.77 (0.61, 0.97)	0.79 (0.62, 1.01)
Intended pregnancy	0.78 (0.64, 0.95)		0.85 (0.69, 1.05)	0.86 (0.70, 1.06)	0.83 (0.68, 1.03)	0.80 (0.64, 0.99)
4 or more antenatal care visits	0.70 (0.56, 0.87)			0.77 (0.60, 1.00)	0.78 (0.6, 1.01)	0.77 (0.59, 1.01)
Institutional delivery	0.80 (0.65, 0.99)			1.02 (0.80, 1.29)	1.05 (0.82, 1.34)	1.08 (0.84, 1.39)
Age appropriate feeding	0.66 (0.56, 0.78)				0.67 (0.56, 0.80)	1.03 (0.83, 1.27)
Mother working	1.24 (0.89, 1.74)					1.17 (0.8, 1.72)
Gender: Male	1.21 (1.05, 1.39)					1.33 (1.14, 1.54)
Child age (months)						
0–5 months	1					1.00
6–11 months	1.62 (1.31, 2.02)					1.59 (1.23, 2.05)
12–17 months	3.03 (2.45, 3.74)					3.05 (2.39, 3.89)
18–23 months	5.06 (4.06, 6.30)					5.04 (3.91, 6.5)
Religion						
Muslim	1					1.00
Hindu	1.18 (0.96, 1.46)					1.13 (0.89, 1.43)
Other	0.35 (0.04, 3.10)					0.34 (0.03, 3.33)
Father's education						
No formal schooling	1					1.00
Primary	1.14 (0.81, 1.61)					1.24 (0.84, 1.83)
Secondary	0.91 (0.77, 1.08)					1.07 (0.88, 1.31)
Higher	0.69 (0.52, 0.91)					0.86 (0.62, 1.20)

Table 6 Association between household, parental and child level characteristics and stunting in children under 2 years *(Continued)*

	Unadjusted OR	I: Home AOR (95% CI)[a]	II: Home and maternal AOR (95% CI)[b]	III: Home, maternal and care practices AOR (95% CI)[c]	IV: Home, maternal, care and feeding practices AOR (95% CI)[d]	V: Full model AOR (95% CI)[e]
SD (se)		0.29 (0.05)	0.26 (0.05)	0.27 (0.05)	0.27 (0.05)	0.28 (0.06)
ICC (se)		0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)

[a]Model I included variables on water tap at home, private toilet, socio-economic status, mother experiencing physical violence and maternal education
[b]Model II included variables on water tap at home, private toilet, socio-economic status, mother experiencing physical violence, maternal education, birth interval and intended pregnancy
[c]Model III included variables on water tap at home, private toilet, socio-economic status, mother experiencing physical violence, maternal education, birth interval, intended pregnancy, 4 or more antenatal care visits and institutional delivery
[d]Model IV included variables on water tap at home, private toilet, socio-economic status, mother experiencing physical violence, maternal education, birth interval, intended pregnancy, 4 or more antenatal care visits, institutional delivery and age-appropriate feeding
[e]Model V included variables on water tap at home, private toilet, socio-economic status, mother experiencing physical violence, birth interval, intended pregnancy, 4 or more antenatal care visits, institutional delivery, age-appropriate feeding, parental education, religion, gender and age of the child

violence against women and poor nutritional outcomes in children [68–70]. The poor physical and mental health of mothers who are survivors may affect childcare in many dimensions. Maternal exposure to physical violence substantially increased a child's risk of stunting in our study.

At the household level, evidence suggests that children in households in the poorest socio-economic groups have higher prevalence of malnutrition [71–73]. This emphasizes the impact of the differential availability of resources to families that act as a major determinant of malnutrition. Household socio-economic position remains a key determinant of nutritional achievement among children [74]. In multivariate analysis, an association between favourable household socio-economic position and better nutritional status was not observed in our study. This is probably explained by the fact that socio-economic differences may be minimal within a sample who all lived in slum conditions and were described as poor. Factors allied to stunting such as inadequate food intake, recurrent illness and poor child care practices are common in slums and affect residents across socio-economic strata.

The strengths of the study were its location in urban slum settlements, its large sample size and the quality of anthropometric data collected. Its main limitation was the cross-sectional nature of the study design, which limited causal inference and documentation of child growth patterns. Residual confounding is also possible. Covariates describing some potential risk factors for malnutrition, such as infection, birth weight and maternal body mass index or height, were not available.

Conclusion

Our findings support a multidimensional aetiology for stunting. While findings such as the importance of maternal education are consistent with the current literature, the study highlights other protective factors that could be used to influence nutritional outcomes in the shorter term. These include interventions that focus on increased spacing between two pregnancies, preventing unwanted pregnancies and reducing violence experienced by caregivers in the household. The results of the study emphasize the importance of women's status and decision-making power in urban India, along with access to and uptake of family planning and services to provide support for survivors of domestic violence. Ultimately, a multilateral effort is needed to ensure the success of nutrition-specific interventions by focusing on the underlying health and social status of women living in urban slums.

Abbreviations

WHO: World Health Organization; UNICEF: United Nations Children's Fund; IYCF: Infant and Young Child Feeding; TEM: Technical error of measurement; HAZ: Height-for-age *z* score; WASH: Water, sanitation and hygiene

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Authors' contributions

SD conceived the study and supervised data collection. AJ helped to design the study. SD and SC analysed data and worked on the manuscript. NSM coordinated the project and commented on drafts of the manuscript. DO, AJ and SP critically reviewed, commented on and revised the drafts. SD had primary responsibility for final content of manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analysed during this study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The trial was approved by the Multi-Institutional Ethics Committee of the Anusandhan Trust, Mumbai, India, and the University College London Research Ethics Committee, London, UK, in January 2012 (reference 3546/001).

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests. SD had full access to all the data in the study and had final responsibility for the decision to submit for publication.

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