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The persistent high burden of child and maternal malnutrition in most states of India: the Global Burden of Disease Study 2016

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Summary

Background: Malnutrition has been a major contributor to disease burden in India, but a systematic understanding of the distribution and time trends of its components is not available for each state of India to track progress among its 1.3 billion heterogeneous population.

Methods: Using all available data, we analysed the disease burden attributable to child and maternal malnutrition, and trends of the indicators for the WHO global nutrition 2025 targets and the Sustainable Development Goals 2030 malnutrition targets, in the 29 states and 7 union territories of India (referred to as states in this analysis) from 1990 to 2016 as part of the Global Burden of Disease Study. We projected the trends so far to assess the probability of every state achieving the global targets by 2025 and 2030.

Findings: Malnutrition was the predominant risk factor for health loss in children under-five years in every state of India in 2016, accounting for 65.2% (95% uncertainty interval 62.7 to 68) of the disability-adjusted life years (DALYs). This DALY rate varied 5-fold between the states of India. Malnutrition was also the largest risk for health loss across all ages in India in 2016, responsible for 14.6% (95% UI, 13.7 to 15.5) of the total DALYs. There were substantial variations between the states in the change from 1990 to 2016 in the malnutrition indicators included in the global targets: low birth weight (-6.2% to 42.6%), childhood wasting (-60.3% to 69.3%), childhood stunting (-56.4% to -5.7%), exclusive breastfeeding for first 6 months (-8.6% to 19.1%), anaemia in reproductive age women (-3.7% to 2.8%), and childhood overweight (-14.8% to 459.1%). In 2016, the prevalence of stunting and anaemia was highest in the less developed states, and that of overweight was highest in the more developed states. If the current trends continue, there is zero probability of achieving the global 2025 targets for low birth weight and anaemia in all states of India, for wasting in most of the states, and for stunting in two-thirds of the states. There is zero probability of achieving the SDG 2030 targets for wasting, stunting, and childhood overweight in all states.

Interpretation: There is a persistent and huge burden of health loss due to malnutrition across most states of India, and the likelihood of achieving the global 2025 and 2030 malnutrition reduction

targets is very low in most states if current trends persist. Policy in India must address malnutrition as the highest national priority if the level of human and economic development that India aspires to has to be achieved, taking into account the specific trends over time in each state.

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Research in context

Evidence before this study

Existing evidence on the magnitude of malnutrition points to a relatively high and persistent burden in India, especially among infants, children, and women of reproductive age. Given its heterogeneous population of 1.3 billion residing in states undergoing varying levels of health transition, a thorough understanding of trends in the burden of key malnutrition indicators in every state of India is central to establishing a strong evidence base to inform state-specific policies and interventions that will effectively address this public health challenge.

Added value of this study

This report provides a systematic and comprehensive account of the burden of child and maternal malnutrition in every state of India over the past quarter century, and makes projections to determine the likelihood of achieving the WHO global nutrition 2025 targets and the Sustainable Development Goals 2030 malnutrition targets by each state of the country. This undertaking used all accessible data and the standardised Global Burden of Disease Study methodology to compute estimates of prevalence and health loss from malnutrition, benefitting considerably from the inputs of expert collaborators of the India State-Level Disease Burden Initiative. While the burden of malnutrition declined in India since 1990, it has persisted as the predominant risk factor for health loss in children under five years in every state even in 2016, and is also the leading risk factor for health loss across the population in the majority of states. The findings highlight that national trends in the prevalence of malnutrition indicators from 1990 to 2016 mask considerable heterogeneity among individual states, especially for wasting, stunting, and childhood overweight. This report projects the trends and finds that if current trends of the malnutrition indicators continue, most states of India are unlikely to achieve the WHO global nutrition 2025 targets and none is likely to achieve the Sustainable Development Goals 2030 malnutrition reduction targets.

Implications of all available evidence

Malnutrition remains a major public health challenge across states of India, though there is substantial heterogeneity between the states for the various malnutrition indicators and their trends over time. The recent resurgence in policy interest in India to reduce malnutrition across the country can benefit from the state-level trends in this report, which highlight the states that need most attention for achieving the targets for each specific malnutrition indicator. The progress in achieving the desired malnutrition reduction has to be monitored closely in all states of India, and attempts must be made to understand trends at the district level as well using robust methods.

Introduction

Malnutrition is a major contributor to disease burden in low and middle-income countries.[1–5] Globally, over half of the deaths in children under five years can be attributed to undernutrition.[1–3,5] Overweight among children is also increasing globally, including in Africa and Asia.[3,6,7] Addressing the challenge of malnutrition in children and women of reproductive age is essential to ensure optimal cognitive growth and development, and overall health and productivity.

The World Health Assembly's endorsement of a comprehensive implementation plan on maternal, infant, and young child nutrition in 2012 sought to accelerate global action through a set of six nutrition targets to address the dual burden of undernutrition and overnutrition by 2025, which include low birth weight, wasting, stunting, exclusive breastfeeding in the first 6 months of life, anaemia in women of reproductive age, and childhood overweight.[8–14] The United Nations Sustainable Development Goals (SDG) have also set targets for wasting, stunting, and childhood overweight aimed at ending malnutrition by 2030.[15] Decades of policy and programmatic efforts have been made to tackle the continuing challenge of malnutrition. India released the National Nutrition Strategy in 2017 that outlined measures to address malnutrition in India across the life cycle,[16] and the Prime Minister of India launched the National Nutrition Mission in early 2018 to bring focus and momentum to this effort.[17,18]

The India State-Level Disease Burden Initiative recently reported a quite varied epidemiological transition among the states of India from 1990 to 2016 as part of the Global Burden of Disease (GBD) Study.[19,20] Given this heterogeneity in health transition, the trajectory of the malnutrition indicators needs to be understood for each state of India to inform state-specific policy action commensurate with their particular situation. In this paper, we report findings on child and maternal undernutrition indicators and childhood overweight across the states of India from 1990 to 2016, and projections for each state of India to determine the probability of meeting the WHO global nutrition targets of 2025 and the SDG malnutrition targets of 2030.

Methods

Overview

The India State-Level Disease Burden Initiative has recently reported overall trends of diseases, injuries, and risk factors from 1990 to 2016 for every state of India.[19,20] This analysis was done as part of the GBD 2016 study, which estimated disease burden due to 333 diseases and injuries organised into three broad categories and 84 risk factors organised into four levels. A detailed description of metrics and analytical approaches used in GBD 2016 has been reported elsewhere.[1] The initiative benefitted from the efforts of expert collaborators in India who helped identify and access all available data sources, assessed their scope and quality for inclusion in the estimation process, and participated in the analysis and interpretation of the findings. The Health Ministry Screening Committee of the Indian Council of Medical Research and the ethics committee of the Public Health Foundation of India approved the work of this initiative. In this paper, we report findings on child and maternal undernutrition indicators and childhood overweight across the states of India from 1990 to 2016, and projections for each state to assess the probabilities of achieving WHO global nutrition targets and SDG malnutrition targets by 2025 and 2030, respectively.

Estimation of malnutrition exposure

The GBD comparative risk assessment framework was used to estimate malnutrition exposure and attributable disease burden, as described in detail elsewhere.[1] The components of child and maternal malnutrition in GBD include low birth weight and short gestation, child growth failure (stunting, wasting, and underweight), suboptimal breastfeeding, and micronutrient deficiencies. All available data sources from India that could be accessed were utilized, which included national household surveys and a variety of dietary and nutrition surveys (Appendix Table 1). The modelling approaches integrated multiple data inputs and borrowed information across age, time, and location to produce the best possible estimates of risk exposure by location, age, sex, and year. The theoretical minimum-risk level (TMREL) for each malnutrition component was established as the level of risk exposure above which there is health loss in the exposed population. Summary exposure

values, a metric summarising the risk-weighted exposure for a population, were computed for each risk; these values ranged from 0% to 100%, with 0% indicating no risk exposure and 100% indicating that the entire population was exposed to the maximum risk. Covariates, which are explanatory variables with a known association to GBD causes, were used to inform the estimation process, especially when location-wise data were scarce.

For the purpose of reporting prevalence of the six malnutrition indicators, we defined low birth weight as less than 2,500 grams, stunting as height-for-age below two standard deviations of the median in the WHO 2006 standard curve, and wasting as weight-for-height below two standard deviations of the median in the WHO 2006 standard curve. We defined exclusive breastfeeding during the first 6 months of life as no other feeding during this period, and anaemia in reproductive age women 15-49 years as haemoglobin less than 120 g/L in non-pregnant women and less than 110 g/L in pregnant women. We defined childhood overweight as body-mass index above the month wise cut-offs for ages 2-4 years as reported in the International Obesity Task Force tables.[1,21]

Estimation of attributable disease burden

The estimation of attributable disease burden included ascertainment of relative risk of disease outcomes for risk exposure-disease outcome pairs with sufficient evidence of a causal relationship as assessed using the World Cancer Research Fund grading system, and has been described elsewhere.[1] Population attributable fractions were estimated from risk exposure, relative risks of outcomes due to exposures, and TMREL. These were used to produce estimates of deaths and disability-adjusted life-years (DALYs) attributable to each malnutrition risk factor by age, sex, year, and location. The major data inputs included vital registration, large population-level surveys, verbal autopsy studies, surveillance data, and hospital- and community-based studies (Appendix Table 1).

Analysis presented in this paper

Findings are reported for 31 geographical units in India: 29 states, Union Territory of Delhi, and the union territories other than Delhi (combining the six smaller union territories of Andaman and Nicobar Islands, Chandigarh, Dadra and Nagar Haveli, Daman and Diu, Lakshadweep, and

Puducherry). The states of Chhattisgarh, Uttarakhand, and Jharkhand were created from existing larger states in 2000, and the state of Telangana was created in 2014. For trends from 1990 onward, the data for these four new states were disaggregated from their parent states on the basis of data from the districts that now constitute these states.[19] Findings are also presented for four groups of states based on epidemiological transition level (ETL) as described previously.[19] Briefly, ETL state groups were defined on the basis of the ratio of DALYs from communicable, maternal, neonatal and nutritional diseases to those from non-communicable diseases and injuries combined in 2016, with a relatively lower ratio indicating higher ETL: low ETL (ratio 0.56-0.75), lower-middle ETL (0.41-0.55), higher-middle ETL (0.31-0.40), and high ETL (less than 0.31). We have previously reported that epidemiological transition ratios of the states of India have a significant inverse relationship with the Socio-Demographic Index computed by GBD based on income, education and fertility levels, which indicates broad correspondence of the ETL groups with sociodemographic development levels.[19]

We present trends in the prevalence of malnutrition indicators among under-five children and women of reproductive age in the states of India from 1990 to 2016. We report DALYs attributable to malnutrition among under-five children and across all ages in each state of India in 2016, and the diseases attributable to malnutrition and its major components in under-five children. The estimates are reported with 95% uncertainty intervals based on 1000 draws where relevant. We also project the prevalence of the six malnutrition indicators included in the global targets up to 2030 to determine the probability of achieving these targets in every state of India. The projections are made using GBD methodology described elsewhere.[22] This includes the use of state trends from 1990 to 2016 to calculate the weighted median annualised rate of change for each state, and a weighting function for recent years within this time period:

$$\text{weight}_{year} = (\text{year} - 1990)^{\omega} / \Sigma^{T}_{t = 1991} (t - 1990)^{\omega}$$

The WHO global nutrition targets for 2025 are: 30% reduction in low birth weight from 2012; childhood wasting less than 5%; 40% reduction in childhood stunting from 2012; 50% or more exclusive breastfeeding; 50% reduction of anaemia in reproductive age women from 2012; and no

increase in childhood overweight from 2012.[8–14] The SDG malnutrition targets are elimination of childhood wasting, stunting, and overweight by 2030,[15] which we defined as prevalence ≤0.5%. We produce 95% uncertainty intervals around each projected estimate, which are used to determine the area under the curve and the probability of each state meeting the corresponding global nutrition target.

Role of the funding source

Some staff of the Indian Council of Medical Research are co-authors on this paper as they contributed to various aspects of the study and this analysis. The other funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of this paper. The corresponding author had full access to all of the data in the study, and had final responsibility for the decision to submit for publication.

Results

Child and maternal malnutrition was the single largest risk factor contributing to health loss in under-five year old children in India in 2016, as well as in each state of the country. It was responsible for 65.2% of the total DALYs in India in 2016 (Table 1). This proportion was relatively lower in the high ETL state group, and ranged from 50.3% in Kerala to 69.0% in Rajasthan. In 1990, malnutrition contributed to 70.8% (95% UI 67.3 to 74.8) of the total DALYs in under-five children in India. The DALY rate due to malnutrition in under-five children was highest in the low ETL state group, and had a 5.2-fold variation between the states in 2016. Child and maternal malnutrition was also the single largest risk factor for health loss across all ages together in India in 2016, responsible for 14.6% of the total DALYs, even after an age-standardized decline of 62.1% (95% UI 58.2 to 65.5) from 1990. Malnutrition was the leading risk factor across all ages together in the majority of states comprising 72% of India's population in 2016 (Table 1). Even in the six states in which malnutrition was not the leading risk factor, it contributed between 7.3% and 10.4% of the DALYs in five of those states; only in Kerala its contribution was relatively lower at 4.4% of the DALYs. The all-age DALY rate of malnutrition varied 6.6-fold between the states in 2016, with the highest rates in Bihar, Rajasthan, Uttar Pradesh and Assam belonging to the low ETL group.

Among the DALYs attributable to child and malnutrition in under-five children, the highest proportions were from low birth weight and short gestation (41.3%) and child growth failure (20.6%), followed by suboptimal breastfeeding (2.9%) and iron deficiency (2.7%) (Appendix Table 2). It is important to note that the cumulative impact of the risk factors is less than the simple addition of their individual contribution as the risk factors overlap. The proportional contribution of low birth weight and short gestation was higher among boys (44.1%; 95% UI 42.4 to 45.9) as compared with girls (38.3%; 95% UI 36.7 to 40.1). Among the diseases attributable to malnutrition in under-five children, the highest proportion of DALYs was from neonatal disorders (55.3%), followed by lower respiratory infections (21.4%), diarrhoeal diseases (10.4%), and protein-energy malnutrition (6%) (Figure 1). The highest proportion of DALYs attributable to low birth weight and short gestation were

from neonatal disorders (87.4%), with a small proportion due to lower respiratory infections (10.2%). The DALYs attributable to child growth failure were mainly from lower respiratory infections (45.9%), diarrhoeal diseases (28.1%), and protein-energy malnutrition (19.1%). The DALYs attributable to suboptimal breastfeeding were from diarrhoeal diseases (52.8%) and lower respiratory infections (47.2%).

Of the total DALYs in under-five children in India in 2016, 19.1% could be attributed to low birth weight. Its prevalence remained unchanged in India from 1990 to 2016 (19.6%; 95% UI 18.4 to 20.8) (Appendix Table 3). Its prevalence did not change significantly in the ETL state groups from 1990 to 2016 (Figure 3), but there were major variations across the states ranging from a decline of 6.2% to an increase of 42.6%. Its prevalence in 2016 was relatively lower in the high ETL state group. There was a 1.8-fold difference between the states (range: 14.1% to 25.9%) in 2016, with the highest prevalence in Maharashtra and Madhya Pradesh (Figure 2). If these current trends of low birth weight continue, there is zero probability of achieving the WHO global nutrition target of 30% reduction from 2012 to 2025 in all states of India (Figure 4).

Child wasting accounted for 18.9% of the total DALYs in under-five children in India in 2016. Its prevalence in India declined by 26.5% (95% UI -29.8% to -22.9%) from 21.6% in 1990 to 15.9% in 2016 (Appendix Table 4). There was a decline in all ETL state groups from 1990 to 2016, which was lower in the high than in the low ETL group (Figure 3). There were marked variations across states, ranging from a decline of 60.3% to an increase of 69.3%. There was a 3.5-fold difference in the prevalence between the states in 2016 (range: 5.5% to 19.5%), with the highest in Maharashtra, Gujarat, and Tamil Nadu (Figure 2). If these current trends of wasting continue, the overwhelming majority of Indian states that are home to 99% of India's population have zero probability of achieving the WHO global target of wasting prevalence less than 5% by 2025 (Figure 4). There is zero probability of achieving the SDG goal target of elimination by 2030 in all states of India.

Of the total DALYs in under-five children in India in 2016, 4.0% could be attributed to child stunting. Its prevalence in India declined by 22.2% (95% UI -26.1% to -18.1%) from 54.1% in 1990 to

42.1% in 2016 (Appendix Table 5). Prevalence declined in all ETL state groups from 1990 to 2016, which was highest in the high ETL group and lowest in the low ETL group (Figure 3). Major variations among the states were observed, ranging from -5.7% to -56.4%. In 2016, the prevalence of stunting was highest in the low ETL state group (49.4%; 95% UI 46.8 to 52) and lowest in the high ETL state group (24.6%; 95% UI 22.5 to 26.7). There was a 2.9-fold difference in prevalence between the states in 2016 (range: 19.2 to 55.3%), with the highest in Bihar and Uttar Pradesh (Figure 2). If these trends of stunting continue, 21 Indian states that have 67% of India's population and are distributed across a mix of ETL groups have zero probability of achieving the WHO global target of at least 40% reduction from 2012 to 2025; nine states, most of which belong to the higher ETL groups, have a probability of less than 10%; and only the state of Kerala in the high ETL group has a 100% probability (Figure 4). There is zero probability of achieving the SDG goal target of elimination by 2030 all states of India.

Non-exclusive breastfeeding in the first 6 months of life was responsible for 2.8% of the total DALYs in under-five children in India in 2016. The prevalence of exclusive breastfeeding in India in 2016 was 39.2% (95% UI 22.3% to 58.3%). This prevalence was not significantly different from 1990 to 2016 for India or any ETL state group (Figure 3 and Appendix Table 6). Variations in the percent change from 1990 to 2016 were observed across the states, ranging from -8.6% to +19.1%. There was a 1.4-fold difference in prevalence between the states in 2016 (range: 32.2 to 46.4%), with the lowest in Sikkim, Goa, Delhi, Gujarat, Meghalaya, and Telangana (Figure 2). If these trends of exclusive breastfeeding continue, the majority of Indian states with 75% of the population have a probability of less than 30% of achieving the WHO global target of at least 50% prevalence by 2025 (Figure 4).

Of the total DALYs in women aged 15-49 years in India in 2016, 7.6% could be attributed to iron deficiency. Prevalence of anaemia in reproductive age women in India in 2016 was 56.2% (95% UI 54.9 to 57.5). This prevalence had not changed significantly from 1990 for India or any ETL state group (Figure 3 and Appendix Table 7). Minor variations in percent change from 1990 to 2016 were

observed across the states (range: -3.7 to 2.8%), but the prevalence did not change significantly. In 2016, there was a 2-fold difference in prevalence between the states (range: 33.9% to 67%), with the highest in Assam, Bihar, and Jharkhand (Figure 2). If the current trends of anaemia continue, there is zero probability of achieving the WHO global target of at least 50% reduction from 2012 to 2025 in all states of India (Figure 4).

The prevalence of overweight in children aged 2-4 years in India in 2016 was 11.8% (95% UI 7.1 to 17.9%), which was not significantly different than in 1990. There was an increasing trend in the prevalence in all ETL state groups during this period, with the increase statistically significantly in the high and higher-middle ETL state groups (Figure 3 and Appendix Table 8). There was an increasing prevalence gradient in 2016 from the low to the high ETL group. Major variations among the states were observed, ranging from a decline of 14.8% to an increase of 459.1%. In 2016, the prevalence was higher in the high and higher-middle ETL state groups spread in different parts of India than in the low ETL group. There was a 5.3-fold difference in prevalence between the states in 2016 (range: 5.4 to 28.4%) (Figure 2). If these trends of childhood overweight continue, 19 Indian states that have 54% of India's population and primarily from the higher ETL groups have a probability of less than 10% of achieving the WHO global target of no increase from 2012 to 2025, and most of the rest have a probability of less than 20% (Figure 4). There is zero probability of achieving the SDG goal target of elimination by 2030 in all states of India.

Discussion

In the early part of the 20th century, India suffered major food shortages and widespread chronic undernutrition coupled with low agricultural yield and a poor food distribution system, which was transformed by the Green Revolution starting in the late 1960's that resulted in increasing self-sufficiency in food production and a shift towards establishing food security.[23–25] However, even with the progress in food production, India has continued to suffer from persistent undernutrition, which now is coupled with evidence of overnutrition in a subset of the population.[25–30] This report provides a systematic compilation of the trends of the major indicators of malnutrition in all states of India since 1990 than can help understand the specific challenges that need to be addressed in each state.

Though the burden of child and maternal malnutrition has declined in India since 1990, it remains the predominant risk factor for health loss in under-five children in every state of the country, and the leading risk factor for health loss across all ages in the majority of the states. Regarding the recommended indicators for tracking malnutrition, the prevalence of low birth weight in India was 20% in 2016, which had not changed significantly since 1990. The prevalence of childhood wasting decreased in India by 26% and that of childhood stunting by 22% from 1990 to 2016, and their prevalence in 2016 was 16% and 42%, respectively. The prevalence of exclusive breastfeeding in the first 6 months of life and anaemia in reproductive age women in India in 2016 was 39% and 56%, respectively, which had not changed significantly since 1990. The prevalence of childhood overweight increased in India by 55% from 1990 to 2016, with a prevalence 12% in 2016.

Behind these national estimates are substantial subnational variations. The variations between the states were high for childhood wasting, stunting and overweight, but relatively modest for low birth weight, exclusive breastfeeding, and anaemia in reproductive age women. The prevalence of both wasting and stunting in 2016 varied about 3-fold between the states. The prevalence of stunting, an indicator of chronic undernutrition, was unsurprisingly highest in the less developed states. On the hand, the prevalence of wasting, indicative of acute undernutrition, was highest in some of the more developed states because these states have been able to prevent a

larger proportion of children from tipping over into chronic undernutrition and these states have also had the largest declines in stunting. Interestingly, there has been previous reference to the relatively higher rates of underweight in South Asian countries compared to Sub-Saharan African countries despite comparable or higher income levels.[30,31] The GBD findings confirm this discrepancy, with South Asia, including India, continuing to have higher summary exposure values for underweight, wasting, and stunting as compared with Sub-Saharan Africa.[32]

If the current prevalence trends of the malnutrition indicators continue, most states of India are projected not to achieve the WHO 2025 global nutrition targets, and no state is projected to achieve the SDG 2030 malnutrition elimination targets. In addition to improving the rate of reduction of stunting and wasting, clear policy emphasis is also needed to address the stagnation in the trends of low birth weight, exclusive breastfeeding, and anaemia in reproductive age women across most of India. In addition, the increasing trend of childhood overweight in most states of India has to be addressed as well.

The Government of India has launched numerous initiatives in past decades to emphasize nutrition as part of the national development agenda. The National Nutrition Policy in 1993 aimed to address nutritional challenges that were amenable to change through direct interventions targeted at vulnerable groups, as well as multi-sectoral policy tools such as food security, land reforms, and nutrition monitoring and surveillance.[33] The previous National Nutrition Mission included a multi-sectoral nutrition programme to create awareness on malnutrition in pregnant women and lactating mothers, improve maternal and child under-nutrition in high-burden districts, and to reduce anaemia burden.[34] The National Food Security Act passed in 2013 emphasised food and nutritional security throughout the life cycle — components included provision of subsidised grains through the Public Distribution System, provision of meals under the Integrated Child Development Services (ICDS) for children under six years and the Mid-Day Meal Scheme for school children, and maternity benefits with monetary entitlements.[35] The National Iron Plus Initiative launched in 2013 includes a

strategy to address iron deficiency anaemia across the life cycle through iron and folic acid supplementation, including for adolescent girls and women of reproductive age.[36]

More recently, as part of the national development agenda, the National Nutritional Strategy released in 2017 proposed strengthening several maternal and child health initiatives, such as the supplementary nutrition component of ICDS, Maternity Benefit Programme, Mid-Day Meal Scheme, dietary diversification to improve iron and folate intake, supplementation, engaging the private sector in food fortification efforts, and placing emphasis on social determinants of health, such as nutrition and water, sanitation and hygiene.[16] Past and ongoing efforts to address suboptimal breastfeeding include guidelines to meet global recommendations, government regulation on breast milk substitutes, supportive policy environments, provisions for lactation support to new mothers, and effective operational platforms to deliver interventions such as ICDS.[27,37–39] To increase rates of exclusive breastfeeding, much is needed by way of health system interventions that educate and train health facility staff to promote optimal infant and young child feeding practices, community-based counselling interventions, and policy-level interventions such as supportive maternity leave.[12,37] The Government recently approved and launched a revamped National Nutrition Mission 2017-2020, an apex body involving the Ministries of Women and Child Development, Health and Family Welfare, and Water and Sanitation, to create synergy across various existing nutrition-related schemes and Ministries, and monitor and guide progress towards reducing stunting, undernutrition, anaemia, and low birth weight across all states and union territories of India as tracked by specific annual targets.[18] The proposed harmonisation of efforts across various Ministries and partners is a much-needed step towards implementation of effective interventions with sustainable impact on malnutrition indicators, including those that address inter-generational issues such as low birth weight earlier during the pregnancy and pre-pregnancy period to yield positive impacts on foetal growth and weight at birth, and overall growth and development.

The increasing prevalence of overweight in children has immediate consequences on metabolic indicators, as well as longer-term chronic effects that linger into adulthood.[4] Interventions

are needed in this vulnerable age group, especially those aimed at modifiable risk factors in the home, schools, and caregiving environments, such as optimal infant and young child feeding practices, a balanced dietary intake, and increasing physical activity. The Food Safety and Standards Authority of India recently released a draft of the Food Safety and Standards (Safe and Wholesome Food for School Children) Regulations 2018 in an effort to promote a balanced diet and limit the availability of foods high in fat, salt, and sugar in schools.[40] Other countries have adopted a variety of approaches, some of which may be pertinent to the Indian context. For example, Mexico proposed national policy objectives to impact both individual-level behaviours, as well as those requiring linkages with the food and beverage industry to reconcile public health objectives and industry interests.[41] Additionally, Brazil has emphasised the importance of school-based interventions to tackle overweight and obesity in children, especially through availability of fresh and minimally-processed foods for school-based feeding programs, and grants to farmers for the provision of fresh produce for schools.[42]

An integrated nutrition policy is needed, especially with seemingly divergent challenges of undernutrition and overnutrition that vary across the states of India.[43] Addressing the persistent burden of undernutrition through a farm system for nutrition model, which considers nutritional criteria in the selection of components of a sustainable farming system, has been suggested as the key to enhancing agricultural productivity, increasing dietary diversity, improving nutritional outcomes, and promoting nutrition-sensitive agriculture.[44] The evolving concept of food security from an initial emphasis on ensuring adequate food production to one that addresses access and availability concerns at the household level, and promotes physical, economic, social and ecological access to a balanced diet and safe drinking water throughout the life cycle needs to be part of nutritional policies.[23] Impactful change will require practically effective strategies to address the determinants of undernutrition, provisions for clean drinking water, reducing rates of open defecation, improving women's status, coupled with integration of initiatives across government

ministries and sectors, political will and good governance, and strategic investments in a multi-sectoral approach.[4,27,31,45–47]

The general limitations of the GBD methodology have been described elsewhere.[1] Limitations specific to the findings in this report include relatively poor data on low birth weight, as birth weight is not recorded well or remembered by parents in most instances in India, which leads to relatively less reliable data on this indicator obtained in household surveys. In addition, other data in nationwide surveys on child health can potentially also have variable quality, highlighted by some wide variations in the estimates between different surveys conducted relatively close to each other. GBD uses all available sources of data and regression techniques to obtain the best possible trends from those, which to some degree avoids erratic estimates from variable survey quality. GBD defined childhood overweight at age 2-4 years using the International Obesity Task Force standards as more data from various countries are available for these ages, whereas WHO global nutrition target uses the WHO child growth reference data for under five years of age from the United States, leading to some differences. The strengths of the findings in this report include the use of all accessible data sources in India to produce robust estimates related to malnutrition indicators in every state of the country over a quarter century, application of the standardised GBD methodology, and comprehensive inputs by leading experts in India on the analysis and interpretation of the findings. In addition, the projections of trends for every state in India to assess if the global nutrition targets of 2025 and 2030 would be achieved are insightful.

Malnutrition remains a significant threat to India's aspirations to achieve further success in economic and social development. Addressing this persistent major development problem requires India to ensure implementation of practically effective policies and interventions that take into account the subnational variations and the context of each state. The findings in this report provide a reference for monitoring the progress of malnutrition indicators over the coming years. Robust estimation of malnutrition indicators and their trends over time at the district level would also be needed to understand intra-state variations, especially in the many large states of India.

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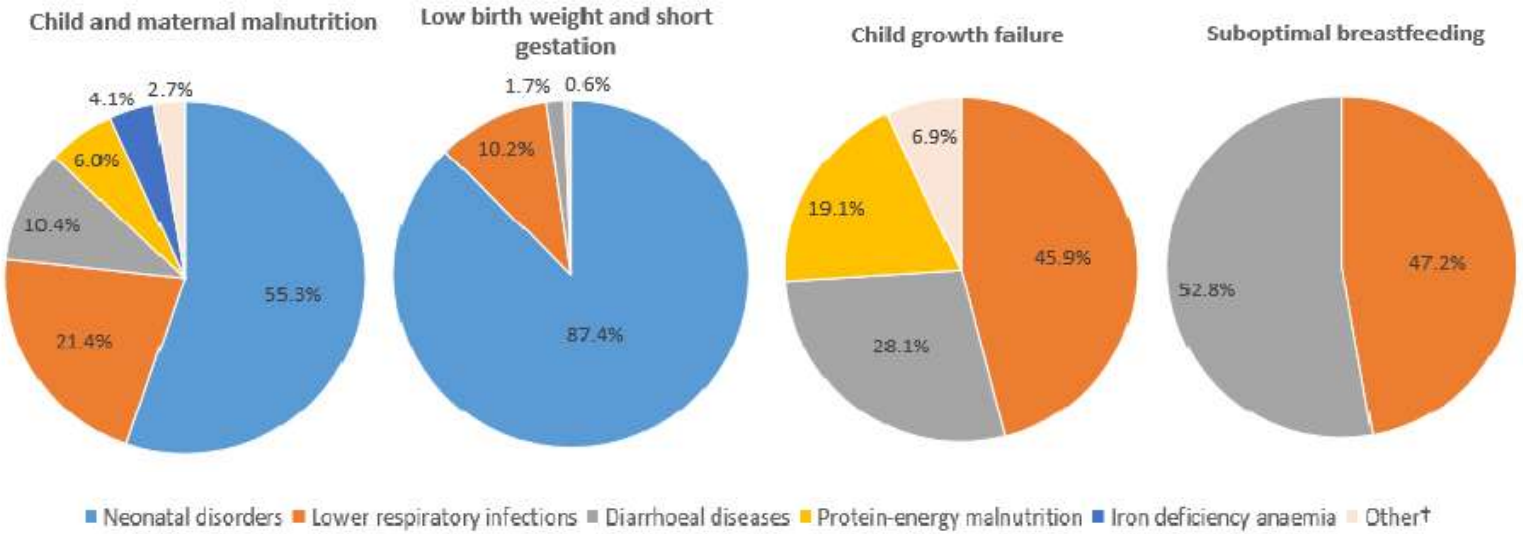
List of tables and figures

Table 1: DALYs attributable to child and maternal malnutrition for India and states grouped by epidemiological transition level, 2016

States of India grouped by ETL (population in 2016)	Under-5 years of age			All-age		
	DALY rate per 100,000 (95% uncertainty interval)	Percent of total DALYs (95% uncertainty interval)	Ranking among all risk factors	DALY rate per 100,000 (95% uncertainty interval)	Percent of total DALYs (95% uncertainty interval)	Ranking among all risk factors
India (1,316 million)	47,762 (44,303 to 51,226)	65.2% (62.7 to 68.0)		5,169 (4,613 to 5,787)	14.6% (13.7 to 15.5)	
Low ETL (626 million)	56,928 (52,054 to 62,156)	65.7% (63.0 to 68.7)		7,001 (6,261 to 7,788)	18.3% (17.1 to 19.6)	
Bihar	57,247 (45,842 to 69,960)	64.1% (60.5 to 68.6)	1	8,045 (6,633 to 9,673)	21.7% (18.8 to 24.8)	1
Jharkhand	53,418 (44,650 to 64,486)	67.5% (64.2 to 70.4)	1	6,005 (5,041 to 7,243)	17.1% (15.0 to 19.6)	1
Uttar Pradesh	58,464 (48,718 to 69,370)	65.3% (61.1 to 69.6)	1	7,195 (6,057 to 8,439)	18.2% (16.0 to 20.5)	1
Rajasthan	59,033 (51,245 to 67,113)	69.0% (65.8 to 72.1)	1	7,331 (6,360 to 8,368)	20.1% (18.0 to 22.3)	1
Meghalaya	40,193 (29,078 to 55,719)	60.2% (56.1 to 64.1)	1	4,720 (3,573 to 6,224)	16.0% (13.0 to 19.5)	1
Assam	64,601 (53,225 to 78,994)	67.4% (63.8 to 70.6)	1	6,928 (5,759 to 8,360)	17.4% (15.2 to 20.0)	1
Chhattisgarh	57,965 (48,050 to 69,544)	68.7% (65.8 to 71.3)	1	6,364 (5,348 to 7,534)	16.4% (14.3 to 18.7)	1
Madhya Pradesh	55,971 (49,329 to 63,415)	66.4% (62.9 to 69.3)	1	6,663 (5,855 to 7,605)	17.7% (15.9 to 19.6)	1
Odisha	42,870 (32,668 to 56,196)	60.8% (56.4 to 65.7)	1	4,960 (3,898 to 6,225)	12.7% (10.5 to 15.2)	1
Lower-middle ETL (92 million)	45,119 (39,305 to 53,853)	64.2% (61.9 to 67.5)		4,798 (4,116 to 5,652)	14.2% (12.8 to 16.1)	
Arunachal Pradesh	34,965 (28,763 to 42,712)	62.2% (58.3 to 65.5)	1	4,139 (3,417 to 5,031)	14.8% (12.7 to 17.3)	1
Mizoram	30,187 (24,732 to 37,119)	52.1% (46.7 to 56.8)	1	3,408 (2,814 to 4,113)	11.5% (9.8 to 13.6)	1
Nagaland	32,635 (19,913 to 50,134)	59.4% (55.1 to 63.6)	1	2,607 (1,737 to 3,808)	10.2% (7.3 to 13.9)	1
Uttarakhand	49,379 (43,533 to 54,903)	62.7% (59.4 to 65.4)	1	4,818 (4,189 to 5,448)	13.5% (12.2 to 15.0)	1
Gujarat	46,046 (38,215 to 57,179)	64.8% (61.9 to 68.5)	1	5,013 (4,181 to 6,057)	14.6% (12.8 to 17.0)	1
Tripura	49,743 (38,021 to 65,366)	66.6% (63.3 to 69.8)	1	5,131 (4,091 to 6,542)	14.8% (12.2 to 18.0)	1
Sikkim	26,961 (20,769 to 34,635)	62.0% (58.7 to 65.4)	1	3,703 (2,896 to 4,607)	14.1% (11.7 to 17.0)	1
Manipur	27,567 (19,256 to 37,839)	59.8% (56.0 to 63.5)	1	2,494 (1,826 to 3,282)	8.3% (6.3 to 10.7)	1
Higher-middle ETL (446 million)	37,320 (33,904 to 41,068)	65.0% (63.0 to 67.4)		3,623 (3,130 to 4,186)	10.9% (10.1 to 11.8)	
Haryana	42,707 (35,419 to 51,162)	65.1% (62.1 to 67.9)	1	4,603 (3,808 to 5,479)	12.7% (11.1 to 14.5)	1
Delhi	39,622 (32,848 to 47,614)	66.1% (63.6 to 68.7)	1	3,473 (2,897 to 4,182)	13.0% (11.2 to 14.9)	1
Telangana	35,591 (29,818 to 42,008)	66.4% (63.1 to 69.5)	1	3,596 (2,985 to 4,264)	11.4% (9.8 to 13.1)	1
Andhra Pradesh	38,881 (32,381 to 47,115)	64.1% (61.2 to 67.0)	1	4,050 (3,381 to 4,841)	11.7% (10.1 to 13.4)	1
Jammu and Kashmir	35,609 (31,157 to 60,901)	62.2% (59.1 to 64.9)	1	3,296 (2,830 to 3,853)	10.9% (9.7 to 12.2)	1
Karnataka	37,666 (29,351 to 47,255)	61.8% (58.4 to 66.1)	1	3,766 (2,982 to 4,614)	10.7% (9.0 to 12.5)	1
West Bengal	37,657 (30,394 to 45,481)	65.0% (62.4 to 67.6)	1	3,445 (2,818 to 4,187)	10.4% (9.0 to 12.0)	4
Maharashtra	35,302 (28,589 to 43,281)	67.5% (65.3 to 69.8)	1	3,382 (2,755 to 4,089)	10.3% (8.8 to 12.0)	3
Union territories other than Delhi	29,662 (18,192 to 48,359)	60.9% (57.4 to 65.0)	1	2,760 (1,957 to 3,982)	10.3% (7.7 to 14.0)	1
High ETL (152 million)	23,316 (19,305 to 27,543)	59.2% (56.2 to 63.6)		2,375 (1,927 to 2,870)	7.5% (6.5 to 8.4)	
Himachal Pradesh	29,873 (23,210 to 37,384)	62.2% (59.1 to 65.3)	1	2,614 (2,095 to 3,237)	9.2% (7.7 to 10.9)	1
Punjab	32,466 (26,245 to 40,237)	61.0% (58.3 to 64.1)	1	3,016 (2,437 to 3,689)	8.9% (7.6 to 10.4)	5
Tamil Nadu	24,291 (17,932 to 31,561)	60.5% (56.3 to 65.2)	1	2,676 (2,056 to 3,364)	8.0% (6.6 to 9.5)	5
Goa	17,280 (9,647 to 30,654)	58.1% (54.0 to 62.5)	1	1,945 (1,263 to 3,036)	7.3% (5.0 to 10.6)	4
Kerala	12,539 (9,719 to 15,673)	50.3% (45.9 to 58.5)	1	1,212 (940 to 1,542)	4.4% (3.7 to 5.2)	9

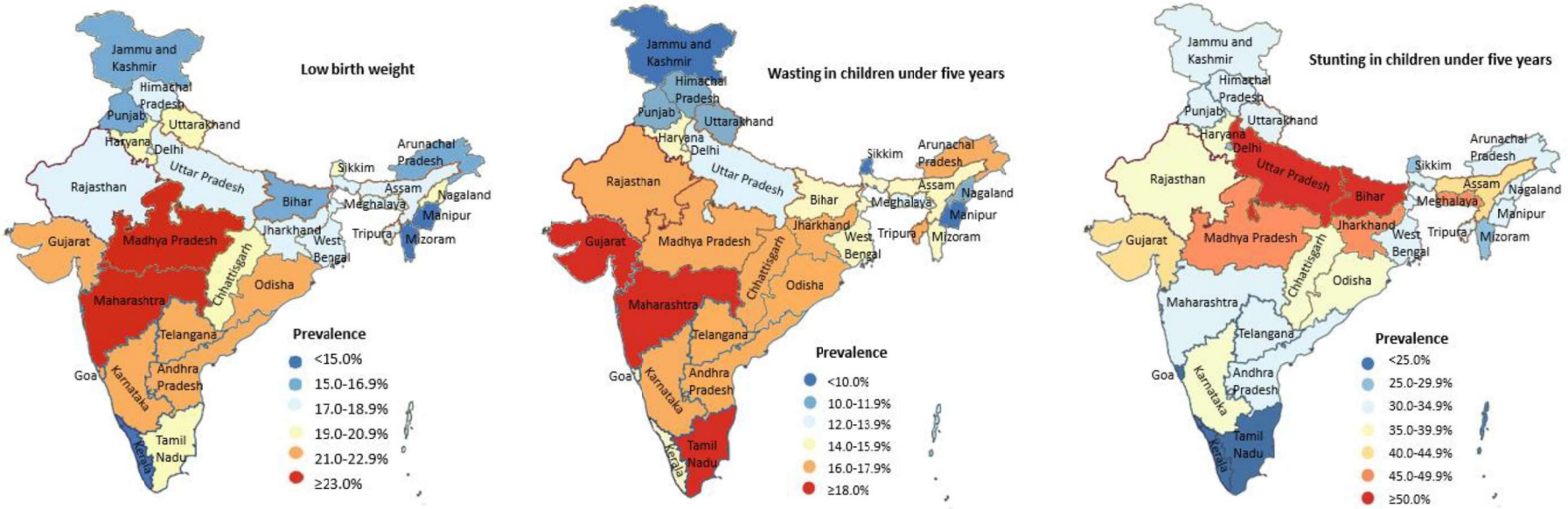
Rankings are reported in relation to the seventeen GBD level 2 risk factors. DALY=disability-adjusted life-year. ETL=epidemiological transition level.

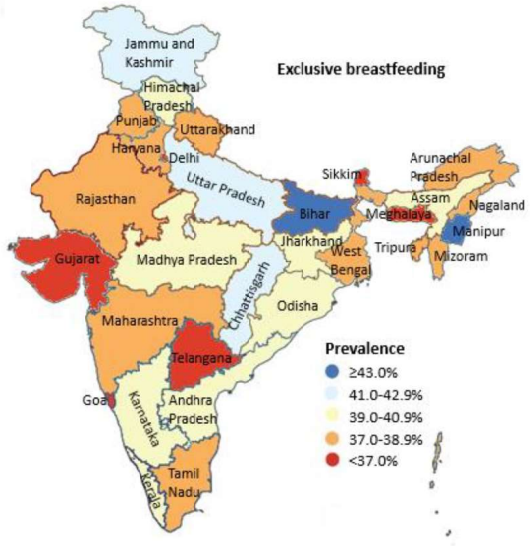
Figure 1: Diseases attributable to child and maternal malnutrition and its major components* in children under five years in India, 2016

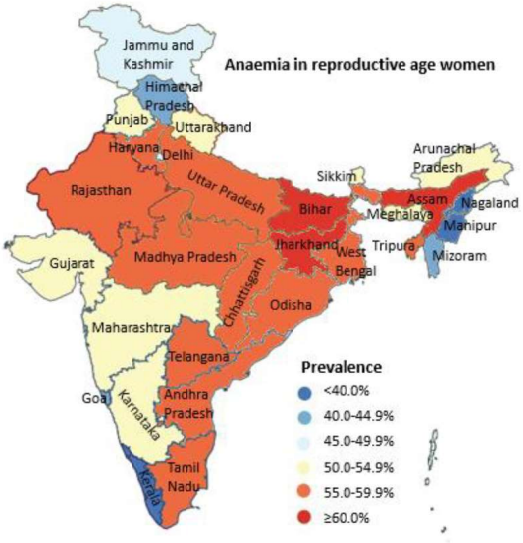


*Data are presented for the three leading components of child and maternal malnutrition; data shown are percent of total DALYs for each risk attributable to different diseases. †For child and maternal malnutrition the other category includes childhood infections other than diarrhoeal diseases and lower respiratory infections, vitamin A deficiency, and sudden infant death syndrome; for child growth failure, the other category includes measles.

Figure 2: Prevalence of the six global nutrition targets in the states of India in 2016




Exclusive breastfeeding
Jammu and Kashmir
Himachal Pradesh
Punjab
Uttarakhand
Haryana
Delhi
Rajasthan
Uttar Pradesh
Bihar
Sikkim
Arunachal Pradesh
Assam
Meghalaya
Nagaland
Manipur
Jharkhand
West Bengal
Tripura
Mizoram
Gujarat
Madhya Pradesh
Chhattisgarh
Odisha
Maharashtra
Telangana
Goa
Karnataka
Andhra Pradesh
Tamil Nadu
Kerala
Prevalence
≥43.0%
41.0-42.9%
39.0-40.9%
37.0-38.9%
<37.0%


Anaemia in reproductive age women
Jammu and Kashmir
Himachal Pradesh
Punjab
Uttarakhand
Haryana
Delhi
Rajasthan
Uttar Pradesh
Bihar
Sikkim
Arunachal Pradesh
Assam
Meghalaya
Nagaland
Manipur
Jharkhand
West Bengal
Tripura
Mizoram
Gujarat
Madhya Pradesh
Chhattisgarh
Odisha
Maharashtra
Telangana
Goa
Karnataka
Andhra Pradesh
Tamil Nadu
Kerala
Prevalence
<40.0%
40.0-44.9%
45.0-49.9%
50.0-54.9%
55.0-59.9%
≥60.0%

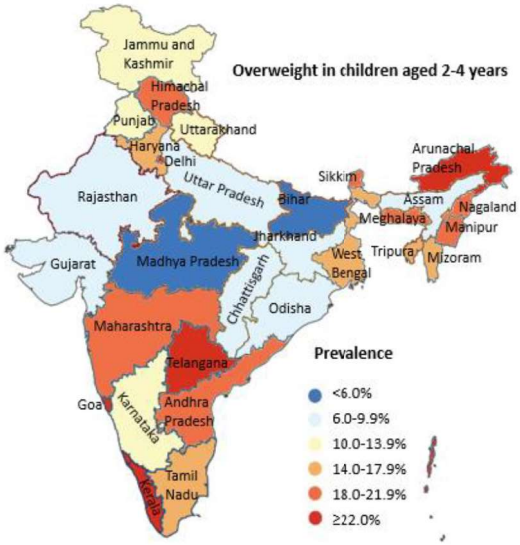
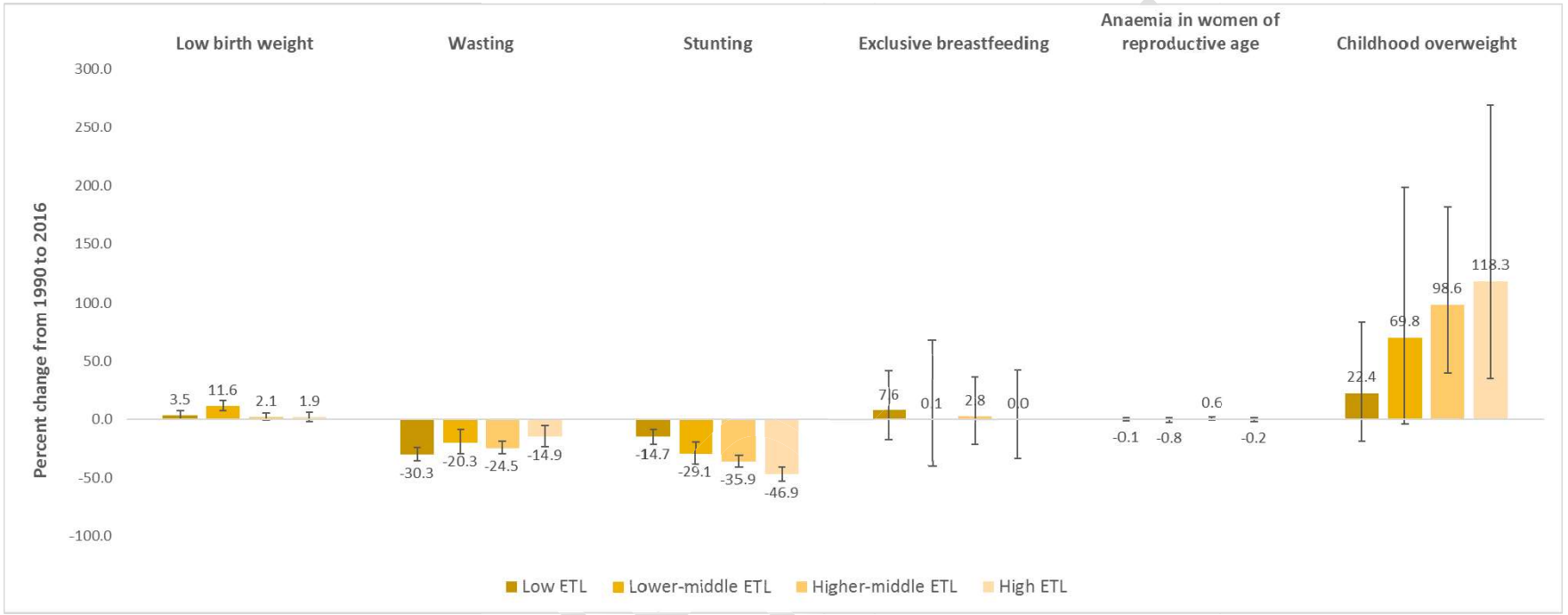

Overweight in children aged 2-4 years
Jammu and Kashmir
Himachal Pradesh
Punjab
Uttarakhand
Haryana
Delhi
Rajasthan
Uttar Pradesh
Bihar
Sikkim
Arunachal Pradesh
Assam
Meghalaya
Nagaland
Manipur
Jharkhand
West Bengal
Tripura
Mizoram
Gujarat
Madhya Pradesh
Chhattisgarh
Odisha
Maharashtra
Telangana
Goa
Karnataka
Andhra Pradesh
Tamil Nadu
Kerala
Prevalence
<6.0%
6.0-9.9%
10.0-13.9%
14.0-17.9%
18.0-21.9%
≥22.0%

Figure 3: Percent change from 1990 to 2016 in the prevalence of the six global nutrition targets in the states of India grouped by epidemiological transition level



The error bars represent 95% uncertainty intervals. ETL=epidemiological transition level.

Figure 4: Probability of achieving global targets for malnutrition by the states of India

States of India grouped by ETL	Probability of achieving WHO Global Nutrition Targets 2012-2025*						Probability of achieving Sustainable Development Goal Targets 2030†		
	Low birth weight	Wasting in under-five children	Stunting in under-five children	Exclusive breastfeeding in first six months	Anaemia in reproductive age women	Overweight in children 2-4 years	Wasting in under-five children	Stunting in under-five children	Overweight in children 2-4 years
India	0%	0%	0%	24%	0%	8%	0%	0%	0%
Low ETL									
Bihar	0%	0%	0%	33%	0%	17%	0%	0%	0%
Jharkhand	0%	0%	0%	29%	0%	16%	0%	0%	0%
Uttar Pradesh	0%	0%	0%	30%	0%	14%	0%	0%	0%
Rajasthan	0%	0%	0%	21%	0%	11%	0%	0%	0%
Meghalaya	0%	0%	0%	18%	0%	13%	0%	0%	0%
Assam	0%	0%	0%	25%	0%	15%	0%	0%	0%
Chhattisgarh	0%	0%	1%	28%	0%	6%	0%	0%	0%
Madhya Pradesh	0%	0%	0%	23%	0%	15%	0%	0%	0%
Odisha	0%	0%	0%	24%	0%	6%	0%	0%	0%
Lower-middle ETL									
Arunachal Pradesh	0%	0%	0%	19%	0%	5%	0%	0%	0%
Mizoram	0%	0%	0%	17%	0%	31%	0%	0%	0%
Nagaland	0%	0%	0%	20%	0%	30%	0%	0%	0%
Uttarakhand	0%	0%	0%	21%	0%	2%	0%	0%	0%
Gujarat	0%	0%	0%	17%	0%	8%	0%	0%	0%
Tripura	0%	0%	<1%	19%	0%	8%	0%	0%	0%
Sikkim	0%	‡	<1%	7%	0%	56%	0%	0%	0%
Manipur	0%	0%	0%	41%	0%	9%	0%	0%	0%
Higher-middle ETL									
Haryana	0%	0%	0%	17%	0%	5%	0%	0%	0%
Delhi	0%	0%	1%	14%	0%	6%	0%	0%	0%
Telangana	0%	0%	3%	24%	0%	13%	0%	0%	0%
Andhra Pradesh	0%	0%	0%	20%	0%	3%	0%	0%	0%
Jammu and Kashmir	0%	‡	0%	28%	0%	9%	0%	0%	0%
Karnataka	0%	0%	0%	23%	0%	6%	0%	0%	0%
West Bengal	0%	0%	<1%	21%	0%	9%	0%	0%	0%
Maharashtra	0%	0%	2%	18%	0%	7%	0%	0%	0%
Union territories other than Delhi	0%	0%	<1%	19%	0%	13%	0%	0%	0%
High ETL									
Himachal Pradesh	0%	0%	0%	24%	0%	3%	0%	0%	0%
Punjab	0%	0%	0%	22%	0%	6%	0%	0%	0%
Tamil Nadu	0%	0%	7%	22%	0%	9%	0%	0%	0%
Goa	0%	0%	0%	11%	0%	4%	0%	0%	0%
Kerala	0%	0%	100%	25%	0%	6%	0%	0%	0%

Probability of achieving global targets

*The WHO global nutrition targets for 2025 are: 30% reduction in low birth weight from 2012; childhood wasting less than 5% in 2025; 40% reduction in childhood stunting from 2012; 50% or more exclusive breastfeeding in 2025; 50% reduction of anaemia in reproductive age women from 2012; and no increase in childhood overweight from 2012. †The malnutrition targets of the Sustainable Development Goals are elimination of childhood wasting, stunting, and overweight by 2030, which were defined as prevalence ≤0.5% for this analysis. ‡Reliable estimates of the wasting global target for 2025 for Jammu and Kashmir and for Sikkim could not be produced due to data issues. ETL=epidemiological transition level.