A LONGITUDINAL ASSESSMENT OF CORRELATES OF LINEAR GROWTH AND STUNTING STATUS IN MAHARASHTRA, INDIA

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ABSTRACT

Undernutrition among under-five children continues to remain a major public health concern in India. It is manifested mainly in the form of low birth weight babies, stunting and wasting among children below five years of age. India accounts for almost one-third of the worlds' total burden of stunting. Childhood stunting is considered irreversible by age two, and it is mostly attributed to long-term consequences of insufficient nutrient intake by young mothers, infant's poor diet, and inadequate sanitation and hygiene practices. This study is based on 886 children under the age of two in 2012 and followed after three years in 2015 from three sub-divisions of Maharashtra, namely Nasik, Aurangabad and Amravati (CNSM Wave 1 and CNSM Wave 2). The present paper examined the influence of changes in WASH and wealth quintile over the longitudinal period and use of ICDS services on the status of stunting using binary logistic regression and Multiple Classification Association (MCA). The results showed that the improved sanitation facility and consumption of supplementary food through ICDS and deworming medication were significantly associated with the decline of stunting among children. About

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33% of children who did not receive supplementary food during the four years (second round of CNSM) suffered from growth faltering. Genetic factors, namely the mother's height, play a significant role in the status of child stunting. This paper corroborates that by strengthening the efficacy of the ICDS, improving the quality and quantity of dietary intake among adolescent and pregnant/lactating mothers will go a long way in reducing stunting among children. Also, cultivating sanitation and safe hygiene practices along with the deworming programme, can reduce child morbidity, thereby assisting in combating stunting in three regions of Maharashtra.

Key Words

Stunting, linear growth, growth failure, growth recovery, persistent stunting, growth trajectories, ICDS, WASH

Introduction

Undernutrition among under-five children is a major public health concern in India. It is reflected by the fact that the prevalence of stunting, wasting and underweight among children in India is about 38%, 21% and 36% respectively.[1] India accounts for one-third of the total burden of stunting in the world.[2] Stunting is defined as the percentage of children aged 0 to 59 months whose height for age is below minus two standard deviations.[3] Childhood stunting is an irreversible process by age two and is a result of long-term consequences of anaemia and poor maternal health conditions. The linear growth in children is considered to be the best indicator of a child's well-being.[4] Millions of children who have failed to achieve their linear growth potential due to suboptimal health conditions and inadequate nutrition and care also suffer from severe irreversible physical and cognitive damage that accompanies stunted growth.[4] Hence, linear growth failure is primarily confined to the intrauterine period and in the first few years of life. Inadequate diet and frequent infections among children cause growth retardation.[5] Many studies have illustrated the correlates of stunting among children. Such as: small size at birth, and childhood stunting linked with women's short adult stature, lean body mass, less schooling of mothers.[5] Two growth periods significantly determine the adult height, first is growth occurring from conception to two years of age and the second, growth occurring during adolescence before the onset of puberty.[6] Therefore, undernutrition among mothers has intergenerational consequences on children born to short-statured women as they tend to have a greater risk of dying than children of mothers with normal height.[7] Initiatives like 'Scaling up Nutrition', the 'Zero Hunger Challenge' and the 'Nutrition for Growth Summit' have targeted stunting as a major public health challenge.[4] World Health Assembly in 2012 proposed stunting as a leading indicator for the post-2015 development agenda.[8] Consequently, POSHAN Abhiyaan*, an Indian flagship programme, started initially in 1976 has been revised to reduce stunting, under-nutrition and anaemia in children, adolescent girls, pregnant and lactating mothers. It has set a target of reducing stunting at 2% per annum to achieve a 25% decline in stunting by 2022. As per fourth round of National Family Health Survey (NFHS), 2015-16, stunting rates for infants less than six months was estimated to be around 20%, indicating that the process of growth faltering unfolds since the prenatal stage.[1] However, stunting rates, after that, inflated sharply, reaching up to 46.9% in the 18–23 months

* *National Nutritional Mission renamed as POSHAN Abhiyan (circular: NNM/61/2018-CPMU Government of India, Ministry of Women and Child Development, May 25, 2018.)*

age range and subsequently declined gradually to 40% in the 48-59 months age range. This characteristic pattern of stunting in early childhood established the period from conception to the second birthday (the first 1,000 days) as the critical window period, during which failure to growth often leads to stunting.[9] For achieving the stunting targets, it is critical to understand the dynamics of growth changes in children over time and examine the burden of stunting across populations.

Globally, few longitudinal studies have examined the prevalence and correlates of stunting, growth recovery, growth faltering and persistent stunting in children between 0-6 years of age. Nonetheless, evidence from longitudinal studies in Bangladesh has shown that the prevalence of stunting increased three-fold in the first two years of life. Empirical evidence further suggests that underweight mothers with height less than 145 cm, no education and belonging to poor households often have stunted children.[10, 11] A longitudinal case-control study in Pakistan concluded that in the sixth month of age, stunting associated with prematurity and duration of breastfeeding. At the 12th month, the association of stunting was with maternal height, birth weight and stunting status of infants at the time of six months. By the 60th month of age, the previous stunting was the only factor identified to be associated with the current stunting status in the child, which implicitly suggested that mother's short stature and the birth weight of child was the cause of stunting among children.[12] Another study in Nepal found that the odds of stunting and underweight among children reduced as Socio-Economic status (SES) of the household improved rise of mother's education from none to secondary or higher educational level.[13] In India, Tandon in 1989 noted a significant decline in severe malnutrition among pre-school children from 19.1% to 8.4% between 1976 and 1985 in ICDS based population.[14] Another study from Lucknow concluded that the Mean Weight of ICDS beneficiaries, in general, was more than that of those who were not covered by ICDS.[15] While a study carried out in Nadia district of West Bengal, found the prevalence of stunting to be higher in ICDS-served areas than non-ICDS areas.[16] Similarly, another study based on 1,286 pre-school children residing in urban, rural and slum areas showed that prevalence of protein-energy malnutrition (PEM) was significantly higher among children covered by ICDS (53.8%) than non-ICDS beneficiaries (46.9%) suggesting the ineffectiveness of the ICDS Programme.[17] Growing evidence suggests the association of stunting with WASH (Water, Sanitation, and Hygiene) conditions, especially among children aged 0–23 months.[18-21] Multivariate analysis has illustrated that in comparison to open defecation, households with access to toilet facility have 16% lower odds of infants aged 0-23 months of being stunted, after adjusting for all potential confounders. On the contrary, improved drinking water source or piped water was not predictive of stunting.[21] The prevalence of stunting among Integrated Tribal Development Agency (ITDA) areas of Maharashtra is as high as 61%, a state where tribal population is greater than 50%.[22] Therefore, the present study focuses on Maharashtra for the current study.

The objective of this paper is to study the changes in prevalence of stunting, growth faltering and growth recovery in children over time by following up a cohort of children from the three sub-divisions of Maharashtra, namely Nasik, Aurangabad and Amravati. We have used the data from two rounds of Comprehensive Nutrition Survey in Maharashtra (CNSM) undertaken in 2012 and 2015. The paper has also

examined the correlates of changes in stunting over a period and assessed the contribution of India's flagship Integrated Child Development Scheme (ICDS) programmatic interventions in the growth recovery or growth faltering.

Methodology

We have used data from two rounds of Comprehensive Nutrition Survey in Maharashtra (CNSM) to explore the longitudinal changes in the nutrition status of children from three administrative divisions in the state. International Institute for Population Sciences (IIPS), Mumbai, India carried the Wave-1 of CNSM with the joint initiative of the Government of Maharashtra and UNICEF. CNSM-1 collected a representative sample derived from the six administrative divisions: Amaravati, Aurangabad, Konkan, Pune, Nagpur and Nashik consisting of 2,650 children living in 2,630 households during February-April, 2012.[23] For the Second Wave of CNSM, 886 children living in 844 households from Amravati, Aurangabad and Nasik divisions were followed up during April-September 2015 with UNICEF funding and IIPS support. The CNSM-1 findings indicated that three divisions, namely: Amravati, Aurangabad and Nashik, needed more focus due to the high prevalence of malnourished children as compared to the Konkan, Pune and Nagpur divisions.[23] Consequently, in the second round of CNSM, children from high prevalence divisions were followed-up (Figure 1). Figure 2 presents the number of households and children selected for the paper.

Outcome Variable

The key outcome variable in this study is stunting and changes in the pattern of stunting over three years. Children with height-for-age Z score below minus two standard deviations(-2SD) from the median of the reference population was considered short for their age or stunted.[24] We have classified the children into four categories based on their growth trajectories during the period from 2012 to 2015, and they are:

Never Stunted: A child whose height for age Z score was above or equal to minus two standard deviations (-2 SD) in both the waves of CNSM.

Growth failure: A child whose height for age Z score was more than or equal to minus two standard deviations (-2 SD) in the first round but round 2, it was minus two standard deviations (-2 SD).

Growth Recovery: A child whose height for age was below minus two standard deviations (-2 SD) in the first round of CNSM but greater than or equal to minus two standard deviations (-2 SD) in the second round of CNSM.

Persistent stunting: A child whose height for age Z score was below minus two standard deviations (-2 SD) in both the waves of CNSM.

Independent variables

Four types of independent variables were used to identify the correlates of changes in the stunting pattern. The demographic variables considered were gender (male or female), age of the child (in the first round of CNSM the classification was<6 months, 6-11 months, 12-17 months and >=17 months and in the second round the groups consisted of <42 months, 42-47 months, 48-53 months and >= 54 months); birth order (classified into 1^{st}, 2^{nd} – 3^{rd}, 4^{th} – 6^{th} and 7^{th}) and height of the mother (classified into <145 cm and >=145 cm). The socio-economic variables considered were educational status of the mother (categorized into <6^{th} standard, 6-10^{th} standard, 11-15^{th} standard and above 15^{th} standard), Social group (classified into General, Scheduled caste, Scheduled tribe, Vimukta Jati,

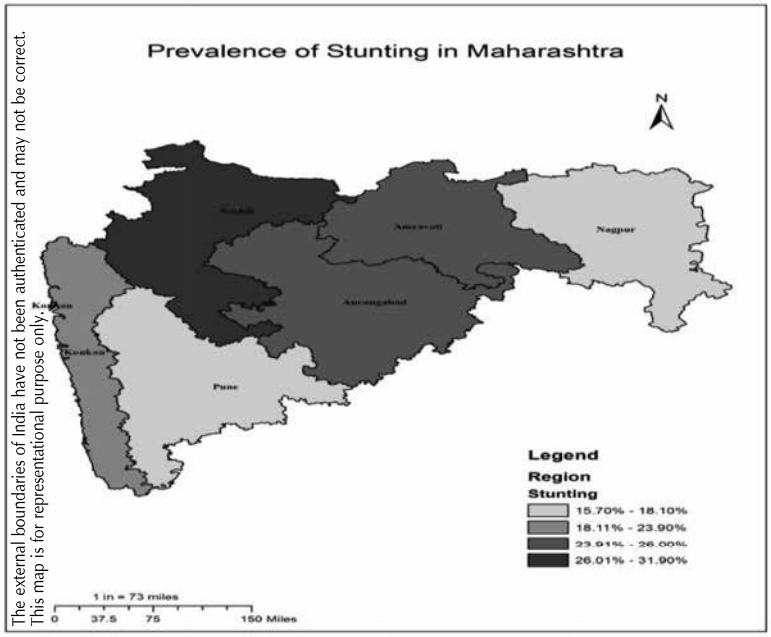
Nomads and Other Background Caste), household wealth quintile* (categorized as Poorest, Poor, Middle, Rich and Richest). The environment and location variables considered were type of residence (Rural and Urban), Water facility (classified into two categories namely improved water facility which includes piped water into dwelling, piped water into plot/yard, public tap/stand pipe, tube well/bore well and protected dug well, and unimproved source which includes unprotected dug well, unprotected spring, cart with small tank, tanker trucks and others), toilet facilities (classified into improved source which includes flush toilet, flush to septic tank, flush/ pour flush to pit latrine, flush/pour flush to elsewhere and pit latrine with slab, and unimproved source which includes pit latrine without slab, dry toilet, hanging toilet, no facility and others). The programmatic variables include immunization status (partially immunized or fully immunized) and supplementary food received from ICDS (yes or no) and whether received deworming medication (yes or no)

Statistical Analysis

The data was analysed using STATA, version 10.0 software. The descriptive and bivariate analyses were done by calculating percentage points. The Chi-Square test and Fishers Exact Test was used to examine the association between dependent and independent variables. The dependent variable was dichotomous and polytomous, so binary logistic regression and multinomial logistic regression were applied on the data set and subsequently converted the coefficients of multinomial logistic regression into adjusted percentages by using Multiple Classification Analysis (MCA) conversion model.

Figure 1

Prevalence of Stunting in Maharashtraa

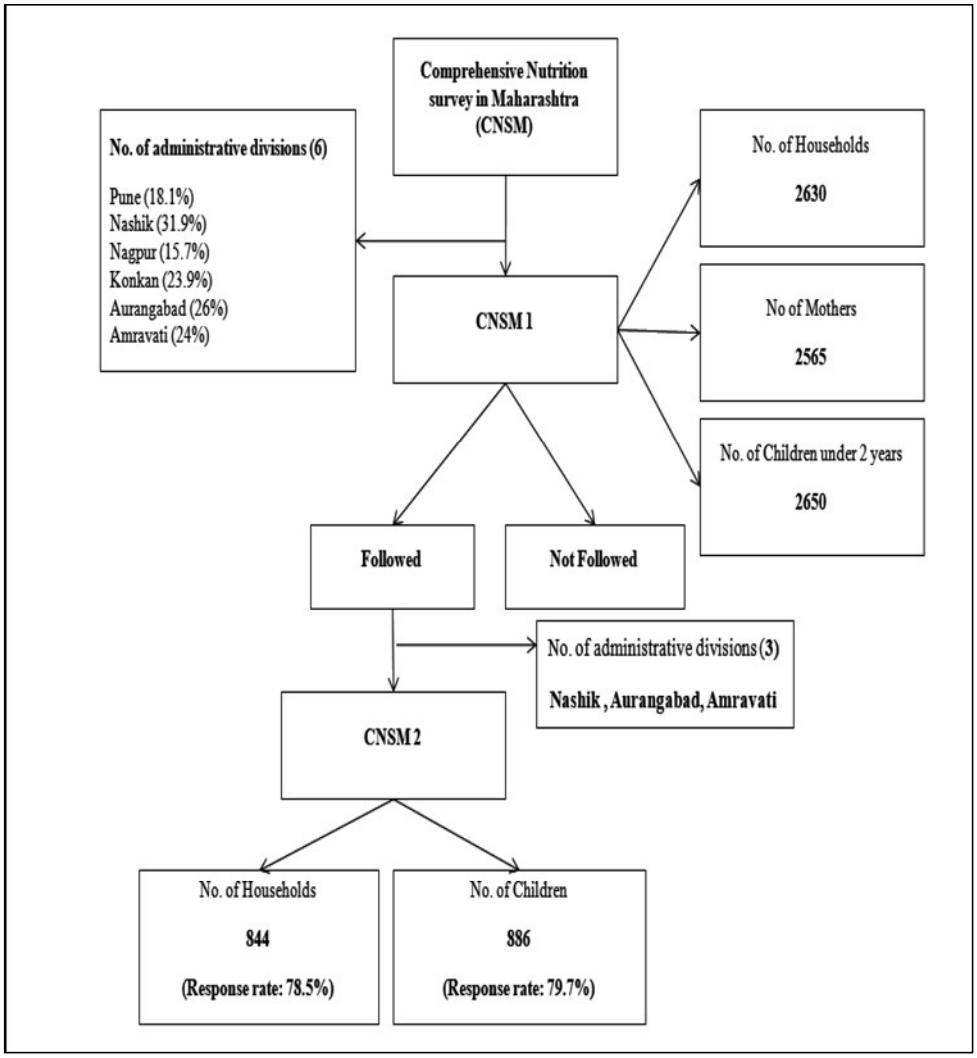


Source: *Comprehensive Nutrition Survey in Maharashtra (CNSM) Report, 2012*

* *The wealth quintiles were constructed using household assets. Each of the household assets were assigned a weight (factor score) generated through Principle Component Analysis (PCA). The resulting asset scores were standardized in relation to a normal distribution with the mean of zero and standard deviation of one*

FIGURE 2

Flow of the survey



RESULTS

Table 1 provides a summary of the sample children covered in CNSM Wave 1 and Wave 2. The total sample of children covered in 1st Wave was 1154, and in 2nd Wave, 886 children were followed up. Majority of children reside in rural areas and more than half (around 57%) of the children were boys. About 52% were second or third birth order child, while 41% were first order births. In Wave 1, about 8% and 56% mothers had completed primary education and secondary education respectively. In Wave 2 about 16% mothers and 49% mothers had completed primary and secondary education respectively. In terms of wealth index, 10% children belonged to the richest quintile in Wave1, whereas it was 20% in Wave 2. A marginal improvement in the availability of drinking water in Wave 2 compared to Wave 1, was noted. The scenario was quite different on availability

of improved toilet facilities in both rounds. The background characteristics of the population covered were almost similar for both survey rounds.

The overall stunting prevalence was recorded as 28% (95% CI: 25.0-31.0) in Wave 1, which increased marginally to 31% (95% CI: 27.6-33.8). A gender-wise comparison showed an increase in stunting among boys (25% in 2012 to a most 30%in 2015), compared to girls (30% in 2012 to 32% in 2015). In terms of administrative regions, the prevalence of stunting was higher in Amravati, where it increased from 25% (95% CI: 18.8-31.50) in the Wave 1 to almost 36% (95% CI: 28.9-43.0) in Wave 2. While, in Nasik region, a marginal increase in the prevalence of stunting was noticed. There was a drop in stunting in Aurangabad region, where the prevalence of stunting fell from 26.5% (95% CI: 22.2-30.8) in 2012 to 25.3% (95% CI: 21.0-29.5) in 2015. There has been a marginal increase of stunting among children residing in rural areas, while in the urban area it has remained almost the same. However, manifold increase in the prevalence of stunting was observed in children belonging to Scheduled Tribe (ST) compared to other social groups. In 2012, 33% (95% CI: 24.3-41.8) of children were stunted in Wave 1, which increased to 45.1% (95% CI: 35.8-54.4) in Wave 2. Amongst all the wealth quintile levels, the prevalence of stunting was considerably increased among children from poor households, i.e., from 27.4% (95% CI: 20.8-34.1) in 2012 to 36.6% (95% CI: 29.4-43.8) in 2015. It was interesting to note that the prevalence of stunting has increased even among children from households with improved toilet facilities while the stunting prevalence remained same over the two waves of CNSM among households with unimproved sanitation facility. However, the prevalence of stunting dropped amongst recipients of deworming medication and among those who had not received deworming medication, the prevalence increased from 26.9% (95% CI: 23.7-30.1) in Wave 1 to 29.6% (95% CI: 24.1-35.0) in Wave 2.

The results of binary logistic regression presented in Table 3 illustrate the contribution of independent variables on stunting in Wave 1 and Wave 2 of CNSM. In Wave 1, the age of the child, education status of the mother, height of the mother and the availability of toilet facilities were significantly associated with stunting. The child's age was positively associated with the stunting (AOR: 1.13, 99% CI: 1.10-1.16). A unit increase in the age of the child increased the risk of the child to be stunted by 1.13 times. The risk of stunting declined with an increase in mother's education level (AOR: 0.93, 95% CI: 0.87-1.00). The likelihood of a child being stunted was 0.39 times lower for those whose mothers' height was above 145 cm compared to those whose mothers' were short stature, i.e., less than 145 cm (AOR: 0.39, 99% CI: 0.22-0.70). The living condition of households showed that children from homes that had unimproved toilet facilities, were 2.1 times more likely to be stunted compared to children from improved toilet facility (AOR: 2.06, 99% CI: 1.20-3.52).

In Wave 2, the factors associated with stunting were the height of the mother, wealth quintile, social-groups and ICDS intervention. The children whose mother's height was greater than 145 cm were 0.29 times less likely to be stunted as compared to children whose mothers were less than 145 cm in height (AOR: 0.29, 99% CI: 0.17-0.51). The multivariate analysis showed that children from the scheduled tribe (ST) social group were 2.07 times more likely to be stunted as compared to other social groups (AOR: 2.07, 95% CI: 1.14 - 3.74). The non-recipients of ICDS's food supplementation were 1.59 times more likely to be stunted compared to recipients of ICDS programme (AOR: 1.59, 90% CI: 0.95 – 2.67).

Table 4 presents the confounder-adjusted effect of background characteristics on the changing status of stunting over a period. In general, we find clustering of children at two ends of a scale – never-stunted and persistent-stunted, though the proportion was especially higher among persistent-stunted category. Further, growth faltering was relatively higher than growth recovery. Nevertheless, the longitudinal data enabled us to understand the association between independent variables on the status of stunting by controlling for other variables.

Assumptions are that adequate nutrition to pregnant/ lactation mother and their children during early childhood will reduce chances of stunting for the next generation. Table 4 showed that there were 43 % never-stunted children below 42 months of age, however, with the increase in the age of the child, the proportion of never-stunted declined to 22% in 54 months and above ages. The reverse was the case for persistent-stunting. Only 15% of children suffered from persistent stunting in the age group of < 42 months, which increased subsequently to 55% in the age group for 54 months and above. A significant growth recovery was also noticed with an increase in age. There were 17 % of children in ages 54 months and above who had experienced growth recovery while it was only 5% in the ages' 42-47 months. The results certainly did not show any differential in the status of stunting by gender when adjusted for other confounding variables.

The education of mothers has a positive association with the growth and development of her offspring. It is assumed that educated mothers will be more watchful of their child's growth and provide necessary care and supplement the diet. Significant growth recovery was observed in children whose mothers had studied beyond primary school (6-10th Standard) compared to those who had not completed primary school.

Short stature and poor maternal nutrition are associated with an increase in the inter-uterine growth retardation. However, presumptions are that proper nutrition and care during the infancy might reverse the situation. As expected, children of short stature mothers suffered largely from persistent stunting (63%) compared to mothers with height above 145 cm (34%). A significant growth failure, of about 20%, was noticed in children whose mothers' height was above 145 cm. However, changes in the households' economic situation did not display any deviation in the stunting status. Perhaps, three years' time period may not necessarily be able to bring about a change in the feeding habits. Nonetheless, results show that changes in the living conditions, particularly in terms of accessibility to proper sanitation facilities, does have an impact on stunting status. Persistent stunting was higher in the households with unsafe toilet facility in Wave 2 than households with safe toilet facility in both the waves.

About 33% of the children who did not receive supplementary food in Wave 2 experienced significant growth failure than those had received food supplementation in Wave 1 and 2. Likewise, those who had received deworming medication in the second wave experienced 6% of growth recovery and those who had received deworming medication in both the waves registered a growth recovery that was as high as 12%.

The paper illustrates that children living in rural areas had experienced a much higher growth failure (25%) than their counterparts (13%). Among the three regions, growth recovery was considerably higher in Aurangabad and Nasik region than Amravati.

Discussion

The paper examined the prevalence of stunting and changes in the growth trajectories, to determine the magnitude of growth recovery and growth faltering among children. We followed the children below age of two years from Wave 1 (2012) of the CNSM, to Wave 2 (2015) allowing us to examine changes in the growth trajectories in three administrative divisions of Maharashtra: Nashik, Aurangabad and Amravati. The results showed growth recovery with the age of the child. This suggests that nutrition and care of pregnant/ lactating mother and their infants from conception to first two years of life is a crucial window period for reducing chances of stunting in the next generation.[4, 25]

Studies have shown that socioeconomic factors such as poverty, water, sanitation, education and gender inequality along with environmental factors determine the nutritional status of an individual.[26-31, 33] We did not find any association between wealth quintile with the changing status of stunting among children. This may be explained by the relatively homogenous nature of the population on which we have the data. Studies also suggests that apart from poverty there are other factors such as availability of food in different agro-climatic regions which affect the nutritional status of an individual.[29] From round 1, we have found food security level is different in different regions, and there is an association between stunting and food security status.[32] However, there is no change in the food security level between two rounds. Hence, food security has not been considered as a variable for further analysis.

Improved accessibility to safe drinking water facility at home during Wave 2 reduced the risk of growth faltering than those who had access to safe drinking water in both the two waves. Safe drinking water has the potential to reduce growth faltering among children in the household where access to safe drinking water improves from Wave 1 to Wave 2.

Women's educational and her position in the household was a significant predictor of growth recovery as they are the primary caregivers.[34-35] Our study suggests that growth recovery was significantly higher among children whose mothers' education was above middle and secondary school than those who below the middle school.

We found significant growth recovery among children who had received deworming medication in Wave 2 than their counterparts who either received medication during both the waves or did not receive medication during Wave 2. Primarily, children who suffered from ascariasis had a higher loss in faecal nitrogen, and deworming treatment improved nitrogen and fat absorption[28,36-37]

The mother's height is the result of genetic and environmental factors, but studies have shown short stature, and poor maternal nutrition was associated with intrauterine growth retardation.[5] The mother's height was significantly associated with changes in stunting, and this is consistent with earlier studies that indicate the intergenerational impact of maternal height on growth failure and stunting among children.[7, 38-39] This was largely attributed to reduced protein turnover and energy levels, smaller uterine and ovary sizes, and limited room for foetal development.[40-41] It is noteworthy that the never stunted children percentage is high as well as low for persistent stunting among the children of mothers whose height is above 145 cm. We suspect that where stunting is a common feature, mothers may not be able to notice growth retardation in their offspring. A lack of diversity of food items in meals and the lack of necessary micronutrients may

be the reason for persistent stunting or growth failure. Hence, we believe that infant and young child feeding practices at home, ICDS supplementation, deworming medication, personal hygiene and sanitation will ameliorate stunting among children. We do find the impact of the ICDS on the growth faltering as children who did not receive supplementary food were at a higher risk of experiencing growth faltering at Wave 2. The results are consistent with previous studies which also showed a severe drop in the prevalence of malnutrition and increase mean weight among the beneficiaries of the ICDS scheme.[14, 15] Growth failure was more in rural areas, and growth recovery was higher in Aurangabad and Nashik region as compared to Amravati region.

Conclusion

We conclude that policies and programmes should ensure access to proper drinking water and sanitation facilities at the household and community level. It may also mitigate the regional variations in stunting. The strengthening of ICDS, deworming medication and provision of diversified food items in the meals for adolescents, pregnant and lactating mothers and children will preclude the intergenerational effects of undernutrition in current generations and promote linear growth in early childhood. Longitudinal studies allow us to study long term effects of nutrition supplementation on undernutrition, stunting and obesity. Furthermore, we propose longitudinal studies in the areas where undernutrition is a major problem to understand the long-term effects of social, economic, biological and environmental factors on malnutrition and changes in growth trajectories. Lastly, a synergy between the existing programmes, such as supplementary nutrition, immunization and diarrhoeal disease control, is essential for promoting child survival and reducing growth trajectories.

Table 1

Distribution of population according to background characteristics

Background	CNSM Round 1		CNSM Round2	
	Numbers	Percent	Numbers	Percent
Gender of the child				
Male	652	56.5	491	56.63
Female	502	43.5	376	43.37
Birth Order of the Child				
1	477	41.3	356	40.18
2-3	592	51.3	459	51.81
4-6	77	6.7	64	7.22
7	8	0.7	7	0.79
Mother's education				
No education	160	13.86	100	12.79
Primary	91	7.89	124	15.86
Secondary	650	56.33	383	48.98
Higher	253	21.92	175	22.38
Wealth quintile				
Poorest	273	23.66	174	20.07
Poor	274	23.74	174	20.07
Second	296	25.65	173	19.95
Rich	201	17.42	172	19.84
Richest	110	9.53	174	20.07

Background	CNSM Round 1		CNSM Round2	
	Numbers	Percent	Numbers	Percent
Caste				
SC	179	15.51	117	14.16
ST	169	14.64	115	13.92
VJ	35	3.03	26	3.15
NT	157	13.6	123	14.89
OBC	264	22.88	187	22.64
Others	350	30.33	258	31.23
Administrative Regions				
Amravati	290	25.13	191	22.03
Aurangabad	493	42.72	407	46.94
Nasik	371	32.15	269	31.03
Type of Locality				
Rural	729	63.17	556	64.13
Urban	425	36.83	311	35.87
Source of drinking water				
Safe	1,059	91.77	820	94.58
Unsafe	95	8.23	47	5.42
Toilet facility				
Improved	382	33.1	257	29.64
Unimproved	772	66.9	610	70.36
Total sample		1154		886

TABLE 2

Prevalence of stunting according to background characteristics

Background Characteristics	Stunting 2012		Stunting 2015	
	Percent	95% CI	Percent	95% CI
Overall	27.99	[25.0 – 31.0]	30.73	[27.6 - 33.8]
Age (months) (First round)				
<6	8.8	[4.8 - 12.8]	31.4	[24.9 – 38.0]
6-11	18.7	[13.5 - 23.9]	30.1	[23.9 – 36.3]
12-17	36.1	[29.7 - 42.6]	29.3	[23.2 – 35.4]
>=17	45.8	[39.2 - 52.3]	32.1	[25.9 – 38.3]
Birth Order				
1	26.1	[21.5 - 30.7]	30.6	[25.8 - 35.4]
2-3	29.6	[25.4 - 33.8]	30.1	[25.9 - 34.3]
4-6	23.4	[12.8 - 34.1]	27	[15.7 - 38.3]
7	57.1	[7.7 - 100]	57.1	[7.7 - 100]
Gender				
Male	25	[26.2 – 34.4]	29.6	[27.4 – 35.8]
Female	30.29	[20.6 – 29.4]	31.6	[24.9 – 34.3]
Mother's education				
No education	27.3	[18.3 – 36.2]	40.8	[30.9 – 50.7]
Primary	27.9	[19.8 – 35.9]	31.7	[23.2 – 40.1]
Secondary	27.4	[22.9 – 31.9]	27.4	[22.9 – 31.9]
Higher	26.8	[20.0 – 33.6]	27	[20.1 – 33.8]

Background Characteristics	Stunting 2012		Stunting 2015	
	Percent	95% CI	Percent	95% CI
Wealth quintile				
Poorest	36.7	[29.3 – 44.0]	39.5	[32.0 – 47.0]
Poor	27.4	[20.8 – 34.1]	36.6	[29.4 – 43.8]
Second	33.5	[26.2 – 40.8]	30.5	[23.4 – 37.6]
Rich	20.5	[14.3 – 26.7]	25.5	[18.7 – 32.2]
Richest	23	[16.5 – 29.5]	21.5	[15.1 – 27.8]
Social group				
SC	30.2	[21.7 – 38.7]	32.8	[24.1 – 41.4]
ST	33	[24.3 – 41.8]	45.1	[35.8 – 54.4]
VJ	34.6	[15.0 – 54.2]	30.8	[11.8 – 49.8]
NT	26.8	[18.9 – 34.8]	29.8	[21.5 – 38.0]
OBC	23.1	[17.0 - 29.2]	29.4	[22.7 – 36.0]
Others	28	[22.5 - 33.5]	24.3	[19.0 – 29.6]
Administrative Regions				
Amravati	25.1	[18.8 – 31.5]	35.9	[28.9 – 43.0]
Aurangabad	26.5	[22.2 – 30.8]	25.3	[21.0 – 29.5]
Nasik	32.2	[26.5 – 37.9]	35.6	[29.8 – 41.5]
Type of Locality				
Rural	29.5	[25.7 – 33.3]	33	[29.1 – 37.0]
Urban	25.2	[20.2 – 30.1]	26.4	[21.4 – 31.5]
Water Facility				
Improved	27.8	[24.6 – 30.9]	30.5	[27.3 - 33.7]
Unimproved	30.6	[19.7 – 41.5]	34	[20.0 – 48.1]
Toilet Facility				
Improved	18.1	[13.5 – 22.8]	27.1	[22.3 – 32.0]
Unimproved	32.4	[28.6 – 36.2]	32.9	[28.8 – 37.0]
Supplementary food				
Received	27.9	[24.6 – 31.4]	31.6	[27.9 -35.2]
Not received	27.7	[20.6 – 34.7]	30.3	[22.9 – 37.5]
Deworming medication				
Received	35	[26.3 – 43.8]	31.3	[27.5 – 35.1]
Not received	26.9	[23.7 – 30.1]	29.6	[24.1 – 35.0]
Immunization				
Partial Immunization			30.28	[26.5 – 34.1]
Full Immunization			30.32	[25.2 – 35.5]

TABLE 3

Binary logistic regression for effect of background characteristics on stunting in CNSM round 1 and CNSM round 2

	CNSM round1			CNSM round2		
	OR	L.C.I	U.C.I	**OR**	L.C.I	U.C.I
Age of the child (months)	1.129***	1.10	1.16	1.011	0.98	1.04
Gender of the child						
Female®						
Male	1.338	0.93	1.93	1.187	0.83	1.70
Birth Order						
1®						
2-3	0.992	0.68	1.45	0.806	0.56	1.16
4-6	0.577	0.19	1.74	0.420	0.13	1.33
7	3.928	0.51	30.32	1.152	0.17	8.00
Educational status of mother	0.931**	0.87	1.00	0.976	0.91	1.04
Height of the mother (cm)						
Less than 145®						
Greater than or equal 145	0.393***	0.22	0.70	0.295***	0.17	0.51
Wealth Quintile						
Poorest®						
Poor	0.647	0.36	1.17	1.114	0.64	1.93
Middle	1.028	0.56	1.88	1.247	0.71	2.19
Rich	0.582	0.30	1.12	1.023	0.55	1.91
Richest	1.319	0.62	2.81	0.471*	0.22	1.03
Social group						
General®						
SC	1.209	0.67	2.18	1.241	0.70	2.21
ST	1.026	0.54	1.97	2.068**	1.14	3.74
VJ	0.854	0.28	2.60	1.253	0.44	3.59
Nomads	0.878	0.49	1.57	0.987	0.56	1.72
OBC	0.763	0.47	1.25	1.191	0.73	1.93
Place of residence						
Rural®						
Urban	0.985	0.57	1.70	1.188	0.73	1.94
Water facility						
Improved®						
Unimproved	0.799	0.41	1.56	1.075	0.47	2.45
Toilet facility						
Improved®						
Unimproved	2.055***	1.20	3.52	0.794	0.52	1.21
Immunization						
Partially immunized®						
Fully immunized				0.835	0.54	1.28
Supplementary food received from ICDS						
Yes®						
No	1.114	0.67	1.85	1.593*	0.95	2.67
Deworming medication						
Yes®						
No	0.970	0.59	1.61	1.020	0.69	1.51
Constant	0.475	0.09	2.42	4.004*	0.95	16.82
	Number of observations	737		Number of observations	672	
	Adjusted R2	0.139		Adjusted R2	0.015	

® Reference category

note: *** p<0.01, ** p<0.05, * p<0.1

TABLE 4

MCA table for effect of background characteristics on the changing status of stunting

Background Characteristics	Never Stunted	Growth Failure	Growth Recovery	Persistent Stunting
Age of the child (months) (Second round)				
Less than 42®	42.83	40.82	1.81	14.55
42 - 47 months	39.37	24.63	5.28**	30.71**
48 – 53 months	26.88	11.69***	10.53***	50.90***
Greater than or equal to 54 months	21.68	6.57	16.92***	54.83***
Gender of the child				
Female®	38.07	19.2	5.82	36.91
Male	34.01	20.64	7.53	37.82
Birth Order of the Child				
1st ®	33.83	22.91	5.83	37.43
2nd – 3rd	36.71	19.51	7.54	36.24
4th +	38.45	11.30*	6.17	44.08
Educational status of mother				
<6®	30.18	19.22	9.54	41.05
6-10th	40.1	18.71	6.55**	34.63
>10th	32.02	22.13	5.95	39.91
Height of the mother (cm)				
Less than 145®	14.44	18.98	3.62	62.97
Greater than or equal to 145	38.97	19.64***	7.06	34.33***
Change in Wealth Quintile				
No change®	37.52	19.57	7.12	35.79
Improved	35.41	24.91	4.95	34.74
Deteriorate	31.63	16.03	8.05	44.28
Change in Water Facility				
Safe in both the rounds®	34.85	20.35	6.49	38.31
Unsafe in the 1st round but Safe in the 2nd round	46.82	9.96*	11.17	32.05
Safe/Unsafe in 1st round but Unsafe in 2nd round of CNSM	36.52	29.69	5.96	27.83
Change in toilet facility				
Safe in both the rounds®	46.83	24.47	6.27	22.43
Unsafe in the 1st round but Safe in the 2nd round	32.74	19.23	5.03	43.01**
Safe/Unsafe in 1st round but Unsafe in 2nd round of CNSM	32.65	18.49	5.02	43.84***
Immunization (Second round)				
Partially immunized®	36.46	20.49	6.2	36.85
Fully immunized	34.59	19.11	7.79	38.52
Supplementary food received from ICDS				
Received in both the rounds®	37.58	17.55	6.06	38.81
Not received in 1st round but received in 2nd round	35.83	17.42	7.4	39.34
Received/Not received food in the 1st round but did not receive in 2nd round of CNSM	29.18	32.56***	7.99	30.27

Background Characteristics	Never Stunted	Growth Failure	Growth Recovery	Persistent Stunting
Deworming				
Received in both the rounds®	32.25	21.92	11.92	33.91
Not received in 1st round but received in 2nd round	35.42	19.59	5.64**	39.35
Received/Not received medication in the 1st round but did not receive in 2nd round of CNSM	37.18	20.08	7.79	34.94
Region				
Amravati®	34.94	18.9	2.81	43.36
Aurangabad	40.39	19	8.73**	31.88
Nashik	28.67	21.63	7.75***	41.95
Social group				
General®	38.95	18.46	6.19	36.41
SC/ST	32.55	21.71	7.31	38.43
Place of residence (First round)				
Urban®	39.51	13.11	6.61	40.77
Rural	33.47	24.60***	6.67	35.25

® Reference category
note: *** p<0.01, ** p<0.05, * p<0.1

REFERENCES

1. IIPS I. National Family Health Survey (NFHS-4), 2015–16. International Institute for Population Sciences (IIPS), Mumbai, India. 2017.
2. Nutrition IC. The achievable imperative for global progress. New York, NY: UNICEF. 2013.
3. Organization WH. Physical status: The use of and interpretation of anthropometry, Report of a WHO Expert Committee. 1995.
4. De Onis M, Branca F. Childhood stunting: a global perspective. Maternal & child nutrition. 2016;12:12-26.
5. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and child undernutrition: consequences for adult health and human capital. The lancet. 2008;371(9609):340-57.
6. Perkins JM, Subramanian SV, Davey Smith G, Özaltin E. Adult height, nutrition, and population health. Nutrition reviews. 2016;74(3):149-65.
7. Özaltin E, Hill K, Subramanian S. Association of maternal stature with offspring mortality, underweight, and stunting in low-to middle-income countries. Jama. 2010;303(15):1507-16.
8. WHO. Resolution WHA65. 6. Maternal, infant and young child nutrition. Sixty□fifth World Health Assembly, Geneva, 21–26 May Resolutions and Decisions, Annexes. 2012.
9. Victora CG, De Onis M, Hallal PC, Blössner M, Shrimpton R. Worldwide timing of growth faltering: revisiting implications for interventions. Pediatrics. 2010;125(3):e473-e80.
10. Das S, Hossain M. LEVELS AND DETERMINANTS OF CHILD UNDERNUTRITION IN BANGLADESH. Pakistan Journal of Statistics. 2008;24(4).
11. Svefors P, Rahman A, Ekström E-C, Khan AI, Lindström E, Persson LÅ, et al. Stunted at 10 years. Linear growth trajectories and stunting from birth to pre-adolescence in a rural Bangladeshi cohort. PloS one. 2016;11(3):e0149700.
12. Saleemi M, Ashraf R, Mellander L, Zaman S. Determinants of stunting at 6, 12, 24 and 60 months and postnatal linear growth in Pakistani children. Acta Paediatrica. 2001;90(11):1304-8.
13. Devakumar D, Kular D, Shrestha BP, Grijalva□ Eternod C, Daniel RM, Saville NM, et al. Socioeconomic determinants of growth in a longitudinal study in Nepal. Maternal & child nutrition. 2018;14(1):e12462.
14. Tandon B. Nutritional interventions through primary health care: impact of the ICDS projects in India. Bulletin of the World Health

Organization. 1989;67(1):77.

15. Pandey V, Awasthi S, Srivastava V, Nigam A, Srivastava P. Study of nutritional status of children attending ICDS services in Lucknow. Indian J Prev Soc Med. 2011;42(2).

16. Biswas S, Bose K, Mukhopadhyay A, Bhadra M. Prevalence of undernutrition among pre-school children of Chapra, Nadia District, West Bengal, India, measured by composite index of anthropometric failure (CIAF). Anthropologischer Anzeiger. 2009;67(3):269-79.

17. Jyothi B. A comparative study on health status of under five children in icds and non icds areas in konanakunte south bangalore: RGUHS; 2006.

18. Dodos J, Mattern B, Lapegue J, Altmann M, Aissa MA. Relationship between water, sanitation, hygiene, and nutrition: what do Link NCA nutrition causal analyses say? Waterlines. 2017;36(4):284-304.

19. Dangour AD, Watson L, Cumming O, Boisson S, Che Y, Velleman Y, et al. Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children. Cochrane Database of Systematic Reviews. 2013(8).

20. Merchant A, Jones C, Kiure A, Kupka R, Fitzmaurice G, Herrera M, et al. Water and sanitation associated with improved child growth. European Journal of Clinical Nutrition. 2003;57(12):1562.

21. Rah JH, Cronin AA, Badgaiyan B, Aguayo VM, Coates S, Ahmed S. Household sanitation and personal hygiene practices are associated with child stunting in rural India: a cross-sectional analysis of surveys. BMJ open. 2015;5(2):e005180.

22. Meshram I, Arlappa N, Balakrishna N, Laxmaiah A, Mallikarjun Rao K, Gal Reddy C, et al. Prevalence and determinants of undernutrition and its trends among pre-school tribal children of Maharashtra State, India. Journal of tropical pediatrics. 2011;58(2):125-32.

23. International Institute of Population Sciences UNCsF, Government of Maharashtra. Comprehensive Nutrition Survey in Maharashtra. 2012.

24. Lee R, Nieman D. Biochemical assessment of nutritional status. Nutritional Assessment, 3a ed New York: McGraw-Hill. 2003.

25. Martorell R. Body size, adaptation and function. Human Organization. 1989:15-20.

26. Coffey D, Deaton A, Drèze J, Spears D, Tarozzi A. Stunting among children: Facts and implications. Economic and Political Weekly. 2013;48(34):68-70.

27. Hong R, Mishra V. Effect of wealth inequality on chronic under-nutrition in Cambodian children. Journal of Health, Population and Nutrition. 2006:89-99.

28. Tripathy K, Duque E, Bolaños O, Lotero H, Mayoral LG. Malabsorption syndrome in ascariasis. The American journal of clinical nutrition. 1972;25(11):1276-81.

29. Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B, et al. Developmental potential in the first 5 years for children in developing countries. The lancet. 2007;369(9555):60-70.

30. Heltberg R. Malnutrition, poverty, and economic growth. Health Economics. 2009;18(S1):S77-S88.

31. Unisa S, Borkotoky K. An Appraisal of Anthropometric Data and Factors Influencing Height of Indian Population. Demography India. 2017; 46(1):22-37.

32. Unisa S., Chattopadhyay A., Fulpagare P., and Sinha A. Food Security and Nutritional Status of Children in Maharashtra. 2017, Working paper No. 12, Mumbai, International Institute for Population Sciences. Available at https://iipsindia.ac.in/sites/default/files/IIPS_Working_Paper_No12.pdf

33. Reyes H, Pérez-Cuevas R, Sandoval A, Castillo R, Santos JI, Doubova SV, et al. The family as a determinant of stunting in children living in conditions of extreme poverty: a case-control study. BMC Public Health. 2004;4(1):57.

34. Barrera A. The role of maternal schooling and its interaction with public health programs in child health production. Journal of Development Economics. 1990;32(1):69-91.

35. Boyle MH, Racine Y, Georgiades K, Snelling D, Hong S, Omariba W, et al. The influence of economic development level, household wealth and maternal education on child health in the developing world. Social science & medicine. 2006;63(8):2242-54.

36. Venkatachalam P, Patwardhan V. The Role of Ascaris lumbricoides in the Nutrition of the Host. Effect of Asoarlasis on Digestion of Protein. Transactions of the Royal society of Tropical Medicine and Hygiene. 1953;47(2):169-75.

37. Tripathy K, González F, Lotero H, Bolaños O. Effects of Ascaris infection on human nutrition. The American journal of tropical medicine and hygiene. 1971;20(2):212-8.

38. Ramakrishnan U, Martorell R, Schroeder DG, Flores R. Role of intergenerational effects on linear growth. The Journal of nutrition. 1999;129(2):544S-9S.

39. Subramanian S, Ackerson LK, Smith GD, John NA. Association of maternal height with child mortality, anthropometric failure, and anemia in India. Jama. 2009;301(16):1691-701.

40. Duggleby SL, Jackson AA. Relationship of maternal protein turnover and lean body mass during pregnancy and birth length. Clinical science. 2001;101(1):65-72.

41. Ibáñez L, Potau N, Enriquez G, De Zegher F. Reduced uterine and ovarian size in adolescent girls born small for gestational age. Pediatric research. 2000;47(5):575.