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RESEARCH ARTICLE

Linkage in stunting status of siblings: a new perspective on childhood undernutrition in India

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Abstract

Almost 30% of the world's stunted children reside in India. This study examined sibling linkage in childhood stunting by assessing the extent of clustering of stunted children born to the same mother. Data were taken from 225,002 children under the age of five from the Indian National Family and Health Survey (NFHS)-4 conducted in 2015–16. States with high fertility and lower socioeconomic development displayed higher clustering of childhood stunting among siblings. Simulating removal of this clustered burden showed an almost 10 percentage point reduction in stunting in India. Multinomial regression analysis highlighted that the propensity to have multiple stunted births was higher among less-educated women, scheduled caste/tribes and poor households. The multilevel model results indicated that the odds of stunting for the index child increased by 1.93 if the older sibling was stunted. The odds of the index child being stunted if the previous child was stunted were high, irrespective of the differences in state-level public health performances and political commitments. Although socioeconomic correlates play a crucial role in determining child stunting status, they also act as proxies for poor-quality intra-generational health. Clustering of stunting among siblings is an indicator of both genetic and environmental association with the height-for-age (HAZ) of children. Mothers with repeated stunted births should be prioritized and monitored over a substantial part of their lives. Inclusion of multiple child beneficiaries in nutrition policies and revisiting the 'one size fits all' concept at the micro level, owing to the substantial village/ward-level variation, might be an effective policy measure.

Keywords: Child growth; Family influences; Stunting

Introduction

According to the World Economic Outlook Update by the International Monetary Fund, India is one of the fastest growing economies in the world. However, this rapid macro-economic growth has not yet been translated into a substantial decline in childhood undernutrition in the country (Subramanyam *et al.*, 2011; Joe *et al.*, 2016). Childhood undernutrition is responsible for the majority of childhood morbidities and is one of the leading causes of child mortality in India (Gragnolati *et al.*, 2005; UNICEF, 1990, 2007; Black *et al.*, 2008; World Health Organization, 2010). Stunting, defined as the *z*-score of height-for-age below minus 2 standard deviation units from the median of a reference population (HAZ), is a strong predictor of adult height and an indicator of restricted linear growth of a child due to chronic undernutrition (Tanner *et al.*, 1956; Onis, 2006; WHO Multicentre Growth Reference Study Group, 2006; World Health Organization, 2010). Empirically, taller adults have higher cognitive abilities, fewer physical impairments over the lifetime and higher earnings (Barker & Osmond, 1986; Barker *et al.*, 1993; Strauss & Thomas, 1998; Glewwe & Miguel, 2007; Hoddinott *et al.*, 2013; Schott *et al.*, 2013; Guven & Lee, 2015).

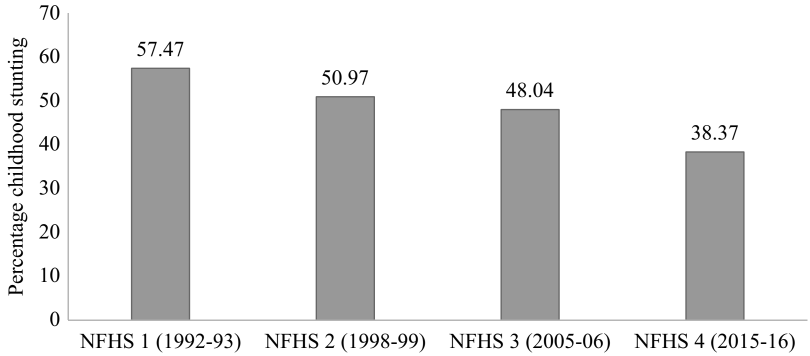

Figure 1. Percentage of childhood stunting in India, NFHS-1 (1990–93) to NFHS-4 (2015–16).

Unfortunately, the percentage of childhood stunting has remained alarmingly high in many parts of India (HUNGaMa Survey Report, 2011). Almost 30% of the world's stunted children are in India – an outlier even among the poorest nations in the world (UNICEF, 2013).

Since the 1990s, India's childhood stunting levels have declined gradually. However, this decrease has not been on a par with that of other countries with similar economic conditions (Gragnolati *et al.*, 2005), decreasing from a level of 57% in 1992–93 to 38% in 2015–16 (Fig. 1). Continuous efforts have been made to combat and eradicate childhood morbidities and undernutrition in India. Some noteworthy initiatives have been the United Nations Children's Fund (associated with India since 1949), the Integrated Child Development Scheme (ICDS) (1975), the National Plan of Action for Children (signatory to the World Summit on Children, 1990), Mid-Day Meals (1995), Reproductive and Child Health-II (2005), Janani Suraksha Yojana (JSY) (2005), Janani Shishu Suraksha Karyakaram (2011) and Pradhan Mantri Matru Vandana Yojana (PMMVY) (2017). Despite such efforts, the recent (2015–16) Indian National Family and Health Survey (NFHS-4) data recorded one in three children to be stunted.

There is a myriad of literature unravelling the determinants of childhood stunting in India. Some of the major child- and mother-level factors predisposing a child to stunting are: mother's health, height, education and socioeconomic status, and the age and sex of the child (Smith & Haddad 2000; Black *et al.*, 2008, 2013; Subramanian *et al.*, 2009; Kanjilal *et al.*, 2010; Fenske *et al.*, 2013; Fledderjohann *et al.*, 2014; Onis & Branca 2016; Singh *et al.*, 2016;). Morbidities such as diarrhoea and acute respiratory infection reduce immunity and weaken children, making them more vulnerable to infection and disease. This leads to the physical inability to absorb nutrients from food (Scrimshaw & SanGiovanni, 1997; Jayachandran & Pande, 2017). However, research on clustering of stunting status in siblings, albeit cardinal in assessing the mechanism of stunting, remains limited in India. This is also called 'clustering of stunting within the same family' and is a widely studied phenomenon in child mortality. The argument in mortality research is that the death of a preceding child has a significant 'scarring effect' on the survival status of the index child. In other words, there are strong linkages between the death status of siblings resulting in clustering of mortality in a family (Das Gupta, 1990; Arulampalam & Bhalotra, 2006, 2008). Malnutrition measures such as underweight status, used in the study of sibling linkage (Singh *et al.*, 2016), are often affected by short-term programme interventions, whereas stunting is a stronger correlate of long-term chronic malnutrition and remains unaffected by short-term interventions. The present study explores the burden of multiple stunted siblings nested under a mother and provides insights on the biological aspect of childhood stunting. It also addresses additional issues of controlling geographical variations by using a multilevel approach.

The nutritional outcomes of siblings are linked by various mechanisms. Three parental concerns that affect the nutritional status of siblings are equity, efficiency and preference

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(Behrman *et al.*, 2017; Mussa, 2015). Equity bias is caused by parents wanting their children to be equally well off. Thus, if nutritional requirements are different for different sexes, a gender bias may arise. Efficiency bias arises when parents are willing to invest more in a child because he/she is more efficient. Preference bias comes into play when parents prefer one child over the other. It has been observed that despite having similar calorie intakes, boys are given more fat and milk with their cereal compared to girls (Das Gupta, 1987). Girl children are less likely to be breastfed according to WHO/UNICEF standards than their male counterparts leading to mortality inequalities among male and female children (Fledderjohann *et al.*, 2014). In some cases, sibling nutritional inequality is observed not only by sex, but also by age and birth order (Mussa, 2015). A mother's experience through her reproductive life is postulated to have a significant impact on her children's health. This is the 'learning hypothesis' as this defines the process by which a mother who has experienced a negative child health outcome such as death in the past may employ her experience to avoid the negative outcome in a later birth (Lee & Mason, 2005; Arulampalam & Bhalotra, 2006).

Inter-generational transmission of poverty is also a leading cause of clustering of childhood undernutrition. Wealthier parents invest more in their children's health, social and educational needs, thereby increasing their chances of earning more, whereas children born to poor households have a higher chance of living a life of drudgery and ending up having a low standard of living. Thus, children of poorer households remain undernourished and show an increased risk of child mortality due to undernutrition (Martorell & Zongrone, 2012; Behrman *et al.*, 2017).

This study focused on the clustering of stunting at the sibling level in India and assessed the contribution of the clustered burden on aggregate-level estimates. A randomized simulation technique was designed to assess the amount of load that would be taken away from the burden of childhood stunting if the siblings found to be stunted, clustered under the same mother, could be eliminated. A multinomial model was applied to produce predicted probabilities of childhood stunting by socioeconomic characteristics to indicate the propensity of clustering among various population sub-groups. A multilevel approach was used to estimate the effect of stunting status of a preceding sibling on the stunting status of the index child by taking the preceding child as a lagged variable. This approach gives reliable statistical estimates by controlling for various geographical levels in a diverse country such as India. Empirical evidence of state dependency in childhood stunting, after controlling for various socioeconomic and geographical characteristics, will assist in providing a new dimension to aetiology of childhood stunting and help in revision of old policies and frame new programmes to effectively deal with the issue of the sluggish decline in childhood stunting in India.

Methods

Data

The NFHS is a nationally representative, large-scale survey aimed at producing reliable maternal and child health indicators in India. It is conducted under the stewardship of the Ministry of Health and Family Welfare, India. The International Institute for Population Sciences (IIPS), Mumbai, is the nodal agency for conducting the NFHS. A two-stage stratified sample was collected in NFHS-4 from 29 states and seven union territories. For the very first time, district-level information was available in the data. A detail of the sampling techniques and size can be obtained from the national report of the NFHS 4 (IIPS & ICF, 2017). In NFHS-4, information was collected from 601,509 households with a response rate of 97.6%.

The sample size of the children below 60 months (under 5 years) in NFHS-4 was 259,627. The number of mothers who gave birth to children in the 5-year time period preceding the survey was 190,898. For the purpose of this study, children with missing information for height and age were deleted and the analysis was carried out on 225,002 children from 167,969 mothers.

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The anthropometric measures of both children between 0 and 59 months of age and mothers aged 15–49 years were collected. Weights were measured using a Seca 874 digital scale. The heights of mothers, and children aged 24–59 months, were measured using a Seca 213 stadiometer. The recumbent length of children below 2 years, or 85 cm, was measured using a Seca 417 infantometer. The preceding child and index child can be easily identified using the birth index and birth order numbers. Several socioeconomic, demographic and biological variables were considered in the study. The data are publicly available and can be downloaded from the Demographic Health Survey (DHS) website (https://dhsprogram.com/data/available-datasets.cfm).

Variables

Outcome variable

The outcome variable of interest was the height-for-age *z*-score (HAZ) from which the stunting status of children below 5 years of age was estimated. It is important to note how various measures of malnourishment differ from each other and what they actually signify. While wasting and underweight are generally considered to be short-term measures of acute malnourishment, stunting is considered to be a measure that not only encompasses the present lack of nutrition but also capture long-term deficiencies, usually inherited through transgenerational undernutrition (Caulfield *et al*., 2006; Bhutta *et al*., 2008; World Health Organization, 2010). In this study, the main aim was to assess sibling linkage, which inevitably depicts a genetic linkage. Thus, stunting was conceptualized to be the most suitable measure.

Explanatory variables

The main explanatory variable was the stunting status of the preceding child, coded as 0 if the HAZ was below minus 2 standard deviations and 1 otherwise. The model was controlled for a set of maternal and child demographic and socioeconomic characteristics, along with nutrition behaviour, and community-level sanitary practices as a proxy for neighbourhood disease environment. The percentages of stunting by the selected background characteristics are provided in Table 1.

Analysis

The sibling-level clustered burden of childhood stunting was estimated by identifying children below 59 months who were themselves stunted and were living with one or multiple stunted siblings. A simple, step-by-step, randomized simulation technique was designed to understand the burden of sibling-level clustering on the aggregate level of childhood stunting for various states and union territories of India. A univariate random sampling distribution was used to rank the children nested within mothers. The ranks were provided randomly. Stunted children with lower rank were simulated to be not stunted to obtain the estimates for aggregate stunting level without the clustered burden.

To assess the burden of stunting among various socioeconomic sub-groups, multinomial logit regression was used. Here, the dependent variable was the number of stunted children per mother. Clustering was noted if a mother had two or more stunted children below 5 years of age. The marginal probabilities by three major proxies for socioeconomic status were calculated from the fitted model. The proxies taken were: mother's education level, social class (caste) and wealth status of the household.

To analyse sibling linkage, a multilevel approach using a binomial response model (multilevel binary response) estimated by the second-order penalized or predictive quasi-likelihood (PQL2) method was applied. For this model, the stunting status of children was coded as a binomial variable. This method is often preferred over the first-order marginal quasi-likelihood method (MQL1) as this may produce results that are biased downwards. Since there was not much difference between the estimates from MQL1 and PQL2, the Markov Chain Monte Carlo (MCMC) method was not used in the analysis. The model was controlled at three levels for some of the

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Table 1. Childhood stunting levels by background characteristics of mother and child, NFHS-4 (2015–16)

Background characteristic	Percentage of stunted index children	Total children[a]
Child health and demographic characteristics		
Status of preceding child		
Not stunted	30.56	28,019
Stunted	52.19	23,293
No preceding children	37.78	173,690
Age of index child		
0–6 months	19.75	31,315
6 months–1 year	25.86	20,651
1–3 years	43.34	97,631
3 years and above	41.47	94,911
Sex of preceding child		
Male	40.31	23,010
Female	40.46	28,302
No. preceding children	37.78	173,690
Birth order		
1	33.29	96,212
2	37.09	79,670
3+	46.38	83,745
Size of child at birth		
Small	46.85	31,380
Average	37.83	177,739
Large	34.29	44,094
Safe disposal of stool		
Safely	31.21	99,407
Not safely	42.84	155,019
Any morbidity in last 2 weeks		
No	38.37	223,077
Yes	38.34	36,550
Age-appropriate immunization		
No	39.92	100,495
Yes	37.15	124,507
Minimum diet diversity		
No	37.75	124,122
Yes	39.11	100,880

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Table 1. *Continued*

Background characteristic	Percentage of stunted index children	Total children[a]
Mother's health and status		
Mother's age at birth		
≤19 years	41.56	17,900
20–29 years	37.78	190,977
≥30 years	39.58	50,750
Mother's BMI		
Underweight	45.79	53,285
Normal	38.08	139,706
Overweight/obese	27.38	32,007
Education of mother		
No education	50.76	68,978
Primary	43.42	32,835
Secondary	32.79	102,191
Higher	20.81	209,98
Household characteristics		
Place of residence		
Urban	30.99	53,483
Rural	41.20	171,519
Caste		
SC/ST	43.11	86,980
OBC	38.70	88,803
Other	30.92	40,790
Religion		
Hindu	38.48	163,089
Non-Hindu	37.96	61,913
Wealth index		
Poor	47.74	111,492
Middle	36.50	45,136
Rich	26.07	68,374
Total	38.37	225,002

[a]Excluding children with no information.
SC/ST: Scheduled Caste/Scheduled Tribe; OBC Other Backward Class.

selected states: district, primary sampling unit (PSU) and individual child level. The PSU consists of villages in rural areas and wards in urban areas. The PSU and community are used interchangeably in this work. At the national level, the model was additionally controlled for states. The states selected for multilevel analysis were: Bihar, Uttar Pradesh, Madhya Pradesh, Gujarat, Punjab, Odisha and Tamil Nadu. These states fell in different positions in the stunting continuum and provided evidence to check if clustering of childhood stunting was state-specific or family-specific. This will provide insights on the type of programmes and policies that need to be bolstered.

Results

Descriptive statistics of the sample

Table 1 provides estimates of the percentage of stunting among the index children by the control variables used in the study. In cases where the preceding child was stunted, the percentage of stunting of the index child was as high as 52%. There was a rise in the percentage of stunted children after the age of 1 year. A similar percentage of stunting was observed among the index children irrespective of the sex of the preceding child. The percentage of stunting was found to rise with birth order. Around 47% of children of small birth size, and 43% of those whose stool was not safely disposed of, were stunted. Almost 40% of children who did not receive age-appropriate immunization were found to be stunted. Almost 38% of children who did not meet the Minimum Diet Diversity (MDD) level were stunted. The MDD is calculated following NFHS guidelines, which include all children who, irrespective of their breastfeeding status, have consumed items from four or more food groups (IIPS & ICF, 2017). Mothers whose age at child birth was below 19 years had 42% stunted children. Underweight mothers gave birth to 46% of the stunted children. In rural India, 41% of children were stunted compared with 31% in urban areas. The percentage of stunting was higher among Scheduled Caste/Scheduled Tribes (SC/ST) and Other Backward Class (OBC) mothers with no formal education or only primary education and belonging to lower wealth quintiles. The percentage of households that practised open defecation had a positive correlation with low HAZ. This was taken as a continuous variable at the community level.

Level of sibling-linked clustering of childhood stunting

Table 2 provides the clustering estimates of childhood stunting along with 95% confidence intervals in the states and union territories of India. Here, the percentage of children who are themselves stunted and who are living with at least one other stunted sibling and the percentage of mothers with multiple stunted children are presented. Almost 11% of stunted siblings were clustered within 6% of mothers (Table 2). This indicates that out of all children below 5 years of age, 11% were themselves stunted and were living with one or more stunted sibling. The states with a high level of aggregate childhood stunting (Table 3) like Bihar (18%), Meghalaya (15%), Uttar Pradesh (15%), Madhya Pradesh (13%) and Jharkhand (12%) showed the highest percentages of clustered stunted siblings (Table 2). This implies that a heavy burden of stunting was clustered within mothers in these states. Most of the Empowered Action Group (EAG) states remained in the top quintile of heavy sibling-level burden of stunting. Among the union territories, the highest percentage of clustering was observed in Dadra and Nagar Haveli (11%). The sibling-level clustered burden was only 1% in Kerala. This huge variation in the clustering of childhood stunting is an indicator of the inequality between the states of India.

Contribution of clustered stunting at an aggregate level

In the NFHS-4, the highest burdens of stunting were in Bihar, Uttar Pradesh, Jharkhand, Meghalaya, Madhya Pradesh, Dadra and Nagar Haveli (union territory), Rajasthan, Gujarat and Chhattisgarh. The percentages of stunted children in these states were higher than the national level, which was 38%. The estimate of childhood stunting included mothers with multiple stunted children, mothers with one stunted child and mothers with no stunted children born in the 5 years preceding the survey. The ideal case scenario is to achieve mothers with no stunted children. However, to completely eliminate stunting is a ‘one step at a time’ task. In Table 3, three scenarios are simulated. Scenario 1 estimates the aggregate-level childhood stunting if the mothers who had more than two stunted children had exactly two stunted children and no more. Scenario 2 provides aggregate-level stunting estimates if the mothers with multiple stunted children had only one stunted child.

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Table 2. Percentage (95% CI) of sibling clustered childhood stunting in states of India, NFHS-4 (2015–16)

State	Stunted children living with at least one other stunted sibling (%)	Mothers with 2 or more stunted children (%)	Total children[a]	Total mothers[a]
Andaman and Nicobar Islands	2.63 (1.51, 4.55)	1.55 (0.70, 3.37)	578	476
Andhra Pradesh	7.70 (6.71, 8.83)	4.70 (3.81, 5.78)	2599	1921
Arunachal Pradesh	5.88 (5.09, 6.77)	3.45 (2.78, 4.28)	3851	3028
Assam	6.13 (5.58, 6.73)	3.42 (2.97, 3.93)	8855	7462
Bihar	17.86 (17.3, 18.43)	11.59 (11.03, 12.17)	22,275	15,001
Chandigarh	6.33 (3.42, 11.39)	4.06 (1.69, 9.44)	174	135
Chhattisgarh	9.78 (9.03, 10.58)	6.08 (5.39, 6.84)	8230	6173
Dadra and Nagar Haveli	11.24 (7.97, 15.64)	7.45 (4.54, 12.01)	277	208
Daman and Diu	4.19 (2.51, 6.92)	2.43 (1.15, 5.08)	329	269
Delhi	4.41 (3.11, 6.22)	2.60 (1.57, 4.28)	1145	932
Goa	3.16 (1.76, 5.59)	1.88 (0.82, 4.25)	378	315
Gujarat	9.28 (8.43, 10.19)	5.37 (4.64, 6.2)	6444	4902
Haryana	8.70 (7.99, 9.47)	5.12 (4.49, 5.84)	6875	5030
Himachal Pradesh	4.74 (3.85, 5.82)	2.83 (2.08, 3.83)	2525	1999
Jammu and Kashmir	5.66 (5.06, 6.33)	3.3 (2.79, 3.91)	7093	5451
Jharkhand	12.41 (11.73, 13.11)	7.75 (7.12, 8.42)	10,507	7846
Karnataka	9.24 (8.38, 10.18)	5.63 (4.87, 6.51)	6308	4773
Kerala	1.82 (1.28, 2.57)	0.98 (0.59, 1.64)	2235	1933
Lakshadweep	1.39 (0.52, 3.64)	0.81 (0.20, 3.20)	281	238
Madhya Pradesh	12.78 (12.27, 13.31)	7.85 (7.36, 8.36)	21,272	15,336
Maharashtra	7.40 (6.64, 8.25)	4.55 (3.87, 5.35)	7990	6094
Manipur	6.02 (5.36, 6.76)	3.34 (2.8, 3.99)	5256	4194
Meghalaya	15.09 (13.93, 16.33)	8.78 (7.72, 9.98)	3823	2691
Mizoram	5.69 (4.76, 6.78)	3.33 (2.54, 4.37)	4309	3280
Nagaland	6.27 (5.49, 7.14)	3.33 (2.68, 4.12)	3825	2619
Odisha	5.88 (5.37, 6.43)	3.32 (2.90, 3.79)	9728	8046
Puducherry	2.82 (1.51, 5.2)	1.73 (0.71, 4.14)	945	770
Punjab	4.70 (3.98, 5.54)	2.67 (2.08, 3.43)	4746	3792
Rajasthan	10.81 (10.27, 11.37)	6.51 (6.02, 7.05)	14,916	10,764
Sikkim	4.10 (2.94, 5.69)	2.12 (1.30, 3.45)	898	812
Tamil Nadu	5.05 (4.50, 5.67)	3.08 (2.59, 3.64)	6836	5344
Telengana	7.67 (6.53, 8.98)	4.88 (3.86, 6.16)	2029	1515
Tripura	2.40 (1.65, 3.49)	1.34 (0.78, 2.28)	1188	1057
Uttar Pradesh	14.94 (14.53, 15.35)	9.31 (8.93, 9.71)	36,465	25,730
Uttarakhand	8.93 (8.07, 9.86)	5.31 (4.55, 6.19)	5007	3734
West Bengal	5.46 (4.80, 6.20)	2.99 (2.47, 3.61)	4810	4099
India	10.51 (10.35, 10.68)	6.29 (6.14, 6.45)	2,25,002	167,969

[a]Excluding children with no information.

Table 3. Predicted reduction in aggregate childhood stunting after removal of clustered sibling burden, NFHS-4 (2015–16)

State	Original (in descending order)	Scenario 1: had exactly two stunted children	Scenario 2: had only one stunted child	Scenario 3: had no stunted children
Bihar	48.38	47.86	39.19	30.53
Uttar Pradesh	46.27	45.81	38.57	31.33
Jharkhand	45.54	45.34	39.24	33.13
Meghalaya	43.94	43.57	36.21	28.84
Madhya Pradesh	41.94	41.65	35.41	29.16
Dadra and Nagar Haveli	41.84	41.84	36.22	30.59
Rajasthan	39.08	38.77	33.52	28.27
Gujarat	38.31	38.07	33.55	29.04
Chhattisgarh	37.60	37.43	32.63	27.82
Karnataka	36.28	36.09	31.56	27.03
Assam	36.25	36.20	33.16	30.11
Maharashtra	34.23	34.14	30.48	26.82
Odisha	34.08	34.03	31.12	28.20
Haryana	34.00	33.76	29.53	25.30
Uttarakhand	33.87	33.57	29.25	24.94
West Bengal	32.72	32.67	29.97	27.26
Delhi	32.11	31.97	29.83	27.70
Andhra Pradesh	31.44	31.29	27.52	23.74
Sikkim	29.42	29.38	27.35	25.32
Arunachal Pradesh	29.3	29.19	26.31	23.43
Chandigarh	29.22	29.22	26.06	22.90
Manipur	28.78	28.59	25.67	22.75
Nagaland	28.51	28.27	25.25	22.24
Mizoram	27.86	27.74	24.96	22.17
Jammu and Kashmir	27.70	27.64	24.84	22.04
Telagana	27.61	27.58	23.76	19.95
Tamil Nadu	27.16	27.03	24.57	22.11
Lakshadweep	26.55	26.55	25.86	25.17
Himachal Pradesh	26.40	26.34	24.00	21.66
Punjab	25.75	25.59	23.32	21.06
Tripura	23.98	23.98	22.78	21.58
Puducherry	23.79	23.79	22.38	20.97
Andaman and Nicobar Islands	23.27	23.27	21.96	20.64
Daman and Diu	23.12	22.93	20.93	18.93
Goa	20.00	20.00	18.42	16.84
Kerala	19.99	19.99	19.08	18.17
India	38.37	38.11	32.98	27.85

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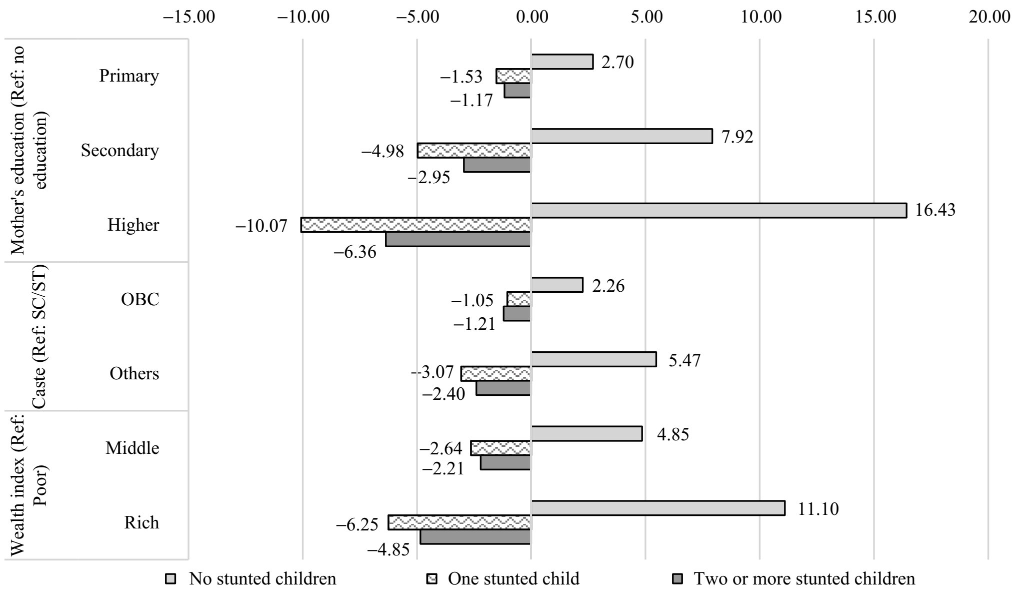

Figure 2. Marginal effect (percentage) of mother's wealth index, caste and education level on number of stunted children born to mothers, NFHS-4 (2015–16).

Scenario 3 captures the ideal situation where if mothers with multiple stunted children had no stunted children. In most of these states, there could be a noticeable decrease in the percentage of stunting if multiple stunted children could be reduced to one stunted child per mother. In states where the burden of childhood stunting was higher, like Bihar and Uttar Pradesh, a more than 7 percentage point decrease could be obtained if mothers with multiple stunted children could be reduced to have only one stunted child. However, in states like Kerala, where the aggregate-level burden was already low, not much difference can be noticed after removal of sibling-level clustering of stunting. The decrease in child stunting percentage for Bihar was as high as 18 percentage points and that for Uttar Pradesh was 15 percentage points if mothers with multiple stunted children could be assisted to have no stunted children by improving the *z*-scores of these children. If Scenario 3 could be achieved, an almost 10 percentage point reduction could be made in the stunting percentage at the national level.

Clustering of childhood stunting

The burden of multiple stunted children was found to be clustered among the lower socioeconomic categories. The probability of having no stunted children was higher for more educated women belonging to the general social class and richer households (Fig. 2). After controlling for the principal co-factors, the results of the multilevel binary response model indicated that the chance of the index child being stunted increased by an odds ratio of 1.93 if the preceding child was stunted (Table 4). The selected states were very diverse in demographic characteristics, geographic attributes, economic transition, policy implementation, community-level participation and social commitment. However, the odds ratio for sibling linkage was above 1 and statistically significant for all selected states. After controlling for district- and PSU-level (village/ward) variation, mother-level heterogeneity was nearly zero. This indicates that, within the PSUs of districts, the behaviour of mothers was homogeneous. Hence, mothers were dropped as a hierarchical level. District level accounted for 0.3–1.5% of the variation for the selected states, whereas PSU level explained 2.1–4.7% of the variation in the model. This emphasized the heterogeneity between

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Table 4. Multilevel analysis of clustered burden of childhood stunting in India and selected states, NFHS-4 (2015–16)

State	OR	States variance (percentage explained)	District variance (percentage explained)	PSU variance[a] (percentage explained)
Bihar	2.23* (0.06)		0.29 (0.01)	2.94 (0.02)
Uttar Pradesh	2.16* (0.05)		0.59 (0.01)	2.35 (0.01)
Madhya Pradesh	1.8* (0.06)		1.18 (0.01)	3.82 (0.02)
Gujarat	1.93* (0.13)		1.18 (0.02)	2.06 (0.03)
Punjab	1.86* (0.17)		0.29 (0.01)	4.71 (0.05)
Odisha	1.86* (0.12)		1.47 (0.02)	2.65 (0.03)
Tamil Nadu	2.39* (0.13)		0.29 (0.01)	4.71 (0.04)
India	1.93* (0.02)	0.88 (0.01)	1.18 (0.01)	3.53 (0.01)

Standard errors in parentheses.
The model controlled for child age, preceding child's sex, birth order, child's size at birth, childhood morbidity, age-appropriate immunization, child satisfying minimum diet diversity, safe disposal of child's stool, mother's age at birth, mother's education, whether mother received full ANC or not, place of residence, caste, religion, wealth index and percentage of households in the PSU with unimproved sanitation.
[a] Village/ward level.
*$p<0.05$.

the PSUs of the districts of the selected states. In India, state level contributed 3.5% to the variation in the model.

Discussion

After missing the Millennium Development Goal (MDG) of reducing child malnourishment by half in 2015, India now aims to eradicate childhood malnourishment by 2030 under the Sustainable Development Goals (SDGs) designed in 2016. For India to take a positive step in that direction, a supply-side strategy highlighting the structural causes of childhood stunting needs to be bolstered rather than extolling economic achievements (Joe *et al.*, 2016; Subramanian *et al.*, 2016). The present study assessed the clustering of multiple stunted children in the same household in India. It first assessed the burden of sibling-level clustering of childhood stunting by randomized simulation. It then further addressed the issue of clustering of childhood stunting within certain lower socioeconomic strata. The study used a multilevel approach to confirm that sibling linkage in childhood stunting is a common phenomenon irrespective of the socioeconomic and demographic profile of the state in India. The importance of the village/ward level in addressing the issue of childhood stunting has been highlighted in the study.

The study showed that aggregate state-level childhood stunting reduced in almost all states in the study decade. However, Bihar and Meghalaya had the highest fertility in 2015–16, and showed very high levels of clustering. Bihar had a total fertility rate of 3.41, whereas Meghalaya's stood at 3.04. Higher fertility is often linked to son preference, poor health-seeking behaviour, low maternal education and low female autonomy (Arnold *et al.*, 1998; Vikram *et al.*, 2012). Moreover, higher fertility also increases the probability of sibling clustering of stunting as the sample to which the event may occur increases. However, this needs empirical evidence. Most of the poorest performing states belong to the EAG, characterized by higher fertility and large socioeconomic and health inequalities (Pande & Yazbeck, 2003). The Government of India has designed many programmes to ameliorate the situation of child undernutrition. Unfortunately, the gap between the existence of a programme and its actual implementation is one of the major hurdles in addressing child undernutrition in India. Although the ICDS is one of the biggest nutrition supplementation programmes in India, its coverage is appallingly low in the states that emerged as the

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poorest performers in this study (Lokshin *et al.*, 2005). The large economic and social inequality between and within the states of India is a major contributor to rising inequalities in child undernutrition (Subramanian *et al.*, 2007). The mixed performance of various public programmes also adds to the disparity in childhood undernutrition scenario (Chalasani, 2012).

The multinomial model suggested that childhood stunting was clustered within uneducated mothers, and those belonging to scheduled caste/tribes and of lower economic status. This may be due to the fact that prolonged poor socioeconomic status and inter-generational transfer of poverty can act as strong proxies for poor maternal and child health. The result of the vicious cycle of poverty and marginalization is a continuum of poor health. A multilevel approach was used in this study to check for the sibling linkage in childhood stunting in states belonging to different ranks in the stunting continuum. Despite controlling for social and economic factors, the empirical findings of the present study uphold a strong 'scarring effect' of childhood stunting. Sibling outcomes are often found to be highly correlated due to shared family background and socioeconomic status (Solon *et al.*, 1991). The present study highlights that this remains undisputed, irrespective of the social and political commitment of the states.

After controlling for the various geographical regions in India, within PSUs (villages/wards) the mothers were found to behave homogenously. The learning hypothesis takes into account that a mother who has a child with stunted growth should be able to prohibit the stunting of later children by using her learnings from her experience. In that case, the scarring effect should have been negative or insignificant. However, the results indicate otherwise. Thus, the learning hypothesis of the mother is rejected. Homogeneity at the mother level is often interpreted as similar impact of genetic traits, maternal ability, maternal behaviour, feeding practices and gender preferential behaviour (Das Gupta, 1990; Sastry, 1997; Arulampalam & Bhalotra, 2008). Equity, efficiency and preference bias, which result in differential treatment of siblings, are also unobserved maternal traits.

The results of the multilevel model provide evidence for the need for state-specific policies keeping villages/wards as an administrative unit of implementation. In a country as diverse as India, 'one size fits all' is a faulty programmatic approach. In a previous study on childhood wasting in India, a community nutrition approach was suggested to assist families with a clustered burden of wasting (Griffiths *et al.*, 2002). Nutrition policies such as ICDS, Mother and Child Tracking, JSY and PMMVY need to be strengthened by linking them to village/ward-level data. Mainstream policies urgently need to integrate *adarsh gram* and 'aspirational district' perspectives to achieve a holistic improvement in childhood stunting at the state level (Subramanian *et al.*, 2018).

States like Tamil Nadu and Odisha have been lauded for their impressive state-customized policies. The Tamil Nadu Integrated Nutrition Programme (TINP) has effectively reduced undernutrition in Tamil Nadu (Heaver, 2002). In Odisha, since the early 2000s there has been a synergy in the various sectors and robust management that has helped execute effective and efficient nutritional policies (Mohmand, 2012). However, Table 4 shows that the odds of a child being stunted if the preceding sibling is stunted are 1.86 and 2.39 in Odisha and Tamil Nadu, respectively. This emphasizes the need to adopt a mother-level lifecycle approach in nutrition policies and programmes in India. In other words, mothers with repeated stunted births should be prioritized in maternal and child nutrition policies and monitored over a substantial period of their lives.

Despite constant efforts by the Government of India, there are several lacunae in the design and strategy adopted in most nutrition policies. An example can be cited from one of the recent policies formulated by the Central Government – the PMMVY. This maternity benefit programme has many good measures that may help address maternal and child health issues in India. In the guidelines of this policy, the government states that poor *in utero* nutrition can result in degraded health throughout the lifespan. This policy also takes into account that mothers with poor health have a higher chance of giving birth to undernourished children. The beneficiaries of this policy

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are pregnant women and lactating mothers not in regular employment with Central or State Government or PSUs, and not enjoying similar benefits from other sources. However, the benefits of this policy cover the first living child only. The beneficiaries can withdraw the entitlement of Rs5000 only once (Ministry of Women and Child Development, 2017). The policy does not account for clustering of stunting. This paper documents that there has been a reduction in childhood stunting in India from 2005–06 to 2015–16. However, it also provides statistical evidence that there exists sibling linkage in stunting status. If the preceding child is stunted, the chances of the index child being stunted increase by the odds of 1.93. This clustered burden of stunting among siblings aged below 5 years is more prominent in certain states. The inclusion of multiple births in any maternal and child health programme, especially in the poorest performing villages and wards, can help in improving the stunting status of children aged 5 years or below.

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Ethical Approval. The study used secondary data publicly accessible from the Demographic Health Survey (DHS) site (https://dhsprogram.com/data/available-datasets.cfm). The Demographic Health Survey follows all standard ethical considerations while collecting data.

References

Arnold F, Choe MK and Roy TK (1998) Son preference, the family-building process and child mortality in India. *Population Studies* **52**(3), 301–315.

Arulampalam W and Bhalotra S (2006) Sibling death clustering in India: state dependence versus unobserved heterogeneity. *Journal of the Royal Statistical Society: Series A (Statistics in Society)* **169**(4), 829–848.

Arulampalam W and Bhalotra S (2008) The linked survival prospects of siblings: evidence for the Indian states. *Population Studies* **62**(2), 171–190.

Barker DJP, Godfrey KM, Gluckman PD, Harding JE, Owens JA and Robinson JS (1993) Fetal nutrition and cardiovascular disease in adult life. *The Lancet* **341**(8850), 938–941.

Barker DJP and Osmond C (1986) Infant mortality, childhood nutrition, and ischaemic heart disease in England and Wales. *The Lancet* **327**(8489), 1077–1081.

Behrman JR, Schott W, Mani S, Crookston BT, Dearden K, Duc LT *et al*. (2017) Intergenerational Transmission of Poverty and Inequality: Parental Resources and Schooling Attainment and Children's Human Capital in Ethiopia, India, Peru, and Vietnam. *Economic Development and Cultural Change* **65**(4), 657–697.

Bhutta ZA, Ahmed T, Black RE, Cousens S, Dewey K, Giugliani E *et al*. (2008) What works? Interventions for maternal and child undernutrition and survival. *The Lancet* **371**(9610), 417–440.

Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M *et al.* (2008) Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet* **371**(9608), 243–260.

Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet* **382**(9890), 427–451.

Caulfield LE, Richard SA, Rivera JA, Musgrove P and Black RE (2006) Stunting, wasting, and micronutrient deficiency disorders. In Jamison DT *et al.* (eds) *Disease Control Priorities in Developing Countries*. Oxford University Press, New York, pp. 551–567.

Chalasani S (2012) Understanding wealth-based inequalities in child health in India: a decomposition approach. *Social Science & Medicine* **75**(12), 2160–2169.

Gupta, MD (1987) Selective discrimination against female children in rural Punjab, India. *Population and Development Review* **13**(1), 77–100.

Das Gupta M (1990) Death clustering, mothers' education and the determinants of child mortality in rural Punjab, India. *Population Studies* **44**(3), 489–505.

Fenske N, Burns J, Hothorn T and Rehfuess EA (2013) Understanding child stunting in India: a comprehensive analysis of socio-economic, nutritional and environmental determinants using additive quantile regression. *PloS One* **8**(11), e78692.

https://doi.org/10.1017/S0021932019000725 Published online by Cambridge University Press

Fledderjohann J, Agrawal S, Vellakkal S, Basu S, Campbell O, Doyle P *et al.* (2014) Do girls have a nutritional disadvantage compared with boys? Statistical models of breastfeeding and food consumption inequalities among Indian siblings. *PloS One* **9**(9), e107172.

Glewwe P and Miguel EA (2007) The impact of child health and nutrition on education in less developed countries. *Handbook of Development Economics* **4**, 3561–3606.

Gragnolati M, Shekar M, Das Gupta M, Bredenkamp C and Lee Y-K (2005) India's undernourished children: a call for reform and action No. *Health, Nutrition and Population (HNP) Discussion Paper*, World Bank Publications, Washington, DC.

Griffiths P, Matthews Z and Hinde A (2002) Gender, family, and the nutritional status of children in three culturally contrasting states of India. *Social Science & Medicine* **55**(5), 775–790.

Guven C and Lee W-S (2015) Height, aging and cognitive abilities across Europe. *Economics & Human Biology* **16**, 16–29.

Heaver R (2002) India's Tamil Nadu Nutrition Program: Lessons and Issues in Management and Capacity Development. *HNP Discussion Paper*, World Bank, Washington, DC.

Hoddinott J, Behrman JR, Maluccio JA, Melgar P, Quisumbing AR, Ramirez-Zea *et al.* (2013) Adult consequences of growth failure in early childhood. *American Journal of Clinical Nutrition* **98**(5), 1170–1178.

Naandi Foundation (2011) *HUNGaMA: Fighting Hunger and Malnutrition*. Naandi Foundation, Hyderabad.

IIPS and ICF (2017) *National Family Health Survey (NFHS-4), 2015–16: India*. Mumbai, India.

Jayachandran S and Pande R (2017) Why are Indian children so short? The role of birth order and son preference. *American Economic Review* **107**(9), 2600–2629.

Joe W, Rajaram R and Subramanian SV (2016) Understanding the null-to-small association between increased macroeconomic growth and reducing child undernutrition in India: role of development expenditures and poverty alleviation. *Maternal & Child Nutrition* **12**(S1), 196–209.

Kanjilal B, Mazumdar PG, Mukherjee M and Rahman MH (2010) Nutritional status of children in India: household socio-economic condition as the contextual determinant. *International Journal for Equity in Health* **9**(1), 19.

Lee S-H and Mason A (2005) Mother's education, learning-by-doing, and child health care in rural India. *Comparative Education Review* **49**(4), 534–551.

Lokshin M, Das Gupta M, Gragnolati M and Ivaschenko O (2005) Improving child nutrition? The integrated child development services in India. *Development and Change* **36**(4), 613–640.

Martorell R and Zongrone A (2012) Intergenerational influences on child growth and undernutrition. *Paediatric and Perinatal Epidemiology* **26**(s1), 302–314.

Ministry of Women and Child Development (2017) *Pradhan Mantri Matru Vandana Yojana (PMMVY) : Scheme Implementation Guidelines*. Ministry of Women and Child Development, New Delhi.

Mohmand SK (2012) *Policies Without Politics: Analysing Nutrition Governance in India*. UKAid, Institute of Development Studies. URL: http://www.ids.ac.uk/idsproject/analysing-nutrition-governance

Mussa R (2015) Intrahousehold and interhousehold child nutrition inequality in Malawi. *South African Journal of Economics* **83**(1), 140–153.

Onis M (2006) Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. *Acta Paediatrica* **95**(S450), 56–65.

Onis M and Branca F (2016) Childhood stunting: a global perspective. *Maternal & Child Nutrition* **12**(S1), 12–26.

Pande RP and Yazbeck AS (2003) What's in a country average? Wealth, gender, and regional inequalities in immunization in India. *Social Science & Medicine* **57**, 2075–2088.

Sastry N (1997) Family-level clustering of childhood mortality risk in Northeast Brazil. *Population Studies* **51**(3), 245–261.

Schott WB, Crookston BT, Lundeen EA, Stein AD and Behrman JR (2013) Periods of child growth up to age 8 years in Ethiopia, India, Peru and Vietnam: key distal household and community factors. *Social Science & Medicine* **97**, 278–287.

Scrimshaw NS and SanGiovanni JP (1997) Synergism of nutrition, infection, and immunity: an overview. *American Journal of Clinical Nutrition* **66**(2), 464S–477S.

Singh A, Arokiasamy P, Pradhan J, Jain K and Patel SK (2016) Sibling- and family-level clustering of underweight children in Northern India. *Journal of Biosocial Science* **49**(3), 348–363.

Smith LC and Haddad LJ (2000) *Explaining Child Malnutrition in Developing Countries: A Cross-Country Analysis*. Research Report 111. International Food Policy Research Institute, Washington, DC.

Solon G, Corcoran M, Gordon R and Laren D (1991) A longitudinal analysis of sibling correlations in economic status. *The Journal of Human Resources* **26**(3), 509–534.

Strauss J and Thomas D (1998) Health, nutrition, and economic development. *Journal of Economic Literature* **36**(2), 766–817.

Subramanian SV, Ackerson LK, Smith GD and John NA (2009) Association of maternal height with child mortality, anthropometric failure, and anemia in India. *JAMA* **301**(16), 1691–1701.

Subramanian SV, Joe W and Venkataramanan R (2018) India lives in her villages, not districts: an exclusive focus on districts in policymaking can be misleading in the presence of large village-level variation. *Live Mint*. URL: https://www.livemint.com/Opinion/fPriQPiSkdJb64UWW6mMZI/India-lives-in-her-villages-not-districts.html (accessed 20th April, 2018).

Subramanian SV, Kawachi I and Smith GD (2007) Income inequality and the double burden of under- and overnutrition in India. *Journal of Epidemiology & Community Health* **61**(9), 802–809.

Subramanian SV, Mejía-Guevara I and Krishna A (2016) Rethinking policy perspectives on childhood stunting: time to formulate a structural and multifactorial strategy. *Maternal & Child Nutrition* **12**(S1), 219–236.

Subramanyam MA, Kawachi I, Berkman LF and Subramanian SV (2011) Is economic growth associated with reduction in child undernutrition in India? *PLoS Medicine* **8**(3), e1000424.

Tanner JM, Healy MJR, Lockhart RD, Mackenzie JD and Whitehouse RH (1956) Aberdeen growth study: I. The prediction of adult body measurements from measurements taken each year from birth to 5 years. *Archives of Disease in Childhood* **31**(159), 372.

UNICEF (1990) *Strategy for Improved Nutrition of Children and Women in Developing Countries*. UNICEF, New York.

UNICEF (2007) *The State of the World's Children 2008: Child Survival*, Volume **8**. UNICEF, New York.

UNICEF (2013) *Improving Child Nutrition: The Achievable Imperative for Global Progress*. UNICEF, New York.

Vikram K, Vanneman R and Desai S (2012) Linkages between maternal education and childhood immunization in India. *Social Science & Medicine* **75**(2), 331–339.

WHO Multicentre Growth Reference Study Group (2006) *WHO Child Growth Standards.* World Health Organization, Geneva.

World Health Organization (2010) *Nutrition Landscape Information System (NLIS) Country Profile Indicators: Interpretation Guide*. WHO Document Production Services, World Health Organization, Geneva.

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