Determinants of stunting and poor linear growth in children under 2 years of age in India: an in-depth analysis of Maharashtra’s comprehensive nutrition survey

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Abstract

We use a representative sample of 2561 children 0–23 months old to identify the factors most significantly associated with child stunting in the state of Maharashtra, India. We find that 22.7% of children were stunted, with one-third (7.4%) of the stunted children severely stunted. Multivariate regression analyses indicate that children born with low birthweight had a 2.5-fold higher odds of being stunted [odds ratio (OR) 2.49; 95% confidence interval (CI) 1.96–3.27]; children 6–23 months old who were not fed a minimum number of times/day had a 63% higher odds of being stunted (OR 1.63; 95% CI 1.24–2.14); and lower consumption of eggs was associated with a two-fold increased odds of stunting in children 6–23 months old (OR 2.07; 95% CI 1.19–3.61); children whose mother’s height was <145 cm, had two-fold higher odds of being stunted (OR 2.04; 95% CI 1.46–2.81); lastly, children of households without access to improved sanitation had 88% higher odds of being severely stunted (OR 1.88; 95% CI 1.17–3.02).

Attained linear growth (height-for-age z-score) was significantly lower in children from households without access to improved sanitation, children of mothers without access to electronic media, without decision making power regarding food or whose height was <145 cm, children born with a low birthweight and children 6–23 months old who were not fed dairy products, fruits and vegetables. In Maharashtra children’s birthweight and feeding practices, women’s nutrition and status and household sanitation and poverty are the most significant predictors of stunting and poor linear growth in children under 2 years.

Keywords: stunting, linear growth, children, Maharashtra, India.

Introduction

Global figures indicate that 25% of children under age 5 years (i.e. 159 million) have stunted growth (United Nations Children’s Fund, UNICEF, World Health Organization, WHO, World Bank Group, WBG 2015). It is estimated that stunting – a height-for-age below minus two z-scores of the median height-for-age in the World Health Organization Child Growth Standards – is the cause of about one million child deaths annually (Black et al. 2013). For the children who survive, stunting causes lasting damage, including poor cognition and educational performance in childhood, reduced productivity and lower earnings in adulthood and, when accompanied by excessive weight gain in later childhood, increased risk of chronic diseases (Victora et al. 2008; Dewey & Begum 2011; Black et al. 2013).

India’s latest National Family Health Survey in 2006 showed that 48% of Indian children 0–59 months old were stunted (International Institute of Population Sciences (IIPS) 2007). Thus, it is estimated that at any one point an average, 61 million Indian children are stunted and therefore unable to survive, grow and develop to their full potential, which is the same potential as that of children in developed countries (Bhandari et al. 2010; World Health Organization (WHO) 2006). Recent reports indicate that the current (2014) prevalence of child stunting in India would be 38.8% (Ministry of Women and Child Development, MWCD, Government of India 2015). This means that between 2006
and 2014, the prevalence of child stunting in India declined at an average 2.4% rate annually, well above the rate of 1.7% estimated on the basis of previous surveys (International Food Policy Research Institute, IFPRI 2014). However, India remains in the category of countries with a high prevalence of stunting (30.0–39.9%) (Onis de et al. 2012).

In Maharashtra – India’s second most populous state with a population over 112 million people (Office of the Registrar General and Census Commissioner of India. Ministry of Home Affairs, Government of India 2011) – the poor nutrition situation of children was confirmed by India’s National Family Health Survey, which indicated that 38.8% of Maharashtra’s children 0–23 months old were stunted and over one-third of the stunted children (14.7%) were severely stunted (IIPS 2007). In response to this situation, the Government of Maharashtra created the State Nutrition Mission under the chairmanship of the State Chief Minister. The Mission was mandated to coordinate inter-sectoral efforts to reduce child undernutrition, initially (2005) in the five districts with the highest levels of child undernutrition and eventually (2009 onwards) across Maharashtra’s 35 districts.

In 2012, the Government of Maharashtra commissioned an independent survey to assess progress and identify priority areas for action. The Comprehensive Nutrition Survey in Maharashtra (CNSM) showed that the prevalence of stunting in children under 2 years had declined from 38.6% in 2006 to 23.3% in 2012 (International Institute for Population Studies, IIPS 2012). Thus, a 15.3% point decline over a 6-year period, with an average annual rate of reduction (AARR) of 2.6, significantly higher than the AARR of ~0.5 reported until 2005 (United Nations Children’s Fund, UNICEF 2013). Findings from a multidisciplinary analysis on the drivers of the decline of stunting in Maharashtra have indicated that the vision and skills of the Nutrition Mission’s leadership and staff allowed much to be accomplished, from maintaining political impetus and focus to motivating frontline workers to deliver better quality services at greater scale (Haddad et al. 2014).

However, despite such significant progress, Maharashtra’s 2012 survey indicated that almost one-fourth (23.3%) of children 0–23 months old were stunted and that one-third of the stunted children (7.8%) were severely stunted. Therefore, the goal of this research is to support the State Nutrition Mission to identify future policy, programme and investment priorities on maternal and child nutrition in Maharashtra through an in-depth understanding of the most important determinants of child stunting and poor linear growth. Specifically, the objective of our analysis is four-fold: (1) to characterize the epidemiology of stunting in children 0–23 months old in Maharashtra; (2) to identify the most significant predictors of stunting in children 0–23 months old; (3) to identify the most significant correlates of linear growth (height-for-age) in children 0–23 months old; and (4) to identify policy, programme and investment priorities in the context of Maharashtra’s Nutrition Mission Phase III post-2015.

**Key messages**

- One in five (22.7%) of children 0–23 months old in the state of Maharashtra were stunted, and one-third (7.4%) of the stunted children were severely stunted.
- Birthweight, child feeding, women’s nutrition and household sanitation were the most significant predictors of stunting and poor linear growth in children under 2 years.
- Children born to mothers whose height was below 145 cm, had two-fold higher odds of being stunted; children born with a low birthweight had a 2.5-fold higher odds of being stunted.
- Low feeding frequency and low consumption of eggs, dairy products, fruits and vegetables were associated with stunting and poor linear growth in children 6–23 months old.
- Children of households without access to improved sanitation had 88% higher odds of being severely stunted.

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Methods

We use data from the CNSM, the independent nutrition household survey conducted in 2012 at the request of the Government of Maharashtra. CNSM was designed and supervised by the International Institute for Population Studies (IIPS), the lead research agency for India’s three national Family Health Surveys—the customized version of the Demographic and Health Survey to suit the data and information needs of India—in 1992, 1999 and 2006.

The representative sample of Maharashtra’s Comprehensive Nutrition Survey was designed to provide estimates of a series of key indicators on the nutrition situation of children under 2 years (0–23 months old) and their mothers in urban areas, rural areas and each of the six administrative divisions of the state: Amravati, Aurangabad, Konkan, Nagpur, Nashik and Pune. The survey used three questionnaires:

- The household questionnaire: used to collect information on all de jure (usual residents) household members, the household and the dwelling. For each person listed, information was collected on age, sex, literacy, caste/tribe and household food security and assets among other variables.
- The mother’s questionnaire: administered to all women who had at least one living child in the age group 0–23 months at the time of the survey. It collected information on mother’s age, marital status, age at marriage, educational attainment, exposure to mass media, decision-making power and access to essential services among other variables.
- The child’s questionnaire: administered to the mother or principal caretaker of children 0–23 months old. It was used to collect information on birth date, birthweight and feeding practices, including breastfeeding and complementary feeding practices in the 24h preceding the survey, to assess internationally agreed Infant and Young Child Feeding (IYCF) indicators (World Health Organization, WHO, United Nations Children’s Fund, UNICEF 2008).

The nutritional status of children and their mothers was assessed by measuring their height and weight following internationally agreed upon anthropometry measurement procedures (World Health Organization, WHO 1995). A detailed description of the survey design and sample selection can be found elsewhere (IIPS 2012). In brief, a 30% prevalence of stunting in children 0–23 months old and a 10% non-response rate for anthropometry were assumed to estimate the size of the sample. The selection of the sample used a multi-stage stratified procedure. The rural sample was selected in two stages. In the first stage, villages were randomly selected with probability proportional to population size as Primary Sampling Units (PSU). In the second stage, households with at least one child 0–23 months old were randomly selected within each of the selected PSUs. In urban areas, a three-stage sampling procedure was used. In the first stage, wards were randomly selected with probability proportional to population size. In the second stage, Census Enumeration Blocks (CEB) were randomly selected with probability proportional to size. Lastly, in the third stage, a household listing was carried out in each of the selected CEB, and households with at least one child 0–23 months old were randomly selected. The survey received ethical clearance from IIPS’ Research Ethics Board. Data collection was carried out during February–April 2012. Caregivers were asked for individual consent to participate in the survey.

A total of 2630 households were included in the survey. For our analysis, data from the child data set, which contains one record for every eligible child born in the 2 years prior to the survey, were used. Children with missing age and/or height were not included in the analytical sample. Stunting and severe stunting were defined as a height-for-age below −2 (moderate and severe stunting) or below −3 (severe stunting) z-scores of the median height-for-age of the World Health Organization Child Growth Standards (World Health Organization, WHO, 2006). Children with implausible height-for-age z-score (HAZ < −6 or HAZ > +6) were excluded from the analysis. In our analysis, we are interested in three outcome variables and the exposure variables that are significantly associated with them: stunting (HAZ < −2) as the indicator of choice both for surveys and global targets on child nutrition; severe stunting (HAZ < −3) to document the severity of child stunting in the population; and attained linear growth, measured as children’s HAZ.
Analyses were performed using Stata statistical software (College Station, TX, USA), release 12, 2011. We used sample weights to adjust standard errors for the complex survey design of CNSM. In models using stunting or severe stunting as the dependent variables, we report on odds ratios and 95% confidence intervals from logistic regression models. In models that regress the outcome variable (attained linear growth in HAZ) on exposure variables, we report on regression coefficients and 95% confidence intervals around point estimates from multiple linear regression. For all tests, \( p \)-values < 0.05 were considered statistically significant.

**Findings**

The survey included a representative sample of 2650 children 0–23 months old. The analysis presented here pertains to 2561 children (96.6%) for whom information on age and anthropometry – and therefore on HAZ, stunting and severe stunting – was available. Children that were stunted were 22.7%, and about one-third (32.7%) of the stunted children were severely stunted (Table 1).

Table 2 summarizes the socio-economic characteristics of the children included in the analysis. **Households:** 91.7% had access to piped water, 57.0% were food secure, 45.0% were located in rural areas, 40% were from Scheduled Castes/Scheduled Tribes and 37.9% used improved sanitation facilities. **Children:** a significantly higher proportion (55.2%) were boys. Most children (91.9%) were weighed at birth, and about one in five (19.4%) of them had a low birthweight (<2500 g). **Mothers:** 17.5% had no/less than primary education, almost one in three (29.9%) was married before reaching age 18 years and over one-third (37%) was not involved in making decisions – jointly or alone – about buying usual food items. Most women (90%) received nutrition counselling at antenatal care during their last pregnancy; however, a significant proportion ate less than normal (30%), and/or did not eat foods of animal origin (40.5%), eggs (48.8%) or milk/dairy products (55.4%). Regarding mothers’ anthropometry, 10.5% of mothers were stunted (height < 145 cm) and 32.2% were too thin (BMI < 18.5 kg/m²).

Table 3 summarizes infant and young child feeding practices. **Breastfeeding** was universal as 99.4% of children were breastfed; however, less than 60% were put to the breast within 1 hour of birth (59.4%) or were exclusively breastfed (59.8%) if they were under 6 months old. Almost all children (91.1%) continued to breastfeed at 1 year, and three in four (74.9%) continued to breastfeed at 2 years. **Complementary feeding** practices in children 6–23 months old were poor. Only 58.6% of children 6–8 months old were fed complementary foods (solid, semi-solid or soft foods) as recommended. Furthermore, while 77.0% of children 6–23 months old were fed complementary foods a minimum number of times per day (meal frequency), only 12.1% were fed iron-rich foods (diet quality), and a mere 6% were fed a minimum number of food groups daily (diet diversity).

**Table 1.** Prevalence of stunting (moderate and/or severe) by age group. In-depth analysis of the 2012 Comprehensive Nutrition Survey in the state of Maharashtra, India.

| Age (months) | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Proportion (%) of stunted children severely stunted | Number of children by age group |
|--------------|-----------------------------------------------|----------------------------------------------------|---------------------------------------------------|--------------------------------|
| 0 to 5       | 9.2                                           | 3.6                                                | 39.0                                              | 635                            |
| 6 to 8       | 13.0                                          | 2.9                                                | 22.4                                              | 386                            |
| 9 to 11      | 14.9                                          | 3.6                                                | 24.1                                              | 315                            |
| 12 to 17     | 30.4                                          | 10.0                                               | 33.0                                              | 684                            |
| 18 to 23     | 40.5                                          | 14.1                                               | 34.8                                              | 541                            |
| 0 to 23      | 22.7                                          | 7.4                                                | 32.7                                              | 2561                           |

HAZ, height-for-age z-score.
The prevalence of stunting was significantly higher in boys (25.4% vs. 19.3% in girls) and children 12–23 months old (34.8% vs. 11.7% in children 0–11 months old). Geographically, the prevalence of stunting was lowest in Pune (18%) and highest in Nashik (31%). Bivariate analysis indicates that the variables that were significantly associated with stunting were as follows: (1) child-level variables: male sex, not weighed at birth, birthweight <2500 g, incomplete vaccination, unsafe disposal of child’s stools, untimely introduction of complementary foods and feeding frequency (Table 4); (2) mother-level variables: age, age at marriage <18 years, low education, no access to print/electronic media, tobacco consumption, age at first birth <18 years, antenatal iron and folic acid (IFA) supplements <90, home delivery, no consumption of milk and/or milk products weekly during pregnancy, height <145 cm and BMI <18.5 kg/m² (Table 5); household-level variables: rural residence, region of residence, caste/tribe, wealth, use of unimproved sanitation, food insecurity and access to Integrated Child Development Services (Table 6).

The exposure variables that were significantly associated with the outcome variables (stunting, severe stunting and HAZ) in bivariate analysis (Tables 4–6) were included in multivariate linear and logistic regression analysis (Tables 7–8).

**Table 2.** Distribution of children 0–23 months old by child, maternal and household characteristics. In-depth analysis of the 2012 Comprehensive Nutrition Survey in the state of Maharashtra, India

| Proportion (%) |
|----------------|
| **Children** |
| Boys | 55.2 |
| Weighed at birth | 91.9 |
| Birthweight <2500 g | 19.4 |
| Child (12–23) has all basic vaccinations | 37.0 |
| **Mothers** |
| Age (years) | |
| <18 | 2.3 |
| 18 to 19 | 9.5 |
| 20 to 24 | 41.7 |
| 24 to 29 | 36.5 |
| ≥30 | 10.1 |
| Mother’s height <145 cm | 10.5 |
| Mother’s BMI <18.5 kg/m² | 32.2 |
| Education | |
| None | 11.6 |
| Primary not completed | 5.9 |
| Primary completed | 20.3 |
| Secondary completed | 41.2 |
| Beyond secondary | 21.1 |
| Mother has access to print media | 24.8 |
| Mother has access to electronic media | 72.4 |
| Mother makes decisions about buying usual food items | 63.0 |
| Mother smokes tobacco or uses smokeless tobacco | 12.4 |
| Mother’s age at marriage <18 years | 29.9 |
| Mother’s age at first birth <18 years | 9.3 |
| Mother’s number of antenatal care visits during the last pregnancy ≥3 | 82.2 |
| Mother received advice on nutrition during the last pregnancy at antenatal visits | 89.9 |
| Mother’s number of antenatal IFA tablets during last pregnancy ≥90 | 56.7 |
| Mother delivered last child in a health facility (public or private) | 86.0 |
| Mother ate less than normal during the last pregnancy | 29.6 |
| Mother ate chicken, meat, fish and/or sea food weekly during the last pregnancy | 59.5 |
| Mother ate milk and/or milk products weekly during the last pregnancy | 44.6 |
| Mother ate eggs weekly during the last pregnancy | 51.2 |
| Mother’s diet meets a minimum diversity (≥4 food groups) | 61.8 |
| **Households** |
| Urban | 55.1 |
| Caste/tribe | |
| Scheduled Caste | 15.3 |
| Scheduled Tribe | 24.8 |
| Other backward class | 24.7 |

(Continues)
Table 3. Breastfeeding and complementary feeding practices in infants and children 0–23 months old*. In-depth analysis of the 2012 Comprehensive Nutrition Survey in the state of Maharashtra, India

| Breastfeeding practices | Proportion (%) |
|-------------------------|---------------|
| Children ever breastfed: proportion (%) of children born in the last 24 months who were ever breastfed | 99.4 |
| Early initiation of breastfeeding: proportion (%) of children 0–23 months who were put to the breast within 1 h of birth | 59.4 |
| Prelacteal feeding: proportion (%) of children 0–23 months old who received prelacteal feeds | 3.7 |
| Exclusive breastfeeding under 6 months: proportion (%) of infants 0–5 months of age who are fed exclusively with breast milk | 59.8 |
| Predominant breastfeeding under 6 months: proportion (%) of infants 0–5 months of age who are predominantly breastfed | 92.2 |
| Continued breastfeeding at 1 year: proportion (%) of children 12–15 months of age who are fed breast milk | 91.1 |
| Continued breastfeeding at 2 years: proportion of children 20–23 months of age who are fed breast milk | 74.9 |

| Complementary feeding practices | Proportion (%) |
|---------------------------------|---------------|
| Introduction of solid, semi-solid or soft foods: proportion (%) of infants 6–8 months of age who receive solid, semi-solid or soft foods | 58.6 |
| Minimum meal frequency: proportion (%) of children 6–23 months who receive solid/semi-solid/soft foods a minimum number of times/day | 77.0 |
| Minimum dietary diversity: proportion of children 6–23 months of age who receive foods from four or more food groups | 6.0 |
| Consumption of iron-rich or iron-fortified foods: proportion of children 6–23 months who are fed iron-rich foods† | 12.1 |

*For full definitions of the indicators for assessing infant and young child feeding practices, refer to the following: World Health Organization (WHO), United Nations Children’s Fund (UNICEF). (2008) Indicators for assessing infant and young child feeding practices. WHO. Geneva, Switzerland. †Or an iron-fortified food that is specially designed for infants and young children, or that is fortified in the home.

Table 4. Prevalence of stunting and mean height-for-age in children 0–23 months old by child characteristics. In-depth analysis of the 2012 Comprehensive Nutrition Survey in the state of Maharashtra, India

| Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|----------------------------------------------|---------------------------------------------------|--------------------------------------------------|
| Sex                                          |                                                   |                                                  |
| Boys                                         | 25.4                                              | 9.4                                              | −1.06                                           |
| Girls                                        | 19.3                                              | 5.0                                              | −0.88                                           |
| P-value                                      | 0.001                                             | 0.000                                            | 0.001                                           |
| Age (months)                                 |                                                   |                                                  |
| 0 to 5                                       | 9.2                                               | 3.6                                              | −0.25                                           |
| 6 to 11                                      | 13.9                                              | 3.2                                              | −0.69                                           |
| 12 to 17                                     | 30.4                                              | 10.0                                             | −1.36                                           |
| 18 to 23                                     | 40.5                                              | 14.1                                             | −1.74                                           |
| P-value                                      | 0.000                                             | 0.000                                            | 0.000                                           |
| Birthweight                                  |                                                   |                                                  |
| Weighed at birth                             | 21.9                                              | 6.7                                              | −0.94                                           |
| Not weighed at birth                         | 30.6                                              | 16.3                                             | −1.36                                           |
| P-value                                      | 0.001                                             | 0.000                                            | 0.000                                           |
| Birthweight ≥2500 g                          | 17.8                                              | 4.9                                              | −0.78                                           |
| Birthweight <2500 g                          | 37.8                                              | 12.6                                             | −1.55                                           |
| P-value                                      | 0.000                                             | 0.000                                            | 0.000                                           |
| Vaccinations                                 |                                                   |                                                  |
| Child (12–23) has all basic vaccinations     | 34.2                                              | 10.6                                             | −1.48                                           |
| Child (12–23) does not have all basic vaccinations | 35.9                                             | 13.8                                             | −1.60                                           |
| P-value                                      | 0.000                                             | 0.000                                            | 0.000                                           |
| Sanitation                                   |                                                   |                                                  |
| Child’s (0–23) stools are disposed safely    | 17.2                                              | 4.7                                              | −0.76                                           |

(Continues)
Multivariate regression analysis — after controlling for potential confounding — indicates that the most significant household-level predictors of stunting were household wealth and access to sanitation. The odds of stunting in children from the four lower wealth quintiles were 70–90% higher than in children from the highest wealth quintile. Children from households without access to improved sanitation facilities had 32% higher odds of being stunted [odds ratio (OR) 1.32; 95% confidence interval (CI) 1.02–1.75] and 88% percent higher odds of being severely stunted (OR 1.88; 95% CI 1.17–3.02) (Table 7).

The most significant mother-level predictors of stunting were maternal height, maternal diet, decision-making power about food, access to electronic media and age at marriage. Children of mothers with a height <145 cm had two-fold higher odds of being stunted (OR 2.04; 95% CI 1.46–2.81) and a 2.6-fold higher odds of being severely stunted (OR 2.62; 95% CI 1.67–4.13). The odds of severe stunting were 60% higher in

| Table 4. (Continued) | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|----------------------|-----------------------------------------------|-------------------------------------------------------|---------------------------------------------|
| Child’s (0–23) stools are not disposed safely | 26.5 | 9.3 | −1.13 |
| P-value | 0.000 | 0.000 | 0.000 |
| Breastfeeding practices | | | |
| Breastfed within 1 h of birth | 24.4 | 7.4 | −1.02 |
| P-value | 0.17 | 0.56 | 0.41 |
| Received prelactal feeds | 20.3 | 7.3 | −0.04 |
| P-value | 0.5 | 0.88 | 0.046 |
| Did not receive prelactal feeds | 9.1 | 4.4 | −0.89 |
| P-value | 0.30 | 0.88 | 0.046 |
| Is exclusively breastfed (0–5 months) | 10.2 | 3.4 | −0.28 |
| P-value | 0.30 | 0.91 | 0.82 |
| Is exclusively breastfed (12–15 months) | 28.8 | 8.5 | −1.32 |
| P-value | 0.55 | 0.11 | 0.24 |
| Is breastfed (20–23 months) | 44.6 | 15.3 | −1.85 |
| P-value | 0.54 | 0.94 | 0.27 |
| Complementary feeding practices | | | |
| Receives complementary foods (6–8 months) | 8.9 | 2.1 | −0.47 |
| P-value | 0.02 | 0.54 | 0.05 |
| Does not receive complementary foods (6–8 months) | 18.8 | 4.0 | −0.73 |
| P-value | 0.02 | 0.399 | 0.000 |
| Is breastfed and receives CFoods (6–23 months) | 28.8 | 10.9 | −1.22 |
| P-value | 0.55 | 0.11 | 0.24 |
| Is not breastfed and/or does not receive CFoods (6–23 months) | 27.8 | 9.3 | −1.28 |
| P-value | 0.06 | 0.71 | 0.03 |
| Receives CFoods a minimum number of times (6–23 months) | 28.7 | 9.1 | −1.32 |
| P-value | 0.02 | 0.399 | 0.000 |
| Does not receive CFoods a minimum number of times/day (6–23 months) | 24.9 | 10.1 | −1.15 |
| P-value | 0.02 | 0.399 | 0.000 |
| Is fed a minimum diversity of diet (6–23 months) | 26.2 | 9.0 | −1.16 |
| P-value | 0.83 | 0.81 | 0.003 |
| Is not fed a minimum diversity of diet (6–23 months) | 28.9 | 9.3 | −1.30 |
| P-value | 0.83 | 0.81 | 0.003 |
| Is fed iron-rich foods (6–23 months) | 26.4 | 5.0 | −1.10 |
| P-value | 0.79 | 0.1 | 0.39 |
| Is not fed iron-rich foods (6–23 months) | 29.2 | 9.9 | −1.32 |
| P-value | 0.79 | 0.1 | 0.39 |
| All combined | 22.7 | 7.4 | −0.98 |

CFoods, complementary foods.
Table 5. Prevalence of stunting and mean height-for-age in children 0–23 months old by mother characteristics. In-depth analysis of the 2012 Comprehensive Nutrition Survey in the state of Maharashtra, India

| Mother’s age (years) | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Mean height-for-age z-score (HAZ) |
|----------------------|-----------------------------------------------|------------------------------------------------------|----------------------------------|
| < 18                 | 24.7                                          | 7.4                                                  | −1.06                            |
| 18 to 19             | 26.7                                          | 12.1                                                 | −1.15                            |
| 20 to 24             | 23.8                                          | 6.8                                                  | −1.02                            |
| 25 to 29             | 19.4                                          | 6.0                                                  | −0.84                            |
| ≥30                  | 22.1                                          | 10.0                                                 | −0.97                            |
| *P*-value            | 0.000                                         | 0.000                                                | 0.000                            |

| Age at marriage (years) | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Mean height-for-age z-score (HAZ) |
|-------------------------|-----------------------------------------------|------------------------------------------------------|----------------------------------|
| <18                     | 27.4                                          | 10.3                                                 | −1.05                            |
| ≥18                     | 20.5                                          | 6.1                                                  | −0.94                            |
| *P*-value               | 0.000                                         | 0.000                                                | 0.013                            |

| Mother’s education      | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Mean height-for-age z-score (HAZ) |
|-------------------------|-----------------------------------------------|------------------------------------------------------|----------------------------------|
| None                    | 31.9                                          | 15.4                                                 | −1.06                            |
| Primary not completed   | 27.7                                          | 12.8                                                 | −1.29                            |
| Primary completed       | 27.2                                          | 9.1                                                  | −1.14                            |
| Secondary completed     | 19.9                                          | 4.8                                                  | −0.92                            |
| Beyond secondary        | 13.8                                          | 4.4                                                  | −0.64                            |
| *P*-value               | 0.000                                         | 0.000                                                | 0.000                            |

| Mother’s access to media| Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Mean height-for-age z-score (HAZ) |
|-------------------------|-----------------------------------------------|------------------------------------------------------|----------------------------------|
| Mother has access to print media | 17.0                                          | 3.3                                                  | −0.81                            |
| Mother does not have access to print media | 24.4                                          | 8.6                                                  | −1.03                            |
| *P*-value               | 0.000                                         | 0.000                                                | 0.001                            |
| Mother has access to electronic media | 19.5                                          | 6.0                                                  | −0.88                            |
| Mother does not have access to electronic media | 30.6                                          | 10.8                                                 | −1.22                            |
| *P*-value               | 0.000                                         | 0.000                                                | 0.000                            |

| Mother’s autonomy       | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Mean height-for-age z-score (HAZ) |
|-------------------------|-----------------------------------------------|------------------------------------------------------|----------------------------------|
| Mother makes decisions about buying usual food items | 23.3                                          | 8.3                                                  | −0.95                            |
| Mother does not make decisions about buying usual food items | 21.4                                          | 5.8                                                  | −1.03                            |
| *P*-value               | 0.63                                          | 0.016                                                | 0.18                             |

| Mother’s tobacco consumption | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Mean height-for-age z-score (HAZ) |
|-----------------------------|-----------------------------------------------|------------------------------------------------------|----------------------------------|
| Mother smokes tobacco or uses smokeless tobacco | 30.6                                          | 11.8                                                 | −1.28                            |
| Mother does not smoke tobacco or use smokeless tobacco | 21.5                                          | 6.7                                                  | −0.93                            |
| *P*-value                   | 0.002                                         | 0.012                                                | 0.000                            |

| Mother’s pregnancy history | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Mean height-for-age z-score (HAZ) |
|-----------------------------|-----------------------------------------------|------------------------------------------------------|----------------------------------|
| Mother’s age at first birth <18 years old | 33.1                                          | 10.7                                                 | −1.16                            |
| Mother’s age at first birth ≥18 years old | 21.5                                          | 7.0                                                  | −0.96                            |
| *P*-value                   | 0.000                                         | 0.047                                                | 0.004                            |
| Number of antenatal care visits during the last pregnancy <3 | 25.1                                          | 10.2                                                 | −1.12                            |
| Number of antenatal care visits during the last pregnancy ≥3 | 21.4                                          | 6.7                                                  | −0.94                            |
| *P*-value                   | 0.11                                          | 0.15                                                 | 0.021                            |
| Mother received advice on nutrition during antenatal care | 21.5                                          | 6.9                                                  | −0.95                            |
| Mother did not receive advice on nutrition during antenatal care | 27.2                                          | 11.4                                                 | −1.18                            |

(Continues)
children of mothers who did not consume milk/dairy products at least once weekly during pregnancy (OR 1.60; 95% CI 1.08–2.32). Similarly, the odds of severe stunting were twice higher in children of mothers without decision-making power about food (OR 1.98; 95% CI 1.31–2.99), while mothers’ lack of access to electronic media increased the odds of stunting in children by 34%. Lastly, children 6–23 months old born to mothers who married before age 18 years had a 70% higher odds of being severely stunted (OR 1.70; 95% CI 1.07–2.70) (Table 7).

The most significant child-level predictors of stunting were birthweight and feeding practices. Children born with a low birthweight had an ~2.5 higher odds of being stunted (OR 2.49; 95% CI 1.96–3.27) or severely stunted (OR 2.37; 95% CI 1.62–3.46). Feeding frequency and diet diversity were significantly associated with stunting in children 6–23 months old. The odds of stunting or severe stunting were >60% higher in children 6–23 months old who were not fed a minimum number of times per day (OR 1.63; 95% CI 1.24–2.14; and OR 1.65; 95% CI 2.01–2.99, respectively); lower

| Table 5. (Continued) | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Mean height-for-age z-score (HAZ) |
|------------------------|---------------------------------------------|-------------------------------------------------|---------------------------------|
| Number of antenatal IFA tablets during the last pregnancy < 90 | 25.1 | 8.4 | −1.04 |
| P-value | 0.07 | 0.006 | 0.019 |
| Number of antenatal IFA tablets during the last pregnancy ≥90 | 20.7 | 6.6 | −0.93 |
| P-value | 0.03 | 0.046 | 0.043 |
| Mother delivered her last child in a health facility (public or private) | 20.9 | 6.5 | −0.91 |
| Mother delivered her last child at home/not in a facility (public or private) | 32.8 | 12.8 | −1.38 |
| P-value | 0.00 | 0.001 | 0.00 |
| Mother’s height | | | |
| Mother’s height < 145 cm | 31.5 | 10.6 | −1.33 |
| P-value | 0.00 | 0.000 | 0.000 |
| Mother’s BMI < 18.5 | 26.7 | 9.1 | −1.17 |
| P-value | 0.00 | 0.004 | 0.000 |
| Mother’s BMI ≥ 18.5 | 20.5 | 6.5 | −0.88 |
| P-value | 0.00 | 0.00 | 0.00 |
| Mother ate chicken, meat, fish and/or seafood weekly | 22.2 | 7.2 | −0.97 |
| P-value | 0.78 | 0.09 | 0.37 |
| Mother did not eat chicken, meat, fish and/or seafood weekly | 23.2 | 7.6 | −0.98 |
| P-value | 0.42 | 0.85 | 0.90 |
| Mother ate milk and/or milk products weekly | 20.6 | 5.6 | −0.87 |
| P-value | 0.02 | 0.001 | 0.001 |
| Mother did not eat milk and/or milk products weekly | 24.0 | 8.7 | −1.06 |
| P-value | 22.4 | 7.1 | −0.97 |
| Mother ate eggs weekly | 22.7 | 7.5 | −0.97 |
| P-value | 0.46 | 0.62 | 0.83 |
| All combined | 22.7 | 7.4 | −0.98 |

HAZ, height-for-age z-score; IFA, iron and folic acid.
Table 6. Prevalence of stunting and mean height-for-age in children 0–23 months old by household characteristics. In-depth analysis of the 2012 Comprehensive Nutrition Survey in the state of Maharashtra, India

| Residence      | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|----------------|-----------------------------------------------|--------------------------------------------------------|---------------------------------------------|
| Urban          | 20.1                                          | 6.8                                                   | −0.9                                        |
| Rural          | 24.7                                          | 7.9                                                   | −1.1                                        |
| *P*-value      | 0.004                                         | 0.2                                                   | 0.1                                         |

| Region         | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|----------------|-----------------------------------------------|--------------------------------------------------------|---------------------------------------------|
| Amaravati      | 23.5                                          | 6.9                                                   | −1.1                                        |
| Aurangabad     | 25.1                                          | 7.9                                                   | −1.0                                        |
| Konkan        | 22.2                                          | 6.9                                                   | −0.9                                        |
| Nagpur         | 14.3                                          | 2.2                                                   | −0.8                                        |
| Nashik         | 31.0                                          | 14.5                                                  | −1.2                                        |
| Pune           | 18.0                                          | 4.4                                                   | −0.8                                        |
| *P*-value      | 0.000                                         | 0.000                                                  | 0.003                                       |

| Caste/tribe    | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|----------------|-----------------------------------------------|--------------------------------------------------------|---------------------------------------------|
| Scheduled Caste| 22.7                                          | 10.3                                                   | −1.1                                        |
| Scheduled Tribe| 27.1                                          | 10.1                                                   | −1.1                                        |
| Other backward class | 19.4                       | 5.8                                                   | −0.9                                        |
| Other          | 21.8                                          | 5.4                                                   | −0.9                                        |
| *P*-value      | 0.007                                         | 0.000                                                  | 0.000                                       |

| Wealth index   | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|----------------|-----------------------------------------------|--------------------------------------------------------|---------------------------------------------|
| Poorest        | 25.7                                          | 9.6                                                   | −1.0                                        |
| Second         | 25.6                                          | 7.7                                                   | −1.1                                        |
| Middle         | 26.1                                          | 9.3                                                   | −1.1                                        |
| Fourth         | 22.9                                          | 7.1                                                   | −0.9                                        |
| Richest        | 12.8                                          | 3.3                                                   | −0.7                                        |
| *P*-value      | 0.000                                         | 0.000                                                  | 0.000                                       |

| Number of household members | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|----------------------------|-----------------------------------------------|--------------------------------------------------------|---------------------------------------------|
| ≤4                         | 22.0                                          | 7.0                                                   | −1.0                                        |
| >4                         | 22.7                                          | 7.4                                                   | −1.0                                        |
| *P*-value                 | 0.7                                           | 0.9                                                   | 0.9                                         |

| Water, hygiene and sanitation | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|-------------------------------|-----------------------------------------------|--------------------------------------------------------|---------------------------------------------|
| Household uses piped water into dwelling/yard/plot | 19.9                                          | 10.4                                                   | −0.9                                        |
| Household uses piped water into dwelling/yard/plot | 22.9                                          | 7.1                                                   | −1.0                                        |
| *P*-value                    | 0.3                                           | 0.3                                                   | 0.1                                         |
| Household uses improved sanitation facilities | 16.1                                          | 3.5                                                   | −0.8                                        |
| Household uses unimproved sanitation facilities | 26.7                                          | 9.8                                                   | −1.1                                        |
| *P*-value                    | 0.000                                         | 0.000                                                  | 0.005                                       |

| Household food security | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|-------------------------|-----------------------------------------------|--------------------------------------------------------|---------------------------------------------|
| Household is food secure | 19.6                                          | 5.0                                                   | −0.9                                        |
| Household is food insecure | 26.9                                         | 10.6                                                  | −1.1                                        |
| *P*-value               | 0.002                                         | 0.000                                                  | 0.2                                         |
| Household is food secure | 19.6                                          | 5.0                                                   | −0.9                                        |
| Household is mildly food insecure | 24.7 | 7.3                                                   | −1.1                                        |
| Household is moderately food insecure | 27.7 | 11.0                                                  | −1.2                                        |
| Household is severely food insecure | 28.8 | 14.3                                                  | −1.1                                        |
| *P*-value               | 0.006                                         | 0.000                                                  | 0.000                                       |

(Continues)
consumption of grains, roots and tubers was associated with a 34% increased odds of stunting (OR 1.34; 95% CI 1.01–1.78), while low consumption of eggs was associated with a two-fold increase in the odds of stunting in children (OR 2.07; 95% CI 1.19–3.61, respectively) (Table 7).

The models regressing the continuous outcome variable HAZ on the exposure variables indicate that the likelihood of poor linear growth in children was significantly higher among children from households without access to improved water or sanitation and children of mothers who did not have access to electronic media, did not have decision-making power regarding food, consumed tobacco and/or whose height was less than <145 cm. Four child-level variables were significantly associated with poor linear growth in children: low birthweight, being a boy, being 12–23 months old and – among children 6–23 months old – not being fed dairy products, fruits and vegetables ($P < 0.05$) (Table 8).

### Discussion

Between 2006 and 2012, the prevalence of stunting in children 0–23 months old in Maharashtra declined from 38.6% (IIPS 2007) to 23.3% (IIPS 2012), with an AARR of 2.5% points. Despite this significant decline, one of the fastest documented (Haddad et al. 2014), one in four children under age 2 years in Maharashtra has stunted growth. We used data from the 2012 Comprehensive Nutrition Survey to characterize the epidemiology of child stunting in Maharashtra, identify the most significant predictors of stunting and poor linear growth in infants and young children 0–23 months old and – on the basis of these findings – identify advocacy, policy, programme and research priorities post-2015.

We find that 22.7% of the children were stunted and one-third of the stunted children (7.4%) were severely stunted. The mean HAZ deteriorated significantly with children’s age – from −0.25 in infants 0–5 months old to −1.74 in children 18–23 months old – reflecting the chronic/cumulative nature of nutrition deprivation in infancy and early childhood. Similarly, the prevalence of stunting was four-fold higher among children 18–23 months old than among children 0–5 months old (40.5% vs. 9.2%, respectively). Studies in nine countries in Africa, Asia and the Caribbean have reported similar findings, indicating that poor linear growth and stunting set very early in children’s life (Jones et al. 2014).

We find significant gender differentials in linear growth and stunting. Poor linear growth was significantly higher among boys than among girls (mean HAZ in boys −1.06 vs. −0.88 in girls; $P = 0.001$) and so was the prevalence of stunting (25.4% in boys vs. 19.3% in girls; $P = 0.001$). Multivariate regression analysis indicates that the odds of stunting were 38% higher in boys than in girls. Studies in Bangladesh, Bhutan, Ghana and Indonesia among others have also documented a 10% to 30% higher prevalence of stunting in boys than in girls (Hong 2007; Semba et al. 2008; Aguayo et al. 2015).

Poor linear growth and stunting were significantly less prevalent among children living in urban areas (20.1% vs. 24.7% in rural areas; $P < 0.005$) and children from the richest wealth quintile (12.8% vs. ≥22.9% in

### Table 6. (Continued)

| Household access to ICDS | Proportion (%) of children stunted (HAZ < −2) | Proportion (%) of children severely stunted (HAZ < −3) | Children’s mean height-for-age z-score (HAZ) |
|--------------------------|---------------------------------------------|------------------------------------------------------|-----------------------------------------------|
| Household has access to ICDS services | 25.1 | 8.7 | −1.1 |
| Household does not have access to ICDS services | 18.4 | 5.2 | −0.8 |
| P-value | 0.006 | 0.000 | 0.000 |
| All combined | 22.7 | 7.4 | −0.98 |

HAZ, height-for-age z-score; ICDS, Integrated Child Development Services.

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Table 7. Adjusted odds ratios of stunting and severe stunting in children 0–23 months old by child, maternal and household characteristics. In-depth analysis of the 2012 Comprehensive Nutrition Survey in the state of Maharashtra, India

| Age group | 0–23 months old | 0–5 months old | 6–23 months old | 6–23 months old |
|-----------|-----------------|----------------|-----------------|----------------|
|           | Age (12–23 months vs. 0–11 months) | Sex (boys vs. girls) | Birthweight (<2500 g vs. >2500 g) | Child (12–23 months) is fully immunized (no vs. yes) |
| Stunting  | AOR (95% CI)    | AOR (95% CI)    | AOR (95% CI)    | AOR (95% CI)    |
| Sev. stunting | AOR (95% CI)    | AOR (95% CI)    | AOR (95% CI)    | AOR (95% CI)    |
| Age (12–23 months vs. 0–11 months) | 4.64*** 3.556–6.084 | 1.37*** 1.749* 1.106–1.737 | 2.49*** 2.367*** 1.956–3.266 | 1.157 0.894 |
| Sex (boys vs. girls) | 5.803*** 3.645–9.240 | 2.080** 2.810–4.200 | 6.813*** 5.441–8.582 | 3.818–13.79 5.252–15.63 |
| Birthweight (<2500 g vs. >2500 g) | 0.901–1.498 0.600–1.332 | 0.972 0.97 | 0.97 2.713 | 0.97 2.713 |
| Child (12–23 months) is fully immunized (no vs. yes) | 1.01 0.987 | 1.043 0.972 | 0.696 0.491 | 0.822 1.713 |
| Child faeces are safely disposed of (no vs. yes) | 0.781–1.328 0.641–1.518 | 0.452–2.046 0.477–15.44 | 0.209–2.384 0.348–6.924 | 0.523–1.388 0.415–1.827 |
| Mother’s age (<18 years vs. ≥18 years) | 1.074 1.536* | 0.613 2.824 | 1.264 1.700** | 1.264 1.700** |
| Mother’s age at marriage (<18 years vs. ≥18 years) | 0.789–1.449 0.987–2.390 | 0.221–1.693 0.418–19.10 | 0.921–1.735 1.071–2.697 | 0.921–1.735 1.071–2.697 |
| Mother’s age at birth of the index child (<18 years vs. >18 years) | 1.175 0.694 | 2.831 0.362 | 1.107 0.711 | 1.107 0.711 |
| Mother’s education (≥secondary education vs. <secondary education) | 1.193 1.227 | 0.785 0.908** | 1.235 1.356 | 1.235 1.356 |
| Mother’s access to print media (no vs. yes) | 0.923–1.572 0.788–1.910 | 0.339–1.894 0.114–0.721 | 0.936–1.628 0.854–2.153 | 0.936–1.628 0.854–2.153 |
| Mother’s access to electronic media (no vs. yes) | 0.969 1.02 | 0.765 1.153 | 1.021 1.012 | 1.021 1.012 |

(Continues)
Table 7. (Continued)  

| Age group | 0–23 months old | 0–5 months old | 6–23 months old | 6–23 months old |
|-----------|-----------------|----------------|-----------------|-----------------|
|           | Stunting        | Sev. stunting  | Stunting        | Sev. stunting   | Stunting        | Sev. stunting  | Stunting        | Sev. stunting   |
|           | AOR             | (95% CI)       | AOR             | (95% CI)        | AOR             | (95% CI)       | AOR             | (95% CI)        |
| Mother makes decisions on buying food items (no vs. yes) | | | | | | |
| Mother received advice on nutrition at antenatal care (no vs. yes) | | | | | | |
| Mother consumes tobacco (no vs. yes) | | | | | | |
| Mother consumed IFA during last pregnancy (<90 tablets vs. >90 tablets) | | | | | | |
| Mother delivered in a health facility (no vs. yes) | | | | | | |
| Mother’s height (<145 cm vs. >145 cm) | | | | | | |
| Mother’s BMI (<18.5 kg/m² vs. >18.5 kg/m²) | | | | | | |
| Mother ate milk and/or milk products weekly during pregnancy (no vs. yes) | | | | | | |
| Household residence (rural vs. urban) | | | | | | |

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Table 7. (Continued)

| Age group | 0–23 months old | 0–5 months old | 6–23 months old | 6–23 months old |
|-----------|-----------------|----------------|-----------------|-----------------|
|           | Stunting        | Sev. stunting  | AOR             | (95% CI)        |
|           | AOR             | AOR            | AOR             | AOR             |
|           | 0.603–1.208     | 0.373–1.123    | 0.603–1.208     | 0.373–1.123     |
| Household belongs to a Scheduled Tribe (yes vs no) | 1.046          | 1.032          | 1.284*          | 1.332           |
| Household wealth index (poorest vs. richest) | 1.689*         | 1.558          | 1.689*          | 1.558           |
| Household wealth index (poorer vs. richest) | 0.957–2.847    | 0.651–3.725    | 0.957–2.847     | 0.651–3.725     |
| Household wealth index (middle vs. richest) | 1.019–2.659    | 0.662–3.025    | 1.019–2.659     | 0.662–3.025     |
| Household wealth index (rich vs. richest) | 1.891***       | 1.424          | 1.891***        | 1.424           |
| Household has access to improved sanitation (no vs. yes) | 1.182–2.481    | 0.520–1.832    | 1.182–2.481     | 0.520–1.832     |
| Household is food secure (no vs. yes) | 0.891–1.754    | 0.662–1.608    | 0.891–1.754     | 0.662–1.608     |
| Household benefits from ICDS programme (no vs. yes) | 0.696–1.130    | 0.387–1.933    | 0.696–1.130     | 0.387–1.933     |
| Child is exclusively breastfed (no vs. yes) | 1.016–1.754    | 0.662–1.608    | 1.016–1.754     | 0.662–1.608     |
| Child's diet meets a minimum dietary diversity (no vs. yes) | 0.599–1.099    | 0.422–1.106    | 0.599–1.099     | 0.422–1.106     |

(Continues)
| Age group         | Stunting | Sev. stunting | Stunting | Sev. stunting | Stunting | Sev. stunting | Stunting | Sev. stunting |
|-------------------|----------|---------------|----------|---------------|----------|---------------|----------|---------------|
| 0–23 months old   | AOR      | AOR           | 0.529–1.547 | 0.354–2.436 | 1.477**  | 1.819**       | 0.529–1.547 | 0.354–2.436   |
| 0–5 months old    | AOR      | AOR           | 1.627**  | 1.651**       | 1.087–2.006 | 1.108–2.987 | 1.627**  | 1.651**       |
| 6–23 months old   | AOR      | AOR           | 0.902    | 0.692*        | 0.704–1.156 | 0.466–1.027 | 0.902    | 0.692*        |
| Child’s diet meets a minimum meal frequency (no vs. yes) | —        | —             | 1.236–2.140 | 1.061–2.569 | 0.704–1.156 | 0.466–1.027 | 1.236–2.140 | 1.061–2.569   |
| Child was fed dairy products (milk, yoghurt, cheese) (no vs. yes) | —        | —             | —         | —             | —         | —             | 0.704–1.156 | 0.466–1.027   |
| Child was fed grains, roots and tubers (no vs. yes) | —        | —             | —         | —             | —         | —             | —         | —             |
| Child was fed vitamin A-rich fruits and vegetables (no vs. yes) | —        | —             | —         | —             | —         | —             | —         | —             |
| Child was fed other fruits and vegetables (no vs. yes) | —        | —             | —         | —             | —         | —             | —         | —             |
| Child was fed eggs (no vs. yes) | —        | —             | —         | —             | —         | —             | 0.75     | 0.862        |
| Child was fed flesh foods (meat, fish, poultry, liver/organ meats) (no vs. yes) | —        | —             | —         | —             | —         | —             | 0.75     | 0.862        |
| Child was fed legumes and/or nuts (no vs. yes) | —        | —             | —         | —             | —         | —             | 0.75     | 0.862        |
| Number of observations | 2263    | 2263          | 569      | 569           | 1685     | 1685          | 2263    | 2263          |

AOR, adjusted odds ratios; CI, confidence interval; IFA, iron and folic acid; ICDS, Integrated Child Development Services. ***P < 0.01, **P < 0.05, *P < 0.1.
Table 8. Associations between exposure variables and linear growth measured as HAZ. In-depth analysis of the 2012 Comprehensive Nutrition Survey in the state of Maharashtra, India

| Variable                                                                 | HAZ (0–23 months old) Coefficient | HAZ (6–23 months old) Coefficient |
|--------------------------------------------------------------------------|-----------------------------------|----------------------------------|
| Age (12–23 months vs. 0–11 months)                                      | −1.064***                         | −0.0891                          |
| Sex (boys vs. girls)                                                    | −0.154***                         | −0.0653                          |
| Birthweight (<2500 vs. ≥ 2500)                                          | −0.624***                         | −0.370***                        |
| Child (12–23 months old) is fully immunized (no vs. yes)                | −0.00738                          | −0.127**                         |
| Safe disposal of child’s faeces (no vs. yes)                            | −0.00377                          | −0.0305                          |
| Mother’s age at marriage (<18 years vs. ≥18 years)                      | 0.101                             | 0.139                            |
| Mother’s age at child’s birth (<18 years vs. ≥18 years)                 | −0.0455 to 0.247                  | −0.199 to 0.0717                |
| Mother’s education (<secondary education vs. ≥ secondary education)      | −0.0729                           | −0.151**                         |
| Mother’s access to print media (non vs. yes)                            | 0.0308                            | 0.139                            |
| Mother’s access to electronic media (non vs. yes)                       | 0.0465 to 0.219                   | 0.208 to 0.0380                  |
| Mother’s decision-making about buying new food items (no vs. yes)        | −0.118**                          | −0.114**                         |
| Mother received advice on nutrition during antenatal care (no vs. yes)   | −0.0677                           | −0.106                           |
| Mother consumes tobacco (yes vs. no)                                    | −0.222**                          | −0.0133                          |
| Mother consumed IFA during the last pregnancy (<90 tablets vs. >90 tablets) | −0.102*                           | 0.00711                          |
| Mother delivered in a health facility (no vs. yes)                      | −0.14                             | −0.137                           |
| Mother’s height (<145 cm vs. >145 cm)                                   | −0.514***                         | −0.337 to 0.0636                |
| Mother’s BMI (<18.5 kg/m² vs. >18.5 kg/m²)                              | −0.0969                           | −0.298***                        |
| Mother consumed milk and/or milk products weekly during pregnancy (no vs. yes) | −0.0661                           | −0.0782                          |
| Household residence (rural vs. urban)                                   | 0.127                             | −0.0122                          |
| Household belongs to a Scheduled Tribe (yes vs. no)                     | −0.00784                          | −0.00768                         |
| Household wealth index (poorest vs. richest)                            | −0.0494                           | 0.0391                           |
| Household wealth index (poorer vs. richest)                             | −0.0792                           | 0.00931                          |
| Household wealth index (middle vs. richest)                             | −0.195*                           | −0.0639                          |
| Household wealth index (rich vs. richest)                               | −0.0421                           | 0.0156                           |
| Household has access to improved water (no vs. yes)                     | −0.217**                          | −0.0239                          |
| Household has access to improved sanitation (no vs. yes)                | −0.168***                         | −0.029                           |
| Household belongs to a Scheduled Tribe (yes vs. no)                     | −0.150 to 0.134                   | −0.139 to 0.124                 |
| Household wealth index (poorest vs. richest)                            | −0.0494                           | 0.0391                           |
| Household wealth index (poorer vs. richest)                             | −0.0792                           | 0.00931                          |
| Household wealth index (middle vs. richest)                             | −0.195*                           | −0.0639                          |
| Household wealth index (rich vs. richest)                               | −0.0421                           | 0.0156                           |
| Household has access to improved water (no vs. yes)                     | −0.217**                          | −0.0239                          |
| Household has access to improved sanitation (no vs. yes)                | −0.168***                         | −0.029                           |

(Continues)
However, multivariate adjusted models, after controlling for potential confounding, indicate that the odds of being stunted were not significantly different between children living in rural or urban areas. On the contrary, the stunting differential associated with household wealth remained statistically significant in multivariate regression models as the odds of being stunted were ~70% lower in children from the richest wealth quintile compared with children from the other wealth quintiles ($P < 0.01$). Studies in Asia and Africa have shown that – like in Maharashtra – children from the poorer households had significantly higher odds of stunted growth, even after adjustment for other household, maternal and child variables (Hong et al. 2006; Hong 2007; Aguayo et al. 2015).

Our analysis indicates that in Maharashtra, the most consistent predictors of stunting and poor linear growth in children under 2 years were birthweight and child feeding (child-level variables), women’s nutrition and status (mother-level variables) and household sanitation and poverty (household-level variables).

Children born with low birthweight had a 2.5-fold higher odds of being stunted and a 2.4-fold higher odds of being severely stunted. Low maternal height predicted stunting in children under 2 years even after controlling for birthweight, as children of mothers with a height $<145$ cm had two-fold higher odds of being stunted than children of mothers with a height $\geq 145$ cm. In addition, children born to women who married before the age of 18 years had significantly higher odds of being severely stunted.

Studies have shown that maternal height is an important determinant of intrauterine growth restriction and low birthweight, particularly in developing countries. In turn, intrauterine growth restriction and

Table 8. (Continued)

|                                | HAZ (0–23 months old) | HAZ (6–23 months old) |
|--------------------------------|-----------------------|------------------------|
|                                | Coefficient          | Coefficient            |
|--------------------------------|-----------------------|------------------------|
| Household is food secure (no vs. yes) | (-0.296 to -0.0405)  | (-0.147 to 0.0890)    |
|                                | -0.0833               | 0.0696                 |
| Household benefits from ICDS programme (no vs. yes) | (-0.201 to 0.0345)  | (-0.0394 to 0.179)    |
|                                | 0.239***              | 0.0432                 |
|                                | (0.0944 to 0.383)     | (-0.0904 to 0.177)    |
| Child (0–23 months) is appropriately breastfed (no vs. yes) | -0.111                | 0.134*                 |
|                                | (-0.282 to 0.0600)    | (-0.0243 to 0.292)    |
| Child’s diet meets a minimum meal frequency (no vs. yes) | -0.163                | (-0.532 to 0.207)     |
|                                | -0.000219             | (-0.161 to 0.160)     |
| Child was fed dairy products (milk, yoghourt and cheese) (no vs. yes) | 0.151**               | (0.0185 to 0.283)     |
|                                | (0.0944 to 0.359)     | (-0.161 to 0.129)     |
| Child was fed grains, roots and tubers (no vs. yes) | 0.12                  | (0.0438 to 0.220)     |
| Child was fed vitamin A-rich fruits and vegetables (no vs. yes) | 0.254**               | (0.077 to 0.461)      |
|                                | (0.0477 to 0.446)     | (-0.075 to 0.484)     |
| Child was fed other fruits and vegetables (no vs. yes) | -0.109                | 0.199                  |
| Child was fed eggs (no vs. yes) | (-0.438 to 0.220)     | (-0.0471 to 0.446)    |
| Child was fed flesh foods (meat, fish, poultry and liver/organ meats) (no vs. yes) | 0.104                 | (0.022 to 0.484)      |
| Child was fed legumes and/or nuts (no vs. yes) | 0.199                 | (-0.0471 to 0.446)    |
| Number of observations         | 2263                  | 1685                   |

HAS, height-for-age z-score; BMI, body mass index; IFA, iron and folic acid. ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. © 2016 The Authors. Maternal & Child Nutrition published by John Wiley & Sons Ltd Maternal & Child Nutrition (2016), 12 (Suppl. 1), pp. 121–140
low birthweight are predictors of growth failure and stunting in early childhood. Analysis of data from 54 low-income and middle-income countries has shown that maternal height was inversely associated with stunting in infancy and childhood (Özaltin et al. 2010). It is estimated that intrauterine growth restriction (estimated by rates of low birthweight) accounts for 20% of the global burden of child stunting (Black et al. 2013). Similarly, adolescent pregnancy has been shown to be associated with low weight at birth and stunting in early childhood in the offspring. Longitudinal data from five countries show that younger maternal age (≤19 years) was associated with a significantly higher risk of low birthweight (OR 1.18; 95% CI 1.02–1.36) and 2-year stunting (OR 1.46; 95% CI 1.25–1.70) in the offspring, compared with mothers aged 20–24 years (Fall et al. 2015).

In our analysis, mothers’ access to improved diets – as marked by the consumption of milk and dairy products during pregnancy – was associated with significantly lower odds of severe stunting in children under 2 years. Similarly, low feeding frequency and low consumption of eggs, dairy products, fruits and vegetables in children 6–23 months old were associated with poor linear growth and stunting. Studies have indicated that complementary feeding indicators are positively associated with HAZ and a reduced risk of stunting. For example, diet diversity in children 6–23 months old was positively associated with HAZ in Bangladesh and India and with lower odds of stunting in India (Zongrone et al. 2012; Menon et al. 2015). A recent study including pooled data from 14 low-income countries found that all of the WHO indicators on complementary feeding (except the indicator defining minimum meal frequency) were associated with a significantly lower probability of stunting in children (Marriott et al. 2012). Global evidence suggests that greater dietary diversity and the consumption of foods from animal sources are associated with improved linear growth (Ruel & Menon 2002; Arimond & Ruel 2004; Steyn et al. 2006; Onyango et al. 2013).

In our analysis, household access to improved sanitation was associated with healthier linear growth in children. Conversely, children of households without access to improved sanitation had 88% higher odds of being severely stunted. Recent analyses in rural India have indicated that improved sanitation is significantly associated with reduced prevalence of stunting (Rah et al. 2015). Globally, it is recommended that community-based interventions to improve water, sanitation and hygiene, and to protect children from diarrhoeal diseases and malaria, intestinal worms and environmental causes of subclinical infection be an integral part of a comprehensive framework for action to improve children’s linear growth and reduce stunting (World Health Organization, WHO 2015).

**Conclusion**

Despite significant progress in reducing child undernutrition over the last years, a significant proportion of infants and young children in Maharashtra fail to achieve their growth and development potential as indicated by the high levels of stunting and severe stunting in children 0–23 months old. Our analysis of the epidemiology – prevalence, severity, distribution and drivers – of child stunting in Maharashtra provides political leaders, policy makers and programme managers with important insights for the effective allocation of human and financial resources to improve children’s linear growth and reduce further the prevalence of stunting in Maharashtra and, potentially, the rest of India.

Specifically, our analysis indicates that in its Phase III post-2015, the State Nutrition Mission in Maharashtra needs to prioritize policies, programmes and investments to achieve results in three key areas: (1) improve women’s nutrition and reduce low birthweight; (2) improve complementary foods and feeding practices for children 6–23 months old; and (3) improve access to and use of sanitation facilities while mitigating household poverty through effective social safety nets coupled with effective communication and counselling.

Evidence indicates that – given the contribution of Maharashtra and the rest of India to the global burden of child stunting – aggressive and sustained policy and programme investments in these three results areas will contribute significantly to the achievement of the global target to reduce the number of stunted under 5 years of age by 40% by 2025 (World Health Organization, WHO 2015). Recent analyses indicate that the scale-up of high-impact interventions focused on the 1000-day
window – from conception to age 2 years – can be delivered at an additional cost of $US8.50 per child per year to meet the global target for the reduction of child stunting (World Bank Group 2015).

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Conflicts of interest
The authors declare that they have no conflicts of interest.

Contributions
VMA designed the study, led data analysis, data interpretation and manuscript writing. NB led data management. RN and VK contributed to data interpretation and manuscript writing. All authors have read and approved the final manuscript. The opinions expressed on this paper are those of the authors and do not necessarily represent an official position by UNICEF of the Government of Maharashtra.

References
Aguayo V.M., Badgaiyan N. & Paintal K. (2015) Determinants of child stunting in the Royal Kingdom of Bhutan: an in-depth analysis of nationally representative data. Maternal and Child Nutrition 11 (3), 333–45.

Arimond M. & Ruel M.T. (2004) Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. Journal of Nutrition 134, 2579–85.

Bhandari N., Bahl R., Taneka S., de Onis M. & Bhan M.K. (2010) Growth performance of affluent Indian children is similar to that in developed countries. Bulletin of the World Health Organization 88, 189–95.

Black R.E., Victora C.G., Walker S.P., Bhutta Z.A., Christian P., de Onis M. & et al. (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 382, 427–451.

Dewey K.G. & Begum K. (2011) Long-term consequences of stunting in early life. Maternal and Child Nutrition 7, 5–18.

Fall C.H., Sachdev H.S., Osmond C., Restrepo-Mendez M.C., Victora C., Martorell R. et al. (2015) Association between maternal age at childbirth and child and adult outcomes in the offspring: a prospective study in 5 low-income and middle-income countries. Lancet Global Health 3 (7), e366–77.

Haddad L., Nisbett N., Barnett I. & Valli E. (2014) Maharashtra’s Child Stunting Declines: What is Driving Them? Findings From a Multidisciplinary Analysis. Institute of Development Studies (IDS): Brighton, United Kingdom.

Hong R. (2007) Effect of economic inequality on chronic childhood undernutrition in Ghana. Public Health Nutrition 10 (4), 371–378.

Hong R., Banta J.E. & Betancourt J.A. (2006) Relationship between household wealth inequality and chronic childhood undernutrition in Bangladesh. International Journal of Equity in Health 5, 15.

International Food Policy Research Institute (IFPRI) (2014) Global Nutrition Report 2014. In: Actions and Accountability to Accelerate the World’s Progress on Nutrition. IFPRI: Washington, DC.

International Institute of Population Sciences (IIPS) (2007) National Report: National Family Health Survey (NFHS-3) 2005–06. IIPS: Mumbai, India.

International Institute for Population Studies (IIPS) (2012) Comprehensive Nutrition Survey in Maharashtra. IIPS: Mumbai, India.

Jones A.D., Ickes S.B., Smith L.E., Mbuya M.N.N., Chasekwa B., Heidkamp R.A. et al. (2014) World Health Organization infant and young child feeding indicators and their associations with growth measures in 14 low-income countries. Maternal and Child Nutrition 10 (1), 1–17.

Marriott B.P., White A., Hadden L., Davies J.C. & Wallingford J.C. (2012) World Health Organization infant and young child feeding indicators: associations with growth and development: a synthesis of recent findings. Maternal and Child Nutrition 10 (1), 1–17.

Menon P., Bamezai A., Subandoro A., Ayoya M.A. & Aguayo V.M. (2015) Age-appropriate infant and young child feeding practices are associated with child nutrition in India: insights from nationally representative data. Maternal and Child Nutrition 8 (3), 354–370.

Ministry of Women and Child Development (MWCD), Government of India (2015) Rapid survey on child nutrition 2013–14. http://www.nnda.nic.in. Accessed on August 15, 2015.

Office of the Registrar General and Census Commissioner of India. Ministry of Home Affairs, Government of India (2011) Population census of India 2011. http://www.
Onyango A.W., Borghi E., de Onis M., Casanovas M.D. & Garza C. (2013) Complementary feeding and attained linear growth among 6–23-month-old children. *Public Health Nutrition* **19**, 1–9.

Onis de M., Blössner M. & Borghi B. (2012) Prevalence and trends of stunting among pre-school children, 1990–2020. *Public Health Nutrition* **15**, 142–148.

Özaltin E., Hill K. & Subramanian S.V. (2010) Association of maternal stature with offspring mortality, underweight, and stunting in low- to middle-income countries. *Journal of the American Medical Association (JAMA)* **303** (15), 1507–16.

Rah J.H., Cronin A.A., Badgaiyan B., Aguayo V.M., Coates S. & Ahmed S. (2015) Household sanitation and personal hygiene practices are associated with child stunting in rural India: a cross-sectional analysis of surveys. *British Medical Journal Open* **5**: e005180.

Ruel M.T. & Menon P. (2002) Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the demographic and health surveys. *Journal of Nutrition* **132**, 1180–7.

Semba R.D., Pec S., Sun K., Sari M., Akhter N. & Bloem M.W. (2008) Effect of parental formal education on risk of child stunting in Indonesia and Bangladesh: a cross-sectional study. *The Lancet* **371**, 322–328.

Steyn N.P., Nel J.H., Nantel G., Kennedy G. & Labadarios D. (2006) Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? *Public Health Nutrition* **9**, 644–50.

United Nations Children’s Fund (UNICEF) (2013) *Improving Child Nutrition: The Achievable Imperative for Global Progress*. UNICEF: New York, USA.

United Nations Children’s Fund (UNICEF), World Health Organization (WHO), World Bank Group (WBG) (2015) *Levels and Trends in Child Malnutrition. Joint Child Malnutrition Estimates. Key Findings of the 2015 Edition*. UNICEF, WHO, WBG: New York, USA.

Victora C.G., Adair L., Fall C., Hallal P.C., Martorell R., Richter L. *et al.* (2008) Maternal and child undernutrition: consequences for adult health and human capital. *The Lancet* **371**, 340–357.

World Health Organization (WHO) (1995) Physical status: the use and interpretation of anthropometric data. *Technical Report Series, 854*. WHO: Geneva, Switzerland.

World Health Organization (WHO) (2006) Multicentre Growth Reference Study Group. Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. *Acta Paediatrica* **95** (Suppl. 450), 56–65.

World Health Organization (WHO) (2006) Multi-Center Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. *Acta Paediatrica* **95** (Suppl. 450), 76–85.

World Health Organization (WHO), United Nations Children’s Fund (UNICEF) (2008) *Indicators for Assessing Infant and Young Child Feeding Practices*. WHO: Geneva, Switzerland.

World Health Organization (WHO) (2015) *World Health Assembly Global Nutrition Targets 2025. Stunting Policy Brief*. WHO: Geneva, Switzerland.

World Bank Group, Results for Development, Children’s Investment Fund Foundation and Bill and Melinda Gates Foundation. Reaching the global target to reduce stunting: how much will it cost and how can we pay for it? [http://pubdocs.worldbank.org/pubdocs/publicdoc/2015/8/460861439997767818/Stunting-Costing-and-Financing-Overview-Brief.pdf](http://pubdocs.worldbank.org/pubdocs/publicdoc/2015/8/460861439997767818/Stunting-Costing-and-Financing-Overview-Brief.pdf). Accessed on October 26, 2015.

Zongrone A., Winskell K. & Menon P. (2012) Infant and young child feeding practices and child undernutrition in Bangladesh: insights from nationally representative data. *Public Health Nutrition* **15**, 1697–1704.