Maternal & Child Nutrition

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Stop Stunting in South Asia. Improving Child Feeding, Women’s Nutrition and Household Sanitation

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Maternal & Child Nutrition

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Aims and Scope
Maternal & Child Nutrition is a forum for the dissemination of the latest research and innovation in all aspects of practice and policy that impinge on nutrition and its outcomes in women and their children, both in early and later life. Drawing from global sources, the Journal provides an invaluable source of up-to-date information for health professionals, academics and service users with interests in maternal, infant and child nutrition. The scope of Maternal & Child Nutrition includes pre-conception, antenatal and postnatal maternal nutrition, women’s nutrition throughout their reproductive years, and fetal, neonatal, infant and child nutrition, up to and including adolescence.

Topics covered include:
- Nutritional needs of mothers and their children in health and illness
- Physiological, socio-cultural, psychological, economic and political aspects of the nutrition of mothers and their children
- Infant and young child feeding, including breastfeeding and complementary feeding
- Research directed at the translation of scientific findings into programmatic and policy initiatives to improve maternal and child nutrition
- Implementation and effectiveness of culturally acceptable, cost-effective and sustainable programmes aimed at improving health
- Evaluation of inter-agency initiatives and programmes
- Health promotion and health education initiatives
- Food safety, and related environmental and regulatory issues
- Studies relating nutrition to health or disease risk in mothers and their children
- Role of nutrition in healthy groups and in high risk and vulnerable groups
- Development of research methods and validation of measures

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Stop stunting: improving child feeding, women’s nutrition and household sanitation in South Asia

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Abstract

The latest available data indicate that 38% of South Asia’s children aged 0–59 months are stunted. Such high prevalence combined with the region’s large child population explain why South Asia bears about 40% of the global burden of stunting. Recent analyses indicate that the poor diets of children in the first years of life, the poor nutrition of women before and during pregnancy and the prevailing poor sanitation practices in households and communities are important drivers of stunting, most likely because of underlying conditions of women’s status, food insecurity, poverty, and social inequalities. With this evidence in mind, UNICEF Regional Office for South Asia convened the Regional Conference: Stop Stunting: Improving Child Feeding, Women’s Nutrition, and Household Sanitation in South Asia (New Delhi, November 10–12, 2014). The Conference provided a knowledge-for-action platform with three objectives: (1) share state-of-the-art research findings on the causes of child stunting and its consequences for child growth and development and the sustainable growth and development of nations; (2) discuss better practices and the cost and benefits of scaling up programmes to improve child feeding, women’s nutrition, and household sanitation in South Asia; and (3) identify implications for sectoral and cross-sectoral policy, programme, advocacy and research to accelerate progress in reducing child stunting in South Asia. This overview paper summarizes the rationale for the focus on improving child feeding, women’s nutrition, and household sanitation as priority areas for investment to prevent child stunting in South Asia. It builds on the invited papers presented at or developed as a follow on to the Stop Stunting Conference.

Keywords: stunting, child feeding, women’s nutrition, household sanitation, South Asia.

Child stunting in South Asia. Why does it matter?

The linear growth of healthy children from birth to five years of age is remarkably similar the world over (Multicenter Growth Reference Study Group 2006). Yet, the latest global figures indicate that ~25% of children under age five (i.e. 159 million) have stunted growth because of chronic nutrition deprivation (UNICEF, WHO, WBG 2016). Stunting—a height-for-age below −2 standard deviations of the median height-for-age in the Child Growth Standards of the World Health Organization—happens early in life. There is now broad agreement that most stunting happens during the first thousand days—from conception through the first two years of life—although additional linear growth faltering may still happen after the first two years of life (Leroy et al. 2014).

In their paper in this special issue de Onis and Branca, from the World Health Organization, remind us that besides early beginnings, stunting also has far-reaching consequences (de Onis & Branca 2016). It is estimated that stunting is the cause of about one million child deaths annually. For the children who survive, stunting in infancy and early childhood causes lasting damage, including increased morbidity, poor cognition and educational performance in childhood, short stature in adulthood, increased risk of perinatal and neonatal death for women, lower productivity and reduced earnings in adults and—when accompanied by...
excessive weight gain later in childhood—increased risk of chronic diseases. Therefore, it is accurate to say that stunting hampers the development of entire societies (Victora et al. 2008; Dewey & Begum 2016; Black et al. 2013; de Onis & Branca 2016).

The latest available data indicate that 38% of South Asia’s children under five years of age are stunted. Levels of child stunting in South Asia are comparable to those in sub-Saharan Africa (37%) and three times higher than those in East Asia and the Pacific (12%) or Latin America (11%). The high prevalence of stunting and the region’s large child population (26% of the world’s children under five) means that South Asia, with about 40% of the global burden of stunting, is the epicentre of the global stunting crisis (United Nations Children’s Fund, UNICEF 2015a,b). Recent analyses indicate that three main drivers of child stunting in South Asia are the poor diets of children in the first years of life, the poor nutrition of women before and during pregnancy and the prevailing poor sanitation practices in households and communities (Smith & Haddad 2016).

With this evidence in mind, UNICEF Regional Office for South Asia convened a regional conference in New Delhi, India under the theme: Stop Stunting: Improving Child Feeding, Women’s Nutrition and Household Sanitation in South Asia (November 10–12, 2014). The Conference provided a knowledge-for-action platform with three objectives: (1) share state-of-the-art research findings on the causes of child stunting and its consequences for child growth and development and the sustainable growth and development of South Asian nations; (2) discuss better practices and the cost and benefits of scaling up programmes to improve child feeding, women’s nutrition and household sanitation in South Asia; and (3) identify implications for sectoral and cross-sectoral advocacy, policy, programme and research to accelerate progress in reducing child stunting in South Asia.

The Regional Conference was attended by about 200 participants representing national governments and regional organizations as well as bilateral, multilateral and non-governmental development partners, representatives of research and academic institutions and resource persons from South Asia and globally. This special issue of Maternal and Child Nutrition includes the guest presentations made at the Conference and a series of invited papers that were developed in preparation for or as a follow up to the Conference.

The drivers of child stunting in South Asia

There is emerging consensus that economic growth can have a positive impact on reducing child stunting. However, the relationship between economic growth and child stunting is not always a straightforward one. In this issue, Joe et al. investigate why economic growth did not result in a significant reduction of child stunting in India between 1993 and 2006. They conclude that economic growth did not lead to significant increases in public development expenditure, considerable reductions in poverty and/or increased equity, the pathways through which economic growth is expected to reduce stunting in low income and middle income countries (Joe et al. 2016).

Applying comparable statistical techniques to Demographic and Health Surveys (DHS) data collected between 1993 and 2013 in Bangladesh, India, Nepal

Key messages

- More than a third of South Asia’s children aged 0–59 months are stunted because of persistent nutritional deprivation. South Asia bears about 40% of the global burden of stunting.
- Three important drivers of child stunting in South Asia are the poor diets of children in the first 2 years of life, the poor nutrition of women before and during pregnancy, and poor sanitation practices and conditions in households and communities.
- Economic growth alone will not improve stunting without commensurate strategic investments in evidence-based large scale programmes that place their emphasis on closing equity gaps, especially for the most vulnerable children and populations.
and Pakistan, Headey et al. extract a set of explanatory variables that cover a broad range of the hypothesized distal drivers of nutrition change. They find that improvements in household asset accumulation (reduced poverty), combined with improvements in women’s education and reductions in open defecation, account for much of the observed nutritional change in height-for-age $z$-scores in children 0–59 months in these four countries. India’s relative poorer performance (1993–2006) is driven by smaller changes in these variables (Headey et al. 2016).

Lastly, Subramanian et al. critique the over-reliance on macroeconomic growth as a policy instrument to improve nutrition in children and argue that the evidence that an economic growth-mediated strategy only can reduce child stunting at scale is no longer compelling. They also critique a disproportionate focus on interpreting single-factorial (often proximal in nature) approaches to reducing stunting. They argue that instead of addressing one risk factor at a time—whether proximal or distal—a support-led multi-sectoral approach is needed to stop stunting in South Asia (Subramanian et al. 2016).

Focusing on India, Aguayo et al. analyse a representative sample of children 0–23 months old to identify the factors most significantly associated with child stunting in the State of Maharashtra. They find that stunting and poor attained linear growth (height-for-age $z$-score) were significantly poorer in children born with low birth weight, children born to mothers whose height was $<$145 cm, children of mothers without decision making power regarding food, children 6–23 months old who were not fed a minimum number of times per day, children who were not fed eggs, dairy products, fruits and/or vegetables and children from households without access to improved sanitation (Aguayo et al. 2016).

Taken together, these papers emphasize that while economic growth is an important imperative for South Asia, particularly to generate government revenues that can be invested in social policies and programmes, it is also equally imperative to make the necessary policy and programme investments that can help to accelerate progress in improving child feeding, women’s nutrition and household sanitation. Investments in this region, and in these issues, are critical if the world is to achieve the global target of reducing by 40% the number of children under five who are stunted, from 171 million in 2010 to about 100 million in 2025 (WHO 2015). The papers in this special issue of Maternal and Child Nutrition highlight some of the challenges, and more importantly, the successes of attempts to shape these determinants.

### The challenge of improving child feeding

Most stunting happens in the first 1000 days, from conception to age two years, when children’s linear growth is most sensitive to nutrition deprivation and environmental stress. During the first 500 days, from conception to about 6 months of age, the child is entirely dependent for its nutrition on the mother, either via the placenta during pregnancy or via breastmilk during the initial 6-month exclusive breastfeeding period. However, the largest proportion of stunting occurs during the complementary feeding period (6–23 months), the ~500-day transition time from exclusive breastfeeding in the first 6 months of life, to consuming a wide range of family foods while breastfeeding continues. Adequate complementary feeding is critical to support optimal physical growth and brain development in children. Complementary foods need to be nutrient-rich and be fed frequently to prevent stunting.

The most recent data indicate that fewer than 25% of children 6–23 months old in Afghanistan, Bangladesh, India, Nepal and Pakistan are fed diets that meet the minimum requirements in terms of frequency and diversity (United Nations Children’s Fund, UNICEF 2015a,b).

Addressing this subject, Dewey reviews in this special issue the various options for improving the diets of pregnant and lactating women and their children in the first two years of life. These options include dietary diversification and increased intake of nutrient-rich foods for women, improved complementary foods and feeding practices for children and micronutrient supplements, fortified foods and products specifically designed for infants, young children, pregnant women and lactating women. Dewey’s review indicates that these interventions, both prenatal and postnatal, can...
have a positive impact on child growth. However, there is significant heterogeneity in linear growth response to such interventions. Such variation is likely to be related to the potential to benefit (i.e. is the population undernourished?) and the potential to respond to improved nutrition (i.e. are there other factors constraining linear growth?). Hence, the importance of understanding the aetiology of poor linear growth and stunting and the need for integrated approaches that address the potentially multifactorial aetiology of stunting (Dewey 2016).

In their paper, Paintal and Aguayo remind us that optimal infant and young child feeding (IYCF) practices are particularly crucial when children are sick or convalescent as children’s nutritional status can deteriorate rapidly if the additional nutrient requirements associated with illness and convalescence are not met and nutrients are diverted from growth and development towards the immune response. Their review of survey and research evidence shows that in South Asia, IYCF practices during common childhood illnesses are far from optimal. Most children continue to be breastfed when they are sick, but few are breastfed more frequently, as recommended. In addition, restriction or withdrawal of complementary foods during illness is frequent because of children’s anorexia (perceived or real), poor awareness of caregivers’ about the feeding needs of sick children, traditional beliefs/behaviours and/or sub-optimal counselling and support by health workers (Paintal & Aguayo 2016).

Evidence from the region suggests that large-scale improvements in IYCF are possible when interventions are designed for and delivered at scale. Sanghvi et al. review the experience of the Alive & Thrive programme in Bangladesh, which focused on a population of 8.5 million mothers and their families/communities. After 4 years of implementation, the programme documented rapid and significant improvements in key breastfeeding and complementary feeding practices. Promotion strategies reached a high percent of the priority groups through repeated contacts. Scale-up was achieved by mainstreaming tools and strategies in the work of government programmes and local NGO implementing partners with an extensive community-based platform. Improving the performance of frontline workers and volunteers in delivering timely, high-quality counselling to mothers while reinforcing interpersonal counselling with mass media campaigns, advocacy and community mobilization were central to the success of the programme (Sanghvi et al. 2016).

Similarly, Haselow et al. review the evolution and impact of the enhanced homestead food production (EHFP) programme, which aims to increase year-round availability and intake of diverse nutrient-rich foods while promoting optimal feeding and nutrition practices in poor households. Programme evaluation in Bangladesh, Cambodia, Indonesia, Nepal and the Philippines indicates that EHFP had a positive impact on poor households’ year round food production, food consumption – particularly among women and children 6–59 months of age – and food security. Results from randomized and non-randomized programme evaluations in Bangladesh and Nepal have shown significant improvements in a range of practices known to impact positively child growth, with reductions in child stunting ranging from 10.5% to 18.0% (Haselow et al. 2016).

It is clear from this set of papers that despite the challenges, there are good programme examples in South Asia that may be replicated and scaled up to accelerate improvements in IYCF. These must, however, be adapted to new settings other than their originating context, and more evidence must be built around these adaptations to strengthen the regional evidence base.

**Improving women’s nutrition outcomes**

There is broad agreement that direct maternal nutrition interventions are needed to improve women’s nutrition, birth outcomes and children’s linear growth in infancy and early childhood. However, there are few programme examples – beyond those related to improving antenatal care services during pregnancy – that are explicitly focused on improving women’s nutrition before, during or after pregnancy. For South Asia this is a crucial area of investment as it looks ahead.

In addition, over the last decade a number of studies have documented the role of non-nutrition determinants on women’s nutrition and the nutrition of their offspring. In her paper, Vir reviews the evidence on the impact of different dimensions of women’s agency
such as age at marriage and conception, formal education, decision making power relative to men and control over resources, on the nutrition of women and children. Vir concludes that combining direct nutrition interventions with measures that empower women is essential. A range of programme platforms in sectors such as health, education, agriculture, employment, microfinance and social protection can be used strategically to improve women’s access to food, health and care before and during pregnancy and lactation as well as to strengthen women’s knowledge, skills and agency to feed and care for their children (Vir 2016).

**The challenge of bringing together nutrition and sanitation**

It is becoming increasingly clear that all post-natal stunting cannot be completely reversed by improving children’s diets if children live in highly unhygienic environments. Growing evidence suggests that there is a link between children’s linear growth and the sanitation practices in the households where children live. The ingestion of high quantities of faecal bacteria by young children through mouthing soiled fingers and household items leads to intestinal infections which affect children’s nutritional status by diminishing appetite, reducing nutrient absorption, and increasing nutrient losses. Although the proportion of people using improved sanitation in South Asia increased by 18 percentage points between 1990 and 2011, the pace of this improvement has not kept up with population growth; as a result, the region accounts for almost two thirds of the global population practicing open defecation.

In this special issue, Cumming and Cairncross review how poor water, sanitation and hygiene (WASH) conditions can have a significant detrimental effect on child growth through sustained exposure to enteric pathogens and wider social and economic mechanisms. Mbuya and Humphrey argue that the unhygienic environments in which many infants and young children live cause an environmental enteric dysfunction (EED), whereby the children’s guts have: (1) reduced absorptive capacity that results in nutrient maldigestion and malabsorption; and (2) reduced structural integrity (i.e. a ‘leaky gut’) that results in chronic immune activation and the diversion of nutrients to fight infection rather than growth. These two overlapping pathways result in poor linear growth and stunting (Cumming & Cairncross 2016; Mbuya & Humphrey 2016). In light of the above, there is renewed interest in how WASH interventions might be targeted or modified to support efforts in the Nutrition sector.

The evidence of how WASH interventions might support nutrition interventions to improve linear growth and reduce stunting is still ‘under construction’. Large WASH intervention studies are currently underway both in rural and urban settings to add to this evidence base. Cumming and Cairncross argue that the main challenge for nutrition-sensitive WASH strategies is to ensure that populations with a high burden of stunting are targeted before or when growth faltering occurs and with appropriate WASH interventions alongside nutrition-specific interventions (Cumming & Cairncross 2016). A recent Cochrane review reporting that the effect of WASH interventions on child stunting was greatest in children aged 0–23 months validates this focus (Dangour et al. 2013). Mbuya and Humphrey suggest that a package of baby-WASH interventions (sanitation and water improvement, handwashing with soap, ensuring food hygiene and a clean infant feeding and play environment) to interrupt feco-oral transmission in the first two years of a child’s life may make important contributions to global efforts to reduce stunting where poor sanitation is a major challenge (Mbuya & Humphrey 2016).

**Cost and benefits of reducing stunting**

Two major considerations for the delivery of interventions to improve child feeding, women’s nutrition and household sanitation are the costs and benefits of investing in these outcomes. In this special issue, the review by Shekar et al. on the costs and benefits of reducing stunting indicates that the global public investment required to scale up critical nutrition interventions globally is estimated at US$10.3 billion above and beyond existing investments. Such investment would reduce the number of stunted children by about 30 million and save at least 1.1 million lives. Shekar et al.
argue that rigorous estimations of the costs and benefits of nutrition investments to children and societies are an important next step in South Asian countries. Such cost-benefit analyses will help identify the reduction of stunting as a national development and investment priority, drive political commitment and action, and ramp up the effective allocation of resources to reduce child stunting (Shekar et al. 2016).

In an attempt to address this issue, Menon et al. estimate that in India US$ 4.5 billion/year are required to deliver the package of 10 nutrition-specific interventions promoted by the Scaling Up Nutrition (SUN) movement, while US$ 5.9 billion/year are required to deliver the package of 14 nutrition specific interventions that are encompassed in India’s nutrition policy frameworks, with an average cost of US$ 140 child/year. It is important to mention that maternity cash benefits (49%) and food 14 supplements (40%) contribute to almost 90% of the total cost. The authors conclude that there is an urgent need for further costing studies on the true unit costs of high-impact nutrition interventions to be able to project accurate national and subnational budgets for nutrition in India (Menon et al. 2016).

**Country-focused strategies to reduce stunting in South Asia: what will it take?**

In developing this special issue, we requested planning, programme, and research specialists based in South Asia to share their reflections on child stunting in their countries (Higgins-Steele et al. for Afghanistan; Ahmed et al. for Bangladesh; Dzed and Wangmo for Bhutan; Avula et al. for India; Das & Bhutta for Pakistan; and Devkota & Adhikari for Nepal). These perspective papers highlight similarities and challenges across South Asian countries. All papers emphasize the multisectoral nature of the interventions that are needed to reduce stunting and therefore, the need for high-level leadership to enable the scale up of nutrition-specific interventions as well as of investments to improve the underlying drivers of stunting in a nutrition-sensitive manner, particularly food security, women’s status, and hygiene and sanitation. The papers from Afghanistan, India and Pakistan also highlight the importance of sub-national variability, and therefore the need for strategies that are specifically tailored to context so as to enable lagging regions to catch up. However, despite strong economic growth in much of the region, few of the country perspective papers reflect on the importance of advocating for a model of economic growth of fuels further public investments in social sectors, poverty reduction, increased equity and the role of non-government stakeholders and private sector actors. Similarly, few of the country perspectives reflect on additional research needs to support a better understanding of what strategies might work better across the region. Our own perspective is that these areas – increased and equitable social sector investments, the role of non-government actors and the importance of better research and knowledge – are crucial as there are context-specific needs in terms of social investments, public–private partnerships, and research needs to support the scale up of nutrition-specific interventions, to inform integration with nutrition-sensitive interventions, and to strengthen political commitments to nutrition across the region.

**Stop stunting in South Asia: what is next?**

As we mention in our introduction, this special issue of *Maternal and Child Nutrition* captures much of what was discussed in preparation for and during the Regional Conference: *Stop Stunting: Improving Child Feeding, Women’s Nutrition and Household Sanitation in South Asia*. As a summary to the rich discussions that took place during the conference, we requested Shawn Baker, Director for Nutrition at the Bill and Melinda Gates Foundation, to share his views about what works, what is missing, and what is next to stop stunting in South Asia. His views, in the form of 10 take home messages are a good conclusion to this overview paper.

**Message 1: Children from all regions of the world have similar potential for growth and development in early childhood**

Child stunting is a powerful marker of failed development. In nations where stunting has declined many
things have worked in favour of children. Conversely, wherever stunting remains high, development is failing children. Children’s growth is a mirror of the state of a society and stunting is possibly the most sensitive indicator of overall societal equity and well-being. Therefore, it makes perfect sense that child stunting be one of the lead nutrition indicators for the post-2015 Sustainable Development Goals.

Message 2: Stunting is an outrage that demands a response commensurate with the damage it is doing to children and nations

Stunting has declined in South Asia but still compromises the future of 38% of underfives – almost 65 million children – and the future of the region as a whole. Good physical growth and brain development are every child’s birth right. Stunted children do not have a voice and their plight is so ubiquitous that it is viewed as the ‘normal’ state of affairs. However, evidence from within and outside the region proves that large scale declines in stunting – for millions of children at a time – can be achieved.

Message 3: We need to create ‘a new normal’ for the drivers of child stunting in South Asia

This new state of affairs needs to comprise a new normal for child feeding that includes age-appropriate foods for infants and young children, and ensures quality, quantity and safety; a new normal for women’s lives that includes good nutrition, healthy height, healthy weight, no anaemia and the right to make decisions affecting their lives; and finally, a new normal for household hygiene and sanitation practices that includes access to safe water and sanitation, washing with soap at critical times, and the end of open defecation.

Message 4. South Asian countries can afford to act and cannot afford the cost of inaction

Evidence shows that economic growth alone will not improve stunting without commensurate investments in other accompanying interventions. We need to move from expecting that economic growth will ‘trickle down’ to making strategic investments on evidence-based large scale programmes that place their emphasis of the most vulnerable children and populations. South Asian countries need to seize the opportunity of economic growth to invest in the future of children. It will cost, but it is an investment that ‘locks in the potential’, with benefits that far exceed the cost.

Message 5. The one-thousand days from conception to age two years are a key window in which interventions to prevent stunting should focus

A growing number of national nutrition programmes are responding to the challenge of child stunting by focusing on the golden one-thousand days and ensuring that children under two years of age and their mothers meet their nutrient needs. Nutrient density and diet diversity for children and women are of the essence. Evidence shows that they can be improved at scale using a mix of interventions that includes locally-available foods, fortified foods, and supplementary foods where food insecurity is a problem.

Message 6: Act now and for the future. Multiple drivers need multiple actions

It is essential that we deliver known solutions at scale to address the underlying causes of stunting: child feeding, women’s nutrition and household sanitation. However, it will be crucial that we partner with kindred spirits to address the more distal and inter-generational drivers of child stunting in South Asia: adolescent marriage and pregnancy, women’s illiteracy and poor decision making power, and household poverty and social exclusion. It will be essential to define the roles and responsibilities of each sector in reducing child stunting and, importantly, to co-locate the interventions of all sectors.

Message 7: We need to start with focus and scale in mind

The response to child stunting in South Asia needs to be commensurate with the scale of the problem. Multiple platforms can be used to deliver the interventions that will stop stunting: antenatal care visits, institutional deliveries, adolescent-focused programmes, mother-and-child services, home visits and community-based
programmes, social protection schemes and women’s micro-credit programmes are a few examples. Scaling up improved hygiene and sanitation practices and ending open defecation will be essential to ensure that improved nutrient intakes result into improved growth outcomes.

**Message 8. Know your epidemic, know your response**

The drivers of child stunting change in nature and intensity from country to country and within countries. Therefore it is important to have an accurate understanding of what is driving poor nutrition in children and women (availability, access, use, knowledge, choice, markets, poverty, exclusion…) and poor hygiene and sanitation practices in the household (infrastructure, beliefs, norms, tradition, gender, awareness…) to tailor a response that brings about a significant decline in child stunting. In all instances it will be crucial that national strategies prioritize the most vulnerable children: the youngest, the poorest and the socially excluded.

**Message 9: Engage strategically with and monitor carefully the private sector**

The private sector – commercial and non-for-profit – is an increasingly large player in the sectors that affect child stunting: food, health, water, sanitation, education, communication and employment. National and sub-national governments have the opportunity to optimize the potential added value of and mitigate the potential harm from the private sector by establishing quality standards, enforcing adequate regulation and legislation measures, and ensuring competition. The expertise of the non-food private sector in supply chain and logistics, mobile technology and mass media communication, demand creation, and capacity building could potentially be used to support interventions but this will need further exploration.

**Message 10: Serious problems require serious measurement**

There is no doubt that we need a data revolution if we are serious about reducing stunting in South Asia. National and sub-national governments need to collect more frequent and more disaggregated data to measure progress towards the World Health Assembly nutrition goals, including child stunting, as well as the coverage of effective interventions in different age, gender, geographic and socio-economic groups. Measuring the performance of national systems in delivering essential interventions to prevent stunting and tracking investments and expenditures against costed plans ensure public accountability and indicate good governance.

**Conclusion**

Nutrition is key to children’s survival, growth and development. Well-nourished children are healthier and cleverer than their undernourished peers, they grow and develop to their full potential and they perform better in school and as adults. Despite significant progress over the last two decades, an estimated 38% of children under the age of five in South Asia are stunted because of persistent nutrition deprivation. Besides being a moral imperative, investing to prevent stunting in South Asia is a development imperative. It is our hope that the wealth of research and programmatic evidence included in this special issue of *Maternal and Child Nutrition* will inform the post-2015 drive to stop stunting in South Asia.

**Conflicts of interest**

The authors declare that they have no conflicts of interest. The opinions expressed on this paper are those of the authors and do not necessarily represent an official position by UNICEF or IFPRI.

**Contributions**

Both authors contributed to manuscript writing and have read and approved the final submission.

**References**


Abstract

Childhood stunting is the best overall indicator of children’s well-being and an accurate reflection of social inequalities. Stunting is the most prevalent form of child malnutrition with an estimated 161 million children worldwide in 2013 falling below –2 SD from the length-for-age/height-for-age World Health Organization Child Growth Standards median. Many more millions suffer from some degree of growth faltering as the entire length-for-age/height-for-age z-score distribution is shifted to the left indicating that all children, and not only those falling below a specific cutoff, are affected. Despite global consensus on how to define and measure it, stunting often goes unrecognized in communities where short stature is the norm as linear growth is not routinely assessed in primary health care settings and it is difficult to visually recognize it. Growth faltering often begins in utero and continues for at least the first 2 years of post-natal life. Linear growth failure serves as a marker of multiple pathological disorders associated with increased morbidity and mortality, loss of physical growth potential, reduced neurodevelopmental and cognitive function and an elevated risk of chronic disease in adulthood. The severe irreversible physical and neurocognitive damage that accompanies stunted growth poses a major threat to human development. Increased awareness of stunting’s magnitude and devastating consequences has resulted in its being identified as a major global health priority and the focus of international attention at the highest levels with global targets set for 2025 and beyond. The challenge is to prevent linear growth failure while keeping child overweight and obesity at bay.

Keywords: stunting, malnutrition, infant and child growth, child development, healthy growth.

Introduction

Linear growth is the best overall indicator of children’s well-being and provides an accurate marker of inequalities in human development. This is tragically reflected in the millions of children worldwide who not only fail to achieve their linear growth potential because of suboptimal health conditions and inadequate nutrition and care; they also suffer the severe irreversible physical and cognitive damage that accompanies stunted growth.

Stunting often goes unrecognized in communities where short stature is so common that it is considered normal. The difficulty in visually identifying stunted children and the lack of routine assessment of linear growth in primary health care services explain why it has taken so long to recognize the magnitude of this hidden scourge. However, after many years of neglect, stunting is now identified as a major global health priority and the focus of several high-profile initiatives like Scaling Up Nutrition, the Zero Hunger Challenge and the Nutrition for Growth Summit. Stunting is also at the heart of the six global nutrition targets for 2025 that the World Health Assembly adopted in 2012 (WHO 2012), and it has been proposed as a leading indicator for the post-2015 development agenda.

Increased international attention is the result of greater awareness of the significance of stunting as a major public health problem. First, it affects large numbers of children globally. Second, it has severe short-term and long-term health and functional consequences, including poor cognition and educational performance, low adult wages and lost productivity. Third, there is consensus regarding its definition and a robust standard to define normal human growth that is applicable everywhere. Fourth, there is agreement...
on a critical window – from conception through the first 2 years of life – within which linear growth is most sensitive to environmentally modifiable factors related to feeding, infections and psychosocial care. Fifth, it is a cross-cutting problem calling for a multisectoral response. Action to reduce stunting requires improvements in food and nutrition security, education, WASH (water, sanitation and hygiene interventions), health, poverty reduction and the status of women.

Stunting results from a complex interaction of household, environmental, socioeconomic and cultural influences that are described in the World Health Organization (WHO) Conceptual Framework on Childhood Stunting (Stewart et al. 2013). Readers are referred to this framework for a comprehensive review of the contextual and causal factors that lead to stunted growth. This paper reviews the definition of stunting, how to measure it and the timing of growth faltering; describes worldwide patterns and recent trends; reviews the consequences of stunting for child survival, growth and cognitive development and long-term health; and discusses the WHO’s global target for reducing stunting by 2025.

**Childhood growth faltering: a broader definition of stunting**

Stunting is identified by assessing a child’s length or height (recumbent length for children less than 2 years old and standing height for children age 2 years or older) and interpreting the measurements by comparing them with an acceptable set of standard values. There is international agreement that children are stunted if their length/height is below –2 SDs from the WHO Child Growth Standards median for the same age and sex (WHO 2008; de Onis et al. 2013). Similarly, children are considered severely stunted if their length/height is below –3 SDs from the WHO Child Growth Standards median for the same age and sex.

The use of cut-off points is required to determine the limits of ‘normality’, and this practice is not unique to anthropometry but widely applied in clinical and laboratory tests. Nevertheless, it is important to bear in mind that in reality there are no two distinct populations – one stunted and the other growing adequately – but rather a gradation of growth faltering. That is, the risk of being stunted and suffering from its devastating consequences does not change dramatically simply by crossing the cut-off line; significant deterioration within the ‘normal’ range may also occur.

Fig. 1 shows, using the India National Family Health Survey 2005–2006 (International Institute for Population Sciences (IIPS) & Macro International 2007), that the entire length-for-age/height-for-age z-score distribution is shifted to the left (compared with the WHO Child Growth Standards), indicating that all children, and not only those falling below a specific cut-off, are affected by some degree of growth faltering. From a public health standpoint, it is important not to lose sight of this population perspective as height deficits are associated with large gaps in cognitive achievement. For example, Spears documented a height-achievement slope among Indian children (Spears 2012) using the India Human Development Survey, a representative sample of 40000 households that matches anthropometric data to learning tests. Being one SD taller was associated with being 5 percentage points more likely to be able to write, a slope that falls to only 3.4 percentage points by controlling for a long list of contemporary and early life conditions (Spears 2012). Thus, there are developmental

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**Key messages**

- Stunting is a scourge that has early beginnings and far-reaching consequences. Of the world’s 161 million stunted children in 2013, about half lived in Asia and over one-third in Africa.
- Stunting often goes unrecognized in communities where short stature is the norm. Measuring length/height – not just weight – should be standard practice when assessing child growth.
- Stunting’s impact on neurocognitive function has devastating consequences. Stunted children have stunted brains and live stunted lives, hampering the development of entire societies.
- Stunting is the result of a complex array of causal and contextual factors. Solutions will require multifaceted and transdisciplinary approaches.
consequences for all children and not just those falling below internationally agreed cut-off levels.

**Challenges in measuring childhood stunting: methods and community norms**

Families and health workers often fail to recognize childhood stunting in communities where short stature is so common that it is considered normal. This is largely because linear growth is not routinely measured as part of community health programmes, in addition to lack of awareness of stunting’s devastating health consequences. Assessment of linear growth is essential for determining whether a child is growing adequately or has a growth problem or tendency towards a growth problem that should be addressed. Fig. 2a provides the example of two girls from the Maldives of identical height (86 cm). While one of the girls, at 2 years and 2 months, is growing adequately, the other, who is 4 years and 4 months old, is severely stunted (Fig. 2b). It was impossible to distinguish which girl was stunted merely by observing them play and interact with each other. Awareness of their age difference triggered alarms, but it was only when their heights were measured and compared with the WHO standards that the very severe stunted growth of one of the girls became evident. Measuring children’s length (up to 24 months) or height (from 24 months onwards) should be standard practice.

Assessing linear growth is not difficult, but it requires adherence to key principles and attention to detail. The accuracy and reliability of length and height measurements are highly dependent on the robustness, precision, maintenance and calibration of the anthropometric equipment; the measurement techniques and the establishment of data quality procedures (de Onis et al. 2004a). Variability in length and height measurements can result from a variety of influences, including the setting where measurements are taken, the behaviour and cooperation of the child, the accuracy and precision of the instruments, the anthropometrist’s technical capability and data recording methods. Appropriate training and adherence to standardized methods and procedures are thus essential to reduce measurement error and minimize bias (de Onis et al. 2004a).

Fig. 3 shows the correct positioning of a baby’s feet and a health worker’s hands for measuring recumbent length in children below 2 years of age. Measuring length in young infants is particularly delicate because of the

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Fig. 1. SD score distribution for length-for-age/height-for-age of Indian children compared with the World Health Organization (WHO) Child Growth Standards (India National Family Health Survey (NFHS-3) 2005–6).
gentle pressure on the knees required to straighten the
legs. Various training materials are available for different
levels of expertise. The WHO Training Course on Child
Growth Assessment (WHO 2008) teaches the basic
skills needed to measure the weight and length/height
of children and to plot and interpret the measurements.
Errors in plotting on charts are common, and even the
most experienced professionals can inadvertently make
them, yet correct plotting and interpretation of measure-
ments are essential for identifying growth problems.

The interpretation of anthropometric measurements
is heavily dependent on the growth standards used to
compare and interpret values (de Onis et al. 2006a).
Choice of a growth reference has received considerable
attention (Dale et al. 2009; Isanaka et al. 2009; Saha et
al. 2009; van Dijk & Innis 2009; Bois et al. 2010; Vesel
et al. 2010; Kerac et al. 2011; Maalouf-Manasseh et al.
2011) to the point of becoming the subject of passionate
debate. Since the release of the WHO Child Growth
Standards (de Onis et al. 2006b; WHO 2006; WHO

Fig. 2. (a) Two Maldivian girls below 5 years of age – which is the stunted one? (Photo taken in the Maldives. © WHO/Mercedes de Onis, 2005) (b) Height-for-age measurements of two Maldivian girls plotted relative to the World Health Organization Child Growth Standards.
Multicentre Growth Reference Study Group 2006b; WHO 2007; WHO 2009), the prevailing international consensus is that, on average, children of all ethnic backgrounds have similar growth potential. Today, over 140 countries are using the robust methodology of the WHO standards, which accurately describe physiological growth and harmonize child growth assessment the world over (de Onis et al. 2012).

The WHO Child Growth Standards increased attention to stunting by revealing that it is a greater problem than previously believed (de Onis et al. 2006a). Based on the observation that children of well-off populations in developing countries experience similar growth patterns to those of healthy, well-nourished children in developed countries (Bhandari et al. 2002; Mohamed et al. 2004; Owusu et al. 2004; WHO Multicentre Growth Reference Study Group 2006a), the WHO Multicentre Growth Reference Study (MGRS) was conducted to develop normative standards based on an innovative prescriptive approach. The methodology and conduct of the MGRS is described elsewhere (de Onis et al. 2004b). A critical result of the study was the remarkable similarity in linear growth of the six MGRS populations (3% and 70% inter-individual and inter-site variability, respectively), demonstrating that, when health, environmental and care needs are met, human growth potential is universal to at least 5 years of age (WHO Multicentre Growth Reference Study Group 2006a). Beyond time and borders, the WHO standards stand as a symbol of children’s right to achieve their genetic growth potential.

The similarity in growth across human populations in early life has been recently reinforced by evidence from the multi-country study Intergrowth-21st. Using methods and a prescriptive approach similar to those in the MGRS, the eight study sites of Intergrowth-21st showed that fetal growth and newborn length are similar across diverse geographical settings when mothers’ nutritional and health needs are met and environmental constraints on growth are few (Villar et al. 2014a). Furthermore, the Intergrowth-21st study, implemented several years after completion of the MGRS, reported strikingly similar findings: the mean birth length for term newborns in Intergrowth-21st was 49.4 cm (SD 1.9) compared with 49.5 cm (SD 1.9) in the MGRS (Villar et al. 2014a). These results provided the conceptual frame for developing matching international standards for fetal growth, newborn size according to gestational age and preterm post-natal growth (Papageorghiou et al. 2014; Villar et al. 2014b; Villar et al. 2015).

The timing of growth faltering

Stunting often begins in utero and continues for at least the first 2 years of post-natal life. The India National Family Health Survey 2005–2006 presented in Fig. 1 illustrates a typical pattern. At birth, stunting rates in this national sample are already estimated to be around 20% indicating the process of growth failure started prenatally. Thereafter, rates increase sharply, reaching 58% in the 18–23 month age range (International Institute for Population Sciences (IIPS) and Macro International 2007). This characteristic pattern of stunting in early childhood has established the period from conception to the second birthday (the first 1000 days) as the critical window during which failure to grow is part of an active process of becoming stunted (Victora et al. 2010).

Prenatally, the introduction of the WHO standards made it clear that intrauterine growth faltering is a greater problem than previously believed based on the prior National Center for Health Statistics references (de Onis et al. 2006a). The proportion of growth
failure that occurs prior to compared with after birth is still not fully understood and will likely vary across populations. For example, in Malawi, it was estimated that ~20% of the 10-cm deficit in height (compared with WHO Child Growth Standards) at 3 years of age is already present at birth (Dewey & Huffman 2009). Similarly, analyses using data from 19 birth cohorts estimated that 20% of stunting has in utero origins (Christian et al. 2013). This may be an underestimate of the influence of prenatal factors, however, as some of the stunting that occurs after birth may have been programmed in utero (Martorell & Zongrone 2012). In some settings, prenatal determinants of stunting appear to be more influential than in others. In a study in Indonesia (Schmidt et al. 2002), newborn length was a stronger determinant of length-for-age at 12 months than any other factor examined. More recently, using the WHO Child Growth Standards, a study that examined the timing of growth faltering in under-5 years of age children in India, based on nationally representative data, concluded that about half (44% to 55% depending on the survey year) of growth faltering was already present at birth (Mamidi et al. 2011).

After birth, the average length-for-age z-score among infants in deprived populations continues to decline until around 24 months of age. This sustained growth faltering is observed everywhere, although its magnitude varies by region (Victora et al. 2010) (Fig. 4). This timing is not surprising as healthy infants experience maximal growth velocity during the first few months of life (WHO 2009; de Onis et al. 2011). Likewise, as discussed later, given the well-documented rapid brain growth in the first 2 years (Tanner 1990), this early period is also critical for long-term neurodevelopment. It is not just a matter of when growth falters but which tissues and organs grow more rapidly during different age ranges. Emphasis on the first 1000 days is thus based not only on the magnitude of faltering but also on its long-term impact on adult human capital (Victora et al. 2008). Although stunting at a population level follows the trajectory just described, it is noteworthy that there is widespread variability in stunting patterns when individual child growth curves are examined.

After 24 months of age, and without seeking to underplay the importance of the period from conception to 24 months, it has recently been proposed that growth continues to falter in poor environments beyond 2 years of age and that there are other windows of opportunity to address stunting that might well offer additional opportunities for intervention (Prentice et al. 2013; Leroy et al. 2014). In particular, based on longitudinal data from the Consortium for Health Orientated Research in Transitioning Societies (COHORTS) study (Brazil, Guatemala, India, Philippines and South Africa) and from rural Gambia, Prentice and colleagues consider adolescence to provide an additional window of opportunity during which substantial life cycle and intergenerational effects can be accrued (Prentice et al. 2013). Published data from four low-income and middle-income countries (Ethiopia, India, Peru and Vietnam) also found substantial recovery from early stunting in school-aged children (Schott et al. 2013; Fink & Rockers 2014; Lundeen et al. 2014a). However, there has been some debate about using absolute (centimetres) vs. relative (z-scores) scales to describe changes in growth over time (Leroy et al. 2013; Leroy et al. 2014; Lundeen et al. 2014b; Victora et al. 2014). For example, Leroy and colleagues in a comparison of absolute height-for-age differences (HAD) with height-for-age z-scores in 51 surveys showed that, while height-for-age z-scores appeared to level off between 24 and 60 months, HAD continued to increase; 70% of the absolute accumulated height deficit (HAD) at 60 months was found to be due to faltering occurring in the first 1000 days (conception to 24 months), and 30% was the result of continued increases in deficit from age 2 to 5 years (Leroy et al. 2014). The question of potential recovery beyond 24 months of age is important. The causes and dynamics of continued growth faltering beyond 2 years of age, and whether interventions would effectively improve lean mass rather than increase the risk of long-term obesity, remains to be elucidated.

In addition to the timing of growth faltering, the intergenerational effects on linear growth are well documented. Stunting is a recurrent process whereby women who were themselves stunted in childhood are at greater risk of bearing stunted offspring, thereby contributing to a self-perpetuating intergenerational cycle of poverty and impaired human capital that is difficult to interrupt. Among
possible mechanisms explaining intergenerational effects on linear growth are shared genetic characteristics, epigenetic effects, programming of metabolic changes and the mechanics of a reduced space for fetal growth. There are also important socio-cultural factors at play such as the intergenerational transmission of poverty and deprivation (Martorell & Zongrone 2012). Substantial improvements in linear growth can be achieved through child adoption and migration and following rapid economic and social development. Despite clearly documented intergenerational effects, it would seem that nearly normal lengths can be achieved in children born to mothers who themselves were malnourished in childhood when profound improvements in health, nutrition and the environment take place before they conceive. In fact, recently published data (Garza et al. 2013) provide strong evidence that even short-term nutritional improvement (during intrauterine life and childhood) can result, within a single generation, in a mean gain in adult height up to 8 cm greater than the mean parental height. In other words, in developing countries, trans-generational improvements in height are achievable faster than expected if women of reproductive age have adequate health and nutrition, and access to health care.

Levels and trends in stunting (1990–2013)

Stunting is the most prevalent form of child malnutrition. United Nations Children’s Fund (UNICEF), WHO and the World Bank release yearly updated estimates of child malnutrition worldwide (United Nations Children’s Fund, World Health Organization, & The World Bank 2014). Using the WHO Child Growth Standards, in 2013 there were an estimated 161 million stunted under-5 years of age children, which is a 37% decrease from the estimated 257 million in 1990. About half of all stunted children lived in Asia and over one-third in Africa. Although fewer stunted children live in the Americas, several countries in this region have prevalence rates of stunting as high as those found in Asia and Africa.

Global prevalence decreased from an estimated 40% in 1990 to 25% in 2013 (Fig. 5). Regionally, impressive progress has been made in Asia, with a decline in the proportion of stunted children from 48% to 25% between 1990 and 2013. In Africa, there was a substantially lower decline (from 42% to 34%), and owing to population growth, the absolute number of stunted children is increasing. At present, Eastern and Western Africa and South-Central Asia...
have the highest prevalence estimates among United Nations subregions (43% in East Africa, 34% in West Africa and 35% in South-Central Asia). Oceania also has a very high rate of stunting (38% in 2013) yet contributes little in numbers affected because of its relatively small population (United Nations Children’s Fund, World Health Organization, & The World Bank 2014). Overall, while there has been progress, millions of children are still suffering from stunting’s functional consequences.

At national level, there is great variation in rates of childhood stunting. Fig. 6 maps countries according to their latest stunting prevalence estimates. Rates are categorized by degrees of severity, ranging from low (below 20%) to very high (≥40%). Extremely high levels appear in countries like Timor Leste, Burundi and Niger, with levels above 50% in most recent surveys. Other countries of sub-Saharan Africa and South-Central and South-Eastern Asia also present high or very high stunting rates.

Within countries, there are substantial inequalities between regions and population subgroups. In most countries, stunting prevalence among children younger than 5 years is about 2.5 times higher in the lowest wealth quintile compared with the highest (Black et al. 2013). Sex inequalities in child stunting tend to be substantially smaller than economic inequalities, with rates only slightly higher in boys than in girls (Black et al. 2013). Place of residence is also an important risk factor for stunting, with rates consistently higher in rural than in urban areas.

Country-specific prevalence data, disaggregated by age group, sex, urban/rural residence and region, are available from the WHO Global Database on Child Growth and Malnutrition (www.who.int/nutgrowthdb) and the UNICEF/WHO/World Bank joint child...
malnutrition estimates (http://www.who.int/nutgrowthdb/estimates2013/en/).

Consequences of stunted growth

Stunting is a syndrome where linear growth failure serves as a marker of multiple pathological disorders associated with increased morbidity and mortality, loss of physical growth potential, reduced neuro-developmental and cognitive function and an elevated risk of chronic disease in adulthood. A thorough review of the short-term and long-term consequences of stunting is beyond the scope of this paper, which will summarize only the most important ones; the reader is referred to several comprehensive reviews of this topic (Stein et al. 2005; Black et al. 2008; Victora et al. 2008; Dewey & Begum 2011; Stewart et al. 2013; Prendergast & Humphrey 2014).

Stunting is associated with increased morbidity and mortality from infections, in particular pneumonia and diarrhoea (Kossmann et al. 2000; Black et al. 2008; Olofin et al. 2013), but also sepsis, meningitis, tuberculosis and hepatitis, suggesting a generalized immune disorder in children with severely stunted growth (Olofin et al. 2013). The interplay of poor nutrition and frequent infection leads to a vicious cycle of worsening nutritional status and increasing susceptibility to infection. Infection impairs nutritional status through reduced appetite, impaired intestinal absorption, increased catabolism and direction of nutrients away from growth and towards immune response. In turn, undernutrition increases the risk of infection by its negative impact on the epithelial barrier function and altered immune response (Scrimshaw et al. 1968; Solomons 2007).

Growth failure in the first 2 years of life is associated with reduced stature in adulthood (Coly et al. 2006; Stein et al. 2010). The magnitude of growth deficits is considerable. For example, in their Senegalese study, Coly and colleagues found that the age-adjusted height deficit between stunted and non-stunted children was 6.6 cm for women and 9 cm for men (Coly et al. 2006). For women, maternal stunting is a consistent risk factor for perinatal and neonatal mortality (Lawn et al. 2005; Ozaltin et al. 2010).

Stunting has important economic consequences for both sexes at the individual, household and community level. There is a body of evidence that shows associations between shorter adult stature and labour–market
outcomes such as lower earnings and poorer productivity (Hoddinott et al. 2013). For example, it has been estimated that stunted children earn 20% less as adults (Grantham-McGregor et al. 2007) compared with non-stunted individuals, and in World Bank estimates, a 1% loss in adult height due to childhood stunting is associated with a 1.4% loss in economic productivity (World Bank 2006). Yet, for the vast majority of occupations, there is no obvious link between physical stature and productivity, and attained height is considered to act as a marker of human capital dimensions like cognitive ability, social skills attained in adolescence, schooling outcomes or general healthiness (Martorell 1996; Hoddinott et al. 2013). For example, data from the COHORTS study showed that adults who were stunted at age 2 years completed nearly 1 year less of schooling compared with non-stunted individuals (Martorell et al. 2010). In other analyses, a 1 SD increase in height at age 2 years was associated with a 24% reduced risk of non-completion of secondary school (Adair et al. 2013). The body of evidence showing that stunted children have impaired behavioural development in early life, are less likely to enrol at school or enrol late, tend to achieve lower grades, and have poorer cognitive ability than non-stunted children has been summarized elsewhere (Hoddinott et al. 2013; Prendergast & Humphrey 2014). Importantly, these damaging effects are aggravated by the interactions that fail to occur. Stunted children often exhibit delayed development of motor skills such as crawling and walking, are apathetic and display diminished exploratory behaviour, all of which reduce interaction with caregivers and the environment (Brown & Pollitt 1996).

The first 24 months of age are critical for brain development. It is known that the development and arborization of apical dendrites from the brain cortex continue post-natally and are completed around the second year of age. The few available studies concerning dendritic spine pathology in undernourished infants during the critical post-natal brain development period show that the changes comprise a shortening of the apical dendrite, a significant decrement of the number of spines and the presence of abnormal forms defined as dysplastic spines (Fig. 7) (Cordero et al. 1993; Benitez-Bribiesca et al. 1999). It is conceivable that the altered higher brain functions and varying degrees of mental retardation present in infants suffering from nutritional deprivation during early post-natal life are attributable in part to a deficient development of the dendritic spine apparatus. However, much more remains to be learned about the pathways by which undernutrition in early childhood affects brain structure and function (e.g. cognition, attention, memory, fluency, spatial navigation, locomotor skills, learning and visuospatial ability).

Lastly, stunting has also been reported to affect adult health and chronic disease risk. Studies of infants born with low birthweight have demonstrated consistent associations with elevated blood pressure, renal dysfunction and altered glucose metabolism (Huxley et al. 2000; Whincup et al. 2008). Likewise, data from the COHORTS study show that lower birthweight and greater undernutrition in childhood were risk factors for high glucose concentrations, high blood pressure and harmful lipid profiles after adjusting for adult body mass index and height (Victora et al. 2008). The evidence linking stunting with obesity risk or altered energy expenditure is mixed (Stettler 2007; Wilson et al. 2012; Adair et al. 2013). While it is unclear whether stunting may be a risk factor for obesity per se, rapid weight gain, particularly after the age of 2–3 years among individuals born small at birth, is thought to lead to a particularly high risk of chronic disease in later life (Gluckman et al. 2007).

The World Health Organization’s global target for reducing stunting by 2025

In 2012, the WHO adopted a resolution on maternal, infant and young child nutrition and agreed on a set of six global targets to hold the world accountable for reducing malnutrition (WHO 2012). Chief among these was a target to reduce by 40% the number of stunted under-5 years of age children by 2025. The stunting target was based on analyses of time series data from 148 countries and national success stories in tackling undernutrition (de Onis et al. 2013). The global target translates into a 3.9% annual reduction and implies decreasing the number of stunted children from 171 million in 2010 to about 100 million in 2025. However,
at current rates of progress, there will be 127 million stunted children by 2025, that is, 27 million more than the target or a reduction of only 26%. A full account of the rationale for the target and how it was established is provided elsewhere (de Onis et al. 2013).

For the global stunting target to be achieved, countries are expected to define how they will contribute and set their own targets. Translating the global target into individual national targets is dependent on nutrition profiles, risk factor trends, demographic changes, experience with developing and implementing nutrition policies and degree of health system development. Establishing national targets will help in developing national policies and programmes and estimating the level of resources required for their implementation. To assist this process, in 2014, WHO, UNICEF and the European Commission jointly developed a tracking tool that allows countries to explore different scenarios taking into account varying rates of progress for the target and the time left to 2025 (http://www.who.int/nutrition/trackingtool/en/). The effort required to achieve the target will be largely influenced by current trends in stunting and estimated country-specific population growth rates.

In addition to setting their own national target, a key question is what countries should do to meet the target. The comprehensive implementation plan illustrates a series of priority actions that should be jointly implemented by member states and international partners (WHO 2012). Because stunting is not treatable, it calls for preventive measures; however, it remains unclear which actions and when in the life course are the most efficacious interventions to be implemented at scale within limited development budgets. Nutrition interventions alone will be insufficient, hence the importance of ongoing efforts to foster nutrition-sensitive programmes and approaches that address the underlying determinants of malnutrition (Ruel et al. 2013) and encourage development of multisectoral plans to deal with stunting on a national scale by combining direct nutrition interventions with strategies concerning health, family planning, water supply and sanitation, and other factors that affect the risk of stunting (Casanovas et al. 2013). In support of these actions, WHO has developed a policy brief to increase awareness of and investment in a set of cost-effective interventions and policies aimed at reducing stunting among under-5 years of age children (WHO 2014a). A deliberate equity-driven approach targeting the most vulnerable populations will be an effective strategy for reducing national stunting averages. Most of the highly affected countries are characterized by inequities defined by region-specific socio-geographic contexts that call for

**Fig. 7.** Effects of undernutrition on brain development (adapted from Cordero et al. 1993).
adapted strategies, levels of effort and resources for programme implementation (WHO 2014b).

An accountability framework is being developed and surveillance systems are devised to monitor the achievement of commitments and targets (International Food Policy Research Institute 2014). The global monitoring framework on maternal, infant and young child nutrition, endorsed at the World Health Assembly in May 2014, comprises two sets of indicators: a core set to be reported by all countries and an extended set from which countries will select those indicators that suit their specific epidemiological patterns and the actions implemented in response to their priority nutrition challenges. Full details on the framework can be found at http://apps.who.int/gb/ebwha/pdf_files/WHA68/A68_9-en.pdf.

The WHO stunting target has raised the profile of nutrition and thus contributed to its positioning within the post-2015 development agenda. As the Sustainable Development Goals are discussed and established; the question arises as to what the 2025 global target for stunting would translate into if taken to 2030. To reach the 2025 global target, the annual average rate of reduction was calculated as 3.9% per year. With a concerted global effort to decrease stunting’s prevalence, such as through the SUN movement and other high-profile initiatives, it should be possible to maintain or accelerate this rate of improvement an additional 5 years. Projecting the same annual average rate of reduction of 3.9% until 2030, the estimated number of stunted children in 2030 should not exceed 86 million. This translates into roughly a 50% reduction in numbers of stunted children compared with the 2012 baseline. Major country and regional differences in the stunting burden exist, and new data on stunting reduction rates are emerging. These estimates would need to be fine-tuned accordingly.

Conclusions

Childhood stunting is the best overall indicator of children’s well-being and an accurate reflection of social inequalities. Stunting is the most prevalent form of child malnutrition, affecting millions of children globally. Despite its high prevalence and consensus regarding how to define and measure it, stunting often goes unrecognized in communities where short stature is the norm.

Growth faltering often begins in utero and continues for at least the first 2 years of post-natal life. The severe irreversible physical and neurocognitive damage that accompanies stunted growth is a major barrier to human development. Increased awareness of stunting’s magnitude and devastating consequences has resulted in its being identified as a major global health priority and the focus of international attention at the highest levels with global reduction targets set for 2025 and beyond. The challenge ahead is to prevent linear growth failure while keeping child overweight and obesity at bay.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

MdO conceptualized and wrote the paper. FB presented at the workshop and read and approved the final submission.

References


Reducing stunting by improving maternal, infant and young child nutrition in regions such as South Asia: evidence, challenges and opportunities

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Abstract

Meeting the high nutrient needs of pregnant and lactating women and their young children in regions such as South Asia is challenging because diets are dominated by staple foods with low nutrient density and poor mineral bioavailability. Gaps in nutritional adequacy in such populations probably date back to the agricultural revolution ~10 000 years ago. Options for improving diets during the first 1000 days include dietary diversification and increased intake of nutrient-rich foods, improved complementary feeding practices, micronutrient supplements and fortified foods or products specifically designed for these target groups. Evidence from intervention trials indicates that several of these strategies, both prenatal and post-natal, can have a positive impact on child growth, but results are mixed and a growth response is not always observed. Nutrition interventions, by themselves, may not result in the desired impact if the target population suffers from frequent infection, both clinical and subclinical. Further research is needed to understand the mechanisms underlying both prenatal and post-natal growth restriction. In the meantime, implementation and rigorous evaluation of integrated interventions that address the multiple causes of stunting is a high priority. These intervention packages should ideally include improved nutrition during both pregnancy and the post-natal period, prevention and control of prenatal and post-natal infection and subclinical conditions that restrict growth, care for women and children and stimulation of early child development. In regions such as South Asia, such strategies hold great promise for reducing stunting and enhancing human capital formation.

Keywords: child growth, complementary feeding, maternal nutrition, micronutrient malnutrition, nutritional interventions, stunting.

Introduction

It is widely recognized that the key ‘window of opportunity’ for reducing stunting is the ~1000 days from conception until 2 years of age (Victora et al. 2010, http://www.thousanddays.org). Assuring adequate maternal nutrition prior to conception is also likely to be important (Bhutta et al. 2013a; Prentice et al. 2013). This paper will briefly discuss the challenges to meeting nutrient needs during the first 1000 days, the various strategies that can be used to improve nutrient intake in these target groups, the evidence for an impact on linear growth or stunting from prenatal and post-natal nutrition
interventions and the need for integrated approaches that address the multifactorial etiology of stunting, with an emphasis on South Asian populations.

**Challenges to meeting nutrient needs during the first 1000 days**

Nutrient requirements are high during pregnancy and lactation because of the need to support fetal growth and production of breast milk. In comparison with a non-pregnant, non-lactating woman, energy needs are 13% higher during pregnancy and 25% higher during lactation, and protein needs are 54% higher during both periods (Institute of Medicine 2006). For several micronutrients, the relative increase in recommended intake is ≥50%, such as for folate and iron during pregnancy and for vitamin A, vitamin C, vitamin B6, iodine and zinc during lactation. This poses a challenge because women in low-income settings often have limited access to nutrient-dense foods.

Children under 2 years of age also have high nutrient needs to support growth and development. Moreover, breastfed infants typically consume relatively small amounts of foods other than breast milk (Dewey & Brown 2003). Infants need complementary foods with much higher nutrient density (amount of each nutrient per 100 kcal) than is required for adult diets. For example, per 100 kcal of complementary food, a breastfed infant at 6–8 months needs nine times as much iron and four times as much zinc as a male adult (Dewey 2013).

The greatest challenge for meeting micronutrient needs of breastfed children typically occurs during the second 6 months of life. Infants should receive the most nutrient-rich foods available in the household, yet often the opposite is the case in low-income settings where they are typically fed nutrient-poor, watery porridges. Gaps in nutrient intake at this age are generally greatest for iron and zinc (Vitta & Dewey 2013), but other nutrients may be problematic (such as calcium, vitamin A and certain B vitamins) depending on the types of foods consumed (Dewey 2013). Even if breastfed infants are given family foods that are nutritionally adequate for the rest of the household, their intake of certain key nutrients is likely to be lower than recommended (Vossenaar & Solomons 2012).

Infants are often fed cereal-based porridges as the primary complementary food, but heavy reliance on such foods is problematic for several reasons. First, the porridges prepared from cereal flours tend to be very low in energy density, so the child has to consume a large volume in order to meet energy needs. The child’s stomach capacity limits how much can be consumed in a single feeding, thus if meal frequency is low, the ‘bulkiness’ of cereal-based diets can be a limiting factor (Dewey & Brown 2003). Second, if the infant consumes a typical amount of porridge (100–200 kcal day⁻¹), the amounts of other nutrient-rich foods that can be consumed are limited because total energy needs from complementary foods are

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**Key messages**

- Meeting the high nutrient needs of pregnant and lactating women and their young children in regions such as South Asia is challenging because diets are dominated by staple foods with low nutrient density and poor mineral bioavailability.
- Gaps in nutritional adequacy in such populations probably date back to the agricultural revolution ~10 000 years ago.
- Options for improving diets during the first 1000 days include dietary diversification and increased intake of nutrient-rich foods, improved complementary feeding practices, micronutrient supplements and fortified foods or products specifically designed for these target groups.
- Evidence from intervention trials indicates that several of these strategies, both prenatal and post-natal, can have a positive impact on child growth. However, there is considerable heterogeneity in growth response to such interventions.
- Nutrition interventions should cover both pregnancy and the post-natal period and are likely to have a greater impact on child growth if they are delivered as part of a package that addresses the multiple causes of stunting, including prevention and control of prenatal and post-natal infection and subclinical conditions that restrict growth, care for women and children and stimulation of early child development.
only 200–300 kcal day\(^{-1}\) at 6–12 months. Last, the inhibition of iron and zinc absorption by phytate in cereal-based diets makes it difficult to meet requirements for those nutrients, which are high during infancy.

The challenges described earlier have affected human populations for thousands of years, ever since the agricultural revolution when farming became the principal means by which food was procured, rather than hunting and gathering wild foods. Estimates based on presumed food intake of hunter-gatherers suggest that diets before the agricultural revolution ~10 000 years ago were much higher in many nutrients than modern diets (Eaton & Eaton 2000). Pre-agricultural humans consumed a wide variety of animal-source foods and wild plant foods, while cereal grains and legumes were minor parts of the diet. Estimates of the nutrient intakes of infants and young children in pre-agricultural societies, based on breast milk and premasticated foods provided by their mothers, suggest that the typical pre-agricultural diet was probably more than adequate to meet nutrient requirements (Dewey 2013). The agricultural revolution resulted in a dramatic shift in human diets towards consumption of cereal grains and other starchy foods, which was accompanied by a deterioration in nutritional status in many populations and a reduction in average adult height. In high-income countries, average height has increased over the past ~100 years in parallel with improved nutrition (e.g. increased consumption of animal-source foods) and reduced infectious disease. In low-income populations, however, stunting in height remains widespread.

In South Asia, children’s diets are very poor. For example, in Afghanistan, Bangladesh, India, Nepal and Pakistan, the proportion of children 6–24 months old who are fed even a minimally adequate diet ranges from 12% in Afghanistan to 24% in Nepal (Afghanistan Ministry of Public Health & UNICEF 2013; NIPORT et al. 2015; Ministry of Women and Child Development (MWCD) 2015; Ministry of Health and Population (MOHP), New ERA, and ICF International 2012; NIPS & ICF International 2013). Low dietary diversity is a major reason for this situation. The latest surveys in these countries indicate that less than 30% of children in this age group were fed foods from at least four of the seven key food groups the day prior to the survey. Correspondingly, the prevalence of stunting among children under 5 years in this region is very high, 38% (UNICEF 2015).

**Strategies to meet nutrient needs during the first 1000 days**

The most common options for meeting nutrient needs of pregnant and lactating women in lower-income populations include dietary diversification and selection of nutrient-rich foods, fortification or biofortification of staple foods, supplementation with multiple micronutrients and use of fortified food products specifically designed for this target group. Dietary diversification and increased consumption of nutrient-rich foods is the primary long-term goal, but this requires resolving barriers posed by limited access and high cost of such foods. Even with a relatively diverse diet, it may still be difficult to meet iron needs in pregnancy. Thus, other strategies have been implemented to help close the nutrient gaps for pregnant and lactating women. One option is fortification or biofortification of staple foods, which can increase intake of certain key nutrients such as iron, zinc and vitamin A. Another option is multiple micronutrient supplementation, which has been extensively evaluated for pregnant women. A third option is promotion of fortified food products that are designed for pregnant and lactating women and contain both micronutrients and macronutrients, thus providing essential fatty acids and high-quality protein in addition to vitamins and minerals.

There are also several options for meeting nutrient needs of breastfed infants and children during the period of complementary feeding (6–24 months). Again, dietary diversification and selection of nutrient-rich complementary foods is the main long-term goal, but access and cost are often barriers, and it is challenging to meet iron needs even with a relatively diverse diet (Vitta & Dewey 2012). For infants and young children, fortification of staple foods that are consumed by the general population (e.g. wheat
flour, maize and rice) is unlikely to close a significant portion of the ‘gap’ in micronutrient intake from complementary foods (particularly for iron and zinc), because children under 2 years typically eat very small quantities. For this reason, specialized products targeted at infants and young children have been developed.

Fortified products for complementary feeding have been categorized into three general types (Dewey & Vitta 2013): (1) fortified blended foods; (2) micronutrient powders; and (3) complementary food supplements. Fortified blended foods are typically made from cereals, legumes and sugar or oil and fortified with certain micronutrients. When pre-cooked, they are convenient because they require little preparation time. In addition, the use of central processing facilitates quality control. The main disadvantages of fortified blended foods are that (1) it is difficult to ensure adequate micronutrient intake from such products because of the large variability in the amount of product consumed (Dewey 2003), (2) the daily ration of such products usually provides a relatively large amount of energy (e.g. 200 kcal day$^{-1}$), which may displace breast milk, and (3) over-reliance on a single food may reduce dietary diversity and limit intake of animal-source foods, fruits and vegetables. In part to overcome these disadvantages, micronutrient powders and complementary food supplements have been developed. Micronutrient powders usually contain only vitamins and minerals and are used for home fortification of traditional infant foods. Adding micronutrient powders to complementary foods just before a feeding ensures that the child receives a full daily dose of micronutrients with no nutrient losses due to cooking. Because these products usually contain little or no energy, they will not displace breast milk or other foods, and they are generally less expensive than food-based options. The disadvantages of micronutrient powders are that it is difficult to include all of the essential nutrients without splitting the sachet into two portions per day, and they generally do not increase energy, fat or fatty acid, or protein content of the diet. In addition, strong communication strategies may be needed to ensure long-term adherence and compliance with instructions (e.g. mixing the powder with the first portion of food offered so the full dose is consumed). Complementary food supplements are fortified food-based products to be added to other foods (i.e. for home fortification) or eaten alone to improve both macronutrient and micronutrient intake, such as small-quantity (e.g. 20 g day$^{-1}$) lipid-based nutrient supplements (LNS) and fortified full-fat soy flour (e.g. Ying Yang Bao (Sun et al. 2011)). These products can provide essential fatty acids, micronutrients, macrominerals and high-quality protein (usually from powdered milk), depending on the formulation. As with micronutrient powders, complementary food supplements provide the full intended dose of key nutrients regardless of the amount of staple food typically consumed, and there is no loss in nutrient content due to cooking. Because the energy content is relatively low, these products are unlikely to displace breast milk. However, complementary food supplements are usually more expensive than micronutrient powders, so it is important to evaluate whether the potential benefits of increased energy density, essential fatty acid content and protein content of complementary foods are important in the target population.

**Impact of prenatal nutrition interventions**

In low-income and middle-income countries, ~20% of stunting in children under 5 years of age is attributable to small size at birth (Christian et al. 2013), although this percentage will likely vary considerably across populations. Thus, it is critical to understand the potential impact of prenatal nutrition interventions on fetal linear growth and newborn stunting. Unfortunately, many studies have reported only birth weight, not length, so the evidence to directly evaluate this question is sparse.

Girard & Olude recently evaluated the impact of nutrition education and counselling during pregnancy on birth weight and other pregnancy outcomes (Girard & Olude 2012). In a meta-analysis of 13 studies, there was an increase in mean birth weight (+105 g), but this was significant only when nutrition education/counseling was coupled with nutrition support in the form of food supplements, micronutrient supplements or nutrition safety net interventions. The authors did not report on birth length.
Numerous trials have examined the effect on birth outcomes of prenatal multiple micronutrient (MMN) supplementation, and results have been summarized in two meta-analyses (Fall et al. 2009; Ramakrishnan et al. 2012). In the first meta-analysis (Fall et al. 2009), there was a small but significant effect on mean birth weight (+2.2 g) and an 11–17% reduction in the incidence of low birth weight (<2500 g) but no significant effect on birth length (+0.06 cm). In the second meta-analysis (Ramakrishnan et al. 2012), there was a significant (+5.3 g) effect on mean birth weight and a 14% reduction in low birth weight; data on birth length were not presented. Results from a recent large trial of MMN supplementation in rural Bangladesh (n = 285,16 live-born infants; West et al. 2014) were very similar to the estimates from the 2012 meta-analysis: a significant (+5.4 g) effect on mean birth weight, a 12% reduction in low birth weight and a small (+0.2 cm) but significant effect on birth length. In all of these trials, the effect of MMN supplementation may have been underestimated because the control group usually received iron and folic acid tablets, which may also have had an impact on fetal growth (Imdad & Bhutta 2012a).

Balanced energy–protein supplementation of pregnant women is another intervention strategy that has been evaluated in several populations. In a meta-analysis published in 2003 (Kramer & Kakuma 2003), there was a significant effect on mean birth weight (+38 g) but not birth length (+0.1 cm). In an updated meta-analysis in 2012 (Imdad & Bhutta 2012b), the increase in mean birth weight was somewhat larger (+73 g) and there was a 32% reduction in low birth weight; data on birth length were not reported.

There have been only a few evaluations of fortified food products specifically designed for pregnant and/or lactating women. Three studies to date have reported the impact of LNS designed for this target group. One was a trial comparing medium-quantity LNS (373 kcal day$^{-1}$) with MMN tablets, both given prenatally (n = 1296) (Huybregts et al. 2009). While the difference in birth weight between groups was not significant (+3.1 g, P = 0.2), birth length was significantly greater in the LNS group (+0.46 cm, P = 0.001). The same research group previously showed that MMN (vs. the control) increased birth length by 0.36 cm (Roberfroid et al. 2008); thus, the total predicted impact of LNS vs. control would be 0.46 + 0.36 = 0.82 cm. The effect on birth length of LNS vs. MMN was greater in higher-risk mothers [those with body mass index (BMI) < 18.5 kg m$^{-2}$ and those with anaemia at baseline]. Two studies have examined the effect on birth outcomes of small-quantity LNS (118 kcal day$^{-1}$) compared with MMN tablets or iron and folic acid (Adu-Afarwuah et al. 2015; Ashorn et al. 2015). In Ghana (Adu-Afarwuah et al. 2015), there was a significant (+8.5 g) difference in birth weight compared with the iron and folic acid group, but the difference in birth length was not significant in the study group as a whole. However, among first-time mothers (who had lower BMI and were more likely to be anaemic and have malaria at baseline than multiparous women), infants in the LNS group had greater birth length (+0.91 cm), head circumference (+0.5 cm) and birth weight (+2.37 g) compared with the iron and folic acid group; similar differences were found when comparing the LNS and MMN groups among first-time mothers. In Malawi, there were no significant intervention group differences in birth size except for arm circumference (which was larger in the LNS group), but among women with educational levels below the median (<4 years), the proportion of infants with newborn stunting was significantly lower in the MMN (10.3%) and LNS (14.9%) groups than in the iron and folic acid group (22.5%).

In a recent cluster-randomized effectiveness trial (the Rang-Din Nutrition Study, clinicaltrials.gov NCT01715038) conducted within a community health program in rural Bangladesh, 4011 pregnant women were randomly assigned to receive small-quantity LNS or iron and folic acid during pregnancy (Mridha et al. 2016). There was a significant effect of LNS on mean birth weight (+41 g) and birth length (+0.2 cm) and a reduction in the percentage of infants who were stunted at birth (18.6% vs. 22.6%) and who had a head circumference z-score $<-2$ at birth (20.5% vs. 24.9%). The effects of LNS on newborn stunting were greatest in infants born before a 10-week interruption in LNS distribution (16.1% vs. 23.0%) and in infants born to women $<24$ years of age or with household food insecurity.
All four of the aforementioned trials using LNS have demonstrated heterogeneity in response, with greater impact seen in more vulnerable women. This is important with regard to the potential for targeting of prenatal nutrition interventions to women who are most likely to benefit.

There is considerable interest in whether nutrition interventions that begin before conception have a larger impact than interventions that begin during pregnancy, given that many women in lower-income countries do not seek antenatal care until the second trimester or later. Although several such trials are underway, few published data are available. Results from the Mumbai Maternal Nutrition Project were recently published (Potdar et al. 2014). In this randomly controlled efficacy trial, all women were scheduled to receive a daily snack beginning at least 3 months prior to pregnancy and continuing until delivery; the intervention group received snacks (164 kcal day\(^{-1}\)) that included green leafy vegetables, fruit and milk and contributed 10–23% of the recommended intakes for six micronutrients, whereas the control group received snacks made from low-micronutrient foods (potato and onion; 88 kcal day\(^{-1}\)). In total, 6513 women were enrolled, of whom 2291 became pregnant; newborn measurements were available for 1360 infants. There was no overall effect on birth weight (+26 g, \(P=0.22\)) or length (data not shown) in the sample as a whole, but among those who actually started supplementation at least 3 months before pregnancy, there was a significant effect on birth weight (+48 g) and percentage with low birth weight (34% vs. 41%). Contrary to expectations, these effects were seen only in women with higher BMI at enrollment (\(\geq 18.6 \text{ kg m}^{-2}\)) and not in underweight women. Additional evidence on interventions that begin pre-conception is needed before any conclusions can be drawn regarding programmatic implications.

**Impact of post-natal nutrition interventions**

There are two key periods during the post-natal ‘window of opportunity’: 0–5.9 months, when exclusive breastfeeding is recommended, and 6–23.9 months, when interventions to improve complementary feeding are usually implemented. Although exclusive breastfeeding during the first 6 months has a significant impact on infant morbidity and survival, there is little evidence to date of an impact on stunting when considering evidence from randomized trials to promote exclusive breastfeeding (Bhutta et al. 2008; Black et al. 2013). However, a significant effect on linear growth may be difficult to detect unless the study population has a high rate of infection in early life, when exclusive breastfeeding may promote growth by reducing infection. Some observational studies support this linkage (e.g. Engebretsen et al. 2008), but it is difficult to rule out reverse causation (i.e. that sicker infants are more likely to be supplemented with non-breast milk fluids or foods). Because there is insufficient evidence to evaluate the impact of exclusive breastfeeding during the first 6 months on stunting, the remainder of this section will focus on complementary feeding interventions.

Overall, complementary feeding interventions have strong potential for a major impact on stunting, but the evidence to date is mixed (Bhutta et al. 2013; Dewey & Adu-Afarwuah 2008).

Educational interventions to improve complementary feeding practices are often effective at changing behaviours, but most have shown either no impact or only a modest effect on linear growth (Dewey & Adu-Afarwuah 2008). An exception was a cluster-randomized trial conducted in Peru (Penny et al. 2005) in which stunting at 18 months of age was 5% in the intervention group, compared with 15% in the control group. That trial emphasized three key messages, one of which was consumption of nutrient-rich animal-source foods, and the study was conducted in a population where animal-source foods were available and affordable. Two other studies, in China (Shi et al. 2010) and in India (Vazir et al. 2013), have also demonstrated the potential to reduce stunting via educational approaches emphasizing dietary diversity and consumption of animal-source foods, although in both cases, the impact on linear growth was quite small.

The cluster-randomized trial in India (Vazir et al. 2013), conducted in Andhra Pradesh, is worth highlighting because it included education on both nutrition and child development. There were three intervention
groups (n = 200 mother–infant pairs per group): (1) control [routine Integrated Child Development Services (ICDS)]; (2) ICDS plus 11 messages on breastfeeding and complementary feeding (CF group); and (3) ICDS plus 11 messages on breastfeeding and complementary feeding and additional education and play groups for responsive feeding and psychosocial stimulation (RCF&PG group, 27 messages in total). Both intervention groups received bi-weekly visits by trained village women for 12 months, when infants were between 3 and 15 months of age. Infants in the CF group (but not the RCF&PG group) had greater length gain than infants in the control group, but the differences in stunting at 15 months were not significant (37% vs. 28% vs. 36% in control, CF and RCF&PG, respectively). The mental development score at 15 months was higher in RCF&PG children than in control children (+3.1 points). The authors observed that micronutrient intakes were low in all groups, despite increases in energy and protein from complementary foods in the intervention groups. This situation, plus the possibility that the number of messages in the RCF&PG may have been overwhelming, may account for the lack of growth response in the RCF&PG group.

In some populations, low energy density of complementary foods may limit energy intake. Interventions to increase the energy density of complementary foods have yielded mixed results. Of five studies previously reviewed (Dewey & Adu-Afarwuah 2008), two had a positive impact on linear growth but three had no impact on energy intake or growth. Increased energy density may be effective when the traditional complementary food has a low energy density and infants are unable to compensate by increasing the volume of food consumed or feeding frequency, but otherwise, this strategy is not likely to affect growth.

Fortification of complementary foods with micronutrients via central processing or home fortification strategies (such as micronutrient powders), without any additional macronutrients (energy, protein or fat), has generally not affected linear growth (Dewey & Adu-Afarwuah 2008, Ouédraogo et al. 2010, CIGNIS Study Team 2010, De-Regil et al. 2011). Similarly, strategies to increase bioavailability of key nutrients such as iron and zinc have generally failed to reduce stunting (Mamiro et al. 2004; Mazariegos et al. 2010). One exception is a randomized trial conducted in India (Dhingra et al. 2004) where milk powder (fortified or unfortified) was given for 1 year to 465 children whose average age was 23 months. The group given the fortified milk had significantly less morbidity and greater weight and height gain than the group given unfortified milk. In this trial, the use of milk powder as the food vehicle for the extra nutrients may have increased the likelihood of a positive growth response to a fortified product, because milk supplies substantial amounts of growth-promoting macronutrients and does not contain ‘anti-nutrients’ such as phytic acid (which can interfere with absorption of critical nutrients).

Numerous interventions have included the provision of complementary foods or a food product offering extra energy (with or without added micronutrients), alone or in combination with some other strategy such as education for caregivers. Some, but not all, of these interventions have had a positive impact on linear growth (Dewey & Adu-Afarwuah 2008). There has been a wide range of impact, from trivial to relatively large, which may reflect variations in the target populations’ food security and the nutrient quality of the food provided. Three studies have directly compared provision of food coupled with an educational intervention vs. education only (Bhandari et al. 2001; Roy et al. 2005; Christian et al. 2015). All were conducted in South Asia, and in all cases, there was a greater impact when the package included food.

The need for integrated approaches

It is becoming increasingly evident that nutrition interventions, by themselves, may not result in the desired impact if the target population suffers from frequent infection, both clinical and subclinical (i.e. asymptomatic). It is well known that infections can cause linear growth retardation, but subclinical conditions such as environmental enteric dysfunction, inflammation and other physiological responses to environmental insults (including mycotoxins and household air pollution) are likely to be far more common than clinically obvious infections and may account for a large proportion...
of stunting (Dewey & Mayers 2011; Khlangwiset et al. 2011; Smith et al. 2011; Prendergast & Kelly 2012; Smith et al. 2012). Research studies are uncovering the mechanisms by which these conditions adversely affect linear growth – both in utero and post-natally. Meanwhile, the reduction of stunting requires strategies to prevent and manage infection and to reduce exposure to the putative causative agents of subclinical conditions that impair growth. It is likely that the combination of these strategies with appropriate nutrition interventions will be most effective, as adequate nutrition can reduce the negative impact of infections on growth by strengthening the immune system, providing extra amounts of nutrients to compensate for effects of infection and allow for catch-up growth, preventing poor appetite caused by nutrient deficiencies, and favouring the growth of beneficial bacteria in the gut that enhance gut function and immune defences (Dewey & Mayers 2011).

A few large-scale trials are underway that combine nutrition and infection control. These include the WASH Benefits Trial (water, sanitation and hygiene interventions: singly, combined or in combination with nutrition interventions – http://www.washbenefits.net/) in Bangladesh and Kenya and the Sanitation, Hygiene, Infant Nutrition Efficacy Project in Zimbabwe (independent and combined effects of improved water, sanitation and hygiene and improved infant feeding http://www.sdc.admin.ch/en/Home/Projects/Project_Detail?projectdbID=218331). Both trials target mainly the post-natal period. Encouraging results were recently published from a cluster-randomized trial in Burkina Faso in which the intervention group received a ‘package’ that included provision of small-quantity LNS to infants between 9 and 18 months of age together with weekly home visits that included morbidity surveillance and treatment of diarrhoea and malaria (Hess et al. 2015). There was a 25% reduction in prevalence of stunting at 18 months (29% vs. 39% in intervention vs. non-intervention children) and significant positive effects on motor, language and personal–social development.

Enhancing child development, not just physical growth, should be an integral part of strategies to reduce stunting and its longer-term sequelae with regard to human capital (Hoddinott et al. 2013). Integrated interventions that include components to improve early child development via psychosocial stimulation, responsive feeding and care for mothers and children may result in a larger impact on growth and behavioural development than would be expected from single interventions (WHO 1999; Yousafzai et al. 2013). Thus, the ideal package would combine improved nutrition, infection control (including WASH) and interventions to enhance child development and would tackle the entire ‘window of opportunity’, i.e. both the prenatal and post-natal periods. To date, this type of comprehensive approach has not yet been attempted in efficacy or effectiveness trials.

Summary and conclusions

In regions such as South Asia, meeting nutrient needs during the first 1000 days is a major challenge. Pregnant and lactating women and their young children need diets with high micronutrient density, but in low-income populations, intakes are usually well below recommended amounts for several key nutrients because diets are dominated by staple foods with low nutrient density and poor mineral bioavailability. Gaps in nutritional adequacy in such populations probably date back to the agricultural revolution ~10 000 years ago. Prior to that time, stunting was less common and intakes of key nutrients were likely considerably higher than observed today. For modern populations relying on predominantly cereal-based diets, nutrient deficiencies and stunting are widespread.

Several options for improving diets of pregnant and lactating women and their infants exist, including dietary diversification and increased intake of nutrient-rich foods, improved complementary feeding practices, micronutrient supplements and fortified foods or products specifically designed for these target groups. Evidence from intervention trials indicates that several of these strategies, both prenatal and post-natal, can have a positive impact on child growth. However, there is considerable heterogeneity in growth response to such interventions, which is likely to be related to the potential to benefit (i.e. is the population malnourished?) as well as the
potential to respond (i.e. are there other factors constraining the ability to increase linear growth?) to improved nutrition.

Thus, to design effective strategies to reduce stunting, we need to better understand the mechanisms underlying both prenatal and post-natal growth restrictions. In particular, research is needed to examine the consequences of clinical and subclinical infection and inflammation, the role of the microbiome, the impact of environmental contaminants (e.g. aflatoxin and household air pollution), the importance of specific nutrients required for lean body mass deposition and other food constituents, the influence of maternal mental health and caregiver behaviours, and the long-term effects of prenatal nutrition and epigenetic influences on growth and development of offspring.

Meanwhile, there are several policy and programmatic implications of the evidence available to date. First, because a considerable proportion of stunting occurs before birth, nutrition interventions should cover both pregnancy and the post-natal period. Second, nutrition interventions are likely to have a greater impact on growth if they are delivered as part of a package of interventions that address the multiple causes of stunting. This means that attention should be paid to prevention and control of prenatal and post-natal infection and subclinical conditions that restrict growth, care for women and children, and stimulation of early child development. This is particularly relevant for South Asia, where it is common for women to be poorly nourished both prior to and during pregnancy, poor hygiene and sanitation are widespread problems, and the prevalence of child stunting is very high. These conditions, combined with the large population of the region, mean that efforts to reduce stunting globally must include an emphasis on South Asia. Integrated interventions that simultaneously address all of these factors hold great promise for reducing stunting and enhancing human capital formation in this region and elsewhere.

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**References**


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Feeding practices for infants and young children during and after common illness. Evidence from South Asia

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Abstract

Global evidence shows that children’s growth deteriorates rapidly during/after illness if foods and feeding practices do not meet the additional nutrient requirements associated with illness/convalescence. To inform policies and programmes, we conducted a review of the literature published from 1990 to 2014 to document how children 0–23 months old are fed during/after common childhood illnesses. The review indicates that infant and young child feeding (IYCF) during common childhood illnesses is far from optimal. When sick, most children continue to be breastfed, but few are breastfed more frequently, as recommended. Restriction/withdrawal of complementary foods during illness is frequent because of children’s anorexia (perceived/real), poor awareness of caregivers’ about the feeding needs of sick children, traditional beliefs/behaviours and/or suboptimal counselling and support by health workers. As a result, many children are fed lower quantities of complementary foods and/or are fed less frequently when they are sick. Mothers/caregivers often turn to family/community elders and traditional/non-qualified practitioners to seek advice on how to feed their sick children. Thus, traditional beliefs and behaviours guide the use of ‘special’ feeding practices, foods and diets for sick children. A significant proportion of mothers/caregivers turn to the primary health care system for support but receive little or no advice. Building the knowledge, skills and capacity of community health workers and primary health care practitioners to provide mothers/caregivers with accurate and timely information, counselling and support on IYCF during and after common childhood illnesses, combined with large-scale communication programmes to address traditional beliefs and norms that may be harmful, is an urgent priority to reduce the high burden of child stunting in South Asia.

Keywords: child feeding, common childhood illnesses, diarrhoea, pneumonia, South Asia.

Introduction

About a quarter (26%) of the world’s children under five live in South Asia. Thirty-eight per cent of them have stunted growth (UNICEF 2015). Stunting, or linear growth retardation during early childhood, is an outcome of biological and/or psychosocial deprivation (Stewart et al. 2013). The short-term and long-term consequences of stunting include impaired survival, physical growth and cognitive development in preschool age children; poor school readiness, school enrolment and learning outcomes in school-age children; increased risk of obstetric complications and mortality in women; and reduced height, productivity and earnings in adults (Grantham-McGregor et al. 2007; Walker et al. 2007; de Onis et al. 2013).

A significant proportion of stunting can happen prenatally. However, evidence indicates that most stunting in low-income and middle-income countries occurs during the first 24 months of life as a result of suboptimal breastfeeding and complementary feeding practices, often in combination with recurrent infections (Stewart et al. 2013; Jones et al. 2014). Furthermore, children’s nutritional status can deteriorate rapidly during/after illness if the additional nutrient requirements associated with illness/convalescence are not
met and nutrients are diverted from growth and development towards the immune response. Children’s poor appetite induced by illness can contribute to perpetuate the vicious cycle of infection and stunting (Brown 2003; Ramachandran & Gopalan 2009; Gulati 2010; Neumann et al. 2012; Richard et al. 2014). Additionally, in low-income and middle-income countries, infant and young child feeding (IYCF) practices during and after common childhood illnesses can be particularly poor owing to harmful traditional practices and the low coverage/quality of primary health care services (Bhutta & Salam 2012; de Onis et al. 2012; Stewart et al. 2013).

Recognizing the importance of optimal IYCF practices for child survival, growth and development, the World Health Organization (WHO) launched in 2003 the Global Strategy for Infant and Young Child Feeding and issued in 2003 the Guiding Principles for Complementary Feeding of Breastfed and Non-Breastfed Children (WHO/UNICEF 2003; WHO 2003a,b). These global frameworks highlight the importance of optimal IYCF practices during and after common childhood illnesses such as diarrhoea and pneumonia and emphasize the need to increase fluid intake during illness while feeding is maintained and increase food intake during convalescence. In addition, appropriate IYCF during and after illness is part of the WHO-led Global Strategy for the Integrated Management of Childhood Illnesses (WHO 2005). The definition and measurement of the indicators for assessing IYCF practices – beyond the scope of this paper – are comprehensively detailed elsewhere (WHO 2008, 2010).

In South Asia, breastfeeding is a quasi-universal practice. An estimated 96% of children are breastfed at some point in their lives, and most (80%) continue to be breastfed at 2 years of age (Dibbly et al. 2010; UNICEF 2015). However, data from household surveys across the region indicate that the majority of South Asian children are not fed as per the internationally agreed upon recommendations: only a quarter (27%) of newborns start breastfeeding within 1 h of birth; less than half (48%) of infants 0–5 months old are exclusively breastfed; only about half (56%) of infants 6–8 month olds are fed soft, semi-solid or solid foods; and a mere 21% of children 6–23 months old are fed a diet that meets the minimum requirements in terms of feeding frequency and diet diversity (Senarath et al. 2012; UNICEF 2015). In view of this situation, researchers and practitioners have not hesitated to refer to IYCF in South Asia as a crisis (Memon 2012). There is evidence that the incidence and severity of common childhood diseases are high in this region (Walker et al. 2013). However, less is known about IYCF practices during and after common childhood illnesses in South Asia.

For the purpose of this paper, South Asia refers to the eight member countries of the South Asia Association for Regional Cooperation, namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

Key messages

- Information on infant and young child feeding (IYCF) behaviours and practices during common childhood illnesses in South Asia is limited. Information of IYCF after illnesses is virtually inexistent. The evidence available indicates that IYCF practices during common childhood illnesses are far from optimal.
- When sick, most children (up to 98%) continue to be breastfed although a significant proportion (up to 49%) is breastfed less frequently than usual. Few sick children (<20%) are breastfed more frequently than usual, as is recommended, to compensate for the additional fluid and nutrient requirements associated with illnesses.
- When sick, many children (up to 75%) see their complementary foods restricted in frequency, quantity and/or quality owing to children’s anorexia (perceived or real), lack of awareness of caregivers’ about the feeding needs of sick children, traditional beliefs or suboptimal counselling and support by health workers.
- In general, health providers do not advise mothers to increase breastfeeding frequency while encouraging sick children to eat soft, varied and favourite foods during illness, as is recommended. Important policy, programme and capacity gaps exist with respect to IYCF for children during and after common childhood illnesses in many South Asian countries.
Thus, the objective of this paper is threefold: (1) document the current IYCF practices during and after common childhood illnesses – particularly diarrhoea, fever and pneumonia – and their trends since 1990 in South Asia; (2) document caregiver’s behaviours and health providers’ practices with respect to IYCF during and after common childhood illnesses in South Asia; and in light of the preceding objectives, (3) identify priorities in terms of policy formulation, programme design, research and advocacy to protect, promote and support optimal IYCF practices during and after common childhood illnesses in South Asia post 2015.

**Methods**

We reviewed data and information from two primary sources: Demographic Health Surveys (DHS) and peer-reviewed publications. DHS collects information on care-seeking and care-giving practices during diarrhoea, fever and pneumonia using standardized sampling methodologies, interview tools and data analyses procedures, with minor country-specific adaptations. We reviewed the national DHS surveys conducted in South Asia between 1990 and 2014 to document the prevalence of common childhood illnesses – diarrhoea, fever and pneumonia – in children 0–23 months old, the frequency and type of medical advice that caregivers sought, the type of treatment and/or advice that children received and how children were fed during common childhood illnesses. For countries with two data points, trends in IYCF practices during and after common childhood illness were estimated as well as the average annual rate of improvement to quantify the average improvement in a given indicator per year between the base year and end year.

We also conducted a comprehensive review of the peer-reviewed literature published between January 1990 and December 2014. Peer-reviewed articles were identified through an online PubMed search using the following search terms and search filters: (1) search terms: <feeding>, <sick>, <morbidity>, <pneumonia>, <diarrhea/diarrhoea> and <IMCI/IMNCI>, each term combined with <Afghanistan>, <Bangladesh>, <Bhutan>, <India>, <Maldives>, <Nepal>, <Pakistan>, <Sri Lanka> and/or <Asia>; (2) search filters: age <child 0–59 months>; language: <English>; text availability: <abstract>; species :<human>; and search fields: <title/abstract>. Although children 0–23 months old are the focus of our analysis, we expanded our ‘child age’ search criteria to 0–59 months to capture additional publications that, while focusing on ‘children under five’ or ‘preschool-age children’, also address IYCF practices in the first 2 years of life.

The PubMed search identified 367 publications with one or more of the search terms in the title and/or abstract. In-depth scrutiny of the titles excluded 158 publications as not relevant to our review and identified 209 as potentially relevant. In-depth scrutiny of the abstracts of these 209 publications excluded 126 as not relevant to our review and identified 83 as likely relevant. Lastly, full-text scrutiny of these 83 publications excluded 54 as not relevant to our review and identified 29 articles that were relevant to our review. In addition, we reviewed the bibliographic references of these 29 papers to identify any additional publication that could have been missed by our online search and found three additional publications that were relevant to our analysis. Hence, 32 publications were included in our analysis as they focused specifically on IYCF practices during diarrhoea, fever and/or pneumonia in South Asian countries (Fig. 1).

In addition, we conducted interviews with 13 key informants. The purpose of the key informant interviews was not to collect key informants’ views, opinions or recommendations but rather to help the authors of the paper identify the existing national policies, guidelines and programmes related to IYCF during and after common childhood illnesses in the eight countries included in the analysis. In the five large countries (Afghanistan, Bangladesh, India, Nepal and Pakistan), we interviewed two UNICEF staff by country, namely the Chief of Health and the Chief of Nutrition, while in the three smaller countries (Bhutan, Maldives and Sri Lanka), we interviewed one UNICEF staff per country, namely the Chief of the Health and Nutrition programme. This made a total of 13 key informants who in turn consulted with relevant national counterparts to complete the information-gathering process.
Findings

Household survey evidence on infant and young child feeding and care practices during and after illness

Six countries – Bangladesh, India, Maldives, Nepal, Pakistan and Sri Lanka – had at least one DHS survey that included information on common childhood illnesses and IYCF practices (Afghanistan’s 2010 DHS did not include data collection on child morbidity, and no DHS survey was available for Bhutan). DHS survey data indicate that in the countries included in the analysis, children 0–23 months old suffer from common childhood illnesses frequently. Up to 20–30% of the mothers/caregivers interviewed reported that their children had suffered from diarrhoea or pneumonia in the 2 weeks prior to the survey. The prevalence of common childhood illnesses – diarrhoea, fever and pneumonia – was highest in Pakistan. In all countries, the prevalence of fever was higher than the prevalence of diarrhoea or pneumonia. Similarly, in all countries, the prevalence of common childhood illnesses was lowest during the exclusive breastfeeding period (0–5 months) and highest during the early complementary feeding period (6–11 months) (Table 1).
The proportion of caregivers who sought medical advice in the event of diarrhoea was highest in India and Pakistan (>60%); the proportion of caregivers who sought medical advice in the event of fever was highest in Maldives and Sri Lanka (>80%); lastly, the proportion of caregivers who sought medical advice in the event of pneumonia was highest in India and Pakistan (>65%). The lowest proportion of caregivers seeking medical advice for common childhood illnesses was recorded in Bangladesh (30.1%, 31.4% and 41.4% for diarrhoea, fever and pneumonia, respectively (Table 2).

Data on the type of treatment/care provided to children 0–23 months old who experienced diarrhoea, fever or pneumonia in the 2 weeks preceding the survey and for whom advice or treatment was sought from a health facility or health provider were available for Bangladesh, India, Nepal and Pakistan. The proportion of children who received oral rehydration solutions (ORS) or increased fluids was highest in Bangladesh (>75%) and lowest in India (<20%) (Table 3). Similarly, the proportion of children who received antibiotic therapy for the treatment of fever and pneumonia was highest in Bangladesh (>66%) and lowest in India (<15%) (Table 4).

In these four countries – Bangladesh, India, Nepal and Pakistan – DHS information on IYCF practices during/after common childhood illnesses focused only on feeding practices during diarrhoea (Table 5). No information was available on IYCF practices when children had fever or pneumonia or after episodes of diarrhoea, fever or pneumonia. The proportion of

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**Table 1.** Number and percentage of children 0–23 months old who experienced diarrhoea, fever or pneumonia in the 2 weeks preceding the survey (South Asia, Demographic and Health Surveys)

<table>
<thead>
<tr>
<th>Country</th>
<th>0–5 months</th>
<th>6–11 months</th>
<th>12–23 months</th>
<th>0–23 months</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bangladesh, 2011</strong></td>
<td>816</td>
<td>864</td>
<td>1547</td>
<td>3227</td>
</tr>
<tr>
<td><strong>India, 2006</strong></td>
<td>5127</td>
<td>5276</td>
<td>10419</td>
<td>20822</td>
</tr>
<tr>
<td><strong>Maldives, 2009</strong></td>
<td>406</td>
<td>441</td>
<td>822</td>
<td>1669</td>
</tr>
<tr>
<td><strong>Nepal, 2011</strong></td>
<td>531</td>
<td>491</td>
<td>1000</td>
<td>2022</td>
</tr>
<tr>
<td><strong>Pakistan, 2012</strong></td>
<td>1164</td>
<td>1024</td>
<td>2074</td>
<td>4262</td>
</tr>
<tr>
<td><strong>Sri Lanka, 2007</strong></td>
<td>634</td>
<td>739</td>
<td>1438</td>
<td>2811</td>
</tr>
</tbody>
</table>

Table 2. Among children 0–23 months old who experienced diarrhoea, fever or pneumonia in the 2 weeks preceding the survey, number and percentage for whom advice/treatment was sought from a health facility or health provider (South Asia, Demographic and Health Surveys)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5 months</td>
<td>25 (43.6)</td>
<td>542 (57.1)</td>
<td>—</td>
<td>68 (32.6)</td>
<td>300 (60.0)</td>
<td>—</td>
</tr>
<tr>
<td>6–11 months</td>
<td>73 (30.1)</td>
<td>956 (60.3)</td>
<td>—</td>
<td>118 (41.6)</td>
<td>361 (60.8)</td>
<td>—</td>
</tr>
<tr>
<td>12–23 months</td>
<td>109 (27.0)</td>
<td>1434 (66.1)</td>
<td>—</td>
<td>239 (40.2)</td>
<td>682 (68.0)</td>
<td>—</td>
</tr>
<tr>
<td>0–23 months</td>
<td>207 (30.1)</td>
<td>2932 (62.5)</td>
<td>—</td>
<td>425 (39.4)</td>
<td>1343 (64.3)</td>
<td>—</td>
</tr>
<tr>
<td>Fever</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5 months</td>
<td>155 (36.0)</td>
<td>593 (71.0)</td>
<td>88 (79.9)</td>
<td>91 (34.2)</td>
<td>394 (66.7)</td>
<td>60 (62.5)</td>
</tr>
<tr>
<td>6–11 months</td>
<td>284 (32.8)</td>
<td>1113 (76.4)</td>
<td>152 (86.2)</td>
<td>146 (45.9)</td>
<td>51 (64.9)</td>
<td>169 (87.5)</td>
</tr>
<tr>
<td>12–23 months</td>
<td>466 (29.0)</td>
<td>1991 (71.4)</td>
<td>277 (84.5)</td>
<td>242 (46.2)</td>
<td>962 (66.0)</td>
<td>310 (85.5)</td>
</tr>
<tr>
<td>0–23 months</td>
<td>905 (31.4)</td>
<td>3697 (72.8)</td>
<td>517 (84.2)</td>
<td>479 (43.8)</td>
<td>1407 (66.2)</td>
<td>539 (83.6)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5 months</td>
<td>51 (39.8)</td>
<td>319 (70.7)</td>
<td>—</td>
<td>—</td>
<td>178 (70.7)</td>
<td>14 (0.0)</td>
</tr>
<tr>
<td>6–11 months</td>
<td>64 (42.8)</td>
<td>427 (76.9)</td>
<td>—</td>
<td>—</td>
<td>217 (62.7)</td>
<td>37 (67.6)</td>
</tr>
<tr>
<td>12–23 months</td>
<td>106 (41.4)</td>
<td>743 (69.0)</td>
<td>—</td>
<td>—</td>
<td>420 (65.5)</td>
<td>71 (65.7)</td>
</tr>
<tr>
<td>0–23 months</td>
<td>221 (41.4)</td>
<td>1489 (71.6)</td>
<td>—</td>
<td>—</td>
<td>815 (65.9)</td>
<td>122 (58.7)</td>
</tr>
</tbody>
</table>

Table 3. Among children 0–23 months old who experienced diarrhoea in the 2 weeks preceding the survey and for whom advice or treatment was sought from a health facility or health provider; percentage according to the type of treatment/care that they were provided during the diarrhoea episode (South Asia, Demographic and Health Surveys)

<table>
<thead>
<tr>
<th></th>
<th>ORS given</th>
<th>RHF or RHF given</th>
<th>ORS or RHF given</th>
<th>Zn treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ORS or RHF</td>
<td>Zn syrup</td>
<td>Zn tablet</td>
<td>Zn supplements</td>
</tr>
<tr>
<td>Bangladesh, 2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5 months</td>
<td>46.1</td>
<td>0.0</td>
<td>46.1</td>
<td>1.7</td>
</tr>
<tr>
<td>6–11 months</td>
<td>73.4</td>
<td>9.3</td>
<td>76.2</td>
<td>23.0</td>
</tr>
<tr>
<td>12–23 months</td>
<td>75.7</td>
<td>7.1</td>
<td>77.7</td>
<td>25.5</td>
</tr>
<tr>
<td>0–23 months</td>
<td>71.3</td>
<td>9.8</td>
<td>73.4</td>
<td>21.7</td>
</tr>
<tr>
<td>India, 2006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5 months</td>
<td>13.7</td>
<td>15.6</td>
<td>15.6</td>
<td>2.6</td>
</tr>
<tr>
<td>6–11 months</td>
<td>21.3</td>
<td>15.9</td>
<td>31.8</td>
<td>7.9</td>
</tr>
<tr>
<td>12–23 months</td>
<td>34.6</td>
<td>23.6</td>
<td>48.0</td>
<td>11.1</td>
</tr>
<tr>
<td>0–23 months</td>
<td>26.4</td>
<td>20.8</td>
<td>36.7</td>
<td>8.5</td>
</tr>
<tr>
<td>Nepal, 2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5 months</td>
<td>5.8</td>
<td>—</td>
<td>5.8</td>
<td>13.6</td>
</tr>
<tr>
<td>6–11 months</td>
<td>35.2</td>
<td>—</td>
<td>35.2</td>
<td>9.3</td>
</tr>
<tr>
<td>12–23 months</td>
<td>48.2</td>
<td>—</td>
<td>48.2</td>
<td>17.7</td>
</tr>
<tr>
<td>0–23 months</td>
<td>37.8</td>
<td>—</td>
<td>37.8</td>
<td>14.7</td>
</tr>
<tr>
<td>Pakistan, 2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5 months</td>
<td>25.9</td>
<td>3.3</td>
<td>27.2</td>
<td>7.9</td>
</tr>
<tr>
<td>6–11 months</td>
<td>38.8</td>
<td>10.5</td>
<td>42.7</td>
<td>5.3</td>
</tr>
<tr>
<td>12–23 months</td>
<td>44.4</td>
<td>11.0</td>
<td>48.5</td>
<td>8.2</td>
</tr>
<tr>
<td>0–23 months</td>
<td>38.8</td>
<td>23.6</td>
<td>42.2</td>
<td>7.4</td>
</tr>
</tbody>
</table>

ORS, oral rehydration solution; RHF, recommended home fluids.
mothers/caregivers who fed their children more/same fluids as usual was highest in Bangladesh (72.6%) and lowest in India (Table 5).

We were able to examine time trends in four countries – Bangladesh, India, Nepal and Pakistan, where three DHS surveys were available for the period 1990–2014. Bangladesh and Nepal made significant progress in reducing the prevalence of diarrhoea, fever and pneumonia in children 0–23 months old, mirrored by significant increases in care-seeking behaviour for these common childhood illnesses. Improvements in India were low to nil, while surveys in Pakistan reported a significant deterioration (Table 6).

Table 7 summarizes the trends in feeding and care practices for children 0–23 during diarrhoea episodes. Over the 1990–2014 period, the proportion of children with diarrhoea who were given Oral Rehydration Solution (ORS) increased in Bangladesh, India and Nepal, while there was no improvement in Pakistan. The proportion of children who were not given ORS/recommended home fluids/increased fluids declined in all countries. The highest average annual rate of reduction was recorded in Bangladesh (0.41) and the lowest in India (0.11). Detailed information on trends in IYCF during diarrhoea was available only for Nepal (2006–2011) and Pakistan (2007–2012). In both countries, most mothers reported that the amount of liquids offered to their infants during the diarrhoea episode was ‘same as usual’ in both base year and end year. Only about half the mothers in Nepal and one-third of mothers in Pakistan reported that the amount of food offered to their children was ‘same than usual’ – with no improvement between base year and end year.

Research evidence on caregivers’ behaviours and health providers’ practices on infant and young child feeding during and after common childhood illnesses

The bibliographic search identified 32 peer-reviewed publications that met the inclusion criteria for this review. One study (3%) was from Nepal, eight studies (25%) were from Bangladesh, seven studies (22%) were from Pakistan and 15 studies (47%) were from India.
The majority of the studies ($n = 31; 97\%$) reported IYCF practices during common childhood illness, while only one study reported IYCF practices both during and after illness.

Thirty studies (94\%) reported IYCF practices for children with diarrhoea, eight studies (25\%) reported IYCF practices for children with pneumonia and five studies (16\%) reported IYCF practices for children with fever. Most studies ($n = 29; 91\%$) reported caregivers’ IYCF behaviours when children were sick, while only six studies (19\%) reported health providers’ IYCF counselling to mothers of sick children. Twenty-eight (88\%) were observational studies. Only four (13\%) studies – one in Bangladesh and three in India – assessed the impact of one or more interventions to improve IYCF practices during/after illness.

The findings of our review are organized around the seven key focus areas (Table 8).

**Table 5.** Percentage distribution of children 0–23 months old who had diarrhoea in the 2 weeks preceding the survey by amount of liquids and food offered during the diarrhoea episode compared with normal practice as reported by the mother/primary caregiver (South Asia, Demographic and Health Surveys)

<table>
<thead>
<tr>
<th></th>
<th>Bangladesh 2011</th>
<th>India 2006</th>
<th>Nepal 2011</th>
<th>Pakistan 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liquids (%)</td>
<td>Solids (%)</td>
<td>Liquids (%)</td>
<td>Solids (%)</td>
</tr>
<tr>
<td>Children 0–5 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More</td>
<td>1.7</td>
<td>0.0</td>
<td>2.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Same as usual</td>
<td>71.9</td>
<td>50.1</td>
<td>58.7</td>
<td>23.3</td>
</tr>
<tr>
<td>Somewhat less</td>
<td>16.5</td>
<td>16.5</td>
<td>19.4</td>
<td>11.9</td>
</tr>
<tr>
<td>Much less</td>
<td>5.3</td>
<td>5.3</td>
<td>7.0</td>
<td>6.9</td>
</tr>
<tr>
<td>None</td>
<td>4.6</td>
<td>7.7</td>
<td>12.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Never gave food</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>54.4</td>
</tr>
<tr>
<td>Do not know or missing</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1.0</td>
</tr>
<tr>
<td>Children 6–11 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More</td>
<td>23.0</td>
<td>14.9</td>
<td>7.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Same as usual</td>
<td>44.5</td>
<td>40.0</td>
<td>48.3</td>
<td>30.3</td>
</tr>
<tr>
<td>Somewhat less</td>
<td>25.1</td>
<td>29.4</td>
<td>28.4</td>
<td>25.2</td>
</tr>
<tr>
<td>Much less</td>
<td>7.0</td>
<td>9.3</td>
<td>9.7</td>
<td>7.4</td>
</tr>
<tr>
<td>None</td>
<td>0.4</td>
<td>1.1</td>
<td>5.4</td>
<td>5.6</td>
</tr>
<tr>
<td>Never gave food</td>
<td>—</td>
<td>20.4</td>
<td>—</td>
<td>29.2</td>
</tr>
<tr>
<td>Do not know or missing</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.4</td>
</tr>
<tr>
<td>Children 12–23 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More</td>
<td>25.5</td>
<td>12.5</td>
<td>11.1</td>
<td>1.7</td>
</tr>
<tr>
<td>Same as usual</td>
<td>50.3</td>
<td>54.7</td>
<td>45.7</td>
<td>39.7</td>
</tr>
<tr>
<td>Somewhat less</td>
<td>21.8</td>
<td>23.8</td>
<td>29.8</td>
<td>34.2</td>
</tr>
<tr>
<td>Much less</td>
<td>2.4</td>
<td>4.4</td>
<td>10.6</td>
<td>13.6</td>
</tr>
<tr>
<td>None</td>
<td>—</td>
<td>4.5</td>
<td>2.4</td>
<td>4.0</td>
</tr>
<tr>
<td>Never gave food</td>
<td>—</td>
<td>0.2</td>
<td>—</td>
<td>6.0</td>
</tr>
<tr>
<td>Do not know or missing</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.4</td>
</tr>
<tr>
<td>Children 0–23 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More</td>
<td>21.7</td>
<td>11.8</td>
<td>8.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Same as usual</td>
<td>50.9</td>
<td>49.0</td>
<td>49.0</td>
<td>33.6</td>
</tr>
<tr>
<td>Somewhat less</td>
<td>22.3</td>
<td>24.9</td>
<td>27.4</td>
<td>27.1</td>
</tr>
<tr>
<td>Much less</td>
<td>4.4</td>
<td>6.2</td>
<td>9.6</td>
<td>10.3</td>
</tr>
<tr>
<td>None</td>
<td>0.7</td>
<td>3.4</td>
<td>5.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Never gave food</td>
<td>—</td>
<td>1.1</td>
<td>—</td>
<td>0.4</td>
</tr>
<tr>
<td>Do not know or missing</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Table 6. Percentage of children 0–23 months old who experienced diarrhoea, fever or pneumonia in the 2 weeks preceding the survey and for whom advice/treatment was sought from a health facility or health provider (Demographic Health Surveys, 1990–2013)

<table>
<thead>
<tr>
<th>Country</th>
<th>1994</th>
<th>2004</th>
<th>2011</th>
<th>AARI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children 0–23 months old with diarrhoea (%)</td>
<td>13.2</td>
<td>10.1</td>
<td>6.4</td>
<td>−0.40</td>
</tr>
<tr>
<td>Children with diarrhoea seeking medical advice (%)</td>
<td>20.6</td>
<td>18.8</td>
<td>30.1</td>
<td>+0.56</td>
</tr>
<tr>
<td>Children 0–23 months old with fever (%)</td>
<td>—</td>
<td>46.4</td>
<td>42.5</td>
<td>−0.56</td>
</tr>
<tr>
<td>Children with fever seeking medical advice (%)</td>
<td>—</td>
<td>22.8</td>
<td>31.4</td>
<td>+1.23</td>
</tr>
<tr>
<td>Children 0–23 months old with pneumonia (%)</td>
<td>26.8</td>
<td>26.9</td>
<td>6.9</td>
<td>−1.17</td>
</tr>
<tr>
<td>Children with pneumonia seeking medical advice (%)</td>
<td>29.3</td>
<td>25.4</td>
<td>41.4</td>
<td>+0.71</td>
</tr>
<tr>
<td>Nepal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children 0–23 months old with diarrhoea (%)</td>
<td>13.2</td>
<td>21.1</td>
<td>14.1</td>
<td>+0.06</td>
</tr>
<tr>
<td>Children with diarrhoea seeking medical advice (%)</td>
<td>61.9</td>
<td>61.5</td>
<td>62.5</td>
<td>+0.04</td>
</tr>
<tr>
<td>Children 0–23 months old with fever (%)</td>
<td>22.8</td>
<td>30.3</td>
<td>17.8</td>
<td>−0.36</td>
</tr>
<tr>
<td>Children with fever seeking medical advice (%)</td>
<td>67.7</td>
<td>—</td>
<td>72.8</td>
<td>+0.36</td>
</tr>
<tr>
<td>Children 0–23 months old with pneumonia (%)</td>
<td>7.4</td>
<td>20.2</td>
<td>7.1</td>
<td>−0.02</td>
</tr>
<tr>
<td>Children with pneumonia seeking medical advice (%)</td>
<td>68.3</td>
<td>63.6</td>
<td>71.6</td>
<td>+0.24</td>
</tr>
<tr>
<td>Pakistan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children 0–23 months old with diarrhoea (%)</td>
<td>31.2</td>
<td>18.2</td>
<td>21.1</td>
<td>−0.67</td>
</tr>
<tr>
<td>Children with diarrhoea seeking medical advice (%)</td>
<td>14.1</td>
<td>27.1</td>
<td>39.4</td>
<td>+1.09</td>
</tr>
<tr>
<td>Children 0–23 months old with fever (%)</td>
<td>41.2</td>
<td>21.5</td>
<td>23.7</td>
<td>−1.17</td>
</tr>
<tr>
<td>Children with fever seeking medical advice (%)</td>
<td>33.1</td>
<td>43.8</td>
<td>6.8</td>
<td>−2.14</td>
</tr>
<tr>
<td>Children 0–23 months old with pneumonia (%)</td>
<td>37.8</td>
<td>7.2</td>
<td>8.8</td>
<td>−2.07</td>
</tr>
<tr>
<td>Children with pneumonia seeking medical advice (%)</td>
<td>18.3</td>
<td>42.8</td>
<td>—</td>
<td>+2.45</td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children 0–23 months old with diarrhoea (%)</td>
<td>11.2</td>
<td>21.1</td>
<td>14.1</td>
<td>+0.06</td>
</tr>
<tr>
<td>Children with diarrhoea seeking medical advice (%)</td>
<td>61.9</td>
<td>61.5</td>
<td>62.5</td>
<td>+0.04</td>
</tr>
<tr>
<td>Children 0–23 months old with fever (%)</td>
<td>22.8</td>
<td>30.3</td>
<td>17.8</td>
<td>−0.36</td>
</tr>
<tr>
<td>Children with fever seeking medical advice (%)</td>
<td>67.7</td>
<td>—</td>
<td>72.8</td>
<td>+0.36</td>
</tr>
<tr>
<td>Children 0–23 months old with pneumonia (%)</td>
<td>7.4</td>
<td>20.2</td>
<td>7.1</td>
<td>−0.02</td>
</tr>
<tr>
<td>Children with pneumonia seeking medical advice (%)</td>
<td>68.3</td>
<td>63.6</td>
<td>71.6</td>
<td>+0.24</td>
</tr>
</tbody>
</table>

*Average annual rate of improvement (AARI) quantifies the average rate of change between base year and end year.

continued to breastfeed their sick children irrespective of children’s age or the nature of their illness (Huffman & Combest 1990; Malik et al. 1991; Badruddin et al. 1991, 1997; Kaur et al. 1994; Singh 1994; Bhuiya & Streafield 1995; Piechulek et al. 1999; Gupta & Gupta 2000; Mangala et al. 2000; Kaushal et al. 2005; Shah et al. 2011; Benakappa & Shivamurthy 2012; Dhadave et al. 2012; Dongre et al. 2010; Giri & Phalke 2014). Three studies reported that some mothers (range 8.5–17.0%) breastfed their children more frequently when children were sick (Mangala et al. 2000; Dhadave et al. 2012; Giri & Phalke 2014); conversely, four studies reported that some mothers (range 4.3–49.3%) breastfed their sick children less frequently (Piechulek et al. 1999; Shah et al. 2011; Benakappa & Shivamurthy 2012; Giri & Phalke 2014); lastly, six studies reported that some mothers (range 1–9%) ceased to breastfeed when children were sick (Kaur et al. 1994; Gupta & Gupta 2000; Mangala et al. 2000; Shah et al. 2011; Dhadave et al. 2012; Giri & Phalke 2014). The three main reasons given by mothers for reducing or ceasing breastfeeding while children were sick are: (1) the belief that infants could not digest breast milk when they were sick (two studies; Piechulek et al. 1999; Shah et al. 2011); (2) the perception that children were anorexic/had no appetite and/or refused to be fed (two studies; Bhuiya & Streafield 1995; Benakappa & Shivamurthy 2012); and/or (3) the belief that breast milk had become harmful to the child because of mystical/evil forces and/or that the illness had been transmitted by the mother to the child through mother’s milk (three studies) (Bhuiya & Streafield 1995; Kaushal et al. 2005; Benakappa & Shivamurthy 2012). Two studies reported that a significant proportion of mothers (range 35–61%) – particularly among those with young infants 0–11 months old and/or children with diarrhoea – switched back to predominant or
exclusive breastfeeding when children were sick (Ahmed et al. 1992; Shah et al. 2011).

Fluid intake during and after common childhood illnesses

Ten studies (31%) investigated whether children continued to be given fluids when they experienced common illnesses and/or whether fluid intake increased or decreased when children were sick. Nine studies reported that most mothers (range 40–92%) continued to administer fluids to their sick children (Kaur & Singh 1994; Kaur et al. 1994; Piechulek et al. 1999; Gupta & Gupta 2000; Agha et al. 2007; Gupta et al. 2007; Dongre et al. 2010; Memon et al. 2010; Das et al. 2013). Two

<table>
<thead>
<tr>
<th>Table 7. Percentage of children 0–23 months old who experienced diarrhoea in the 2 weeks preceding the survey, by type of treatment/care they were provided and amount of liquids/food offered compared with normal practice (Demographic Health and Surveys, 1990–2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
</tr>
<tr>
<td>Children given ORS (%)</td>
</tr>
<tr>
<td>Children given recommended home fluids (%)</td>
</tr>
<tr>
<td>Children given increased fluids (%)</td>
</tr>
<tr>
<td>Children not given ORS/recommended home fluids/increased fluids (%)</td>
</tr>
<tr>
<td>Children not given ORS/recommended home fluids/increased fluids (%)</td>
</tr>
<tr>
<td>India</td>
</tr>
<tr>
<td>Children given ORS (%)</td>
</tr>
<tr>
<td>Children given recommended home fluids (%)</td>
</tr>
<tr>
<td>Children given increased fluids (%)</td>
</tr>
<tr>
<td>Children not given ORS/recommended home fluids/increased fluids (%)</td>
</tr>
<tr>
<td>Children not given ORS/recommended home fluids/increased fluids (%)</td>
</tr>
<tr>
<td>Nepal</td>
</tr>
<tr>
<td>Children given ORS (%)</td>
</tr>
<tr>
<td>Children given recommended home fluids (%)</td>
</tr>
<tr>
<td>Children given increased fluids (%)</td>
</tr>
<tr>
<td>Children not given ORS/recommended home fluids/increased fluids (%)</td>
</tr>
<tr>
<td>Children not given ORS/recommended home fluids/increased fluids (%)</td>
</tr>
<tr>
<td>Pakistan</td>
</tr>
<tr>
<td>Children given ORS (%)</td>
</tr>
<tr>
<td>Children given recommended home fluids (%)</td>
</tr>
<tr>
<td>Children given increased fluids (%)</td>
</tr>
<tr>
<td>Children not given ORS/recommended home fluids/increased fluids (%)</td>
</tr>
<tr>
<td>Children not given ORS/recommended home fluids/increased fluids (%)</td>
</tr>
<tr>
<td>Feeding practices: amount of liquids offered to children (%)</td>
</tr>
<tr>
<td>More</td>
</tr>
<tr>
<td>Same as usual</td>
</tr>
<tr>
<td>Less than usual</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Feeding practices: amount of food offered to children (%)</td>
</tr>
<tr>
<td>More</td>
</tr>
<tr>
<td>Same as usual</td>
</tr>
<tr>
<td>Less than usual</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Never gave food</td>
</tr>
<tr>
<td>Feeding practices: amount of liquids offered to children (%)</td>
</tr>
<tr>
<td>More</td>
</tr>
<tr>
<td>Same as usual</td>
</tr>
<tr>
<td>Less than usual</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Do not know or missing</td>
</tr>
<tr>
<td>Feeding practices: amount of food offered to children (%)</td>
</tr>
<tr>
<td>More</td>
</tr>
<tr>
<td>Same as usual</td>
</tr>
<tr>
<td>Less than usual</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Never gave food</td>
</tr>
<tr>
<td>Do not know or missing</td>
</tr>
</tbody>
</table>

AARI, average annual rate of improvement; ORS, oral rehydration solution.
Table 8. Summary table of findings from review of evidence on infant and young child feeding during and after common childhood illnesses in South Asia (1990–2014)

<table>
<thead>
<tr>
<th>Findings</th>
<th>Disease</th>
<th>Breastfeeding (BF)</th>
<th>Fluid intake</th>
<th>Complementary foods (CF) &amp; feeding practices</th>
<th>Traditional beliefs and their role in feeding practices</th>
<th>Community elders/traditional practitioners' advice</th>
<th>Health professionals' advice</th>
<th>Interpersonal and group counselling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agha et al., 2007 Pakistan</td>
<td>Diarrhea ARI</td>
<td>NA</td>
<td>- 88% mothers continued fluids, - 11.7% mothers gave less fluid for diarrhea and lesser for pneumonia, - Caregivers are less resistant to giving more fluids than to food (diarrhea). This is due to emphasis of fluids than food in media campaigns.</td>
<td>- Continued feeding: 17% for Diarrhea &amp; 56% for pneumonia, - Less food: 43.9% children (diarrhea) and 83% with pneumonia, - Mothers gave “butter” to help cure diarrhea.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Ahmed et al., 1992 Bangladesh</td>
<td>Diarrhea</td>
<td>- EBF is increased for children &lt; 1 years from 14.8% to 35.2%, - Mothers partially BF decreased 62.5% to 43.2%, - Increase in exclusive BF due to withholding of other foods.</td>
<td>- 22% had normal family diets, - 237% mothers believed that withholding or adding certain foods can cure diarrhea.</td>
<td>- 50% mothers withheld some food believing - “Some foods cause diarrhea, others increase frequency of loose motion, &amp; withholding or adding some food cures illnesses.” - These children were given special diets. - Buffalo milk commonly given, - Home remedies, herbal medicines &amp; teas were given to</td>
<td>NA</td>
<td>- Elders in the family advised mothers on care of sick child.</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Badruddin et al., 1991 Pakistan</td>
<td>Diarrhea</td>
<td>- &gt; 95% BF continued.</td>
<td>- Withholding CF: None, - 25% decreased food intake due to poor appetite and decreased food intake,</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

(Continues)
<table>
<thead>
<tr>
<th>Study</th>
<th>Disease</th>
<th>Breastfeeding (BF)</th>
<th>Fluid intake</th>
<th>Complementary foods (CF) &amp; feeding practices</th>
<th>Traditional beliefs and their role in feeding practices</th>
<th>Community elders/traditional practitioners’ advice</th>
<th>Health professionals’ advice</th>
<th>Interpersonal and group counselling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badruddin et al., 1997 Pakistan</td>
<td>Diarrhea</td>
<td>~98% BF continued.</td>
<td>NA</td>
<td>NA</td>
<td>- Nature &amp; amount of fluids &amp; foods varied according to disease intensity &amp; duration.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Becker et al., 1991 Bangladesh Benakappa &amp; Shivamurthy, 2012 India</td>
<td>Diarrhea, Fever</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>- Food restriction common</td>
<td>“Special diets”</td>
<td>- 19% gave home remedies on elders’ advice.</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 97% BF continued,</td>
<td>- 57% continued CF,</td>
<td></td>
<td>NA</td>
<td>- Doctors asked to avoid “cold” food, like curds, butter milk, fruit juices and bananas in pneumonia (18%). Fever: avoid rice – 15%, - 6% restrict diet to rice and butter milk (diarrhea), - 62%: not to restrict any kind of food and to follow</td>
</tr>
<tr>
<td>Study</td>
<td>Disease</td>
<td>Breastfeeding (BF)</td>
<td>Fluid intake</td>
<td>Complementary foods (CF) &amp; feeding practices</td>
<td>Traditional beliefs and their role in feeding practices</td>
<td>Community elders/traditional practitioners’ advice</td>
<td>Health professionals’ advice</td>
<td>Interpersonal and group counselling</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------</td>
<td>--------------------</td>
<td>--------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>--------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Bharti et al., 2006 India</td>
<td>Pneumonia</td>
<td>NA</td>
<td>NA</td>
<td>- When children were sick with pneumonia, there were feeding restrictions in a large number of cases.</td>
<td>food considered as “cold” were avoided.</td>
<td>NA</td>
<td>16.5% sought advice from unqualified practitioners.</td>
<td>NA NA</td>
</tr>
<tr>
<td>Bhiuya &amp; Streatfield, 1995 Bangladesh</td>
<td>Diarrhea Fever</td>
<td>- BF is continued in a majority, - No mother reported increase in BF, - 16% reduced BF, - Reduction in BF, highest for fever + cough, fever &amp; diarrhea, - Reasons to reduce or discontinue BF are: “refusal to eat” or “considered harmful”.</td>
<td>NA</td>
<td>- ~ 50% continued CF for diarrhea &amp; fever, - 39% reduced and 10% discontinued CF, - None gave more CF, - Reasons for discontinuing CF: (1) refusal to eat/ anorexia (2) considered harmful (3) imposition by caregiver, - In diarrhea, normal food is believed to be harmful.</td>
<td>NA</td>
<td>- Consulting traditional health care providers was quite common. - Depending on illness, practitioners advised on foods to eat or restrict.</td>
<td>- 100% doctors provide no nutritional advice, - Advice by doctors mainly on medicine or use of ORS (diarrhea): 9%, - 5-10% advised to reduce or stop feeding depending on the illness.</td>
<td>NA</td>
</tr>
<tr>
<td>Das et al., 2013 Bangladesh</td>
<td>Diarrhea</td>
<td>NA</td>
<td>- 61.3% gave same amount, - 108% offered less, - 276% gave homemade fluids like thin watery porridge of maize, rice, or wheat, soup, sugar salt</td>
<td>- No child was given more food, - 71.4% gave same amount, - 28.7% gave less food, - Younger 0-1-y were encouraged to drink/eat more, - Few older children (11–24 m) were encouraged to eat more,</td>
<td>NA</td>
<td>- 39.5% mothers with 0–11 m babies and 20% mothers with 1–2 y children sought advice from unlicensed traditional providers.</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

(Continues)
<table>
<thead>
<tr>
<th>Study</th>
<th>Disease</th>
<th>Breastfeeding (BF)</th>
<th>Fluid intake</th>
<th>Complementary foods (CF) &amp; feeding practices</th>
<th>Traditional beliefs and their role in feeding practices</th>
<th>Community elders/traditional practitioners' advice</th>
<th>Health professionals' advice</th>
<th>Interpersonal and group counselling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ansari et al., 2009 Nepal</td>
<td>Diarrhea</td>
<td>NA</td>
<td>water solution &amp; yogurt.</td>
<td>Few mothers gave more fluids.</td>
<td>Few mothers gave more food.</td>
<td>78.6% did not restrict CF.</td>
<td>-55.7% of mothers gave home based care.</td>
<td>NA</td>
</tr>
<tr>
<td>Dhadave et al., 2012 India</td>
<td>Diarrhea</td>
<td>- 87.2% continued BF, - 8.5% BF more, - 4.3% BF less / stopped.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Dongre et al., 2010 India</td>
<td>Diarrhea</td>
<td>- 69.7% continued BF, - 73% continued BF children (&lt; 1 y) compared to 75% with children &gt; 1y, - 73.2% working mothers continued BF.</td>
<td>- ~50% continued fluids, - 43.5% &lt; 1y and 53.9% &gt; 1 year olds were given extra fluids.</td>
<td>- Reduced CF: 50%, - For children with diarrhea only dry food items are given to eat to reduce stress on baby’s stomach &amp; the frequency of loose stool, - Few mothers responded that children had reduced appetite &amp; eat less. - More children &lt; 1 y given extra CF compared to children &gt; 2 y.</td>
<td>Special diets given to sick children include: - Food items containing oil &amp; sour food were avoided: leads to difficulty in breathing &amp; cause cough, - A large number of sick children were given herbal tea, honey, ginger etc. to provide relief from cough. - Hot foods (such as papaya, egg, apple, dhal) &amp; cold foods (such as curd, banana, guava, pomegranate, lemon &amp; custard apple) were avoided,</td>
<td>- 5.7% mothers went to “faith healers”.</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
### Table 8. (Continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Disease</th>
<th>Breastfeeding (BF)</th>
<th>Fluid intake</th>
<th>Complementary foods (CF) &amp; feeding practices</th>
<th>Traditional beliefs and their role in feeding practices</th>
<th>Community elders/traditional practitioners’ advice</th>
<th>Health professionals’ advice</th>
<th>Interpersonal and group counseling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giri &amp; Phalke, 2014 India</td>
<td>Diarrhea</td>
<td>- 60% continued BF</td>
<td>NA</td>
<td>Lower proportion of children from scheduled tribes’ nomadic tribes given increased CF: - 91% continued CF, - 26.5% decreased CF, - 9% stopped CF, - Among those who continued: 32% preferred thinner consistency and 8% preferred thick consistency of food.</td>
<td>Medicines, syrup, injections &amp; tablets are preferred over home remedies. - 71%: cold food be restricted in cold/cough, - 89%: card be restricted in ARI, - 75%: heavy food be restricted in diarrhea, - 72% oily food be restricted in fever, - Preferred “special diets” during illness: 1) Feeding khichadi (81.5%), milk (67.5%) &amp; biscuits (59%) for ARI, 2) Banana (95%), sago (92.5%) &amp; rice water (89%) during diarrhea.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Gupta &amp; Gupta, 2000 India</td>
<td>Diarrhea</td>
<td>- &gt; 75% continued BF</td>
<td>- 92.2%: continued fluids, - 7.8%: stopped fluids, - 87% children &lt; 1 years stopped</td>
<td></td>
<td>- Household remedies such as rice gruel, spices, onion juice were adopted by 86% mothers.</td>
<td>- Mother-in-law advised mothers on care of the sick child,</td>
<td>- 47.3% mothers prefer private doctors, - 20.4% mothers prefer govt doctors,</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Fever</td>
<td>- 7.8% stopped BF</td>
<td>NA</td>
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<tbody>
<tr>
<td>Gupta et al., 2007</td>
<td>Diarrhea ARI</td>
<td>NA</td>
<td>- 42%: continued fluids, - 30%: stopped fluids, - 42%: gave home-based fluids.</td>
<td>50%: Complementary feeding (CF) continued</td>
<td>30%: gave home cooked family foods.</td>
<td>- Home remedies were generally advised.</td>
<td>not given nutritional advice</td>
<td>- 71% govt. doctors laid emphasis on use of home based fluids/ORS as compared to 27% private practitioners.</td>
</tr>
<tr>
<td>Gupt et al, 2007</td>
<td>Diarrhea</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Hirani, 2012</td>
<td>Diarrhea</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>- CF restriction common</td>
<td>- Mothers prefer traditional practitioners.</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Huffman &amp; Combest, 1990</td>
<td>Diarrhea</td>
<td>- In majority BF continued</td>
<td>NA</td>
<td>- For ARI: milk &amp; rice restricted, - &gt;75% infants often refuse other foods.</td>
<td>- Mothers prefer traditional practitioners.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Kasi et al, 1995</td>
<td>Diarrhea</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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(Homem edicines were generally advised. - 15.9% gave home-based fluids & ORS as first action. These include readymade ORS, sugar-salt solution, Lassi or Shikanji. Not given nutritional advice - 71% govt. doctors laid emphasis on use of home based fluids/ORS as compared to 27% private practitioners.)
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<tr>
<td>Kaur et al, 1994 India</td>
<td>Diarrhea</td>
<td>- 85.5% continued BF; Very few stopped BF.</td>
<td>- 95.8%: Fluids continued, 39.6%: Fluids usual amounts, 50%: Fluids restricted, 41%: Fluids stopped.</td>
<td>- 60%: usual amounts CF, 35.4%: restricted CF, 33% stopped CF due to less appetite, Diets of sick children were modified.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>- CF restriction favored by 98.1% earlier, now is favored by 35%. Very few withheld BF.</td>
</tr>
<tr>
<td>Kaur &amp; Singh, 1994 India</td>
<td>Diarrhea</td>
<td>NA</td>
<td>- Homemade fluids given, Few restricted fluids.</td>
<td></td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>- Health education programme: Giving salt sugar solution increased from 2% to 29.6%; only 23.8% gave 3-4 times/day. Less CF improved from 55% to 29%.</td>
</tr>
<tr>
<td>Kaushal et al, 2005 India</td>
<td>Diarrhea</td>
<td>- &gt;75% continued BF; Refusal to feed was considered “normal during illness” &amp; as a marker of a sickness by most grandmothers &amp; mothers. They believed that health-seeking for poor feeding could be delayed for 1 day.</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Malik et al, 1991 Pakistan</td>
<td>Diarrhea</td>
<td>- 70% continued BF,</td>
<td>NA</td>
<td>- 78%-87%: were given normal family foods.</td>
<td>Sick children also received solid &amp; semi-solid diet which was either “Khitchri” or banana as mentioned by more than half of the respondents.</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Mangala et al, 2000 India</td>
<td>Diarrhea</td>
<td>- 92.4% continued BF, 15.1% BF more frequently, - 86% ceased BF.</td>
<td>- 47% aware of increased fluids.</td>
<td>- 30%; Continued CF: 2.4%; gave “special diets” i.e., cooking practices modified i.e., food mashed or ground food for easier digestion (modification in food quality): 16.7% more CF; Educational intervention: increase of mothers modifying food to make it soft &amp; more easily digestible 2.4% to 26.2%; Increased feeding after illness: None.</td>
<td></td>
<td></td>
<td></td>
<td>After an educational intervention improvements in BF frequency (15.1% to 47.2%); Modification of CF preparation (2.4% to 26.2%); Increased CF after illness (1.2% to 20%)</td>
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<tr>
<td>Memon et al, 2010 Pakistan</td>
<td>Diarrhea ARI Fever</td>
<td>NA</td>
<td>- Most mothers continued fluids, - 40%: aware of increased fluids, - 53%: gave more CF as home cooked meals.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Mishra et al, 1990 India</td>
<td>Diarrhea</td>
<td>NA</td>
<td>- 60-66% CF was given as usual, - 27-30% cases CF modified to make food soft as normal foods can trigger diarrhea, - 6.25% CF was stopped to help child recuperate and restricting food reduces stools.</td>
<td>- 27% to 30% cases: special diets were given to sick children, “Hot” foods are avoided.</td>
<td>NA</td>
<td>NA</td>
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| Piechulek et al, 1999 Bangladesh | Diarrhea ARI | - BF continued in a majority, - 22.2% discontinued BF for diarrhea, Reasons for not BF & giving animal milk: 1) Mother’s belief that fluids are harmful, cannot be absorbed. Another reason for restricting breastmilk: 2) Improvements seen in diminished stool volume. | Diarrhea: None; increased fluids, - 91.5%: continued fluids, - 0.8%: stopped fluids, 87% Fluid restriction (diarrhea) and 9.3% (pneumonia). ARI: 14.8%; Restricted fluids until full recovery. | - 38%: continued CF; None; increased CF, > 546%: restricted/withheld CF, - 59.1% restricted for diarrhea & 22.4% for pneumonia, - 30%: stopped CF for > 24 hrs; of this a small proportion stopped until child’s recovery. Mothers withhold food because 1) medical advice; 2) own belief of “keeping bowels at rest”; 3) poor appetite; Educated mothers less likely to withhold food; Food quality modified to “cure illness”. | - 97% mothers gave special diet to their ill child. According to type of illness, certain foods were avoided or preferred. In all illnesses foods like fish, meat & vegetables are “avoided” as they increase loose motions or prolong disease effects. Special diet to cure cold: warm milk & a syrup of basil “tulsi” leaves (hot foods). Special foods to cure ARI/ | - Many mothers withheld food because of doctors’ advice. | - NA | (Continues)
Table 8. (Continued)

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<tr>
<td>Rashid et al, 2001 Bangladesh</td>
<td>ARI</td>
<td>NA</td>
<td>NA</td>
<td>- CF restricted and given once a day.</td>
<td>- Most mothers modified children’s diets; ‘Cold foods’ i.e., left over or stale foods were avoided as “aggravate pneumonia”. Once a day: only rice &amp; salt or dry bread was provided and pneumonia: foods that aggravate symptoms of cold like fish, duck or pigeon meat; and banana, green papaya, green coconut and some vegetables are avoided. Special foods to cure diarrhea: raw banana &amp; coconut reduce abdominal discomfort &amp; diminish frequency of stools. Fish, milk, meat, or vegetables avoided by ~98% others as they “increase the frequency of loose motions” (diarrhea).</td>
<td>- 16% mothers were advised by mothers-in law to restrict certain types of food, Traditional and allopathic care was sought depending on the perceived</td>
<td>NA</td>
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<tr>
<td>Shah et al, 2011 India</td>
<td>Diarrhea</td>
<td>- 50% BF continued, - 49.3% decreased/ stopped</td>
<td>NA NA</td>
<td>are deprived of vegetables &amp; fruits. NA</td>
<td>severity of the illness. 29% mothers consulted traditional medical practitioners or quacks.</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Sharma &amp; Thakur, 1995 India</td>
<td>Diarrhea Fever</td>
<td>NA NA</td>
<td>- CF is commonly restricted</td>
<td>- CF quality is modified. Foods preferred during cough and fever: Cold &amp; light foods i.e., curd, fruits, rice, sago, barley, and biscuits.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Singh et al, 1994 India</td>
<td>Diarrhea</td>
<td>- BF continued in most cases</td>
<td>NA NA</td>
<td>- Feeding was not withheld but changes made in the nature of foods given which varied by illness type. Special diets given in diarrhea: 1) daliya &amp; khitchri because ‘intestines become weak &amp; children are unable</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Zeitlyn et al, 1993 Bangladesh</td>
<td>Diarrhea</td>
<td>NA</td>
<td>NA</td>
<td>- &gt;36%: restrict CF and 64% gave normal home cooked meals; Withholding food is a first measure to treat diarrhea; 10% stopped CF to give bowels a rest; &lt;25% gave CF as usual; Food is restricted as mothers recognize that children have reduced appetites &amp; are reluctant to force feed to eat.</td>
<td>to digest heavy foods”; 2) Diluted tea &amp; banana to frequency of stools; 3) Cow’s milk as “evil eye had contaminated breast milk. 4) Foods avoided are “wheat flour bread” &amp; milk as it is “too heavy”; and “Hot foods” like apple, mango, jaggery, nearly all pulses as these could enhance the frequency &amp; intensity of diarrhea.</td>
<td>- Special diets: Normal family diets are modified to soft foods to aid digestion. Foods are restricted/modifed due to cultural notions “digestive power in illness”. Soft foods given children &lt;10-months as mothers believe “illness”</td>
<td>- A few mothers reported traditional practitioners advised them to withhold foods when their child had diarrhea, including breastmilk. Mothers in law was the main source of advice to mothers on home remedies.</td>
<td>- Health providers provided nutrition related advice on feeding a sick child during illness. A few mothers reported that health providers advised them to withhold foods when their child had diarrhea.</td>
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<td>Working mothers do not want to force feed the child due to “time constraints”. Soft foods given children &lt;10-months as mothers believe “illness weakens a child’s digestive power &amp; soft diets in the form of gruels &amp; soups are easier to digest”. - Maternal or family’s perceptions of “hot or cold foods” and its perceived beneficial/harmful effects. - Fish is avoided: vehicle attracting “evil” forces that perpetuate illness. - Cold &amp; stale foods i.e., foods cooked several hours earlier are considered breeding grounds for bacteria.</td>
<td>weakens a child’s digestive power &amp; soft diets in the form of gruels &amp; soups are easier to digest”. - Maternal or family’s perceptions of “hot or cold foods” and its perceived beneficial/harmful effects. - Fish is avoided: vehicle attracting “evil” forces that perpetuate illness. - Cold &amp; stale foods i.e., foods cooked several hours earlier are considered breeding grounds for bacteria.</td>
<td>including breastmilk.</td>
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BF: breast feeding; ARI, acute respiratory infection; NA, not applicable.
studies reported that some mothers (range 6–28%) gave additional liquids/fluids to their children during illness (Kaur et al. 1994; Das et al. 2013). Three studies reported that, in addition to water, mothers fed sick children home-made fluids such as watery porridges made from maize, rice or wheat; soups; sugar–salt–water solutions; and/or yogurt (Gupta & Gupta 2000; Gupta et al. 2007; Das et al. 2013). Six studies reported that mothers restricted the amount of liquids/fluids given to sick children (Kaur & Singh 1994; Kaur et al. 1994; Piechulek et al. 1999; Agha et al. 2007; Ansari et al. 2009; Das et al. 2013). Fluid restriction was more frequent during diarrhoea episodes (range 4–87%) (Kaur & Singh 1994; Kaur et al. 1994; Piechulek et al. 1999; Agha et al. 2007; Das et al. 2013) than during episodes of fever or pneumonia (range 8.3–15%) (Piechulek et al. 1999; Gupta & Gupta 2000; Agha et al. 2007). Only one study reported the reasons given by mothers for restricting children’s fluid intake during sickness (Piechulek et al. 1999); these were: (1) the belief that fluids could not be absorbed during diarrhoea and thus were harmful; and (2) the perception that a reduction in the stool volume in children with diarrhoea was an improvement of the child’s condition. Two studies reported that the proportion of mothers who were aware that children need more fluids during sickness ranged between 40% and 47% (Mangala et al. 2000; Memon et al. 2010).

**Complementary foods and feeding practices during and after common childhood illnesses**

Twenty studies (63%) investigated whether children were fed lower, similar or larger amounts of soft, semi-solid or solid foods when they suffered from common childhood illnesses. Thirteen studies reported...
that children (range 25–79%) continued to be fed regular family foods as usual, with no restrictions/changes in frequency and/or quantity (Becker et al. 1991; Badruddin et al. 1991; Malik et al. 1991; Ahmed et al. 1992; Zeitlyn et al. 1993; Kaur et al. 1994; Bhuiya & Streafield 1995; Gupta et al. 2007; Mangala et al. 2000; Dongre et al. 2010; Memon et al. 2010; Dhadave et al. 2012; Das et al. 2013).

However, a significant number of studies (18) indicated that feeding restrictions during common childhood illnesses were frequent; these restrictions affected feeding frequency (4 studies: Mangala et al. 2000; Dongre et al. 2010; Benakappa & Shivamurthy 2012; Giri & Phalke 2014); food quality (11 studies: Mishra et al. 1990; Badruddin et al. 1991; Ahmed et al. 1992; Zeitlyn et al. 1993; Sharma & Thakur 1995; Piechulek et al. 1999; Mangala et al. 2000; Agha et al. 2007; Dongre et al. 2010; Benakappa & Shivamurthy 2012; Giri & Phalke 2014); and/or food quantity (7 studies: Kaur et al. 1994; Bhuiya & Streafield 1995; Piechulek et al. 1999; Mangala et al. 2000; Agha et al. 2007; Dhadave et al. 2012; Das et al. 2013). Food restrictions seemed to be more common during diarrhoea episodes (up to 83% of the mothers interviewed) than during episodes of pneumonia and fever (up to 70% and 47% of the mothers interviewed, respectively). The reasons most commonly reported by mothers for restricting food intake when children were sick were: (1) caregivers’ perception that children had less appetite or refused to eat/be fed (five studies: Zeitlyn et al. 1993; Kaur et al. 1994; Bhuiya & Streafield 1995; Piechulek et al. 1999; Dongre et al. 2010); (2) mothers’ reluctance to ‘force’ the child to eat (two studies: Zeitlyn et al. 1993; Bhuiya & Streafield 1995); (3) mothers’ inability to feed the children more food/more frequently owing to resources (fuel) or time constraints (one study: Zeitlyn et al. 1993); (4) mothers’ belief that illness ‘disturbed’ the digestive system and that feeding ‘normal’ foods was harmful to the sick child as the child’s digestive power was ‘diminished’ and ‘normal foods’ would trigger diarrhoea, produce cough and/or put stress on the child’s stomach (nine studies: Mishra et al. 1990; Ahmed et al. 1992; Zeitlyn et al. 1993; Bhuiya & Streafield 1995; Sharma & Thakur 1995; Mangala et al. 2000; Dongre et al. 2010; Benakappa & Shivamurthy 2012; Giri & Phalke 2014); (5) mothers’ belief that withholding certain foods would help to cure diarrhoea whereas introducing normal foods before the child was cured would have a detrimental effect on the development of the child or would lead to a ‘big belly’ (three studies: Mishra et al. 1990; Ahmed et al. 1992; Zeitlyn et al. 1993); and/or (6) the belief that restricting food intake was a first measure to manage diarrhoea at home and reduce the frequency of loose stools (five studies: Mishra et al. 1990; Zeitlyn et al. 1993; Piechulek et al. 1999; Dongre et al. 2010). Two studies that measured food intake in sick children 6–23 months old reported that the mean energy intake of children was significantly lower than that of healthy children and up to 70% below WHO recommendations (Becker et al. 1991; Benakappa & Shivamurthy 2012). Two studies reported that some mothers (range 10–30%) ceased feeding their child for 24 h or longer following medical advice, because mothers perceived that the children had poor/no appetite and/or because social norms advised ‘to keep bowels at rest’ (Zeitlyn et al. 1993; Piechulek et al. 1999).

None of the studies reported an increase in children’s food intake (frequency, quantity and/or quality). Only four studies assessed mothers’ knowledge about the feeding needs of sick children; few mothers (range 17–38%) recognized the importance of feeding sick children nutritious diets comprising vegetables, pulses, small fish and/or other nutrient-rich foods (Zeitlyn et al. 1993; Piechulek et al. 1999; Agha et al. 2007; Benakappa & Shivamurthy 2012).

Traditional beliefs and their role in IYCF during and after common childhood illnesses

Thirteen studies (41%) explored the importance of traditional beliefs and perceptions on IYCF practices during and after common childhood illnesses. Nine studies reported that when children were sick, caregivers (range 13–98%) replaced children’s usual diets with ‘special diets’ owing to the belief that children’s usual diets need to be modified to aid digestion ‘because intestines become weak’ (Mishra et al. 1990; Ahmed et al. 1992; Zeitlyn et al. 1993; Dongre et al. 2010; Benakappa & Shivamurthy 2012; Giri & Phalke 2014). Young children were often fed home remedies,
herbal medicines and teas, and ‘soft foods’ in the form of soups and gruels (Badruddin et al. 1991; Zeitlyn et al. 1993; Piechulek et al. 1999; Gupta & Gupta 2000; Dongre et al. 2010; Benakappa & Shivamurthy 2012; Giri & Phalke 2014) because they were perceived to ‘be lighter on the stomach’, ‘be easier to digest’, ‘reduce abdominal pain’ and/or ‘diminish the frequency of stools’. Conversely, foods like fish, milk, meat, food items containing oil or even vegetables were avoided because they were considered ‘difficult to digest’ or ‘too heavy to digest’ (Ahmed et al. 1992; Zeitlyn et al. 1993; Piechulek et al. 1999; Giri & Phalke 2014).

Seven studies (Mishra et al. 1990; Zeitlyn et al. 1993; Piechulek et al. 1999; Rashid et al. 2001; Dongre et al. 2010; Benakappa & Shivamurthy 2012; Giri & Phalke 2014) reported that caregivers avoided giving specific ‘hot’ or ‘cold’ foods to sick children because these foods were considered inappropriate for certain diseases. Foods commonly avoided in case of diarrhea were eggs/meat (range 25% to >95%), roti/chapatti/wheat flour breads (~70%) and milk (47–50%); in case of pneumonia, commonly avoided foods were fish/duck/pigeon (>90%) or curd/butter milk (range 76% to 93%); and in case of fever, commonly avoided foods included rice (40%) and curd/butter milk (range 60–70%). Two studies reported that some caregivers (range 16–23%) avoided giving sick children foods like fish, meat or eggs because ‘they attract evil forces’ and thus they were harmful to children (Zeitlyn et al. 1993; Piechulek et al. 1999).

**Community elders/traditional practitioners’ advice on IYCF during/after childhood illnesses**

Five studies (16%) reported on the role of mothers-in-law (four studies: Zeitlyn et al. 1993; Rashid et al. 2001; Kaushal et al. 2005; Gupta et al. 2007) or other family elders (Ahmed et al. 1992) on decision regarding IYCF practices when children were sick. Common advice given by family elders to mothers when children were sick included the following: (1) to opt for home remedies as a first line of treatment (Zeitlyn et al. 1993; Gupta et al. 2007); (2) to accept children’s refusal to eat/be fed as ‘normal’ and delay feeding by one day (Kaushal et al. 2005); and/or (3) to refrain from giving sick children certain foods such as fish, meat, vegetables or milk (Zeitlyn et al. 1993). Nine studies (28%) reported that a varying proportion of mothers (range 5.3–84%) sought help from traditional/unqualified practitioners when their children were sick (Zeitlyn et al. 1993; Kaur et al. 1994; Bhuiya & Streetfield 1995; Rashid et al. 2001; Bharti et al. 2006; Dongre et al. 2010; Shah et al. 2011; Hirani 2012; Das et al. 2013). However, only one study described the role of traditional/unqualified practitioners on IYCF counseling to mothers when children were sick (Bhuiya & Streetfield 1995). This study reported that traditional/unqualified practitioners advised mothers to restrict children’s food intake; however, it did not provide specific details on the types of foods that a mother should avoid when her child was sick.

**Health professionals’ advice on IYCF during and after common childhood illnesses**

Six studies (19%) investigated the role of health professionals in providing IYCF advice to mothers when children were sick (Zeitlyn et al. 1993; Bhuiya & Streetfield 1995; Kasi et al. 1995; Badruddin et al. 1997; Piechulek et al. 1999; Benakappa & Shivamurthy 2012). In general, health professionals gave little or no advice to mothers on how to feed their children during or after the illness episode: three studies reported that health providers (range 46–100%) advised mothers to continue breastfeeding (Bhuiya & Streetfield 1995; Badruddin et al. 1997; Piechulek et al. 1999); two studies reported that health providers (range 9–71%) advised mothers to give oral rehydration solution/home-based fluids to infants and young children suffering from diarrhea (Bhuiya & Streetfield 1995; Kasi et al. 1995). No study reported that health providers advised mothers to increase fluid intake when children were sick. Similarly, no study reported that health providers advised mothers to encourage their sick children to eat soft, varied and favourite foods during illness, as recommended by WHO (WHO 2003a, 2003b). Conversely, two studies (Zeitlyn et al. 1993; Bhuiya & Streetfield 1995) reported that health providers advised mothers (proportion not reported) to withhold breast milk and foods such as rice and buttermilk (in case of diarrhea), rice (in case of fever) or cold foods like curd, buttermilk, fruit juices and bananas (in case of pneumonia or acute respiratory infections). Two studies reported that health professionals (range 7–62%) advised...
mothers to feed their children soft and semi-solid foods only after children had recovered from the illness (Kasi et al. 1995; Benakappa & Shivamurthy 2012).

Interpersonal and group counselling on IYCF during/after common childhood illnesses

Three studies (9%) – all in India – reported the impact of behaviour change communication interventions on mothers’ IYCF practices when children had diarrhoea (Kaur & Singh 1994; Kaur et al. 1994; Mangala et al. 2000). Two studies reported the impact of home visits and group counselling by trained community health workers. In these studies, the proportion of mothers giving ‘less than usual’ amounts of food to their sick children declined from 98% to 35% and from 55% to 29% (Kaur & Singh 1994; Kaur et al. 1994). The third study assessed the impact of cooking demonstrations using locally available foods and interpersonal counselling sessions on mothers’ IYCF practices when children were sick (Mangala et al. 2000). The results of the intervention indicated the following: (1) the proportion of mothers who breastfed more frequently while children had diarrhoea increased from 15% to 47%; (2) the proportion of mothers who modified family foods to make them soft and digestible (i.e. more palatable) increased from 2% to 26%; and (3) the proportion of mothers who fed their children additional food for at least 2 weeks after the diarrhoea episode increased from 0% to 20%.

Review of national policy and programme frameworks for infant and young child feeding during and after common childhood illnesses

We reviewed national policy and programme documents to assess whether national frameworks for maternal and child nutrition integrate IYCF during and after illness. In addition, we conducted interviews with 13 key informants to document the existing national programmes that protect, promote and support optimal IYCF practices for children during and after illness (Table 9).

Five of the eight countries have a national IYCF policy, either as a stand-alone policy framework on infant feeding or as part of a larger policy framework on nutrition/food security. However, only two countries – India and Nepal – have integrated the feeding needs of children during and after illness in their IYCF policy framework.

All countries have national guidelines on IYCF, and seven countries have a national programme for the protection, promotion and support of optimal IYCF. However, only five countries include in their national IYCF guidelines guidance on how children should be fed during and after illness, and only five countries have developed a training package on IYCF for programme staff that includes IYCF for children during and after illness.

All countries have a national programme for the integrated management of childhood illnesses (IMCI); six countries have national IMCI guidelines that include guidance on feeding children during and after illness; however, only four countries have developed an IMCI training package that includes guidance on how to feed children when they are sick and after being sick.

Discussion

We conducted a comprehensive review of the available evidence on IYCF practices during and after common childhood illnesses – diarrhoea, fever and pneumonia – in South Asia (1990–2014) to inform policy formulation, programme design, advocacy and research prioritization to protect, promote and support optimal IYCF practices during and after common childhood illnesses in South Asia post 2015.

Demographic Health Survey data on IYCF during common childhood illnesses were available only for Bangladesh, India, Nepal and Pakistan, which are home to ~96% of the children under 5 years of age in South Asia (UNICEF 2015). Similarly, the 32 publications that met the inclusion criteria of our review focused on these four countries. Furthermore, the available DHS data in these four countries were limited to IYCF during diarrhoea episodes. No survey data were available on IYCF practices after episodes of diarrhoea or during/after episodes of fever or pneumonia. Similarly, the published research was primarily focused on IYCF practices during diarrhoea and to a lesser extent during fever or pneumonia episodes. Research evidence on IYCF after common childhood illnesses was practically inexistent.
Demographic Health Survey data indicate that in the countries included in the analysis, children 0–23 months old suffer from common childhood illnesses frequently, as nearly one-third of the mothers/caregivers reported that their children had suffered from diarrhoea or pneumonia in the 2 weeks prior to the survey. These findings are in line with reports indicating that 39% of child deaths in South Asia are due to diarrhoea and/or pneumonia (UNICEF 2012). Importantly, DHS data indicate that in all the countries included in our review, the occurrence of diarrhoea, pneumonia and fever was lowest during the exclusive breastfeeding period (0–5 months) and highest during the early complementary feeding period (6–11 months). This is most likely due to the well-documented protective benefits of exclusive/pre-dominant breastfeeding in the first 6 months of life and the higher levels of infection in late infancy and early childhood due to children’s increased intake of complementary foods and fluids that may be contaminated as well as the ingestion of faecal bacteria through mouthing soiled fingers or household items when children begin to crawl and explore their environment (Kosek et al. 2003; Dewey & Mayers 2011; WHO 2013).

Our review shows that in South Asia, IYCF behaviours and practices during common childhood illnesses are far from optimal. Most infants and young children continue to be breastfed when they are sick; however, few children (<20%) are breastfed more frequently as recommended. Studies in other settings have reported a similar practice, as most mothers continue to breastfeed their sick children without altering the number of nursing episodes, total amount of time of suckling or energy derived from breast milk (Hoyle et al. 1980; Brown et al. 1990; Martz & Tomkins 1995; Brown 2003).

Similarly, most sick children continue to be fed fluids. However, few children (range 7.4–21.7% in Pakistan and Bangladesh, respectively) were fed fluids more frequently as recommended. Mothers’ awareness about children’s need for more fluids during sickness is low. This evidence is in line with reports indicating that in developing countries, less than a quarter (22%) of children are fed more fluids during illness (UNICEF/WHO 2009). Conversely, a significant proportion of mothers/caregivers in Bangladesh (26.7%), Pakistan (37.9%) and India (42.2%) fed their sick children less fluids than usual or no fluids at all in contrast with reports from other countries (Bani et al. 2002; Saha et al. 2013).

We find that food restrictions are frequent. Many children were fed lower quantities and/or less frequently when they were sick. As many as 36% of mothers/caregivers in Bangladesh, 41% in Pakistan and 43% in India reported that they fed their children less food than usual or no food at all during the last diarrhoea episode. Only one-third (34%) of the mothers/caregivers in India to about half (55%) in Nepal reported that they fed their children same/similar amounts of food as usual during the diarrhoea episode. Studies in Latin America have indicated that anorexia is an important factor in the reduction of children’s dietary intake during illness (particularly when diarrhoea or fever are present) as mothers/caregivers tend to give in when sick children send a ‘food reject’ signal (Bentley et al. 1991, 1995). The combined effects of anorexia and tradition-driven withdrawal of complementary feeding during common childhood illnesses can be devastating (Scrimshaw & Sangiovanni 1997).

Our review indicates that in South Asian countries, mothers/caregivers’ knowledge about the feeding needs of sick children is limited and that feeding practices are often guided by traditional beliefs and norms that encourage the use of ‘special’ foods/diets to replace ‘usual diets’ when children are sick. Similarly, many caregivers seem to avoid giving certain ‘hot’ or ‘cold’ foods to sick children because these foods are considered inappropriate for specific diseases. Studies have reported that deeply held beliefs and traditions determine the types of foods or preparation methods that are ‘healthy’ or ‘unhealthy’ for sick children, when and what types of complementary foods are given to children and how to feed children who are sick and/or do not want to eat. These beliefs are heavily influenced by the individuals who surround mothers – that is, husbands, mothers-in-law, grandmothers and other family/community members – and the health care providers upon whom caregivers depend for support (Martz & Tomkins 1995; Stewart et al. 2013).

Care-seeking practices in South Asia are said to be below global estimates for low-income and middle-income countries (Walker et al. 2012). However, the latest DHS data available for the countries included in our review indicate that a significant proportion of
mothers/caregivers (ranging from 30% to 84% depending on country and illness) took their sick children for medical advice during the last episode of diarrhoea, fever or pneumonia. Our review shows that few published studies have investigated the quality of health providers’ counselling on IYCF to mothers/caregivers when children are sick. The evidence reviewed indicates that when mothers/caregivers seek advice/support in the primary health care system, health professionals provide little or no advice to mothers/caregivers on how to feed children when they are sick/convalescent. In general, health providers do not advise mothers to increase children’s fluid intake and encourage sick children to eat soft, varied and favourite foods during illness, while increasing breastfeeding frequency as is recommended. Moreover, there is indication that a non-negligible proportion of health providers advise mothers to withdraw breast milk and/or specific nutritious foods/all complementary foods until children recover from illness.

Studies in other low-income and middle-income countries have found the following: (1) health workers do not maximize their contacts with women and children to support optimal IYCF; (2) there is poor knowledge among health practitioners on how to feed and/or manage sick children and manage children with poor appetite; (3) even when a national normative and guidance frameworks on IYCF for sick children are in place, a limited proportion of paediatricians and family practitioners follow them; and (4) the quality of care and advice among private practitioners is not necessarily better than among public health system providers (Bezerra et al. 1992; Bojalil et al. 1998; Baker et al. 2013; Lutter et al. 2013).

Conclusion

Diarrhoea and pneumonia remain the leading infectious causes of childhood morbidity and mortality in South Asia (Fischer et al. 2013). Compelling evidence indicates that childhood diarrhoea and pneumonia deaths are avoidable and that scaling up optimal feeding behaviours and practices in combination with appropriate case management can avoid most of these deaths (Bhutta et al. 2013).

Our review shows that information of IYCF behaviours and practices during illnesses in South Asia is limited while information of IYCF after common childhood illnesses is virtually inexistent. The evidence reviewed indicates that in South Asia, IYCF behaviours and practices during common childhood illnesses are far from optimal. In general, sick children continue to be breastfed. However, few are breastfed more frequently to compensate for the additional fluid and nutrient requirements associated with illnesses, while a significant proportion of children is breastfed less frequently than usual. Restriction or withdrawal of complementary foods during illness is frequent because of children’s anorexia (perceived or real), poor awareness by caregivers about the feeding needs of sick children, traditional beliefs and behaviours, and/or suboptimal counselling and support by health workers. As a result, many sick children are fed less frequently and/or lower quantities of complementary foods.

Mothers/caregivers often turn to family/community elders and traditional/non-qualified practitioners to seek advice on how to feed their sick children. Thus, traditional beliefs and behaviours often guide the use of ‘special’ feeding practices, foods and diets for sick children. Our review indicates that when children are sick, a significant proportion of families turn to the primary health care system for advice and support. In general, health professionals give little or no advice to mothers/caregivers on how to feed their children while they are sick. However, the few intervention studies available indicate that inter-personal and group counselling as part of primary health care can substantially improve mothers’ IYCF knowledge and practices during common childhood illnesses.

Global guidance and normative frameworks are in place to address the feeding of sick children during and after illness (WHO 2003a, 2003b; WHO/UNICEF 2003; WHO 2005). All the countries included in our review have national guidelines on IYCF and a national programme for the IMCI. However, there seem to be important policy, guidance and capacity building gaps in these frameworks with respect to IYCF when children are sick or convalescent. Our review indicates that a limited proportion of health practitioners follows all aspects of these guidance.
In light of our findings, it seems reasonable to recommend the following as a way forward to protect, promote and support optimal IYCF practices during and after common childhood illnesses in South Asia post 2015:

1. align national policy frameworks and programmatic guidance with internationally agreed upon recommendations on IYCF during and after common childhood illnesses, with a particular emphasis on diarrhoea, fever and pneumonia;
2. expand the DHS and National Nutrition Surveys to include quantitative information on IYCF during and after common childhood illnesses, with appropriate geographic, socio-economic and gender disaggregation;
3. collect qualitative and quantitative information on caregivers’ behaviours and health workers’ practices related to IYCF during and after common childhood illnesses to identify the most important drivers of current behaviours/practices and bottlenecks to optimal IYCF when children are sick/convalescent;
4. build the capacity of facility-based and community-based health workers to provide mothers/caregivers with timely and accurate information, counselling and support on IYCF when children are sick/convalescent;
5. design and implement effective communication strategies that combine interpersonal communication and mass communication to address harmful beliefs and norms with respect to the nutrient and feeding needs of children during/after common illnesses; and
6. document the effectiveness, impact and lessons learned of the capacity building and communication strategies to improve IYCF during and after common childhood illnesses and their implications for programme scale up and universalization.

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Conflicts of interest

The authors declare that they have no conflicts of interest. The opinions expressed on this paper are those of the authors and do not necessarily represent an official position of UNICEF.

Contributions

VMA designed the study, KP led data analysis. Both authors contributed equally to data interpretation and manuscript writing and have read and approved the final submission.

References


Review Article

Improving women’s nutrition imperative for rapid reduction of childhood stunting in South Asia: coupling of nutrition specific interventions with nutrition sensitive measures essential

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Abstract

The implications of direct nutrition interventions on women’s nutrition, birth outcome and stunting rates in children in South Asia are indisputable and well documented. In the last decade, a number of studies present evidence of the role of non-nutritional factors impacting on women’s nutrition, birth outcome, caring practices and nutritional status of children. The implications of various dimensions of women’s empowerment and gender inequality on child stunting is being increasingly recognised. Evidence reveals the crucial role of early age of marriage and conception, poor secondary education, domestic violence, inadequate decision-making power, poor control over resources, strenuous agriculture activities, and increasing employment of women and of interventions such as cash transfer scheme and microfinance programme on undernutrition in children. Analysis of the nutrition situation of women and children in South Asia and programme findings emphasise the significance of reaching women during adolescence, pre-conception and pregnancy stage. Ensuring women enter pregnancy with adequate height and weight and free from being anemic is crucial. Combining nutrition-specific interventions with measures for empowerment of women is essential. Improvement in dietary intake and health services of women, prevention of early age marriage and conception, completion of secondary education, enhancement in purchasing power of women, reduction of work drudgery and elimination of domestic violence deserve special attention. A range of programme platforms dealing with health, education and empowerment of women could be strategically used for effectively reaching women prior to and during pregnancy to accelerate reduction in stunting rates in children in South Asia.

Keywords: women’s nutrition and anthropometry, low birth weight, IUGR, stunting, women’s empowerment, nutrition specific, nutrition-influencing factors.

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Maternal undernutrition is estimated to account for 20% of childhood stunting (WHO 2014). Women’s nutrition plays a crucial role in optimising pregnancy outcome and influencing maternal, neonatal and child health outcomes (Mason et al. 2012). Low status of women in South Asia has been postulated to be a significant contributor to the unusually high rate of undernutrition in children in South Asia (Ramalingaswamy et al. 1996). Poor socio-economic status of women not only affect fetal growth and pregnancy outcome but also adversely impacts behavioural practices pertaining to appropriate self and child care, which contribute to low body mass index (BMI) in women and stunting in children. Today, there is increasing evidence and recognition among the scientific community that it will be difficult to achieve rapid and significant progress in reducing childhood stunting without scaling up evidence-based direct nutrition interventions as well as simultaneously addressing the underlying socio-economic causes that adversely influence nutrition of women (Bhutta et al. 2008; Ramakrishnan et al. 2012; Smith & Haddad 2015). Women’s nutrition, a low priority in the public health agenda of most developing countries, including South Asia, needs special attention.
for accelerating reduction of stunting rates in children (Ramakrishnan et al. 2012; Saldana et al. 2012). This review paper describes the current nutritional status of women in South Asia, linkage of women’s anthropometry with birth outcome and stunting in children, and presents evidence of the nutrition-specific and nutrition-sensitive interventions including varied dimensions of empowerment of women, which collectively play a crucial powerful role in high rates of undernutrition in South Asia.

**Women’s anthropometry, intrauterine growth restriction, low birth weight and stunting**

Women’s poor nutrition, both before and during pregnancy, contributes to impairment of fetal development and contributes to low birth weights (LBW) and in turn to high rates of stunting. A global analysis of region-wise data between the 1980s and 2000s, including South Asia, reveals that improvement in BMI of women 15–49 years corresponds with a reduction in the rate of LBW (Mason et al. 2012). In South Asia, the percentage of women with low BMI indicating undernutrition ranges from 7.5% in Maldives to over a third of women (36%) in India (Fig. 1). Except in the case of Pakistan and Sri Lanka, the other South Asia countries are noted to have a high percentage of women with low BMI and a corresponding high percentage rate of LBW and stunted children (NNS 2011; UNICEF 2014b). Interestingly in the case of Pakistan, Sri Lanka and Maldives, the prevalence rate of overweight and obesity in women in the reproductive age is high, and despite such a situation, the incidence of LBW is over 10%. Overweight women living in poor economic environment are often suffering from anaemia with possible adverse impact of the dual burden on fetal growth. This needs to be further explored. Improvement in the maternal nutrition situation in Nepal and Bangladesh, on the other hand, is reported to result in larger birth size with substantial contribution in reducing undernutrition in children (Headey & Hoddinott 2014; Headey et al. 2014).

### Key messages

- Towards reducing stunting in South Asia, programme efforts need to ensure that women enter pregnancy with optimum height, adequate weight and free from anemia.
- Combining improving coverage of specific nutrition interventions for women and children with intensification of nutrition sensitive measures for women such as preventing early marriage and conception, promoting completion of secondary education, improving socio-economic status and control over resources, improving access to water, sanitation and cooking fuel facilities and reducing physical workload is essential.
- The implications of dual burden of overweight and anaemia in women living in poor economic environments of South Asia on childhood stunting needs to be explored.

**Fig. 1.** Percentage of women 15–49 years old with low body mass index (BMI), incidence of low birth weight (LBW) and percentage of stunted children under 5 years old in South Asian countries.
In the last decade, an association of maternal anthropometry (height, weight or thinness) and birth weight has been stressed (Black et al. 2013). Maternal stunting (height < 145 cm) increases the risk of both term and preterm small for gestational age (SGA) babies (Black et al. 2013). Pooled analysis of 7630 mother–child pairs from birth cohorts of five countries, Brazil, Guatemala, India, Philippines and South Africa, reveals that maternal height is associated with birth weight and with linear growth over the growing period. Short mothers (<150 cm) are reported to be three times more likely to have a child who is stunted at 2 years of age and as an adult (Addo et al. 2013). An analysis of national demographic survey findings from India reveal a significant decrease in relative risk of stunting in children for every 5 cm increase in maternal height from <145 to >160 cm (Subramanian et al. 2009). Similar findings have been reported from an analysis of 109 demographic surveys undertaken between 1991 and 2008 in 54 countries with a large sample comprising 2 661 519 children born to 751 912 mothers (Ozaltin et al. 2010). This study also reports that the effect size of short maternal height is twice that of being in the lowest education category and 1.5 times that of being in the poorest quintile. The significance of women being provided appropriate and timely inputs for attaining optimum adult height is evident (Subramanian et al. 2009).

Besides poor height or stunting in mothers, significance of weight of women on birthweight is important. In India, mean birth weights of infants born to mothers below 45 kg is reported to be about 2.7 kg as compared with mean birth weight of 2.9 kg in mothers weighing 45–54 kg compared with 3.1 kg in case of mothers 55 kg and above (Ramachandran 1989). Based on a meta-analysis of maternal anthropometry, pre-pregnancy weight is considered a good predictor of LBW and a pre-pregnancy weight of less than 40 kg is proposed as a useful cut-off to predict women who have a high chance to deliver LBW babies (Tontisirin & Bhattacharjee 1999). A recent prospective study from Vietnam concludes maternal pre-pregnancy weight to be the strongest indicator predicting infant birth size (Young et al. 2015). Women with pre-pregnancy weight less than 43 kg or who gained <8 kg during pregnancy are reported to be more likely to give birth to an SGA or LBW infant. Well-designed prospective cohort studies in other developing country settings need to be undertaken to systematically examine the relationship between pre-pregnancy body size and composition and maternal nutrition and child health outcomes (Ramakrishnan et al. 2012).

South Asia carries 52% of the global burden of LBW (UNICEF 2013). Globally, three of the five countries with an incidence of LBW of over 20% are from South Asia – Pakistan, India and Bangladesh (Fig. 1). The situation of LBW in South Asia is possibly much worse because timely and accurate weighing of newborns is a low public health priority and far from a universal practice. In India, only three-fourths of the newborns are reported to be weighed before discharge (JSY 2011; UNICEF 2013), and birth weight is often recorded to a rounded figure of 2500 g to avoid any queries or follow-up management efforts required. Moreover, reporting of LBW incidence does not present the true dimension of the problem of implications of poor nutrition of women on birth outcomes. LBW measure underestimates the problem of fetal growth restriction or intra-uterine growth restriction (IUGR). The SGA measure is considered more appropriate for assessment of problem of poor birth outcome. For instance, using this measure, 46.9% of births in India are estimated to be SGA as against 28% reported LBW (Black 2013, NFHS 3).

Low birth weight children often do not recover from poor start in life and contribute to high rate of stunting in early childhood (Sachdev 2011). An analysis of data of low-income and middle-income countries indicate LBW is associated with 2.5-fold to 3.5-fold higher odds of wasting, stunting and underweight in children (Christian et al. 2013). Impaired fetal development increases the risk of stunting 2.1 to 4.3 times (Sachdev 2011). It is estimated that newborns who are SGA and term have an odds ratio of 2.43 for stunting at 12–60 months, while being SGA and preterm increases the odds ratio to 4.5% (Christian et al. 2013). IUGR infants generally fail to catch up to normal size during childhood (Martorell et al. 1998). Stunting attributable to LBW is highest in the first 6 months – the risk of stunting decreases with increase in age. It is estimated that with 30% LBW in India, child stunting rate attributable to LBW is 37% at 6 months and 13–22% at age 1–5 years (Sachdev 2011). There is adequate evidence supporting the fact that stunting begins in utero, and
newborn size is a strong predictor of achievement of height at 12 months (WHO 2014).

**Life cycle of women: critical periods impacting childhood stunting**

The major increase in the rate of stunting in South Asia, as in other developing worlds, takes place during the period of gestation to approximately 24 months post-delivery (Black et al. 2008). Growth failure in the first 1000 days of life (conception to 2 years) is a strong determinant of adult height (Victora et al. 2010). The prevalence rate of stunting increases rapidly in the first 2 years of life and reaches its peak at about 2 years of age, and the poor growth during this period is largely irreversible. The age-wise data from India reveal 57.8% children are stunted at 18–23 months compared with 20.4% at 6 months 32.0% at 9–11 months and 46.9% at 12–17 months (NFHS-3 2006). A similar pattern of growth and rates of stunting increasing in the first 2 years of life is reported from Pakistan and Maldives (DHS-Maldive 2009; NNS 2011). Recent analysis of nationally representative data of Bhutan reports children 12–23 months have a threefold odds of being stunted compared with infants 0–11 months (Aguayo et al. 2015).

Stunting that occurs in children under 2 years old is largely irreversible. Female children who are stunted in early age therefore have a higher chance of growing up to be stunted adult women. This sets up an intergenerational cycle of undernutrition in women. Care of children 0–24 months is essential to prevent linear growth retardation in early childhood in low-income and middle-income countries (Shrimpton et al. 2001). Recent findings reported by WHO provide evidence that short-term improvement in nutrition, extending from intrauterine life to the first 24 months of childhood, can in fact result in mean gain in adult height of 8 cm greater than mean parental height in just one generation in low-income and middle-income countries (Garza et al. 2013). This finding is encouraging evidence that a faster trans-generational improvement in height is achievable in just one generation than has been assumed earlier (WHO 2014). Appropriate infant and young child feeding, prevention of infection, childhood...
stimulation in the first 2 years of life is crucial. These child care practices are influenced to a great extent by maternal care resources (Fig. 2), which are not limited to mother’s nutrition and physical well-being but to factors that influence mother’s empowerment such as education and knowledge, decision-making power and control over household resources, employment and time availability (UNICEF 1990; Engle et al. 1997). In South Asia, a recent review study indicates that the following three domains of women empowerment, i.e. control of resources and autonomy, workload and time, and social support environment, influence child anthropometry, but the strength and direction of association is reported to differ in the contextual situation including child’s age and household wealth (Cunningham et al. 2015).

The other most important periods in the life cycle that are critical and influence the rate of LBW and in turn childhood stunting are inadequate adolescence care, neglected pre-conception care and poor care and weight gain during pregnancy (Fig. 2). Adolescence is the period of second and last growth spurt, and the final height in adulthood is influenced by gain in height during this period. Optimum gain in height during adolescence in girls is adversely influenced by the onset of conception at young age. The adverse impact of early conception on optimum growth is much worse in a disadvantaged population where the velocity of adolescent growth is slower and is extended for a longer period (Vir 1990). As described later in the paper, adolescence conception as well as inadequate diet and health care hamper optimum height gain resulting in adolescent girls entering adulthood with short stature, poor weight and anaemia with its adverse impact on fetal growth resulting in LBW and stunting. This is further supported by a recent report of a prospective study on data pooled from five low middle-income countries, including India, which demonstrated a stronger association of younger maternal age with lower birth weight, preterm birth and stunting by 2 years of age as compared with such an association in the case of women 20–24 years (Fall et al. 2015).

Besides neglected care in the adolescence stage of life, poor pre-pregnancy care or pre-conception care resulting in poor weight also contribute to LBW and stunting (Fig. 2). In South Asia, women often enter pregnancy not only with inadequate height but often with low weight with serious adverse impact on optimum growth of fetus resulting in high incidence of LBW and contributing to high incidence of stunting. A WHO collaborative study on maternal anthropometry and pregnancy outcomes reports that mothers in the lowest quartile of pre-pregnancy weight carried an elevated risk of 2.55 for IUGR and 2.38 for LBW compared with the upper quartile (WHO 1995). This study also showed that attainment of inadequate maternal weight in 20, 28 and 36 weeks of gestation also raised the risk of IUGR. The findings provide evidence that women in the lowest quartile for both pre-pregnancy weight and weight gain during pregnancy are at the highest risk of producing IUGR infants. This is confirmed by the recent large prospective study from Vietnam, which reports high risk of delivering SGA or LBWs among women who are underweight and with low BMI in pre-conception stage (Ramakrishnan et al. 2012; Young et al. 2015). The study also emphasises the significance of adequate weight gain during pregnancy. Addressing women’s weight prior to onset of pregnancy is crucial and cannot be ignored.

Undernutrition in women and stunting in children: nutrition-specific and nutrition-sensitive issues

Women influence their children’s nutritional status through their impact on pregnancy outcomes as well as through effect on child care practices (Smith et al. 2003 & Bold et al. 2013). Poor dietary intake and poor availability of nutrients consumed due to ill health are well-known immediate and direct causes of undernutrition in women with serious contribution to undernutrition in children. These immediate causes are influenced by a number of underlying socio-economic factors such as purchasing power, gender inequality, decision-making power of women at family level, and investment in nutrition care of self, children and family (Fig. 2). In the last decade, there is increased evidence of such factors influencing women’s nutrition and its association with nutritional status of children. The available evidence, described subsequently, underlies the significance...
and the need to simultaneously address both direct nutrition-specific and nutrition-influencing factors.

**Direct nutrition-specific factors, women’s nutrition and childhood stunting**

**Energy imbalance, poor food diversity and stunting**

Dietary intake of women in South Asia is observed to lack energy and diversity not only during pregnancy but also prior to onset of pregnancy. Rural India data reveal that consumption of mean energy and protein is almost identical in pregnant (1773 cal and 49 g protein) and adult non-pregnant women (1709 cal and 47 g). Only 61% of pregnant women report consuming over 70% of the recommended dietary allowances (RDA) of energy, while only 30% consume over 70% RDA of protein. No increase in intake of iron, vitamin A and calcium is observed during pregnancy with less than 10% consuming >70% RDA of iron and calcium, while only 13% are reported to be consuming >70% RDA of vitamin A (NNMB 2012).

Poor diet diversity during pregnancy has been identified as an important factor that needs to be addressed for reducing prevalence rate of stunting in South Asia (Smith & Haddad 2015). Lack of attention to increasing dietary intake during pregnancy could be attributed to poor purchasing power, inadequate information on the significance of additional requirements of energy and various nutrients during pregnancy as well as an incorrect common cultural practice of ‘eating down’ during pregnancy, which is prevalent in some regions of India and possibly in the neighbouring South Asia countries. Primary reason for poor dietary intake seems to be lack of knowledge regarding appropriate dietary care during pregnancy. This is evident from the fact that intensive counselling to pregnant mothers in Northern India resulted in significant increase in calorie consumption (Garg & Kashyap 2006). A recent randomised control trial from Bangladesh also reports that monthly education sessions, promoting consumption of local food item ‘Khichuri’ during the third trimester of pregnancy, resulted in maternal weight gain in the third trimester to be 60% higher, mean birth weight 20% higher and the rate of LBW to be 94% lower in the intervention group compared with control (Khurshid et al. 2014). A recent report from Southern India of a large-scale innovative trial of providing one hot cooked meal per day with diversified food items at a subsidised rate to pregnant women along with nutrition education resulted in a much higher increase in weight gain during pregnancy and reduction in the incidence of LBW (Chava 2012). Meta-analysis reports a significant reduction of 31% in the risk of giving birth to SGA infants when pregnant women are provided with balanced protein energy supplements (Imdad & Bhutta 2011). Targeting of mothers having low BMI with supplement of more than 700 kcals per day is estimated to reduce SGA by 32% (Bhutta et al. 2008). Dietary supplement providing 25% of energy as protein is crucial and is reported to increase birth weight by 73 g and reduce SGA by 34% (Black 2013). On the other hand, questions have also been raised regarding the functional consequences of such maternal supplement to thin women (Kramer 2003).

Besides dietary intake, excessive energy expenditure due to heavy workload adversely influences pre-pregnancy weight, BMI of women and gestational weight gain during pregnancy. Studies have demonstrated that in situations where energy intake is suboptimal, manual physical activity during pregnancy lowers weight gain during pregnancy with increase in incidence of SGA and lower birth weight babies (Tafari et al. 1980; Launer et al. 1990). In rural India, high levels of daily physical activity, related to agriculture and domestic tasks, have been reported to have an inverse relationship with birth weight (Rao et al. 2003). A direct relationship between maternal physical activity and birth weight has also been reported (Muthaya 2009). Working in farms or fetching water are other activities that are reported to have a significant inverse relationship to birth size even after adjusting for maternal co-founding factors (Rao et al. 2003). Farming activities reveal a seasonal energy stress on women depending on lean or harvesting agriculture period with its impact on energy balance and impact on pregnancy outcome. Reduction in activity during harvest season, when food
is in plenty, has been proposed for improving birth size of farming communities.

The other emerging problem in South Asia is increase in rate of overweight and obesity in women. In Maldives and Sri Lanka, over a third of women are overweight or obese (UNICEF 2014b). A high rate of overweight is also noted in four states (Kerala, Goa, Punjab and Delhi) of India with over a quarter of women reported being overweight (NFHS3). Recent analysis of nationally representative data from Pakistan reveals that in 106 of 143 districts, more women are overweight than underweight (Cesare et al. 2015). Implications of such a trend of increase in rate of overweight in women on birth outcome or stunting rates in children in South Asia have not been systematically explored and deserve attention.

**Micronutrient deficiencies, anaemia and stunting**

Requirements for micronutrients increase substantially during pregnancy, and maternal micronutrient deficiencies of iron and iodine are reported to be associated with adverse birth outcome, including LBW (Ramakrishnan et al. 2012; Zimmerman 2012). Maternal iron deficiency anaemia prior to and early pregnancy places the mother at increased risk of significant decrements in fetal growth, preterm birth or LBW delivery (Allen 2000; Scholl 2005). In South Asia, most women enter pregnancy anaemic. Prevalence rate of anaemia among adolescent girls is over 40% in all South Asia countries, except Bhutan which has a comparatively lower prevalence rate of 26.4% (WHO SEARO 2011). Anaemia rates in non-pregnant women is also reported to be high in most of the large South Asia countries – 25% Afghanistan, 46% Bangladesh, 55% India, 36% in Nepal, 28% Pakistan and 16% in Maldives (UNICEF 2007; UNICEF 2009). The anaemia situation worsens during pregnancy with higher requirements for iron. It is estimated that on average, 56% of pregnant women in developing countries are anaemic compared with 18% of pregnant women in developed countries (Allen 2000; Abu-Saad & Fraser 2010).

The primary reason for the high prevalence rate of anaemia is poor intake of dietary iron, low availability of iron from cereal-based diet and poor consumption of animal foods or haem iron due to cultural practices or cost in most South Asian countries (WHO 2011). Data from Pakistan indicate higher intake of iron compared with the RDA, but the source of iron is primarily from wheat, which is not biologically available (NNS 2011). In rural India, only 23.0% adolescent girls, 15.2% adult women and 9.6% pregnant women are reported to consume over 70% RDA of iron (NNMB 2011). The main source of iron in India and other South Asia countries is cereals. In Maldives, despite regular but low consumption of animal source food, anaemia remains a public health problem but of much less magnitude than other South Asian countries (UNICEF 2007; DHS-Maldives 2009).

It is also well established that deficiency of iron in the first trimester of pregnancy results in significant decrements in fetal growth and is generally more damaging to pregnancy outcome than iron deficiency anaemia in the second or third trimesters (Abu-Saad & Fraser 2010). Iron supplementation is documented to have a significant effect on LBW (Balarajan et al. 2013; Khanal et al. 2014). In Nepal, mothers not consuming iron supplement during their pregnancy are reported to more likely have LBW babies (Imdad & Bhutta 2012). In each of the eight South Asia countries, provision of daily iron-folic acid (IFA) supplements to pregnant women is an integral part of antenatal care (ANC) services. Coverage and compliance of IFA is low with only 44% of pregnant women in South Asia reported using IFA supplements compared with 53% globally (Gwatkin et al. 2007; UNICEF 2014b). Deworming in the second trimester of pregnancy in Nepal has been reported to lower the rate of severe anaemia and improve birth weight (Christian et al. 2004).

The significance of women entering pregnancy with adequate iron nutrition is well recognised, and weekly IFA supplements (WIFS) for prevention of anaemia in adolescent girls and women in reproductive age group are recommended (WHO 2009). The WIFS policy is already in place in India, Bangladesh, Sri Lanka and Bhutan (UNICEF 2014a). Successful lessons synthesised from global WIFS experience have been incorporated in the operational guidelines of these countries (WHO 2012). The benefits of WIFS are not limited to improvement in outcomes of pregnancy but have implications on improving concentration at work, school retention and education (WHO 2014).
Multiple micronutrient supplementation (MMNS) has been reported to reduce LBW by about 10% in low-income countries (Fall et al. 2009). A hospital-based trial from India in pregnant women enrolled at 24–32 weeks of gestation with low BMI and anaemia reports positive impact of adding on MMNS to the regular IFA supplement on improving birth weight by 98 g and increasing birth length by 0.80 cm and a substantial decline in LBW as compared with the placebo group (Gupta et al. 2007). Such positive impact of MMNS has also been reported from Nepal (Viadya et al. 2008), while Bangladesh reports benefits only when mothers have low BMI (Tofail et al. 2008). Replacing IFA with MMNS during pregnancy requires undertaking large-scale effectiveness trials in the South Asia situation to rule out possible adverse impact on neonatal and perinatal mortality in disadvantaged population (Bhutta et al. 2012). There is also a need for developing a suitable MMNS product with composition suitable to meet the required gap in micronutrient intake in countries of the South Asia region.

The association of vitamin A deficiency with IUGR is not consistent (Lyman-Thorne & Fawzi 2012). Reports on consumption of micronutrient-rich foods such as green leafy vegetables and milk, even after adjusting for maternal co-founding factors, are reported to have a significant association with birth weight (Rao et al. 2001). Pune Maternal Nutrition and Foetal Growth Study (PMNS) from India reports birth size is not associated with energy or protein intake but is associated with consumption foods rich in micronutrients. Another study from Northern India reports variation in mean birth weight of babies born during different seasons of the year and has demonstrated an association of incidence of birth weight with availability of seasonal fresh fruits and vegetables and consumption of micronutrients during pregnancy (Tamber 2006). Consumption of green leafy vegetables and locally available seasonal fruits appears crucial for improving micronutrient intakes and improving birth size even when energy intakes are limited during pregnancy. Deficit in non-cereal food supply in South Asia diet with only 40% of the food supply being made up of non-staples such as meats, fruits and vegetables is considered to be a primary contributor of poor women’s nutrition and birth outcome (Smith & Haddad 2015). Extremely poor knowledge and negligible consumption of foods rich in micronutrients such as vegetables and fruits by women in reproductive age is reported from Maldives despite a significant improvement in economic and education situation (NMS 2007; DHS-Maldives 2009). Reducing emphasis on cereals and improving dietary diversity of food in South Asia is recommended to be accorded a special focus for improving women’s nutrition and reducing stunting rates in children (Smith & Haddad 2015).

With the adverse impact of iodine deficiency on fetal and post-natal growth and development of young children, regular use of iodized salt is recommended (Zimmerman 2012). In the last two decades, iodised salt intake in six of the eight countries of South Asia has improved significantly – 69% in Pakistan, 71% in India, 80% in Nepal, 88% in Bangladesh, 92% in Sri Lanka and 96% in Bhutan. Intake of iodised salt is reported to be low in two South Asia countries – 20% in Afghanistan and 44% in Maldives (NNS 2011; UNICEF 2014b).

**Antenatal care services**

Antenatal care services are likely to influence improvements in dietary practices, weight gain and introduction of timely interventions for preventing LBW (Hueston

### Table 1. Highest-risk factors associated with stunting in young children in India, Nepal and Bangladesh

<table>
<thead>
<tr>
<th>Risk factors for stunting</th>
<th>Bangladesh</th>
<th>Nepal</th>
</tr>
</thead>
<tbody>
<tr>
<td>No education of mothers</td>
<td>Domestic violence</td>
<td>Maternal height</td>
</tr>
<tr>
<td>Maternal height</td>
<td>Decision-making power</td>
<td>Water</td>
</tr>
<tr>
<td>Mothers with no institutional delivery</td>
<td>Maternal height</td>
<td>Open defecation</td>
</tr>
<tr>
<td>Households with low standard of living</td>
<td>Secondary education</td>
<td>Born in hospital ANC's visits or more</td>
</tr>
<tr>
<td>Households with no toilet facility</td>
<td>Wealth quintile</td>
<td>Maternal education</td>
</tr>
</tbody>
</table>


et al. 2003; Khanal et al. 2014). An analysis of demographic data of Nepal indicates that non-attendance to ANC clinics increases the odds of having LBW by more than twice (Khanal et al. 2014). Studies in Bangladesh also report that odds of stunting are much higher in cases where mothers do not receive ANC or services at delivery are not provided by a skilled health professional (Hong et al. 2006). In Bhutan, 31% higher odds of being stunted is noted in case of children whose mothers received three or fewer ANC visits while children whose mothers received ANC other than from a trained professional are reported to have 51% higher odds of being stunted (Aguayo et al. 2015). Only 35% women in South Asia are reported to have at least four ANCs compared with almost 80% in East Asia and Pacific and 53% globally (UNICEF 2014b).

Nutrition sensitive factors and stunting in children

Analysis of demographic surveys of three South Asia countries (Table 1) reveals that the highest-risk factors influencing rate of stunting across these countries pertain primarily to a range of issues pertaining to women. These comprise women's health care, education, maternal height, domestic violence experience besides low standard of living, wealth quintiles and access to water (Adhikari et al. 2014; Headey & Hoddinott 2014; Headey et al. 2014). Maternal height, to a great extent, influenced by social issue of early marriage is a high-risk factor for childhood stunting in all these countries (Table 1). These findings concur with the analysis of attributing factors of outstanding decline in child stunting in Brazil where social investments and public policies with universal education of women explain 25.7% of the decline in child undernutrition, while 21.7% of undernutrition reduction is attributed to substantial increase in purchasing power, 11.6% to maternal and child health care services and the remaining 43% to improvement in outreach of water and sewage facilities (Monteiro et al. 2007; Monteiro 2009). A recent report attributes the reduction in the prevalence rate of stunting in South Asia in the past four decades to substantial improvement in women’s education as well as progress in the gender life expectancy ratio besides considerable increase in access to safe water (Smith & Haddad 2015).

Decision-making power of women, gender inequality and undernutrition in children

An analysis of 36 nationally representative data sets of demographic and health surveys of three developing regions (South Asia, sub-Saharan Africa and Latin America and the Caribbean) confirms that women’s decision-making power relative to men has a powerful effect on nutritional status of children (Smith et al. 2003). The impact in South Asia is reported to be through the following two pathways that are influenced by empowerment and a higher decision-making power – firstly through improvement in self-care and prenatal care, and secondly through positive influence on behavioural and caring practices such as timely initiation of breastfeeding, complementary feeding (timely introduction and quality care), treatment of illness, immunisation and quality of substitute caretaking. The study concludes that if women and men had equal status in South Asia, with other factors remaining unchanged, the percentage of underweight children would be reduced by 13 percentage points (from 46 percent to 33 per cent) roughly 13.4 million children (Smith et al. 2003).

It has been reported that in situations where women in India have higher access to money and freedom to choose to go to market, there are less chances of having a stunted child as compared with women with less autonomy for such actions (Shroff et al. 2009). Gender inequality, poor empowerment of women and poor decision-making powers adversely influence socio-economic status and purchasing power, age of marriage and conception, choice of spacing between pregnancies, level of education, and experience of domestic violence, which in turn impact on women’s status with serious implications on rate of childhood stunting. Studies from Pakistan, Bangladesh and India document the association of empowerment of women with food security, dietary diversity, appropriate infant feeding practices and improved growth outcomes (Bold et al. 2013). Gender inequality has been identified as an important factor that cannot be ignored in efforts to reduce stunting rate in South Asia (Smith & Haddad
2015). As discussed subsequently, gender inequalities such as indicated by early age of marriage and conception, poor rate of secondary education of women, low income and poor purchasing power of women play a crucial role in childhood stunting in South Asia.

Early marriage, early conception and stunting in children

Data of South Asia countries reveal that marriage below 18 years and conception at a young age of below 20 years is common in six of the eight South Asia countries (Fig. 3) (UNICEF 2014b). Early marriage is often followed with early conception due to social pressure on newly married women to prove fertility. Early conception hinders optimum gain in height during adolescence – the second and last growth spurt of life. The capacity for catch-up growth and attainment of final optimum adult size is further worsened in situations where these girls are reported to have been stunted at 3 years of age (Rao et al. 1998). The growth velocity of such stunted children is slow during adolescence with delayed growth spurt and elongated growth span. Early conception further hinders height gain.

Poor maternal height of women in turn increases chances of IUGR and LBW resulting in child anthropometric failure and stunting. It is reported that LBW and preterm delivery are twice as common in adolescent pregnancies than in adult pregnancies, while infants are 1.22 times at higher risk of stunting in situations where mothers are adolescent or below 18 years as compared with those over 18 years (Raj et al. 2010; Wu et al. 2012). Analysis of demographic data estimates that 8.6% of stunting cases in South Asia children could have been averted with elimination of teenage pregnancies and birth intervals of less than 24 months compared with a much lower impact of only 3.6% in the Middle East and North Africa (Fink et al. 2014).

Education of mothers and stunting in children

Based on cross-country studies, improvements in women’s education have been reported to be responsible for almost 43% of the total reduction in underweight children between 1970 and 1995 (Bold et al. 2013). Investment in education and health of women is inextricably linked to improvement in nutrition of women and children (Nabarro et al. 2012). A study of 17 countries demonstrates a significant positive association between maternal education and nutritional status of children 3–23 months old (Cleland & Ginneken 1988; UNICEF 2009). The national demographic survey findings of India and Pakistan reveal that with increase in level of education of women, there is significant reduction in percentage of children with stunting as well as other important determinants of women’s nutrition such as percentage with low age of marriage and age of first conception as well as per cent of mothers with low BMI and suffering domestic violence (NFHS-3 2006; NNS 2011). Education empowers women, and secondary education could be considered a proxy indicator of improving decision-making power.
of women. A study from Pakistan reveals that majority of children with signs of undernutrition had mothers who almost virtually had no schooling, and stunting rate dropped by almost 50% when mothers had secondary education compared with those with primary education (Liaqat et al. 2007). Reduction in child nutrition reported in Bangladesh has been associated with high rates of enrolment of girls in secondary education following introduction of subsidised education schemes for girls in the early 1990s (Headey et al. 2014). The following five overlapping pathways linking education and stunting have been proposed – transmission of information on health and nutrition, equipping mothers to acquire knowledge, increasing receptivity to modern medicine, increase in self-confidence with positive impact on decision-making and consulting health professionals, as well as enhancing social networking opportunities (Ruel et al. 2013).

**Domestic violence against women and child undernutrition**

Domestic violence against women, an indicator of definite disempowerment, is common in South Asia with wife beating being acceptable by 52% of adult men and women in the region compared with only 20% in Central and Eastern Europe/Commonwealth of Independent States countries (UNICEF 2014b). Domestic violence resulting in psychological stress has been identified as a risk factor for preterm births and LBW (Hobel & Culhane 2003). The impact of violence is not limited to psychological and physical hazards. In South Asia, stress caused due to abuse during pregnancy is observed to be associated with both higher incidence of LBW and lower mean birth weight (Altarac & Strobino 2002). A study from Bangladesh indicates an association between experience or acceptance of physical domestic violence and child undernutrition and attributes this to lowering of self-esteem and poor mental health, less control over household resources and access to usage of health services (Bhagowalia et al. 2012). The effect of domestic violence on nutrition and growth as well as operative pathways is understudied (Yount et al. 2011). India data demonstrate an association of multiple incidents of domestic violence with anaemia and underweight in women, which is hypothesised to be a result of increase in oxidative stress and metabolic levels (Ackerson & Subramanian 2008). A prospective study of rural Pakistan reveals that newborns of depressed mothers have higher level of growth retardation occurring in infancy (Rahman et al. 2004). Longitudinal studies in four countries, including Bangladesh, reports negative effects of domestic violence on birth weight and child’s growth in the first 2 years of life with higher risk of stunting at 2 years of age as well as short stature at 7 years and adulthood (Yount et al. 2011). The possible factors leading to stunting is possibly through biological and behavioural pathways with adverse impact on fetal growth and pregnancy outcome as well as on self and child care behaviours (Yount et al. 2011; Charlette et al. 2012). Interestingly, the adverse impact of domestic violence on child nutrition and care weakens with increasing age of a child, possibly a reflection of reduced dependency on adults (Babu & Kar 2009; Charlette et al. 2012).

**Poverty, women’s empowerment interventions and stunting**

Association of poverty with stunting is evident from the significant difference noted in undernutrition rate in women and children in low wealth quintile compared with high wealth quintile. In India, the percentage of women with low BMI is 51.5% and stunted children is 59.9% in the lowest wealth index compared with 18.2% mothers with low BMI and 25.3% stunted children in the highest wealth index (NFHS-3 2006). In Bhutan, children 0–23 months from the two lower wealth quintiles had 37% higher odds of being stunted as compared with children from two upper wealth quintiles (Aguayo et al. 2015). A recent analysis of Pakistan survey of 2011 reports that children are better nourished in situations where mothers are from wealthier households (Cesare et al. 2015).

Three types of social safety interventions in developing countries aim to empower women – cash transfer [conditional cash transfer (CCT) or unconditional cash transfer (UCT)], agriculture and microfinance programmes. These interventions aim at increasing purchasing power and thus empowering women to make better choices for self and family care with expected positive influence on nutritional status of...
women and children (IFPRI 2008). An analysis of cash transfer (CT) programmes reveal that CCT programme impacts on child anthropometry are mixed and little is known about the pathways through which nutrition outcome occurs (Bold et al. 2013). It is not clear whether the impact occurs due to conditionality influencing use of health or nutrition services and child care practices or due to other factors that impact improvement in quality of services and enhancement of knowledge which influence the desirable behavioural practices. Interestingly, the study also indicates that CCT interventions with non-health conditionality such as savings or employment have negative impacts on nutritional status, while limited evidence from South Africa of UCT programme reports significant positive impacts on child nutrition. The findings of a recent comprehensive review of CT initiatives and child nutrition reveal a positive role of cash transfer programmes in enhancing resources for food, health and care (Groot et al. 2015). However, the evidence of impact of CT programmes on immediate determinants of child nutrition is reported to be mixed with reference to growth-related outcomes among children. This study points out that ‘CT programmes with a larger transfer and a long duration, targeted at young children in low-income households, with additional supply-side interventions may have the greatest likelihood of success.’

Following the Grameen Bank Programme of Bangladesh, there has been a rapid increase in microfinance and rural livelihood programmes in South Asia with the key objective to empower the poor, particularly women. Rural livelihood programmes for female farmers in Gujarat and tribal belt of Rajasthan, India are reported to empower local communities, especially women with higher control over household finances, greater capacity to make decisions regarding health and education of children and higher autonomy. Information on impact of such interventions on improvements on nutritional status has not been systematically studied, but positive effects on behaviour are reported (Desai & Joshi 2012). Only in certain areas or regions with households living in stressed environment, microcredit programmes have been reported to have a positive effect on health and nutritional status of children (Stewart et al. 2010). It is hypothesised that impact of empowerment of women on nutrition outcome is possibly diluted by continued poor access to quality health services and sanitation (Transform Nutrition 2014). The evidence of microfinance programmes on women’s empowerment measures as well as on nutritional status is limited and mixed with the pathway remaining unexplained. Evaluation designs are often weak or lack credibility (Bold et al. 2013).

Women’s agricultural activities, employment and child nutrition

In South Asia, unlike East Asia and developed economics, the largest share of women’s employment is in agriculture (62.1%) followed by industry (17.3%) and services (16.6%) (UNCTAD 2011). Women’s participation in the work force and its implications on childhood stunting has not been systematically studied. However, there is consensus on the following pathways through which targeted agricultural programmes for women influence nutrition – empowerment and decision-making power, enhancement of social status, increase in control over resources including intra-household resource and time allocation for self and family care, which influence women’s own health and nutritional status through impacting on dietary intake, energy expenditure and exposure to diseases (Ruel et al. 2013). Evidence indicates that agriculture interventions involve women are more likely to use the resulting increase in income for improving household security through positive influence in bargaining power of women within households and in making nutritionally appropriate choices with regard to household expenditure (Gillespie et al. 2012; Bold et al. 2013). On the other hand, a link between excess work during pregnancy and LBW and size is found to be more likely in case of children born to mothers engaged in agriculture work during pregnancy (Herforth 2012). A Pakistan study indicates that women employed in agriculture are three times more likely to be underweight compared with women who are not working and almost twice of those employed in non-agriculture work (Balagamwala et al. 2015). It is also reported that in Pakistan, children of mothers working in agriculture are reported to have 52% stunted children compared with 42% in the case of non-working mothers, 48%
non-agriculture workers and 44% in all mothers. Women’s work in agriculture possibly increase resources available to the family but on the other hand may negatively impact on allocation of time or energy for child care and be a primary barrier in child feeding practices despite mothers having knowledge of appropriate feeding practices (Jones et al. 2012). However, a recent study from Nepal, using Women’s Empowerment in Agriculture Index, reports that women’s autonomy in production and women’s work in agriculture influence diet diversity for children under 2 years old and reduce the incidence of stunting in children but not necessarily impacts women’s nutritional status (Malapit et al. 2013).

Evidence of agriculture interventions on women’s empowerment, time and workload is mixed. Impact of agriculture increases income as well as workload, but implications of these on child care are not well documented (Bold et al. 2013). No conclusive evidence on the effects of agriculture interventions in general or on nutritional status has been reported. However, a positive effect on dietary intake and nutritional status measures such as anthropometric indicators has been reported in most of the vegetable gardening interventions when combined with nutrition counselling component (Berti et al. 2004). A review of agricultural strategies, largely home gardens with or without animal production, reveals a positive impact on consumption of vitamin A-rich fruits and vegetables, while the evidence of positive impact of targeted agriculture interventions on maternal and child nutrition is limited (Girard et al. 2012). In the last decade, Nepal has documented experience of combining home gardening project with intensive information-education-communication (IEC) activities, which resulted in higher consumption of special foods such as eggs, meat, milk, nuts and dried fruits during pregnancy (Jones et al. 2005). In the Helen Keller International Homestead Food Production (HKI-HFP) project of Bangladesh and Nepal, agriculture and livestock support resulted in an increase in consumption of eggs in Bangladesh and of pulses and eggs in Nepal (Talukder et al. 2010; Girard et al. 2012). In these projects, a significant decline in anaemia is also observed. The evidence of such agriculture or home gardening strategies on anthropometric indicators is limited. It is not clear from the review of studies whether the impact on nutritional status is directly due to consumption of diversified foods produced or indirectly influenced through increase in purchasing power because agricultural strategies directed at women possibly influence income, livelihood and gender inequality (Girard et al. 2012). Agriculture interventions accompanied with nutrition education are likely to positively impact on nutrition outcomes (Bold et al. 2013). A need for further research in South Asia to measure and understand how agriculture affects nutrition through women’s empowerment using the recently developed Women’s Empowerment Agriculture Index is considered important.

Looking towards the future in South Asia

Analysis of the situation in South Asia reveals that the coupling of nutrition-sensitive interventions with the package of evidence-based direct nutrition interventions in the first 1000 days is imperative (Bhutta et al. 2013). Women’s empowerment and gender equality plays a central role in influencing women’s health and nutrition. A recent report estimates that desirable improvement in gender inequality itself could contribute to 10 percentage points decline in stunting prevalence rate in children (Smith & Haddad 2015). There is an urgent need for intensifying interventions for the prevention of early age of marriage and conception, improving completion of secondary education by girls, improving access to diversified food and sanitation facilities, enhancing purchasing power and measures for reducing drudgery for water or fuel collection and directing efforts for elimination of domestic violence. Prevention of early marriage and early conception through investment in secondary level education combined with legislation enforcement efforts is crucial. Lessons could be derived from innovative incentivised secondary education programmes for girls in India and Bangladesh for scaling up such efforts in South Asia (Khandker et al. 2003; MoWCD 2014). At the same time, it is also important that the emerging problem of overnutrition in women in South Asia is not ignored and opportunity of contacts with girls in school and with women at the workplace or any other community forum is actively used for imparting nutrition–health education.
Effective use of platforms of micro-financing initiatives, livelihood programmes, cash transfer programme, agriculture interventions for reaching disadvantaged women with knowledge and information to facilitate them to make better choices for self, child and family care is vital. A good example of such a linkage is an innovative large-scale experience from India of using microfinance programme for women as a platform for provision of one full hot cooked meal at a subsidised price to pregnant and lactating women along with intensifying nutrition–health education and ANC services with substantial improvement in weight gain during pregnancy and in reduction of LBW (Chava 2012).

Additionally, the CCT programme could also be designed with the objective to contribute to improve health and nutrition of women and reducing childhood stunting. CCT could be linked to conditions such as age of first conception >18 years, minimum of four antenatal visits, attending monthly weight-monitoring sessions and gaining a minimum of 8 kg weight during pregnancy, compliance of at least 100 IFA tablets and opting for skilled birth delivery. Such conditions are also expected to contribute to increase in demand for better quality prenatal services for impacting on lowering incidence of LBW (Barber & Gertler 2010). Two CCT programmes of India [Janani Suraksha Yojana (JSY) and Indira Gandhi Matritva Sahyog Yojna (IGMSY) and the Bangladesh Shombhob Conditional Cash Transfer] are incentivized on conditions related to pregnancy, institutional delivery and/or child care and feeding practices (JSY 2005; IGMSY 2011; World Bank 2014) The experiences from these countries could provide lessons for introduction of such CCT schemes in other South Asia countries.

In South Asia, special care of women at pre-conception stage is required to promote adequate weight gain and for elimination of anaemia. Vietnam and India experience of reaching newly married couples offers lessons towards formulating such a strategy (Khan et al. 2007; Vir 2013). Family planning interventions for newly married couples or marriage registration contacts are other opportunities that could be used not only for counselling on delaying conception but for improving weight and iron-folic status of women prior to onset of pregnancy. Provision of balanced energy – protein supplements, with 25% energy contributed by protein – to ‘at risk’ women is essential (WHO 2014). Programme design for effective supplementation could be based on a critical study of India experience of Integrated Child Development Services programme, which reports a poor coverage, and the effective Bangladesh targeted food supplementation initiative (NFHS-3 2006; Ortolano et al. 2003). A locally suitable high dense nutrient food product with an appropriate distribution strategy could be developed to target pregnant women with low weight of 40–45 kg or height less than 145 cm or with low BMI < 18.5. Strengthening ANC services with higher priority to regular weight monitoring and counselling on appropriate weight gain during pregnancy is crucial. Irrespective of formal or informal sector, it is imperative that attention is also directed to support energy conservation in day to day work, and country policy is tightened towards provision of maternity protection benefits for ensuring an enabling environment for adequate rest and care during pregnancy and early childhood care.

For rapid reduction of stunting rates in children in South Asia, improving socio-economic situation and decision-making power of women must complement the ongoing efforts of improving coverage of the direct nutrition interventions. Political priority to formulate and implement an explicit policy on women’s nutrition is essential towards reaching the 2010–2025 World Health Assembly goals of reducing the number of stunted children by 40%, LBW by 30% and anaemia in women of reproductive age group of women by 50% (WHO 2013).

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Conflicts of interest

The author declares that she has no conflicts of interest.

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Can water, sanitation and hygiene help eliminate stunting? Current evidence and policy implications

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Abstract
Stunting is a complex and enduring challenge with far-reaching consequences for those affected and society as a whole. To accelerate progress in eliminating stunting, broader efforts are needed that reach beyond the nutrition sector to tackle the underlying determinants of undernutrition. There is growing interest in how water, sanitation and hygiene (WASH) interventions might support strategies to reduce stunting in high-burden settings, such as South Asia and sub-Saharan Africa. This review article considers two broad questions: (1) can WASH interventions make a significant contribution to reducing the global prevalence of childhood stunting, and (2) how can WASH interventions be delivered to optimize their effect on stunting and accelerate progress? The evidence reviewed suggests that poor WASH conditions have a significant detrimental effect on child growth and development resulting from sustained exposure to enteric pathogens but also due to wider social and economic mechanisms. Realizing the potential of WASH to reduce stunting requires a redoubling of efforts to achieve universal access to these services as envisaged under the Sustainable Development Goals. It may also require new or modified WASH strategies that go beyond the scope of traditional interventions to specifically address exposure pathways in the first 2 years of life when the process of stunting is concentrated.

Keywords: sanitation, water, stunting, child nutrition, child public health, early growth.

Introduction
This article was inspired by the ‘Stop Stunting’ Conference held in Delhi last year to convene actors from multiple countries and sectors to address a shared concern: the enduring and seemingly intractable challenge of childhood stunting in South Asia. Huge progress has been made in much of the South Asia region in extending healthcare, education and economic opportunity, and these investments have brought dramatic improvements in maternal and child mortality, in school retention rates and in overall economic output. Despite this laudable progress, the prevalence of childhood stunting in South Asia remains high with profound consequences for those children affected: increasing their susceptibility to infectious disease morbidity and mortality, diminishing their future educational achievements and reducing their economic productivity in later life. The failure to address stunting in South Asia, and other high-burden regions, stands to undermine progress in other sectors and trapping future generations in poverty and ill health.

Stunting is a complex problem as depicted by various conceptual frameworks, focused on ‘child malnutrition’ (UNICEF 1990), ‘maternal and child undernutrition’ (Black et al. 2013) and ‘food and nutrition security’ (Gross et al. 2000). The causes of stunting are multifactorial and inter-linked, spanning biological, social and environmental spheres. Water, sanitation and hygiene (WASH), the focus of this paper, feature at various levels in these frameworks with varying degrees of proximity to the outcome of stunting, as immediate or proximate risk factors but also as more distant causes or determinants of stunting. For example, different aspects of WASH have been plausibly linked to all four ‘pillars’ of the food and nutrition security framework (Cumming et al. in press): food ‘availability’, through water as a resource...
for agricultural production; food ‘access’, through household income diverted from food by the cost of obtaining water and ensuring adequate sanitation; food ‘stability’, through the economic shock of treating related infectious disease or associated inability to work; and lastly food ‘utilization’, through the effect of WASH-related enteric infections on the body’s ability to utilize the available nutrients.

Two broad questions emerge for those considering WASH as a potential component of more effective comprehensive strategies to address stunting. Firstly, can WASH interventions make a significant contribution to reducing the global prevalence of childhood stunting? Secondly, and if so, how can WASH interventions be delivered to optimize their effect on stunting and accelerate progress? These questions are of importance to both the WASH and nutrition sectors, and for wider debates concerning the allocation of scarce resources available for improving public health and other social outcomes in low and middle-income countries where the burden of stunting is highest.

Here, we review how poor water, sanitation and hygiene can influence the process of stunting through biological and social mechanisms and then consider the strength of evidence available for an effect of these interventions on stunting. Secondly, we identify the underlying parameters that might plausibly govern the degree to which WASH interventions reduce the risk of stunting and then discuss the implications for practitioners and policymakers concerned with mobilizing WASH resources in support of broader efforts to reduce stunting.

**Water, sanitation and hygiene**

The importance of safe drinking water, sanitation and hygiene (WASH) has long been recognized with regard to public health in general and the health of infants and young children in particular (Jones 1923). Indeed, the birth of ‘public health’ as a defined area of public policy and as a professional discipline is now synonymous with these endeavours to improve ‘sanitary conditions’, following the pioneering work of Chadwick (1842), Farr (1866) and Snow (1855) in the 19th century. WASH is often divided into four rather than three categories, with ‘water’ interventions divided into two subcategories: ‘water quantity’ and ‘water quality’. The former describes interventions that improve the quantity of drinking water available to the household, and the latter describes interventions that improve the microbial quality of drinking water, whether this is at the water source or at the point of use or consumption. Sanitation concerns technologies and behaviours that serve to safely contain excreta, preventing human contact, and hygiene is commonly used to mean washing with soap at critical times (e.g. after defecation and before eating).

These public health interventions together form an interlocking set of barriers that prevent exposure to disease-causing organisms via five transmission pathways as famously depicted in the ‘F-diagram’ (Fig. 1) of Wagner & Lanoix (1958). The interdependency of these barriers is well illustrated by the cholera outbreak investigated by John Snow in Soho, London, almost two centuries ago (Snow 1855). The index case was an infant whose infected stools were emptied into a poorly constructed cesspool.

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**Key messages**

- Water, sanitation and hygiene (WASH) remain critical interventions for improving maternal and child health.
- A growing body of evidence suggests that WASH are important determinants of childhood stunting.
- WASH interventions influence stunting through multiple direct biological mechanisms and by various social and economic mechanisms.
- There is sufficient evidence to justify the inclusion of WASH within national and international strategies to reduce stunting.
- To address stunting WASH policy and programmes should explicitly address exposures in early childhood.
which contaminated the water source that served the now infamous Broad Street water pump (Johnson 2008). While Snow’s work elegantly demonstrated that cholera was transmitted from host to susceptible individual by the medium of water, the epidemic itself had as much to do with the prevailing sanitation infrastructure and hygiene behaviours as it did with the water supply.

Although WASH interventions are often described in terms of their role in preventing disease transmission, the benefits are not confined to health. Improvements in water supply often serve to reduce the distance travelled to the water source leading to significant time savings for poor households that can transform the lives of the women and children whose responsibility it largely is to collect water [World Health Organization (WHO) & UNICEF 2010]. A senior World Bank economist famously argued that these benefits alone provide sufficient economic justification for the investment costs of water supply without any consideration of the health benefits that may accrue (Churchill et al. 1987). The non-health benefits of sanitation include privacy and convenience afforded by improved facilities. There is now a growing literature that documents that this lack of ‘privacy and convenience’ can lead to an increased risk of violence, whether this is physical, sexual and psychological, that is borne primarily by women. It is perhaps because of these risks that shared and public sanitation facilities have been found to be less preferable to women as compared with men (Biran et al. 2011).

**Global coverage for water, sanitation and hygiene**

The WHO/UNICEF Joint Monitoring Programme tracks progress against target 7.c of the Millennium Development Goals (MDG): ‘to reduce by half the proportion of the population without sustainable access to safe drinking water and improved sanitation by 2015’. At a global level, it has been announced that while the water component of this MDG target was met in 2010, the sanitation target has been missed by a substantial margin.

In most countries defined as low and middle income (LMIC) (Group 2015), most people lack household-level access to a safe and reliable supply of drinking water, and to a safe and acceptable form of sanitation (WHO & UNICEF 2014). Globally, it has been estimated that over one-third of the world’s population are without these services at home (Cumming et al. 2014). While challenges persist in other regions, sub-Saharan Africa and South Asia account for the greatest deficits in access to safe water and sanitation (WHO & UNICEF 2014). Access to, or more appropriately the practice of, safe hygiene is much harder to estimate and is not currently reported at a global level. The most comprehensive published analysis to date, based on the results of a systematic review of studies reporting observed handwashing practice, estimated that fewer than one in five people globally wash their hands with soap after defecation (Freeman et al. 2014b).

Analysis of historical progress and current coverage reveals marked geographic and social disparities in access to these services. Between countries (WHO & UNICEF 2014) but also within many countries (Pullan...
et al. 2014), access to safe water and sanitation varies significantly. Disparities in access between rural and urban communities are well documented, with access to both water and sanitation services in rural generally much lower than in urban areas, especially in LMIC (Bain et al. 2014b). Viewed at the level of mean global averages, the differences between urban and rural areas are striking: in 2012, there were 500 million more people without access to safe water in rural areas vs. urban areas, and 1 billion more without access to sanitation (WHO & UNICEF 2014). However, disparities in access between the poorest quintiles for rural and urban populations are far less marked (Rheingans et al. 2013).

More than half of the world’s population now reside in urban areas, and over one-third of these urban dwellers live in ‘slums or informal settlements’ with that proportion being much higher in LMIC Development, W.H.O.C.F.H., & Programme, U.N.H.S. (2010). Although access to safe water and sanitation is generally higher in urban vs. rural areas (Bain et al. 2014b), the proportion of the urban population with access to safe services is actually falling as investment fails to keep pace with urban population growth (WHO & UNICEF 2015). It has long been recognized that the risk of enteric infection may be greatest in poor urban areas due to the combination of high population density and limited infrastructure (White et al. 1972), which is supported by studies looking at certain soil-transmitted helminth infections (Strunz et al. 2014b) and diarrhoea (Mock et al. 1993) and childhood undernutrition (Olack et al. 2011). A failure to target investments at the growing population living in informal areas may undermine progress on reducing child mortality in some countries (Fotso et al. 2007; Rheingans et al. 2013).

The global prevalence of childhood stunting has declined considerably during the MDG period: while in 1990-40% of children globally were estimated to be stunted (height for age z-score [HAZ]<−2), it is now estimated that this has fallen to below a quarter (Black et al. 2013). In absolute terms, the number of children with stunting has fallen by approximately 100 million, although this still leaves 150 million children stunted today (Black et al. 2013). As with the shortfall in water and sanitation coverage, the global burden of stunting is heavily concentrated in just two regions of the world: South Asia and sub-Saharan Africa.

The broader infectious disease burden attributable to WASH

Safe WASH is of paramount public health importance without considering the plausible impact on childhood stunting. Improved access to WASH can prevent a large infectious disease burden that includes diarrhoeal diseases but also other important infectious diseases. Diarrhoeal disease, encompassing a broad range of bacterial, viral and protozoal enteric infections, and largely preventable with improved WASH, was ranked as the fourth leading cause of disability globally in 2010, after ischaemic heart disease, lower respiratory heart infections and strokes (Murray et al. 2013).

A recent series of papers by a WHO-led group of experts quantified the global diarrhoeal disease burden attributable to poor water, sanitation and hygiene (Bain et al. 2014a; Freeman et al. 2014a; Prüss-Ustün et al. 2014; Wolf et al. 2014). The authors estimated that approximately 500 000, 280 000 and 300 000 deaths are attributable to poor water, sanitation and hygiene, respectively (Prüss-Ustün et al. 2014). Using a formula for the aggregate burden for a cluster of risk factors (Lim et al. 2013), the total diarrhoeal burden of disease for WASH was estimated at over 800 000 deaths, equivalent to 1.5% of the total global burden of disease (Prüss-Ustün et al. 2014). Almost half of these deaths were among children, with WASH accounting for 5.5% of the total burden of disease for this age group (Prüss-Ustün et al. 2014), and diarrhoea remains a leading cause of child deaths globally and especially in high-burden regions, such as sub-Saharan Africa and South Asia (Liu et al. 2012).

Supported by evidence of variable quality, WASH is linked to a wide range of other infectious disease health outcomes, including helminth infections (Ziegelbauer et al. 2012; Strunz et al. 2014a), schistosomiasis (Grimes et al. 2014), trachoma (Stocks et al. 2014), respiratory infections (Rabie & Curtis 2006) and maternal and reproductive infections (Benoa et al. 2014). Aggregating the disease burden for WASH – itself a cluster of overlapping risk factors – to take account of multiple and related outcomes (e.g. diarrhoea and pneumonia) is
methodologically challenging. However, one recent WHO analysis that did this reported that approximately 10% of the total global burden of disease could be prevented with improved WASH (WHO 2008).

**Can safe water, sanitation and hygiene prevent stunting?**

The pathways linking poor WASH to childhood stunting are complex, spanning multiple direct biological routes and many broader, less direct routes. To understand these, it is necessary to place the generally better investigated direct biological linkages within a broader socio-economic framework which considers aspects such as accessibility and affordability of water supplies and sanitation facilities. Here, we first consider the biological mechanisms that plausibly link WASH and stunting, and then secondly, we consider the social and economic mechanisms.

**Biological mechanisms**

Three biological mechanisms, in particular, have been described that link poor WASH to undernutrition directly: (1) via repeated bouts of diarrhoea (Briend 1990; Checkley et al. 2008; Petri et al. 2008; Richard et al. 2013); (2) soil-transmitted helminth infections, *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, and *Necator americanus* (O’Iorcain & Holland 2000; Prüss-Üstün & Corvalán 2006; Hall et al. 2008; Ziegelbauer et al. 2012); and (3), a subclinical condition of the gut, referred to variously as tropical enteropathy (Baker & Mathan 1972; Humphrey 2009a), environmental enteropathy (Fagundes-Neto et al. 1984; Korpe & Petri 2012) or, most recently, and as used here, environmental enteric dysfunction (EED) (Haghighi et al. 1997; Humphrey 2009b; Keusch et al. 2014; Crane et al. 2015). For each of these, the effect of WASH on undernutrition is mediated by exposure to enteric pathogens and symptomatic or asymptomatic infection.

Frequency of diarrhoeal disease, as a syndrome, irrespective of its causes, is strongly correlated with growth faltering (Checkley et al. 2003; Checkley et al. 2008). Demonstrating a causal relationship between diarrhoea and malnutrition though is challenging, as undernutrition can increase both the likelihood and severity of diarrhoea disease (Brown 2003; Caulfield et al. 2004). However, a recent pooled analysis of data from nine countries with longitudinal morbidity and anthropometry provides evidence that repeated bouts of diarrhoea cumulatively increase the risk of stunting in children (Checkley et al. 2008). These findings are consistent with the findings of various other studies (Esrey et al. 1985; Esrey et al. 1991; Prüss-Üstün & Corvalán 2006; Guerrant et al. 2008). While the evidence is more limited, Petri identifies a number of studies linking specific diarrhoeagenic pathogens to malnutrition, including pathogenic *Escherichia coli*, *Shigella*, *Giardia* and *Cryptosporidium* (Petri et al. 2008).

Soil-transmitted helminth infections, or helminthiasis, can be prevented with adequate sanitation (Strunz et al. 2014b) and are strongly associated with childhood undernutrition (Prüss-Üstün & Corvalán 2006). In particular, more severe cases of ascariasis and trichuriasis are associated with growth faltering in children (O’Iorcain & Holland 2000; Hotez et al. 2004; Bethony et al. 2006). Hookworm infections during pregnancy can lead to malabsorption of nutrients and maternal anaemia, which in turn are associated with stunting at birth (Black et al. 2013). Brooker and colleagues estimate that in sub-Saharan Africa, over a quarter of all pregnant women are infected with hookworm (Brooker et al. 2008).

There is growing evidence linking symptomatic and asymptomatic enteric infections to EED. This syndrome was first described in the 1960s (Cook et al. 1969) and referred to as ‘Tropical Enteropathy’ (or ‘jejunitis’). The renaming to environmental enteropathy in the 1980s and 1990s (Fagundes-Neto et al. 1984), and more recently to EED (Keusch et al. 2013; Keusch et al. 2014), reflects a growing appreciation of the role of the environment in the development of this condition. EED is an asymptomatic syndrome causing chronic inflammation, reduced nutrient absorption of the intestine and a weakened barrier function of the small intestine (Keusch et al. 2014; Crane et al. 2015). These abnormalities in gut function and structure may have profound consequences for affected children, including deficits in growth, early childhood development and immune function (McKay et al. 2010; Korpe & Petri 2012; Keusch et al. 2014; Crane et al. 2015). Although
more research is needed, it has been argued that EED, and not diarrhoea, may be the primary causal mechanism linking WASH to child growth (Humphrey 2009a). One observational study in Bangladesh has shown that children living in households with improved WASH are both less likely to have EED, measured by lactulose:mannitol ratios in their urine [a measure of gut permeability (Lunn et al. 1991)], and are less likely to be stunted (Lin et al. 2013).

Social and economic mechanisms

Another important relationship is the energy cost of carrying water for long distances from the source to the home. White et al. (1972) estimated from various sources that the average woman, carrying a typical load of 20 L on level ground, would consume some 39 cal per kilogramme of body weight per hour. With an assumption that 1 g of maize meal yields 3.5 cal, the average cost of water in East Africa, where most people required less than an hour to collect water, was estimated as US$25 per year.

When the water-carrying is performed by professional vendors, as is more often the case in urban areas, it is far more expensive to the consuming household. Typically, vendor prices are 10 to 20 times greater than the prices charged by the official water utility, amounting on average to some 20% of the household’s income (Zaroff & Okun 1984). The prices may seem exorbitant, but this reflects the inefficiency of water transportation by such technologies as hand trolleys, donkey carts, jerry cans and buckets. If the vendors’ prices are understandable in terms of their technology, how are we to understand the willingness to pay of the customers? Seen as a purchase of time, rather than water, the transaction is not as unfavourable as it might seem. Whittington et al. (1990) studied the options open to the customers of vendors in Ukunda, Kenya, and found that they usually chose the more costly, time-saving option only if the trade-off valued their time at more than the unskilled wage rate.

However, that does not per se render it economic for a poor family to opt for the water vendor over collecting water themselves because there may little or no spare income within the household budget to pay for water. The poorer the family, the less remains after food expenditure and so greater is the proportion of household expenditure devoted to food. This relationship is known as Engel’s Law – not after Friedrich Engels, the co-founder of Marxist theory, but for the 19th century Saxon Government accountant Ernst Engel (1821–1896) who first observed this relationship between income and food expenditure (Houthakker 1957).

The pie chart (Fig. 2) shows the breakdown of a typical weekly budget of a household in the low-income areas around Khartoum, Sudan. It is striking that water already accounts for almost 30% of the household budget, and food two-thirds of the budget. So, imagine for a moment that this is your family budget, and that the water price has just doubled; it is hard to see how to meet this need for additional but essential expenditure, without taking from the food budget.

Thus, water supply affects nutritional status not only via the complex metabolic links described in the previous text and elsewhere in this series of papers, but also by the most direct route imaginable: the high cost paid for water by the poorest – and the poor pay for water at by far the highest cost – which leaves them without insufficient funds for an adequate diet. Indeed, bearing in mind the impact of nutrition on mortality, many of the poor pay for water with their very lives.

The fact that poor WASH brings a risk of death from diarrhoeal disease may help to explain why people are

![Fig. 2. Typical breakdown of weekly household expenditure in low-income areas of Khartoum, Sudan (1987). Source: Cairncross & Kinnear 1992.](image)
willing to pay such a high price for water. Table 1 illustrates the inelasticity of demand for it. While the residents of Karton Kassala had to pay three times more than the people in Meiyo for their water, they used roughly the same amount of water per capita — if anything, slightly more. This lack of elasticity with regard to price was accompanied by income inelasticity of demand; households with a wide range of incomes were using roughly the same amounts of water.

These two findings have important policy implications. First, the income inelasticity means that the poorest households are paying the greatest proportion of their income for water, although they can least afford it. Second, the demand inelasticity means that price is highly sensitive to supply. Indeed, cases were found in Sudan where a slight constraint on the availability of water to fill the vendors’ donkey carts led to a doubling or tripling of the price. The contrary is also true; facilitating the business of the water vendor (for example, by drilling more boreholes and offering credit to buy carts and donkeys) should lead to a substantial drop in the price of water. This drop in water prices will free up expenditure for the food budget, especially in the poorest households who most need it.

From this perspective, WASH can appear as a Holy Grail of community-based nutrition projects: delivering savings for more food, particularly to the poorest. As water is regarded as ‘women’s business’, the savings go directly into the pocket of the housewife and mother, the member of the household who may be best placed to ensure that children benefit. The lack of studies documenting this in the literature is evidence of the difficulty of cross-sectoral vision and collaboration. Hopefully, we are now in more enlightened times, when nutritional benefits are achieved by interventions more subtle than handing out food.

**Experimental evidence for the effect of WASH interventions on stunting**

Although a number of studies have found a significant association between access to improved WASH and improved growth after adjusting for confounding using a range of statistical methods (Esrey et al. 1985; Esrey et al. 1991; Spears 2013; Spears et al. 2013), a recent Cochrane review identified only five experimental intervention studies for the effect of WASH on undernutrition. These studies spanned different WASH interventions on childhood stunting: treatment of household drinking water by solar disinfection (Du Preez et al. 2010; Du Preez et al. 2011; McGuigan et al. 2011), chlorination (Luby et al. 2006), flocculants (Luby et al. 2006) and the provision of soap and promotion of handwashing (Luby et al. 2004). Critically, though, no water supply or sanitation interventions were identified. While pooled analysis found no effect of these WASH interventions on weight-for-age z scores and weight-for-height z-scores, a small statistically significant effect was reported on height-for-age z scores [0.08 z-score; 95% confidence interval: 0.00, 0.16] among participants under 5 years, with a larger effect for children under 2 years of age (0.25 z-score; 95% confidence interval: 0.14, 0.35) in subgroup analysis.

Although no sanitation interventions were identified in this Cochrane review, five trials have subsequently published results describing the effect of sanitation interventions on stunting. Two of these studies (Hammer & Spears 2013; Pickering et al. 2015) reported significant effects on stunting, and three found no effect (Cameron et al. 2013; Clasen et al. 2014a; Patil et al. 2014). Notably, the interventions for those trials reporting no effect, two in India (Clasen et al. 2014a; Patil et al. 2014) and one in Indonesia (Cameron et al. 2013), had very low levels of uptake and compliance, which may explain their findings of no effect. By contrast, Pickering et al. report that access to sanitation increased substantially and open defecation reduced as a

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**Table 1. Inelastic demand: water prices and observed daily per capita water consumption in two low-income areas of Khartoum, Sudan, 1987**

<table>
<thead>
<tr>
<th></th>
<th>Meiyo (n = 22)</th>
<th>Karton Kassala (n = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean* household size</td>
<td>7.3</td>
<td>8.3</td>
</tr>
<tr>
<td>Mean* income/head (Sudanese pounds/month)</td>
<td>42</td>
<td>47</td>
</tr>
<tr>
<td>Mean* water price (Sudanese pounds/drum)</td>
<td>1.50</td>
<td>4.64</td>
</tr>
<tr>
<td>Mean* water consumption (litres per capita per day)</td>
<td>24.2</td>
<td>27.0</td>
</tr>
<tr>
<td>Mean* % of income spent on water</td>
<td>16.5</td>
<td>55.6</td>
</tr>
</tbody>
</table>

Source: Cairncross & Kinnear 1992. *Averaged by household, and* averaged by individual.

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result of the intervention evaluated in Mali, West Africa (2015), while the intervention evaluated by Hammer & Spears in India achieved more modest increases in sanitation access (2013). This epidemiological literature confirms what is well known by many WASH implementers that the requisite changes in behaviour are hard to initiate and even harder to sustain over time.

At least three large WASH intervention studies are currently underway that will add to this evidence base and answer important outstanding questions (Humphrey 2013; Arnold et al. 2013; Brown et al. 2015). The factorial design of the Sanitation, Hygiene, Infant Nutrition Efficacy [SHINE] (Humphrey 2013) and WASH Benefits (Arnold et al. 2013) trials will permit the quantification of both the independent effect of WASH interventions on stunting and the combined effect of WASH and food supplementation interventions together. All three trials include biological markers of EED to assess whether improvements in WASH can reduce EED and to what extent the effects of WASH on stunting are mediated by this subclinical condition. Lastly, the interventions assessed in these trials have novel aspects, including the SHINE trial, which specifically addresses maternal and child environmental exposures, and the MapSan trial (Brown et al. 2015), which, for the first time, evaluates an urban on-site sanitation intervention in high-density informal settlements.

How much stunting might be prevented with improved WASH?

The recent Lancet Series on child and maternal undernutrition came to the somewhat sobering conclusion that if it were possible to scale-up 10 ‘evidence-based nutrition interventions’ to almost complete coverage in the 34 countries that have 90% of stunted children, the global prevalence of stunting would be reduced by just one-fifth (Bhutta et al. 2013). These findings along with those of other studies (Dewey & AduAfarwuah 2008) suggest that stunting is unlikely to be eliminated without addressing the underlying determinants of undernutrition alongside deficiencies in the quantity and quality of infant and child nutritional intake. This broad category of interventions that tackle the underlying determinants is sometimes referred to as ‘nutrition-sensitive’ interventions and includes WASH but also things such as family planning services, maternal education and social safety nets (Black et al. 2013). As discussed in the previous text, WASH potentially impacts stunting through multiple and interacting biological and socio-economic mechanisms that are difficult to assess independently.

At the level of public policy, internationally and nationally, much of the interest in WASH and undernutrition boils down to a basic question: how much stunting can be prevented globally with improved WASH? Various studies have estimated the WASH-attributable disease burden over the last two decades (Clasen et al. 2014b), with various single or multiple infectious disease outcomes included, such as diarrhoeal diseases, helminth infections, trachoma and schistosomiasis. Of these though, we are aware of only one analysis that has included undernutrition as an outcome in their burden of disease estimate (Prüss-Üstün et al. 2008). This study conducted by WHO categorized the effects of WASH on undernutrition as ‘direct’, meaning attributable deaths resulting from protein energy malnutrition, and ‘indirect’, meaning attributable deaths resulting from increased susceptibility to infectious diseases as a result of undernutrition. Taken together, this study estimated that in 2004, a huge number of child deaths – approximately 860 000 – caused by malnutrition might be prevented with improved WASH.

How can WASH interventions be mobilized to eliminate stunting?

Evidence is growing that sustained exposure to enteric pathogens in early life mediated by poor WASH conditions may have profound effects on child growth and development (Lin et al. 2013). In addition, there are multiple social and economic mechanisms by which poor access to WASH can increase the risk of stunting and other forms of undernutrition. In light of this, there is renewed interest in how WASH interventions might be targeted or modified to best support efforts in the nutrition sector (Humphrey 2009a). This has implications for both the nutrition and WASH sectors: for the former, reform may be needed to foster and enable greater cohesion with other complementary sectors, including WASH, and, for the latter, strategies may require modification to support broader efforts to reduce childhood undernutrition.
In countries where rapid progress has been made in recent years, such as Brazil or Peru, one consistent feature has been strong inter-sectoralism (Dangour et al. 2013a). While such inter-sectoralism is commonly associated with success, fostering such coordination and integration under the MDG has been challenging (Waage et al. 2010). Under the Sustainable Development Goals, both the nutrition and WASH sectors have dedicated goals – to ‘end hunger, achieve food security, and improve nutrition and promote sustainable agriculture’ and to ‘ensure availability and sustainable management of water and sanitation for all’ – but dedicated efforts to realize synergies and remove barriers to integration are needed (Waage et al. 2015). One opportunity is the Scaling Up Nutrition (SUN) initiative that actively promotes national-level coordinated action across sectors to end malnutrition. Active in over 50 high-burden countries, and supported by global agencies, including donor governments, the United Nations and international civil society organizations, the SUN movement provides a basis for the ‘alignment of actions across sectors and among stakeholders’ (SUN 2015) and an entry point for the WASH sector.

The WASH sector, however, faces its own challenges in delivering effective, equitable and sustainable interventions, supported by well-conceived and resourced national policies and strategies (Bartram & Cairncross 2010). As highlighted in the sanitation trials discussed in the previous text, many WASH interventions are ineffective in mobilizing community uptake and achieving sustained changes in behaviour (Barnard et al. 2013). For example, promoting handwashing with soap and basic on-site sanitation may in principle represent highly cost-effective public health interventions (Jamison et al. 2006), but many of these interventions fail to catalyse significant or sustainable changes in behaviour (Curtis et al. 2011). Conversely, while demand is generally high for improved water supplies, many systems fail or perform poorly due to inadequate provision for the management and maintenance of the infrastructure, thereby preventing use where demand is strong. Reducing stunting will require strong WASH programmes that do not repeat old mistakes of supply-oriented, over-engineered solutions (Cairncross 1992) nor forget the most important lesson of all that people are unlikely to wash their hands or use sanitation facilities unless they actually want to do so (Cairncross 2003).

It is not clear that traditional WASH interventions or strategies will per se deliver or at least maximize the potential nutrition benefits. Traditionally, WASH interventions have focused on ensuring access to WASH for the general population to improve health and other development outcomes. Under the MDG water and sanitation target – ‘to halve, by the year 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation’ – ‘improved’ water and sanitation were defined with minimum benchmarks of community water supply and basic household sanitation. While much progress has been made under the MDG target – with 2.6 billion gaining access to safe water and 2.1 billion gaining access to adequate sanitation (WHO & UNICEF 2015) – it is unclear whether a water pump located hundreds of metres from the household or a rudimentary latrine are sufficient to protect young children from the growth faltering that results from chronic exposure to enteric pathogens. And, improved hygiene, which can be highly efficacious in reducing diarrhoeal disease, was not included under the MDG target, perhaps because of the difficulty of measuring progress.

**Priorities for a nutrition-sensitive WASH sector**

While more research will help strengthen future nutrition-sensitive WASH interventions, clear points emerge from the existing evidence base that can help guide the design of nutrition-sensitive WASH strategies. In essence, the challenge is ensuring that the right people receive the right interventions at the right time. This means ensuring that populations with a high burden of stunting are targeted before or when growth faltering occurs and with appropriate WASH interventions alongside more traditional nutrition-specific interventions. Reaching and protecting those at risk may require interventions that go beyond the scope of the traditional package of WASH interventions, such as ‘improved’ water and sanitation as defined under the MDG target, to ensure that young children are protected from exposure to enteric pathogens.

As both diarrhoeal disease morbidity and mortality (Walker et al. 2013,), and the process of stunting
(Shrimpton et al. 2001), are concentrated in the first 2 years of life, and this growth deficit is thereafter not recovered, attention should be given to how WASH might limit exposure during this specific window. The recent Cochrane review, discussed in the previous text, validates this focus, reporting that the effect of WASH interventions on stunting was greatest in children aged 0–24 months, in an individual participant data subgroup analysis (Dangour et al. 2013b).

Identifying dominant faecal–oral exposure pathways for young children when they are most vulnerable to the deleterious effects of contaminated environments is the first step in identifying those WASH interventions that are likely to be most efficacious. One recent study used structured observation of mother–child couples in Zimbabwe to assess faecal–oral exposure among young children and highlighted the risks associated with the consumption of soil – geophagia – and animal waste in peri-domestic areas (Ngure et al. 2013). A number of recent studies in Mali (Touré et al. 2011; Touré et al. 2013) and in Bangladesh (Islam et al. 2013) have also highlighted the risk to this age group posed by often highly contaminated weaning or complementary food. There has been growing concern, too, about the safe disposal of children’s faeces, which are generally not disposed of safely, as they are often considered to be less pathogenic than those of adults, although the reverse may be true (Brown 2003).

WASH interventions that target critical exposure points for young children should be prioritized alongside relevant nutrition-specific priorities, such as improving infant and young child feeding (WHO & UNICEF 2003). Such WASH interventions might logically include infant food hygiene – the safe preparation, storage and reheating of infant foods – controlling or supervising exploratory play to limit exposure to contaminated soil, fomites and objects (Prendergast & Humphrey 2014) and ensuring that child faeces are disposed of safely. From the perspective of the nutrition sector, this focus and package of interventions is hardly a new concept. Building on a series of seminal studies in the 1970s that demonstrated the effect of repeated infections on growth in early childhood, Mata highlighted the importance of the ‘matro environment’ and the ‘maternal technology’, which included ‘hand-washing… avoidance of faeces during meal preparation and eating times, (and) adequate preservation of food’ (1979).

Mirroring a wider debate in the field of international development and global health, there has been an increased focus on equity and non-discrimination within the WASH sector. Disaggregating MDG progress data by wealth quintile reveals markedly different rates of progress between groups categorized by wealth, with the slowest progress among the poorest (UNICEF 2010). If WASH sector investments are to support efforts to reduce stunting, identifying where stunting is spatially and socially clustered and targeting these populations will be important. As poverty, undernutrition and poor infrastructure often coincide, the potential for positive synergies is high. The public health benefits of targeting WASH interventions at stunted populations are twofold: firstly, that reductions in stunting might be accelerated if WASH interventions deliberately target children at risk, and, secondly, that the impact of WASH on diarrhoea and other diseases might be enhanced by targeting undernourished children who are more susceptible to infection and related mortality (Caulfield et al. 2004).

Conclusions

Improved access to safe and sustainable WASH brings a broad range of well-documented and widely recognized health and non-health benefits. In addition, current evidence suggests that WASH can also bring significant gains in tackling childhood undernutrition. Whether it is by the generally better investigated pathways of enteric pathogen exposure or the plausible but less well-investigated social and economic pathways, poor WASH access is intimately linked to childhood growth and development. Realizing the potential contribution of WASH to global efforts to end stunting will require stronger coordination but may also require that WASH programmes and interventions are modified. While WASH alone will not eliminate stunting, it does have the potential to accelerate progress on eliminating stunting as a critical component of comprehensive strategies.
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Conflicts of interest

The authors declare that they have no conflicts of interest.

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associated with diarrhea, pneumonia, malaria, and measles. 


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Preventing environmental enteric dysfunction through improved water, sanitation and hygiene: an opportunity for stunting reduction in developing countries

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Abstract

In 2011, one in every four (26%) children under 5 years of age worldwide was stunted. The realization that most stunting cannot be explained by poor diet or by diarrhoea, nor completely reversed by optimized diet and reduced diarrhoea has led to the hypothesis that a primary underlying cause of stunting is subclinical gut disease. Essentially, ingested microbes set in motion two overlapping and interacting pathways that result in linear growth impairment. Firstly, partial villous atrophy results in a reduced absorptive surface area and loss of digestive enzymes. This in turn results in maldigestion and malabsorption of much needed nutrients. Secondly, microbes and their products make the gut leaky, allowing luminal contents to translocate into systemic circulation. This creates a condition of chronic immune activation, which (i) diverts nutrient resources towards the metabolically expensive business of infection fighting rather than growth; (ii) suppresses the growth hormone-IGF axis and inhibits bone growth, leading to growth impairment; and (iii) causes further damage to the intestinal mucosa thereby exacerbating the problem. As such, the unhygienic environments in which infants and young children live and grow must contribute to, if not be the overriding cause of, this environmental enteric dysfunction. We suggest that a package of baby-WASH interventions (sanitation and water improvement, handwashing with soap, ensuring a clean play and infant feeding environment and food hygiene) that interrupt specific pathways through which feco-oral transmission occurs in the first two years of a child’s life may be central to global stunting reduction efforts.

Keywords: stunting, nutrition, disease, infant and child nutrition, early growth, sanitation.

The stunting dilemma

In 2011, 165 million (26%) children under 5 years of age worldwide were stunted as indicated by a height-for-age Z-score (HAZ) of −2 or lower (Black et al. 2013). This stunting is associated with greater risk of death from infectious diseases in childhood (Caulfield et al. 2004; Pelletier et al. 1995), poorer cognition, (Grantham-McGregor et al. 2007; Walker et al. 2011) poorer educational outcomes (Alderman et al. 2006; Maluccio et al. 2009) and lower adult earnings (Hoddinott et al. 2013). For these compelling reasons, normalizing child growth during the window of opportunity – between conception and the first two years of postnatal life (Victora et al. 2010) – represents an important long-term investment.

Analyses of the effects of improved dietary intake on child growth suggest that a nutritionally adequate diet is necessary but not sufficient for ensuring optimal linear growth. A comprehensive review of complementary feeding interventions (Dewey and Adu-Afarwuah, 2008) revealed a growth effect (mean effect size) of 0.0–0.64 length-for-age Z-scores. A comparable linear growth effect (standard mean difference) of 0.08–0.62 length-for-age Z-scores was reported in a recent series of reviews (Bhutta et al. 2013; Imdad et al. 2011; Lassi et al. 2013) of 16 randomized and quasi-randomized complementary feeding intervention studies. While statistically significant, these analyses demonstrate that the growth effect of the most efficacious of these interventions was +0.7 Z-scores, which translates to a modest 30% reduction in stunting because
the average linear growth deficit is −2.0 HAZ by 24 months among African and Asian children (Victora et al. 2010).

Similarly, disease explains only a part of the variation in stunting. Infection has long been understood to be central to the interactive relationship between disease and nutrition (Scrimshaw et al. 1968), with infectious disease episodes increasing the risk of a child being undernourished and vice versa. However, the association between diarrhoea, the most studied and most frequent infection in developing countries, and linear growth is modest, particularly because of catch-up growth after illness episodes (Briend, 1990; Briend et al. 1990). In a pooled analysis of nine studies, a higher cumulative burden of diarrhoea before 24 months was associated with greater odds of being stunted at 24 months (Checkley et al. 2008). Additional analyses of seven of these studies (Richard et al. 2013; Richard et al. 2014) revealed that the association between diarrhoea burden and linear growth is small (0.38 cm, which translates to about 1/15th of the average height deficit at 2 years of age among African and Asian children), and provided further evidence of catch-up growth: when diarrhoeal episodes were followed by diarrhoea-free periods in the first two years of life, catch-up growth allowed children to regain their initial trajectories. The findings of these analyses are consistent with other observations that reductions in clinic presentations of diarrhoea were not associated by improvements in nutritional status (Poskitt et al. 1999); and the introduction of a highly effective programme to treat infectious diseases dramatically reduced infant morality but had no effect on growth (Rousham and Gracey, 1997).

The realization that most stunting cannot be explained by poor diet or by diarrhoea, nor completely reversed by optimized diet and reduced diarrhoea has led researchers to reexamine papers published over the past several decades that have posited a linkage between unsanitary living environments leading to an acquired asymptomatic but chronic gut injury with systemic immunostimulation and poor growth (Rosenberg and Solomons, 1978; Rosenberg et al. 1974; Solomons, 2003; Solomons et al. 1993). Frequently, researchers have assumed that any growth benefits of WASH interventions are mediated through reduced diarrhoea. Accordingly, because the linkage between diarrhoea and growth is so weak, the 2008 Lancet Nutrition series estimated that WASH interventions implemented at scale would reduce stunting by only 2.5%, when they modelled the effect through diarrhoea. Other observations suggest the effect of WASH on linear growth may be independent of diarrhoea: in a cross-sectional analysis of DHS data from eight countries, Esrey (1996) noted that optimum water and sanitation were more strongly associated with linear growth than it was with diarrhoea. In a longitudinal cohort of Gambian children from age 8 to 64 weeks, measures of chronic immunostimulation were highly correlated with measures of enteropathy, and together were strongly predictive of poor linear growth (Campbell et al. 2003) further strengthening the hypothesized role of enteropathy and immunostimulation in stunting. Solomons draws parallels between the conditions of these infants and animal husbandry (Solomons, 2003; Solomons et al. 1993); noting that either cleaning up the environmental conditions for chickens or adding antibiotics to pig fodder

Key messages

- The recalcitrance of stunting to diet and disease control interventions has led to the hypothesis that a primary underlying cause of stunting is subclinical gut disease (EED).
- In the context of marginal diets and recurrent infections, EED likely explains a significant portion of the unresolved stunting affecting one in every three children in developing countries.
- Avoiding ingestion of enteric pathogens and other causative microbes by infants and young children could prevent most of the EED burden.
- Interventions aimed at preventing and reducing EED, particularly through baby-targeted WASH interventions, may be critical to global stunting reduction efforts.
can improve growth and enhance meat production, he presents a major clue that the cause of enteropathy is environmental.

Humphrey (2009) integrated this longstanding literature into a hypothesis that exposure to poor sanitation and hygiene causes this enteropathy, now termed environmental enteric dysfunction (EED; Keusch et al. 2013) and that this EED (rather than diarrhoea) is the primary causal pathway from poor sanitation and hygiene to stunting. A more recent observational study supports this hypothesis: Bangladeshi children living in environmentally clean households had less severe EED and higher HAZ than children from contaminated households (Lin et al. 2013).

Environmental enteric dysfunction as a modulator of growth

The healthy gut

The healthy small intestine is a complex organ consisting of multiple functional elements: a mucus layer containing defensins and immunoglobulins, a single layer of epithelial cells sealed by tight junctions, and the lamina propria and submucosa containing immune cells (Hodin and Matthews, 2008; McKay et al. 2010). The intestinal epithelium, illustrated in Fig. 1a [adapted from (Sandler and Douek, 2012)] forms a one-cell-thick interface between the internal organism and external luminal environment. It also comprises two major compartments, the villus and the crypt, which play major roles in the digestion and absorption of nutrients, in absorption and secretion of water and electrolytes and in intestinal immune function (Hodin and Matthews, 2008; Jaladanki and Wang, 2011; Peterson and Artis, 2014). The villous compartment comprises mature, absorptive cells that form finger-like projections extending into the intestinal lumen thereby amplifying the absorptive surface area 20-fold. The crypt is a contiguous pocket of epithelial cells at the base of the villus that is populated by younger epithelial cells involved primarily in secretion of antimicrobial proteins and stem cells that continually divide and migrate towards the villous surface. Collectively, these features are responsible for the barrier, immune and absorptive functions of the small intestine.

The ‘impoverished’ gut: environmental enteric dysfunction

What is it?

Environmental enteric dysfunction is a subclinical disorder of the small intestine that is characterized by villous atrophy, crypt elongation, inflammatory cells infiltrating the crypts and a loss of barrier function or increased permeability (Keusch et al. 2014; Prendergast and Kelly, 2012). The term refers to a phenomenon of impaired intestinal function rather than a clinical syndrome or entity with diagnostic criteria (McKay et al. 2010). The nomenclature for this subclinical condition has evolved with improved understanding from tropical enteropathy to environmental (acquired) enteropathy and is currently referred to as EED (to focus on the functional alterations) (Keusch et al. 2013).

Epidemiology

Initially described as a condition of the tropics (Desai et al. 1969), enteropathy is virtually ubiquitous among persons living in conditions of poverty (Baker, 1976; Keusch, 1972; Menzies et al. 1999). Any explanation of the ubiquity of this condition in developing countries must take into account the observation that the intestinal morphology of stillborn fetuses and newborns in these contexts are normal, thereby demonstrating that the disorder is acquired and not genetic (Cook et al. 1969; Stanfield et al. 1965). South Asian adults with this condition and Peace Corps volunteers who had spent some time in such environments were observed to ‘recover’ when they spent a duration of time away (Gerson et al. 1971; Lindenbaum et al. 1971), suggesting that the causative factor was environmental. However, recovery rates between these groups differ: South Asian adults who migrated to Europe or the United States had enteropathy on arrival, which resolved within ~5 years (Gerson et al. 1971), while asymptomatic American soldiers in Vietnam (Sheehy et al. 1968) and Peace Corps volunteers in Pakistan (Lindenbaum et al. 1971) who acquired enteropathy within a few month’s residence in these settings recovered in the course of 4–5 months after returning to the United States. This suggests that enteropathy is reversible, but that recovery is relatively slow, especially among people who have lived in an
unsanitary environment and presumably had the condition throughout their lifetime.

Aetiology

Although the pathogenesis of EED is unclear, it has been linked to environmental contamination in general and faecal contamination in particular (Baker, 1976; Lindenbaum et al. 1972) and likely represents an adaptive response to a contaminated environment. In response to a prolonged and persistent exposure to enteric pathogens and enterotoxins expressed by pathogenic bacteria, intestinal morphology is altered in a

Fig. 1. The intestinal epithelium in health (a) and with environmental enteric dysfunction (b). Adapted and reprinted with permission from Macmillan Publishers Ltd: Nature Reviews Microbiology; Sandler and Douek (2012).
number of ways; the most frequently observed being crypt hyperplasia and villous atrophy. In EED, illustrated in Fig. 1b, crypts are elongated with rapidly increased cell production rate (Cook et al. 1969; Veitch et al. 2001). This crypt hyperplasia is etiologically related to partial villous atrophy (Desai et al. 1969; Fagundes-Neto et al. 1984) or shortening, fusing and broadening of the villi – resulting in the architecture of the gut becoming flatter and blunted with an appearance of leaves and ridges rather than the typical finger-like projections (Haghighi and Wolf, 1997; Prendergast and Kelly, 2012). The main functional implication of these changes in intestinal architecture is reduced absorptive capacity secondary to the diminished surface area. Because absorptive cells are concentrated in the villous section, shorter villi and deeper crypts have fewer absorptive, and more secretory, cells further compromising nutrient absorption (Nabuurs et al. 1993).

At the cellular level, hyperstimulation of enteric T-cells appears to be important in the pathogenesis of EED (Veitch et al. 2001). In a human fetal intestinal explant model, a cell-mediated immune response was elicited by stimulating T-cells resulting in a 10-fold increase in the rate of crypt epithelial cell proliferation and subsequently shorter villi, demonstrating that activation of T-cells is important in the pathogenesis of EED and that crypt hyperplasia precedes villous atrophy (Ferreira et al. 1990). In similar studies of induced T-cell hypersensitivity (Lionetti et al. 1993; MacDonald and Spencer, 1988), some explants showed villous atrophy and crypt hyperplasia, whereas in others, there was mucosal damage, which increased in severity with increasing specimen age. This suggests that crypt hyperplasia, villous atrophy and mucosal damage represent a continuum of adaptive to destructive responses to hyperstimulation by abnormally high levels of ingested bacteria.

What triggers T-cell hyperstimulation?

This is the same cellular mechanism underlying inflammatory bowel diseases such as celiac disease or Crohn’s disease. However, in EED, these are normal reactions to abnormally high concentrations of bacteria, whereas in these diseases, T-cells are abnormally hyperreactive to normal stimuli. For example, in celiac patients, this stimulus is gluten, a normal antigen in healthy people, but an abnormal antigen for people with this genetic defect. In impoverished populations, most authors suggest the primary cause is high concentrations of faecal microorganisms. Accordingly, in this paper, we focus on the prevention of EED through reducing exposure to faecal microorganisms. It is important to note, however, that other causative factors may be important in the pathogenesis of EED in some contexts; these include mycotoxin exposure (Smith et al. 2012), severe nutritional deficiency (Guerrant et al. 2008), human immunodeficiency virus (Kelly et al. 1997), and diarrhoea (Behrens et al. 1987; Mondal et al. 2012). As such, EED prevention in these contexts could require different interventions.

Environmental enteric dysfunction is self-perpetuating!

The intestinal epithelium selectively limits permeation of potentially harmful luminal substances (Hodin and Matthews, 2008). However, certain microbes or bacterial toxins (endotoxins) perturb barrier function either directly through loosening of the tight junctions or by activating various cytokine, neutrophil and proinflammatory mediators (Arrieta et al. 2006; Meddings, 2010). This permeable gut allows luminal contents, including microbes (microbial translocation) to cross the epithelial barrier and into systemic circulation (Brenchley and Douek, 2012). Chronic exposure to these insults – among Gambian infants 2–15 months of age (Lunn et al. 1991), increased intestinal permeability was observed in 700 out of 922 dual sugar absorption tests (i.e. for 76% of the time) – create a condition of low-level chronic immune activation.

Worryingly, EED can be self-perpetuating once it develops, especially if the host and causative agent are not separated (Gerson et al. 1971; Lindenbaum et al. 1971). Experimental intravenous infusion of bacterial endotoxin administered to healthy humans increased gut permeability (O’Dwyer et al. 1988), suggesting a vicious cycle.

How might environmental enteric dysfunction cause stunting?

Most of the research linking EED and linear growth faltering has been undertaken among rural Gambian
infants and young children over the past two decades. In one of their earlier studies (Lunn et al. 1991), investigators in the Dunn Nutrition Laboratory monitored infants over a mean of 7.5 months. In addition to the negative correlation between intestinal permeability and monthly length gain (corrected for age), they calculated that impaired intestinal permeability accounted for 43% of linear growth faltering during this period. In a subsequent study (Campbell et al. 2003), three different markers of intestinal function (lactulose/mannitol ratio, IgG anti-endotoxin titers and plasma immunoglobulin concentrations) were individually associated with growth faltering and showed substantial degree of overlap in their relationship with growth. In semi-partial regression analysis, the three markers were calculated to explain up to 55% of linear growth faltering, suggesting that intestinal permeability, microbial translocation and inflammatory and immune response are all part of a single mechanism that overall predicted up to 55% of the growth faltering observed in Gambian children. This supports the mechanism of translocation of luminal bacteria or bacterial products across a compromised gut mucosa, leading to stimulation of systemic immune/inflammatory processes and subsequent growth impairment. This growth impairment arises in three ways. First, chronic immune activation is metabolically expensive, resulting in the diversion of nutrients to fuel the immune response (Ganeshan and Chawla, 2014). Second, chronic overproduction of proinflammatory cytokines (e.g. interleukin-6) causes growth impairment that is mediated by a decrease in circulating insulin-like growth factor (IGF-1) levels (De Benedetti et al. 1997). Third, proinflammatory cytokines (e.g. interleukin-1; tumour necrosis factor, TNF; interferon gamma, IFNγ) may directly impede linear growth by inhibiting the process of bone remodelling that is required for long bone growth (Bertolini et al. 1986; Skerry, 1994; Stephensen, 1999).

In the context of high nutrient requirements (Butte et al. 2000; Dewey, 2013) and rapid linear growth in infancy and early childhood (Dewey et al. 1992), EED may cause nutrient malabsorption that could further exacerbate its effects on growth. Morphologic data from nutritionally depleted and nondepleted patients suggested that a decrease in villous height is at least partially responsible for the changes in lactulose/mannitol (L/M) ratio, the dual sugar test of absorption and intestinal permeability (van der Hulst et al. 1998). Decreased mannitol absorption is a result of a diminished absorptive area, while increased permeation of lactulose may, in theory, be due to a facilitated diffusion of lactulose into the crypt region as a consequence of decreased villous height in addition to permeation due to loosening of the tight junctions. In the Gambian studies (Campbell et al. 2002; Campbell et al. 2003), the increase in L/M ratio that strongly predicted growth faltering was due to both reduced M and elevated L uptake, indicating that both barrier and absorptive functions of the small intestine were compromised. Furthermore, the loss of enterocyte brush border enzymes required for digestion and absorption (e.g. lactase) that results from villous atrophy can lead to malabsorption and malnutrition (Lunn, 2000).

Recent studies both confirm and provide further insights on these mechanisms. In the Global Enteric Multicenter Study, 83% of children with moderate-to-severe diarrhoea seeking care (cases) had at least one pathogen in their stool, as did 72% of matched controls (Kotloff et al. 2013) confirming that sub-Saharan African and south Asian children 0–59 months old are infected with multiple enteric pathogens even when they do not have diarrhoea. In the MAL-ED study, measures of intestinal inflammation were associated with linear growth faltering, even after controlling for diarrheal illness (Kosek et al. 2013) providing longitudinal support for the EED-stunting pathway. In a case–control study (Prendergast et al. 2014) of Zimbabwean infants who were stunted (HAZ < –2; cases) compared with non-stunted (HAZ > –0.5 controls) at 18 months, an association was observed between stunting and low-grade inflammation in the first year of life and perturbation of the growth hormone-IGF axis. Chronic inflammation due to microbial ingestion likely underlies a great deal of the prevalent and intractable stunting in developing countries.

The mechanisms linking environmental contamination, EED and stunting are illustrated in Fig. 2. In summary, ingested microbes set in motion two overlapping and interacting pathways that result in a linear growth impairment. Firstly, partial villous atrophy results in a reduced absorptive surface area and loss of
digestive enzymes. This in turn results in maldigestion and malabsorption of nutrients. Secondly, microbes and their products impair the barrier function, causing a ‘leaky gut’, that allows luminal contents to translocate into systemic circulation. Chronic exposure to the microbes creates a condition of chronic immune activation, which (i) diverts nutrient resources (that are both scarce and in high demand) towards the metabolically expensive business of infection fighting rather than growth; (ii) suppresses the growth hormone-IGF axis, and inhibits bone growth and remodelling, leading to growth impairment; and (iii) causes further damage to the intestinal mucosa thereby exacerbating the problem.

There is surprisingly little data in the literature on the relative importance of these pathways (Baker, 1976), especially the malabsorption pathway. We suggest that an effect of malabsorption on growth is plausible only if the amount of nutrients lost in stools is so high that it cannot be compensated by increased food intake. For example, in children, celiac disease can result in stunting of growth without the more classic malabsorptive symptoms of steatorrhoea (Murray, 1999). Also, an effect of infection on growth has been reported during pregnancy (Kayentao et al. 2013; Luntamo et al. 2013), suggesting a direct effect of inflammation as neither nutrient malabsorption nor poor appetite is likely to play a role during intrauterine life. While it is important to ascertain the full nutritional significance of malabsorption in populations where intake is marginal, the effect of chronic immune activation is likely to be the predominant mechanism.
Preventing environmental enteric dysfunction

Based on the observational and mechanistic evidence available, poor sanitation and hygiene contribute to, and are possibly the overriding cause of, EED [Lunn, 2000]. Plausibly, avoiding the ingestion of enteric pathogens and any other causative microbes by infants and young children could prevent most of the EED burden.

Can improvements in WASH prevent or mitigate environmental enteric dysfunction?

The animal literature provides the strongest evidence that cleaning up the environment improves growth. Miller et al. (1986) reported increased crypt depth in pigs that were weaned into a ‘dirty’ environment compared with pigs weaned into a ‘clean’ environment. Also, chicks that are raised in environments with faeces, dust and dander (‘dirty chicks’) have higher circulating IL-1, a major mediator of the immune response, and slower growth than ‘clean chicks’ that are raised in steam-cleaned cages (Roura et al. 1992; Solomons, 2003). This effect is observed even in the absence of pathogenic agents, suggesting an immune response to normally nonpathogenic organisms or other environmental immunogens such as dust and dander. Notably, clean chicks both grow faster and use nutrients more efficiently than dirty chicks (Edwards et al. 1960; Roura et al. 1992).

Human evidence is limited to observational studies. In a study of Zambian adults (Kelly et al. 2004), a hygiene score below the median was independently associated with crypt depth above the median and intestinal permeability (measured by a sugar test of absorption and permeability) above the median. In a recent study (Lin et al. 2013), children in environmentally clean Bangladeshi households had lower levels of parasitic infection, less severe EED (lower L:M ratios, −0.32 SD; lower IgG EndoCAb titers, −0.24 SD) and better indicators of attained linear growth (22% points lower stunting prevalence and 0.54 SDs higher HAZ) than children from environmentally contaminated households. In this study, researchers deliberately selected households representing two extremes of the distribution of household environments in order to maximize observed differences, suggesting that it is possible to improve EED and growth within the continuum between these two environmental extremes of rural Bangladesh.

Which WASH interventions could reduce environmental enteric dysfunction and stunting?

Water, sanitation and hygiene (WASH) interventions have the express objective of preventing the ingestion of harmful microbes by interrupting faecal-oral transmission. In recent reviews, Curtis et al. (2000) and Brown et al. (2013) discuss the variety of these excreta-related transmission routes, either as a result of direct transmission through contaminated hands or indirect transmission via contamination of drinking water, soil, utensils, food and flies, and acknowledge that the importance of each transmission route varies between pathogens and settings, and that different pathogens are more prevalent in some populations. As such, effective interventions need to address the predominant transmission routes for the target population and context. Specifically, WASH interventions seeking to prevent EED should address specific pathways through which feco-oral transmission occurs in the first two years of a child’s life.

A recent study illustrates the difficulty of aligning interventions with the causal pathways of target problems. Researchers enrolled households in a slum area in Kathmandu, Nepal, and randomly assigned geographic areas to a handwashing promotion intervention (Langford et al. 2011). The study reported large reductions in diarrhoea but no improvements in HAZ or EED (mucosal integrity) markers. Additionally, IgG levels rose with age and WAZ and WHZ worsened with age at a faster rate in the intervention group relative to controls. However, there were statistically significant differences between overcrowding and biofuel use in intervention and control areas, which suggests that the poorer health trajectory of children in the intervention group may perhaps reflect conditions of overcrowding and poverty, leading to greater pathogen exposure through pathways unaffected by handwashing behaviours. The authors suggested in conclusion that ‘for children living in highly contaminated, overcrowded environments, with poor access to clean water
and sanitation, handwashing may be necessary, but not sufficient to reduce levels of subclinical mucosal damage and immune stimulation that are strongly associated with growth faltering.

In an in-depth observational study in rural Zimbabwe, infants were found to ingest soil and chicken feces during exploratory play and mouthing behaviours (Ngure et al. 2013; Ngure et al. 2014). Using measurements of Escherichia coli as a marker, we found that active exploratory ingestion of soil (2100 E. coli cfu) and chicken feces (10,000,000 E. coli cfu) posed a greater risk of faecal bacteria exposure in terms of microbial load compared with fingers (no E. coli cfu estimated), food (no E. coli cfu estimated) and drinking water (800 E. coli cfu). Similar observations of faecal contamination of the play and feeding areas of infants and young children, and ingestion of chicken feces have been reported in Peruvian slums and Bangladeshi households (Marquis et al. 1990). In a recent prospective cohort study of Bangladeshi children, a significant association was observed between caregiver-reported geophagy and elevated EED disease activity scores (defined as a composite score derived from faecal markers of intestinal inflammation), providing additional evidence that soil might be a direct exposure route for faecal pathogens (George et al. 2015). Based on these observations, Table 1 presents a framework for ‘baby-WASH’ interventions that target the primary feco-oral microbial transmission pathways among infants and children. This framework can be used to either guide the formulation of context-relevant interventions or as a checklist to ensure that interventions address all relevant pathways through which infants and young children are exposed to and ingest microbes.

Cluster-randomized trials are currently being conducted to ascertain the effects of WASH and improved nutrition (independently and in combination) on EED and stunting in Zimbabwe (clinicaltrials.gov identifier NCT01824940), Kenya (NCT01704105) and Bangladeshi (NCT01590095). These studies will provide much needed causal and mechanistic evidence on the role of WASH in stunting reduction. However, additional complementary questions warrant further research:

- What microbes are important in the aetiology of EED, i.e. commensal vs. pathogenic microbes (Korpe and Petri, 2012)? This question is important in defining the range of environmental microbes and microbial products that interventions should address. Among 40 asymptomatic infants with EED living in an urban Sao Paulo slum, 63% had colonic bacterial proliferation of the small bowel (Fagundes Neto et al. 1994). Moreover, because only pathogenic bacteria cause clinical diarrhoea, sanitation/hygiene messages have often particularly focused on avoiding exposure to faeces of young children – the major carriers of these organisms (Jinadu, 2004; Lanata et al. 1998). However, it may be that high concentrations of any bacteria in the small bowel can cause EED: in experiments comparing germ-free with conventional animals, commensal bacteria in low concentrations exert a trophic effect on the intestinal epithelium shifting morphology from ‘supranormal’ (i.e. very tall villi) to normal, which results in a structurally and functionally competent immune system (Sprinz et al. 1961). Thus, high exposure to all faeces (including those from healthy people and animals) may contribute to EED.
- What are the potential roles of antibiotics, probiotics, other anti-inflammatory agents, and changes in the composition of the microbiome in treating and preventing EED (Petri et al. 2014)? These preventive and therapeutic options for EED represent an area of active research (Galpin et al. 2005; Jones et al. 2014; Ryan et al. 2014; Trehan et al. 2009) and discussion (Petri et al. 2014; Prendergast and Humphrey, 2014), as we simultaneously seek to better understand the pathogenesis, mitigation and measurement of EED.
- What is the role of maternal EED on linear growth faltering that occurs in utero? Approximately 25% of the stunting observed at 2 years occurs in utero, i.e. born shorter than they should be: as such, understanding the contribution of maternal EED would aid the formulation of antenatal, and possibly pre-conception, interventions. This is being investigated through observational and case-control designs within the SHINE trial in Zimbabwe (NCT01824940).
- Which biomarker or biomarkers of EED should be used as (i) normative standards and cutoff points for ‘counting the affected’; (ii) indicators of risk for screening populations and targeting interventions; and (iii) indicators for measuring response(s)
<table>
<thead>
<tr>
<th>Intervention objective</th>
<th>Timing</th>
<th>Access (provision, demand creation)</th>
<th>Practical/technical considerations</th>
<th>Hardware – inputs</th>
<th>Software – behaviour change messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce faecal load in living environment</td>
<td>Always</td>
<td>Household sanitary facility (toilet).</td>
<td>Preferably one that facilitates or ensures fly control.</td>
<td>Preferably one that facilitates or ensures fly control.</td>
<td>Use of sanitary facilities by all household members. Safe disposal of child faeces.</td>
</tr>
<tr>
<td>Reduce faecal transmission via hands</td>
<td>Always</td>
<td>Handwashing facility, soap/scrubbing agent, water (quantity)</td>
<td>Placement of the handwashing facility – (visual) cue to behaviour. Availability of soap or other scrubbing agent (e.g. ash) near handwashing facility.</td>
<td>Placement of the handwashing facility – (visual) cue to behaviour. Availability of soap or other scrubbing agent (e.g. ash) near handwashing facility.</td>
<td>Handwashing with soap by all household members (including children) at key potential contamination events (e.g. after faecal contact, before handling food and before feeding).</td>
</tr>
<tr>
<td>Exclusive breastfeeding</td>
<td>First 6 months</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Breastfeeding only, to the exclusion of non-breastmilk items fed for either nutritive or protective (prevention or treatment of perceived childhood illnesses)</td>
</tr>
<tr>
<td>Improvement of drinking water quality</td>
<td>6 months (after 6 months EBF)</td>
<td>Safe water source. Drinking water storage containers. Treatment agent/model (e.g. solar, chlorine) at the point of use.</td>
<td>Water treatment agent should meet organoleptic (taste and smell) expectations of household members.</td>
<td>Water treatment agent should meet organoleptic (taste and smell) expectations of household members.</td>
<td>Water treatment at the point of use. Drinking of treated water by all household members.</td>
</tr>
<tr>
<td>Avoidance of child faecal ingestion during mouthing and exploratory play (e.g. geophagy, consumption of chicken faeces)</td>
<td>2-4 months (crawling and mouthing)</td>
<td>A clean play and infant feeding environment. (Household improvised or technology, such as a protective play-space)</td>
<td>The play space should ensure that the child is protected from contamination while ensuring their developmental needs for exploration and interaction are met. Any benefits should outweigh technical and sociocultural burdens of any new technology introduced.</td>
<td>The play space should ensure that the child is protected from contamination while ensuring their developmental needs for exploration and interaction are met. Any benefits should outweigh technical and sociocultural burdens of any new technology introduced.</td>
<td>Awareness of risks associated with playing in an environmentally contaminated environment, e.g. geophagy, direct/indirect consumption of animal faeces.</td>
</tr>
</tbody>
</table>

(Continued)
to interventions (Habicht and Stoltzfus, 1997; Habicht et al. 1982)? No single, validated biomarker of EED is available – currently available biomarkers indicate its structural and functional characteristics relative to the interacting and overlapping processes illustrated in Fig. 2. The process of identifying effective biomarkers and defining measurement protocols continues to evolve with heightened interest in the causes, pathogenesis, effects and responsiveness, of EED (Guerrant et al. 2013; Keusch et al. 2013; Keusch et al. 2014; Korpé and Petri, 2012; Kosek et al. 2014; Petri et al. 2014). This process would benefit from taking these objectives and applications of the ‘best’ indicator or indicators (Habicht and Pelletier, 1990) into cognizance.

**Conclusion**

Chronic exposure to a contaminated environment creates a constant state of survival responses characterized by loss, malabsorption, maldigestion and inefficient utilization of nutrients. In the context of marginal diets and recurrent infections, this ‘impoverished gut’ condition likely explains a significant portion of the unresolved stunting affecting one in every three children in developing countries. To prevent stunting, we need to prevent the onset of EED because (i) EED is self-perpetuating once it has developed; (ii) recovery from EED is relatively slow even when there is a dramatic change in environment; and (iii) the window for critical growth and development is short (between conception and the first two years of postnatal life). Interventions such as baby-WASH, aimed at preventing and reducing environmental enteric dysfunction, may be central to global stunting reduction efforts.

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**Conflicts of interest**

The authors declare that they have no conflicts of interest.

**Contributions**

MNNM wrote the first draft of the manuscript, which was critically revised by JHH.

**References**


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.
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: Amaravati, 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

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

HAZ, height-for-age z-score.
Predictors of child stunting: bivariate and multivariate regression analysis

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 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

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

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

*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 fortifed 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

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

(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>
<thead>
<tr>
<th>Child’s (0–23) stools are not disposed safely</th>
<th>Proportion (%) of children stunted (HAZ &lt; −2)</th>
<th>Proportion (%) of children severely stunted (HAZ &lt; −3)</th>
<th>Children’s mean height-for-age z-score (HAZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26.5</td>
<td>9.3</td>
<td>−1.13</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Breastfeeding practices

<table>
<thead>
<tr>
<th></th>
<th>Proportion (%) of children stunted (HAZ &lt; −2)</th>
<th>Proportion (%) of children severely stunted (HAZ &lt; −3)</th>
<th>Children’s mean height-for-age z-score (HAZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breastfed within 1 h of birth</td>
<td>24.4</td>
<td>7.4</td>
<td>−1.02</td>
</tr>
<tr>
<td>Not breastfed within 1 h of birth</td>
<td>21.4</td>
<td>7.0</td>
<td>−0.94</td>
</tr>
<tr>
<td>P-value</td>
<td>0.17</td>
<td>0.56</td>
<td>0.41</td>
</tr>
<tr>
<td>Received prelacteal feeds</td>
<td>20.3</td>
<td>7.3</td>
<td>−0.04</td>
</tr>
<tr>
<td>Did not receive prelacteal feeds</td>
<td>9.1</td>
<td>4.4</td>
<td>−0.89</td>
</tr>
<tr>
<td>P-value</td>
<td>0.30</td>
<td>0.88</td>
<td>0.046</td>
</tr>
<tr>
<td>Is exclusively breastfed (0–5 months)</td>
<td>10.2</td>
<td>3.4</td>
<td>−0.28</td>
</tr>
<tr>
<td>Is not exclusively breastfed (0–5 months)</td>
<td>6.1</td>
<td>2.6</td>
<td>−0.17</td>
</tr>
<tr>
<td>P-value</td>
<td>0.30</td>
<td>0.91</td>
<td>0.82</td>
</tr>
<tr>
<td>Is breastfed (12–15 months)</td>
<td>28.8</td>
<td>8.5</td>
<td>−1.32</td>
</tr>
<tr>
<td>Is not breastfed (12–15 months)</td>
<td>31.2</td>
<td>1.1</td>
<td>−1.15</td>
</tr>
<tr>
<td>P-value</td>
<td>0.55</td>
<td>0.11</td>
<td>0.24</td>
</tr>
<tr>
<td>Is breastfed (20–23 months)</td>
<td>44.6</td>
<td>15.3</td>
<td>−1.85</td>
</tr>
<tr>
<td>Is not breastfed (20–23 months)</td>
<td>40.5</td>
<td>14.3</td>
<td>−1.65</td>
</tr>
<tr>
<td>P-value</td>
<td>0.54</td>
<td>0.94</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Complementary feeding practices

<table>
<thead>
<tr>
<th></th>
<th>Proportion (%) of children stunted (HAZ &lt; −2)</th>
<th>Proportion (%) of children severely stunted (HAZ &lt; −3)</th>
<th>Children’s mean height-for-age z-score (HAZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receives complementary foods (6–8 months)</td>
<td>8.9</td>
<td>2.1</td>
<td>−0.47</td>
</tr>
<tr>
<td>Does not receive complementary foods (6–8 months)</td>
<td>18.8</td>
<td>4.0</td>
<td>−0.73</td>
</tr>
<tr>
<td>P-value</td>
<td>0.02</td>
<td>0.54</td>
<td>0.05</td>
</tr>
<tr>
<td>Is breastfed and receives CFoods (6–23 months)</td>
<td>28.8</td>
<td>10.9</td>
<td>−1.22</td>
</tr>
<tr>
<td>Is not breastfed and/or does not receive CFoods</td>
<td>27.8</td>
<td>9.3</td>
<td>−1.28</td>
</tr>
<tr>
<td>(6–23 months)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-value</td>
<td>0.46</td>
<td>0.71</td>
<td>0.03</td>
</tr>
<tr>
<td>Receives CFoods a minimum number of times (6–23 months)</td>
<td>28.7</td>
<td>9.1</td>
<td>−1.32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Proportion (%) of children stunted (HAZ &lt; −2)</th>
<th>Proportion (%) of children severely stunted (HAZ &lt; −3)</th>
<th>Children’s mean height-for-age z-score (HAZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not receive CFoods a minimum number of times/day</td>
<td>24.9</td>
<td>10.1</td>
<td>−1.15</td>
</tr>
<tr>
<td>P-value</td>
<td>0.02</td>
<td>0.399</td>
<td>0.000</td>
</tr>
<tr>
<td>Is fed a minimum diversity of diet (6–23 months)</td>
<td>26.2</td>
<td>9.0</td>
<td>−1.16</td>
</tr>
<tr>
<td>Is not fed a minimum diversity of diet (6–23 months)</td>
<td>28.9</td>
<td>9.3</td>
<td>−1.30</td>
</tr>
<tr>
<td>P-value</td>
<td>0.83</td>
<td>0.81</td>
<td>0.003</td>
</tr>
<tr>
<td>Is fed iron-rich foods (6–23 months)</td>
<td>26.4</td>
<td>5.0</td>
<td>−1.10</td>
</tr>
<tr>
<td>Is not fed iron-rich foods (6–23 months)</td>
<td>29.2</td>
<td>9.9</td>
<td>−1.32</td>
</tr>
<tr>
<td>P-value</td>
<td>0.79</td>
<td>0.1</td>
<td>0.39</td>
</tr>
<tr>
<td>All combined</td>
<td>22.7</td>
<td>7.4</td>
<td>−0.98</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Proportion (%) of children stunted (HAZ &lt; −2)</th>
<th>Proportion (%) of children severely stunted (HAZ &lt; −3)</th>
<th>Mean height-for-age z-score (HAZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mother’s age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 18</td>
<td>24.7</td>
<td>7.4</td>
<td>−1.06</td>
</tr>
<tr>
<td>18 to 19</td>
<td>26.7</td>
<td>12.1</td>
<td>−1.15</td>
</tr>
<tr>
<td>20 to 24</td>
<td>23.8</td>
<td>6.8</td>
<td>−1.02</td>
</tr>
<tr>
<td>25 to 29</td>
<td>19.4</td>
<td>6.0</td>
<td>−0.84</td>
</tr>
<tr>
<td>≥30</td>
<td>22.1</td>
<td>10.0</td>
<td>−0.97</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Age at marriage (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;18</td>
<td>27.4</td>
<td>10.3</td>
<td>−1.05</td>
</tr>
<tr>
<td>≥18</td>
<td>20.5</td>
<td>6.1</td>
<td>−0.94</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.013</td>
</tr>
<tr>
<td><strong>Mother’s education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>31.9</td>
<td>15.4</td>
<td>−1.06</td>
</tr>
<tr>
<td>Primary not completed</td>
<td>27.7</td>
<td>12.8</td>
<td>−1.29</td>
</tr>
<tr>
<td>Primary completed</td>
<td>27.2</td>
<td>9.1</td>
<td>−1.14</td>
</tr>
<tr>
<td>Secondary completed</td>
<td>19.9</td>
<td>4.8</td>
<td>−0.92</td>
</tr>
<tr>
<td>Beyond secondary</td>
<td>13.8</td>
<td>4.4</td>
<td>−0.64</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Mother’s access to media</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother has access to print media</td>
<td>17.0</td>
<td>3.3</td>
<td>−0.81</td>
</tr>
<tr>
<td>Mother does not have access to print media</td>
<td>24.4</td>
<td>8.6</td>
<td>−1.03</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.001</td>
</tr>
<tr>
<td>Mother has access to electronic media</td>
<td>19.5</td>
<td>6.0</td>
<td>−0.88</td>
</tr>
<tr>
<td>Mother does not have access to electronic media</td>
<td>30.6</td>
<td>10.8</td>
<td>−1.22</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Mother’s autonomy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother makes decisions about buying usual food items</td>
<td>23.3</td>
<td>8.3</td>
<td>−0.95</td>
</tr>
<tr>
<td>Mother does not make decisions about buying usual food items</td>
<td>21.4</td>
<td>5.8</td>
<td>−1.03</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.63</td>
<td>0.016</td>
<td>0.18</td>
</tr>
<tr>
<td><strong>Mother’s tobacco consumption</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother smokes tobacco or uses smokeless tobacco</td>
<td>30.6</td>
<td>11.8</td>
<td>−1.28</td>
</tr>
<tr>
<td>Mother does not smoke tobacco or use smokeless tobacco</td>
<td>21.5</td>
<td>6.7</td>
<td>−0.93</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.002</td>
<td>0.012</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Mother’s pregnancy history</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother’s age at first birth &lt; 18 years old</td>
<td>33.1</td>
<td>10.7</td>
<td>−1.16</td>
</tr>
<tr>
<td>Mother’s age at first birth ≥18 years old</td>
<td>21.5</td>
<td>7.0</td>
<td>−0.96</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.047</td>
<td>0.004</td>
</tr>
<tr>
<td>Number of antenatal care visits during the last pregnancy &lt; 3</td>
<td>25.1</td>
<td>10.2</td>
<td>−1.12</td>
</tr>
<tr>
<td>Number of antenatal care visits during the last pregnancy ≥ 3</td>
<td>21.4</td>
<td>6.7</td>
<td>−0.94</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.11</td>
<td>0.15</td>
<td>0.021</td>
</tr>
<tr>
<td>Mother received advice on nutrition during antenatal care</td>
<td>21.5</td>
<td>6.9</td>
<td>−0.95</td>
</tr>
<tr>
<td>Mother did not receive advice on nutrition during antenatal care</td>
<td>27.2</td>
<td>11.4</td>
<td>−1.18</td>
</tr>
</tbody>
</table>

(Continues)
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>
<thead>
<tr>
<th>P-value</th>
<th>Proportion (%) of children stunted (HAZ &lt; -2)</th>
<th>Proportion (%) of children severely stunted (HAZ &lt; -3)</th>
<th>Mean height-for-age z-score (HAZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of antenatal IFA tablets during the last pregnancy &lt; 90</td>
<td>25.1</td>
<td>8.4</td>
<td>-1.04</td>
</tr>
<tr>
<td>Number of antenatal IFA tablets during the last pregnancy ≥ 90</td>
<td>20.7</td>
<td>6.6</td>
<td>-0.93</td>
</tr>
<tr>
<td>Parent delivered her last child in a health facility (public or private)</td>
<td>0.03</td>
<td>0.046</td>
<td>0.043</td>
</tr>
<tr>
<td>Parent delivered her last child at home/not in a facility (public or private)</td>
<td>20.9</td>
<td>6.5</td>
<td>-0.91</td>
</tr>
<tr>
<td>P-value</td>
<td>32.8</td>
<td>12.8</td>
<td>-1.38</td>
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<tr>
<td>Mother’s anthropometry</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>Mother’s height &lt; 145 cm</td>
<td>31.5</td>
<td>10.6</td>
<td>-1.33</td>
</tr>
<tr>
<td>Mother’s height ≥ 145 cm</td>
<td>17.3</td>
<td>5.4</td>
<td>-0.77</td>
</tr>
<tr>
<td>P-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Mother’s BMI &lt; 18.5</td>
<td>26.7</td>
<td>9.1</td>
<td>-1.17</td>
</tr>
<tr>
<td>Mother’s BMI ≥ 18.5</td>
<td>20.5</td>
<td>6.5</td>
<td>-0.88</td>
</tr>
<tr>
<td>P-value</td>
<td>0.000</td>
<td>0.004</td>
<td>0.000</td>
</tr>
<tr>
<td>Mother’s food consumption during pregnancy</td>
<td>22.8</td>
<td>6.3</td>
<td>-1.02</td>
</tr>
<tr>
<td>Mother did not eat less than normal</td>
<td>22.5</td>
<td>7.8</td>
<td>-0.96</td>
</tr>
<tr>
<td>P-value</td>
<td>0.78</td>
<td>0.09</td>
<td>0.37</td>
</tr>
<tr>
<td>Mother ate chicken, meat, fish and/or seafood weekly</td>
<td>22.2</td>
<td>7.2</td>
<td>-0.97</td>
</tr>
<tr>
<td>Mother did not eat chicken, meat, fish and/or seafood weekly</td>
<td>23.2</td>
<td>7.6</td>
<td>-0.98</td>
</tr>
<tr>
<td>P-value</td>
<td>0.42</td>
<td>0.85</td>
<td>0.90</td>
</tr>
<tr>
<td>Mother ate milk and/or milk products weekly</td>
<td>20.6</td>
<td>5.6</td>
<td>-0.87</td>
</tr>
<tr>
<td>Mother did not eat milk and/or milk products weekly</td>
<td>24.0</td>
<td>8.7</td>
<td>-1.06</td>
</tr>
<tr>
<td>P-value</td>
<td>0.024</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Mother ate eggs weekly</td>
<td>22.4</td>
<td>7.1</td>
<td>-0.97</td>
</tr>
<tr>
<td>Mother did not eat eggs weekly</td>
<td>22.7</td>
<td>7.5</td>
<td>-0.97</td>
</tr>
<tr>
<td>P-value</td>
<td>0.46</td>
<td>0.62</td>
<td>0.83</td>
</tr>
<tr>
<td>All combined</td>
<td>22.7</td>
<td>7.4</td>
<td>-0.98</td>
</tr>
</tbody>
</table>

Table 5. (Continued)

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

<table>
<thead>
<tr>
<th></th>
<th>Proportion (%) of children stunted (HAZ &lt; −2)</th>
<th>Proportion (%) of children severely stunted (HAZ &lt; −3)</th>
<th>Children’s mean height-for-age z-score (HAZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>20.1</td>
<td>6.8</td>
<td>−0.9</td>
</tr>
<tr>
<td>Rural</td>
<td>24.7</td>
<td>7.9</td>
<td>−1.1</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.004</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Region</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amaravati</td>
<td>23.5</td>
<td>6.9</td>
<td>−1.1</td>
</tr>
<tr>
<td>Aurangabad</td>
<td>25.1</td>
<td>7.9</td>
<td>−1.0</td>
</tr>
<tr>
<td>Konkani</td>
<td>22.2</td>
<td>6.9</td>
<td>−0.9</td>
</tr>
<tr>
<td>Nagpur</td>
<td>14.3</td>
<td>2.2</td>
<td>−0.8</td>
</tr>
<tr>
<td>Nashik</td>
<td>31.0</td>
<td>14.5</td>
<td>−1.2</td>
</tr>
<tr>
<td>Pune</td>
<td>18.0</td>
<td>4.4</td>
<td>−0.8</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Caste/tribe</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Scheduled Caste</td>
<td>22.7</td>
<td>10.3</td>
<td>−1.1</td>
</tr>
<tr>
<td>Scheduled Tribe</td>
<td>27.1</td>
<td>10.1</td>
<td>−1.1</td>
</tr>
<tr>
<td>Other backward class</td>
<td>19.4</td>
<td>5.8</td>
<td>−0.9</td>
</tr>
<tr>
<td>Other</td>
<td>21.8</td>
<td>5.4</td>
<td>−0.9</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
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<td><strong>Wealth index</strong></td>
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</tr>
<tr>
<td>Poorest</td>
<td>25.7</td>
<td>9.6</td>
<td>−1.0</td>
</tr>
<tr>
<td>Second</td>
<td>25.6</td>
<td>7.7</td>
<td>−1.1</td>
</tr>
<tr>
<td>Middle</td>
<td>26.1</td>
<td>9.3</td>
<td>−1.1</td>
</tr>
<tr>
<td>Fourth</td>
<td>22.9</td>
<td>7.1</td>
<td>−0.9</td>
</tr>
<tr>
<td>Richest</td>
<td>12.8</td>
<td>3.3</td>
<td>−0.7</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Number of household members</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤4</td>
<td>22.0</td>
<td>7.0</td>
<td>−1.0</td>
</tr>
<tr>
<td>&gt;4</td>
<td>22.7</td>
<td>7.4</td>
<td>−1.0</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.7</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Water, hygiene and sanitation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household uses piped water into dwelling/yard/plot</td>
<td>19.9</td>
<td>10.4</td>
<td>−0.9</td>
</tr>
<tr>
<td>Household does use piped water into dwelling/yard/plot</td>
<td>22.9</td>
<td>7.1</td>
<td>−1.0</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.3</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Household uses improved sanitation facilities</td>
<td>16.1</td>
<td>3.5</td>
<td>−0.8</td>
</tr>
<tr>
<td>Household uses unimproved sanitation facilities</td>
<td>26.7</td>
<td>9.8</td>
<td>−1.1</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.000</td>
<td>0.000</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Household food security</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Household is food secure</td>
<td>19.6</td>
<td>5.0</td>
<td>−0.9</td>
</tr>
<tr>
<td>Household is food insecure</td>
<td>26.9</td>
<td>10.6</td>
<td>−1.1</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.002</td>
<td>0.000</td>
<td>0.2</td>
</tr>
<tr>
<td>Household is food secure</td>
<td>19.6</td>
<td>5.0</td>
<td>−0.9</td>
</tr>
<tr>
<td>Household is mildly food insecure</td>
<td>24.7</td>
<td>7.3</td>
<td>−1.1</td>
</tr>
<tr>
<td>Household is moderately food insecure</td>
<td>27.7</td>
<td>11.0</td>
<td>−1.2</td>
</tr>
<tr>
<td>Household is severely food insecure</td>
<td>28.8</td>
<td>14.3</td>
<td>−1.1</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.006</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

(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)

<table>
<thead>
<tr>
<th>Household access to ICDS</th>
<th>Proportion (%) of children stunted (HAZ &lt; −2)</th>
<th>Proportion (%) of children severely stunted (HAZ &lt; −3)</th>
<th>Children’s mean height-for-age z-score (HAZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household has access to ICDS services</td>
<td>25.1</td>
<td>8.7</td>
<td>−1.1</td>
</tr>
<tr>
<td>Household does not have access to ICDS services</td>
<td>18.4</td>
<td>5.2</td>
<td>−0.8</td>
</tr>
<tr>
<td>P-value</td>
<td>0.006</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>All combined</td>
<td>22.7</td>
<td>7.4</td>
<td>−0.98</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Age group</th>
<th>0–23 months old</th>
<th>0–5 months old</th>
<th>6–23 months old</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stunting</td>
<td>Sev. stunting</td>
<td>Stunting</td>
</tr>
<tr>
<td></td>
<td>AOR (95% CI)</td>
<td>AOR (95% CI)</td>
<td>AOR (95% CI)</td>
</tr>
<tr>
<td>Age (12–23 months vs. 0–11 months)</td>
<td>4.642*** (3.556–6.084)</td>
<td>5.803*** (3.645–9.240)</td>
<td>—</td>
</tr>
<tr>
<td>Sex (boys vs. girls)</td>
<td>1.377*** (1.066–1.737)</td>
<td>1.749*** (1.210–2.530)</td>
<td>—</td>
</tr>
<tr>
<td>Birthweight (&lt;2500 g vs. &gt;2500 g)</td>
<td>2.494*** (1.956–3.266)</td>
<td>2.367*** (1.619–3.462)</td>
<td>—</td>
</tr>
<tr>
<td>Child (12–23 months) is fully immunized (no vs. yes)</td>
<td>1.157 (0.901–1.498)</td>
<td>0.987 (0.783–1.328)</td>
<td>—</td>
</tr>
<tr>
<td>Child faeces are safely disposed of (no vs. yes)</td>
<td>1.01 (0.901–1.120)</td>
<td>0.987 (0.841–1.151)</td>
<td>—</td>
</tr>
<tr>
<td>Mother's age (&lt;18 years vs. ≥18 years)</td>
<td>1.043 (0.783–1.328)</td>
<td>0.972 (0.641–1.518)</td>
<td>—</td>
</tr>
<tr>
<td>Mother's age at marriage (&lt;18 years vs. ≥18 years)</td>
<td>1.074 (0.657–1.651)</td>
<td>1.536* (0.482–1.962)</td>
<td>—</td>
</tr>
<tr>
<td>Mother's age at birth of the index child (&lt;18 years vs. ≥18 years)</td>
<td>1.175 (0.789–1.449)</td>
<td>0.987 (0.694–1.363)</td>
<td>—</td>
</tr>
<tr>
<td>Mother's education (≥ secondary education vs. &lt; secondary education)</td>
<td>1.193 (0.756–1.826)</td>
<td>1.227 (0.353–1.363)</td>
<td>—</td>
</tr>
<tr>
<td>Mother's access to print media (no vs. yes)</td>
<td>0.969 (0.730–1.302)</td>
<td>1.02 (0.621–1.676)</td>
<td>—</td>
</tr>
<tr>
<td>Mother's access to electronic media (no vs. yes)</td>
<td>1.341** (1.292)</td>
<td>1.292 (1.250–1.336)</td>
<td>—</td>
</tr>
</tbody>
</table>

(Continues)
Table 7. (Continued)

<table>
<thead>
<tr>
<th>Age group</th>
<th>0–23 months old</th>
<th>0–5 months old</th>
<th>6–23 months old</th>
<th>6–23 months old</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stunting</td>
<td>Sev. stunting</td>
<td>AOR (95% CI)</td>
<td>Stunting</td>
</tr>
<tr>
<td>Mother makes decisions on buying food items (no vs. yes)</td>
<td>1.010–1.769</td>
<td>1.02</td>
<td>0.840–2.098</td>
<td>1.08</td>
</tr>
<tr>
<td>Mother received advice on nutrition at antenatal care (no vs. yes)</td>
<td>0.846–1.320</td>
<td>1.135</td>
<td>0.592–4.906</td>
<td>0.734–2.223</td>
</tr>
<tr>
<td>Mother consumes tobacco (no vs. yes)</td>
<td>0.806</td>
<td>1.118</td>
<td>0.977</td>
<td>3.72</td>
</tr>
<tr>
<td>Mother consumed IFA during last pregnancy (&lt;90 tablets vs. &gt;90 tablets)</td>
<td>0.551–1.192</td>
<td>1.131</td>
<td>0.247–2.528</td>
<td>0.582–1.296</td>
</tr>
<tr>
<td>Mother delivered in a health facility (no vs. yes)</td>
<td>0.894–1.418</td>
<td>1.007</td>
<td>0.485–2.000</td>
<td>0.860–1.389</td>
</tr>
<tr>
<td>Mother’s height (&lt;145 cm vs. &gt;145 cm)</td>
<td>0.657–1.522</td>
<td>2.035***</td>
<td>0.248–3.800</td>
<td>0.699–1.661</td>
</tr>
<tr>
<td>Mother’s BMI (&lt;18.5 kg/m² vs. &gt;18.5 kg/m²)</td>
<td>1.460–2.809</td>
<td>1.152</td>
<td>0.799–4.491</td>
<td>1.513–2.614</td>
</tr>
<tr>
<td>Mother ate milk and/or milk products weekly during pregnancy (no vs. yes)</td>
<td>0.916–1.476</td>
<td>0.979</td>
<td>0.244–1.411</td>
<td>0.917–1.496</td>
</tr>
<tr>
<td>Household residence (rural vs. urban)</td>
<td>0.779–1.241</td>
<td>0.852</td>
<td>0.68–2.784</td>
<td>0.70–1.157</td>
</tr>
</tbody>
</table>

(Continues)
Table 7. (Continued)

<table>
<thead>
<tr>
<th>Age group</th>
<th>0–23 months old</th>
<th>0–5 months old</th>
<th>6–23 months old</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stunting</td>
<td>Sev. stunting</td>
<td>Stunting</td>
</tr>
<tr>
<td></td>
<td>AOR</td>
<td>(95% CI)</td>
<td>AOR</td>
</tr>
<tr>
<td>Household belongs to a Scheduled Tribe (yes vs no)</td>
<td>0.603–1.208</td>
<td>0.373–1.123</td>
<td>0.271–2.648</td>
</tr>
<tr>
<td>Household wealth index (poorest vs. richest)</td>
<td>1.046</td>
<td>1.032</td>
<td>1.554</td>
</tr>
<tr>
<td>Household wealth index (poorer vs. richest)</td>
<td>0.681</td>
<td>0.662–1.608</td>
<td>0.663–3.554</td>
</tr>
<tr>
<td>Household wealth index (middle vs. richest)</td>
<td>1.019–2.659</td>
<td>0.410–2.056</td>
<td>0.580–16.88</td>
</tr>
<tr>
<td>Household wealth index (rich vs. richest)</td>
<td>1.891***</td>
<td>1.424</td>
<td>3.302*</td>
</tr>
<tr>
<td>Household has access to improved sanitation (no vs. yes)</td>
<td>1.182–2.481</td>
<td>0.520–1.832</td>
<td>0.854–11.36</td>
</tr>
<tr>
<td>Household is food secure (no vs. yes)</td>
<td>1.101–1.754</td>
<td>1.166–3.024</td>
<td>0.326–1.742</td>
</tr>
<tr>
<td>Household benefits from ICDS programme (no vs. yes)</td>
<td>0.89</td>
<td>1.316</td>
<td>1.980*</td>
</tr>
<tr>
<td>Child is exclusively breastfed (no vs. yes)</td>
<td>0.696–1.130</td>
<td>0.897–1.933</td>
<td>0.927–2.461</td>
</tr>
<tr>
<td>Child's diet meets a minimum dietary diversity (no vs. yes)</td>
<td>0.804</td>
<td>0.683</td>
<td>0.793</td>
</tr>
</tbody>
</table>

(Continues)
<table>
<thead>
<tr>
<th>Age group</th>
<th>0–23 months old</th>
<th>0–5 months old</th>
<th>6–23 months old</th>
<th>6–23 months old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stunting</td>
<td>AOR (95% CI)</td>
<td>Sev. stunting</td>
<td>AOR (95% CI)</td>
<td>Stunting</td>
</tr>
<tr>
<td></td>
<td>AOR (95% CI)</td>
<td></td>
<td>AOR (95% CI)</td>
<td>AOR (95% CI)</td>
</tr>
<tr>
<td>Child’s diet meets a minimum meal frequency (no vs. yes)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Child was fed dairy products (milk, yoghurt, cheese) (no vs. yes)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Child was fed grains, roots and tubers (no vs. yes)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Child was fed vitamin A-rich fruits and vegetables (no vs. yes)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Child was fed other fruits and vegetables (no vs. yes)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Child was fed eggs (no vs. yes)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Child was fed flesh foods (meat, fish, poultry, liver/organ meats) (no vs. yes)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Child was fed legumes and/or nuts (no vs. yes)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Number of observations</td>
<td>2263</td>
<td>569</td>
<td>1685</td>
<td>1684</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Exposure Variable</th>
<th>HAZ (0–23 months old) Coefficient</th>
<th>HAZ (6–23 months old) Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (12–23 months vs. 0–11 months)</td>
<td>-1.064***</td>
<td>-0.0891</td>
</tr>
<tr>
<td>Sex (boys vs. girls)</td>
<td>-0.154***</td>
<td>-0.0653</td>
</tr>
<tr>
<td>Birthweight (&lt;2500 vs. ≥ 2500)</td>
<td>-0.624***</td>
<td>-0.370***</td>
</tr>
<tr>
<td>Child (12–23 months old) is fully immunized (no vs. yes)</td>
<td>-0.00738</td>
<td>0.127**</td>
</tr>
<tr>
<td>Safe disposal of child’s faeces (no vs. yes)</td>
<td>-0.00377</td>
<td>-0.0305</td>
</tr>
<tr>
<td>Mother’s age at marriage (&lt;18 years vs. ≥18 years)</td>
<td>0.010</td>
<td>-0.0637</td>
</tr>
<tr>
<td>Mother’s age at child’s birth (&lt;18 years vs. ≥18 years)</td>
<td>0.0308</td>
<td>0.139</td>
</tr>
<tr>
<td>Mother’s education (&lt;secondary education vs. ≥ secondary education)</td>
<td>-0.0729</td>
<td>-0.151**</td>
</tr>
<tr>
<td>Mother’s decision-making about buying new food items (no vs. yes)</td>
<td>-0.118**</td>
<td>-0.114**</td>
</tr>
<tr>
<td>Mother received advice on nutrition during antenatal care (no vs. yes)</td>
<td>-0.0677</td>
<td>-0.106</td>
</tr>
<tr>
<td>Mother consumes tobacco (yes vs. no)</td>
<td>-0.222**</td>
<td>-0.0133</td>
</tr>
<tr>
<td>Mother consumed IFA during the last pregnancy (&lt;90 tablets vs. &gt;90 tablets)</td>
<td>-0.102*</td>
<td>0.00711</td>
</tr>
<tr>
<td>Mother delivered in a health facility (no vs. yes)</td>
<td>-0.14</td>
<td>-0.137</td>
</tr>
<tr>
<td>Mother’s height (&lt;145 cm vs. &gt;145 cm)</td>
<td>-0.514***</td>
<td>0.0288</td>
</tr>
<tr>
<td>Mother’s BMI (&lt;18.5 kg/m² vs. &gt;18.5 kg/m²)</td>
<td>-0.0969</td>
<td>-0.296***</td>
</tr>
<tr>
<td>Mother consumed milk and/or milk products weekly during pregnancy (no vs. yes)</td>
<td>-0.0661</td>
<td>-0.0782</td>
</tr>
<tr>
<td>Household residence (rural vs. urban)</td>
<td>0.127</td>
<td>-0.0122</td>
</tr>
<tr>
<td>Household belongs to a Scheduled Tribe (yes vs. no)</td>
<td>-0.00784</td>
<td>-0.00768</td>
</tr>
<tr>
<td>Household wealth index (poorest vs. richest)</td>
<td>-0.0494</td>
<td>0.0391</td>
</tr>
<tr>
<td>Household wealth index (poorer vs. richest)</td>
<td>-0.0792</td>
<td>0.00931</td>
</tr>
<tr>
<td>Household wealth index (middle vs. richest)</td>
<td>-0.195*</td>
<td>-0.0639</td>
</tr>
<tr>
<td>Household wealth index (rich vs. richest)</td>
<td>-0.0421</td>
<td>0.0156</td>
</tr>
<tr>
<td>Household has access to improved water (no vs. yes)</td>
<td>-0.217**</td>
<td>-0.0239</td>
</tr>
<tr>
<td>Household has access to improved sanitation (no vs. yes)</td>
<td>-0.168***</td>
<td>-0.029</td>
</tr>
</tbody>
</table>

(Continues)
the other wealth quintiles). 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)

<table>
<thead>
<tr>
<th></th>
<th>HAZ (0–23 months old)</th>
<th>Coefficient</th>
<th>HAZ (6–23 months old)</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household is food secure (no vs. yes)</td>
<td>(−0.296 to −0.0405)</td>
<td>−0.0833</td>
<td>(−0.147 to 0.0890)</td>
<td>0.0696</td>
</tr>
<tr>
<td>Household benefits from ICDS programme (no vs. yes)</td>
<td>0.239***</td>
<td>(0.0944 to 0.383)</td>
<td>0.0432</td>
<td>(−0.0904 to 0.177)</td>
</tr>
<tr>
<td>Child (0–23 months) is appropriately breastfed (no vs. yes)</td>
<td>−0.111</td>
<td>(−0.282 to 0.0600)</td>
<td>0.134*</td>
<td>(−0.0243 to 0.292)</td>
</tr>
<tr>
<td>Child’s diet meets a minimum meal frequency (no vs. yes)</td>
<td></td>
<td>−0.163</td>
<td></td>
<td>−0.000219</td>
</tr>
<tr>
<td>Child’s diet meets a minimum dietary diversity (no vs. yes)</td>
<td>0.151**</td>
<td>(0.0185 to 0.283)</td>
<td></td>
<td>(0.161 to 0.160)</td>
</tr>
<tr>
<td>Child was fed dairy products (milk, yoghourt and cheese) (no vs. yes)</td>
<td></td>
<td>0.0157</td>
<td></td>
<td>(0.161 to 0.129)</td>
</tr>
<tr>
<td>Child was fed grains, roots and tubers (no vs. yes)</td>
<td>0.12</td>
<td>(−0.0944 to 0.335)</td>
<td>0.254**</td>
<td>(0.0477 to 0.461)</td>
</tr>
<tr>
<td>Child was fed vitamin A-rich fruits and vegetables (no vs. yes)</td>
<td>0.104</td>
<td>(−0.438 to 0.220)</td>
<td>0.199</td>
<td>(0.075 to 0.484)</td>
</tr>
<tr>
<td>Child was fed other fruits and vegetables (no vs. yes)</td>
<td>0.12</td>
<td></td>
<td></td>
<td>(0.0471 to 0.446)</td>
</tr>
<tr>
<td>Child was fed eggs (no vs. yes)</td>
<td></td>
<td>−0.109</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child was fed flesh foods (meat, fish, poultry and liver/organ meats) (no vs. yes)</td>
<td>0.104</td>
<td>(−0.275 to 0.484)</td>
<td>0.199</td>
<td>(0.075 to 0.484)</td>
</tr>
<tr>
<td>Child was fed legumes and/or nuts (no vs. yes)</td>
<td>0.199</td>
<td>(0.0471 to 0.446)</td>
<td>1685</td>
<td>(0.075 to 0.484)</td>
</tr>
</tbody>
</table>

HAS, height-for-age $z$-score; BMI, body mass index; IFA, iron and folic acid. ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. 

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
Achieving behaviour change at scale: Alive & Thrive’s infant and young child feeding programme in Bangladesh

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Abstract

The Alive & Thrive programme scaled up infant and young child feeding interventions in Bangladesh from 2010 to 2014. In all, 8.5 million mothers benefited. Approaches – including improved counselling by frontline health workers during home visits; community mobilization; mass media campaigns reaching mothers, fathers and opinion leaders; and policy advocacy – led to rapid and significant improvements in key practices related to breastfeeding and complementary feeding. (Evaluation results are forthcoming.) Intervention design was based on extensive formative research and behaviour change theory and principles and was tailored to the local context. The programme focused on small, achievable actions for key audience segments identified through rigorous testing. Promotion strategies took into account underlying behavioural determinants and reached a high per cent of the priority groups through repeated contacts. Community volunteers received monetary incentives for mothers in their areas who practised recommended behaviours. Programme monitoring, midterm surveys and additional small studies to answer questions led to ongoing adjustments. Scale-up was achieved through streamlining of tools and strategies, government branding, phased expansion through BRAC – a local non-governmental implementing partner with an extensive community-based platform – and nationwide mainstreaming through multiple non-governmental organization and government programmes.

Keywords: scaling up nutrition, behaviour change, hygiene improvement, breastfeeding, complementary feeding, Bangladesh.

Introduction

Direct nutrition interventions such as improving infant and young child feeding (IYCF) practices are considered a high priority for programmes aimed at improving health and nutritional status and child survival (Dewey & Brown 2003; Lutter et al. 2011; Onyango 2013). Breastfeeding is one of the most cost-effective life-saving interventions known (Bhutta et al. 2008). Stewart et al. (2013) highlighted the role of complementary feeding in reducing stunting. Bhutta et al. (2013) estimated that more than 220 000 lives would be saved each year with delivery of an infant and young child nutrition package that includes breastfeeding and complementary feeding. In Bangladesh, scaling up these interventions would benefit, in terms of child health and mortality, the two poorest wealth quintiles more than twice as much as upper quintiles, suggesting an important effect on reducing health and economic disparities (Bhutta et al. 2013).

According to the World Health Organization (WHO), in many countries, less than a fourth of infants 6–23 months of age receive the WHO-recommended amounts and variety of foods, including breast milk (WHO 2015). Stewart et al. (2013) emphasized the complex web of community and societal factors that influence decisions about IYCF. Barriers may include poor food availability and purchasing power, knowledge gaps, social norms or a combination of these. Programmes need to address multiple factors (Lutter et al. 2013).

Effective IYCF interventions have included the following: (1) time-targeted interpersonal counselling, individually and in groups, provided by trained health...
care professionals or lay workers; (2) assistance to pregnant and newly delivered mothers in initiating lactation immediately after delivery and in continuing breastfeeding; (3) provision of food and related supplements for complementary feeding; (4) media and marketing approaches; and (5) legislation to support restriction of the indiscriminate marketing of breast milk substitutes and parental leave to enable mothers to breastfeed exclusively for 6 months (Caulfield et al. 1999; Merten et al. 2005; Bhutta et al. 2008; Dewey & Adu-Afarwuah 2008; Imdad et al. 2011; Wakefield et al. 2011; Lutter & Lutter 2012).

A number of countries, including Bangladesh, have incorporated recommendations from WHO’s Global Strategy for Infant and Young Child Feeding (2003) in their national strategies. Scaling up proven interventions has been a challenge, however.

The Bill & Melinda Gates Foundation designed the Alive & Thrive (A&T) initiative to develop scale models for IYCF in three distinct geographies: Bangladesh, Ethiopia and Vietnam. In this paper, we document the process of scaling up an evidence-based IYCF intervention in Bangladesh. Results of quantitative studies documenting significant changes in IYCF practices in the A&T programme area are forthcoming. Information on the A&T programmes in Ethiopia and Vietnam is available at www.aliveandthrive.org. See also Baker et al. (2013).

Materials and methods

In Bangladesh, the programme aimed to develop a streamlined and easily scaled-up package of activities. A&T partnered initially with the Essential Health Care (EHC) programme of BRAC, a respected national non-governmental organization (NGO) operating large community-based public health, education and microfinance programmes. Programme design involved four components: advocacy, interpersonal counselling and community mobilization, mass communication and the strategic use of data (Box 1 and Fig. 1). All strategic decisions were evidence based. After programme launch, ongoing data from programme monitoring, assessments, small studies and quantitative surveys were used to adjust strategies. The programme thus evolved during the process of scale-up. Summarized thereafter are the categories and timing of research conducted.

Situation analysis and first round of formative research – 2009

Alive & Thrive’s situational analysis included a review of policies and strategy guidelines of the GOB, data on media habits, case studies and relevant research (Haider et al. 2000; Kimmons et al. 2005; Saha et al. 2008; Rasheed et al. 2009) and further analyses of IYCF

Key messages

- Well-designed and well-implemented large-scale interventions that combine interpersonal counselling, community mobilization, advocacy, mass communication and strategic use of data have great potential to improve IYCF practices rapidly.
- Formative research and ongoing studies are essential to tailor strategies to the local context and to the perspectives of mothers, family members, influential community members and policymakers. Continued use of data to adjust programme elements is also central to the process.
- Scale-up can be facilitated through strategic selection of partners with existing community-based platforms and through mass media, where a high proportion of the target audience can be reached through communication channels such as broadcast media.
- Sustaining the impacts will involve commitments from government and capacity building. The next step for capacity building would involve understanding barriers and constraints and then coming up with appropriate strategies to address them. One of the limitations we experienced was rapid transition of staff in key positions of implementing agencies, in government leadership, donors and other stakeholders. There was a need for continued advocacy, orientation and teaching related to strategic programme design, behaviour change, effective implementation and use of data.

and household indicators in the two most recent Bangladesh Demographic and Health Surveys (NIPORT 2005; NIPORT 2009).

Formative research tools were adapted from a process developed by the Pan American Health Organization called ProPAN (PAHO 2004). These studies are described in Haider et al. (2010) and Rasheed et al. (2011), and the results have already been published in these articles. They were carried out from May 2009 to October 2009 in collaboration with the International Centre for Diarrhoeal Disease Research, Bangladesh, in three areas with high malnutrition: Sylhet, Chittagong

**Box 1. A&T programme components (excluding research)**

Advocacy to promote child nutrition and accelerate scale-up of programmes:
- Local, regional and national decision makers and stakeholders: Advocacy video shows on IYCF, meetings with the national alliance of over 20 stakeholders under the Institute of Public Health Nutrition (IPHN)/Government of Bangladesh (GOB), dissemination of government-branded materials to implementing stakeholders.
- Engaging journalists: Orientations and scholarships for journalists, TV talk shows and newspaper supplements.
- Individualized dialogue with government decision makers and donors: memorandum of understanding (MOU), task forces and sharing evidence.

Interpersonal counselling and community mobilization
- Mothers: Counselling provided through home visits at specific ages of the child on breastfeeding, complementary feeding and handwashing before feeding, and group community meetings of pregnant and lactating women with trained community workers.
- Community opinion leaders: Mobilization of support for child nutrition and IYCF through orientations, video shows, seminars and forums to reach doctors, religious leaders, fathers, local government and NGOs working at community level.
- Health providers: 3- to 5-day in-service training, pre-service medical/nursing curriculum through partnerships with medical associations, mass media and print materials, messages through national and regional newspapers, wall posters for government and private clinics, job aids for government staff and materials tailored for formal and informal health practitioners.

Mass media
- Families, frontline workers and opinion leaders: TV and radio spots on key topics for mothers, fathers, frontline workers and opinion leaders at all levels.
- Rural community members in media dark areas: Interactive community events including village theatre, community video showings and quiz shows on IYCF and handwashing topics.

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**Fig. 1. Framework for delivering nutrition behaviour change results at scale.**
and Dhaka slums. Research focused on mothers’ perceptions and practices, media habits and reach, health worker practices and work environment, and promotion of breast milk substitutes at the retail level and through the media. Table 1 lists the methods and organizations responsible for the research. A&T selected priority nutrition practices for programme focus (Box 2), followed by rapid trials of practices with mothers to the test feasibility of introducing small changes into current behaviours.

**Baseline survey – 2010**

Alive & Thrive partner International Food Policy Research Institute (IFPRI) conducted a baseline household survey in 2010 with a sample of 2000 households having children below 24 months of age. The study was carried out in 20 sub-districts from five of six regions in Bangladesh. Questions focused on the WHO-recommended IYCF practices; household, maternal and child characteristics; and mothers’ knowledge, contacts with health workers and media habits.

**Second round of formative research to design handwashing interventions – 2011 to 2012**

After programme launch, A&T collaborated with International Centre for Diarrhoeal Disease Research, Bangladesh, ICDDR,B, International Centre for Diarrhoeal Disease Research, Bangladesh; IFPRI, International Food Policy Research Institute; IYCF, infant and young child feeding; KAP, knowledge, attitudes and practices.

### Table 1. Formative research components

<table>
<thead>
<tr>
<th>Methods</th>
<th>Topics covered</th>
<th>Respondents and data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formative research at start-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household survey</td>
<td>Practices and access to services/media</td>
<td>N = 358 mothers of children aged 0–23 months</td>
</tr>
<tr>
<td>24-h dietary recall</td>
<td>Dietary intake and complementary feeding</td>
<td>N = 197 children aged 6–23 months</td>
</tr>
<tr>
<td>Rapid trials of practices</td>
<td>Barriers, motivations and drivers of behaviour change</td>
<td>N = 119 mothers of children aged 0–18 months</td>
</tr>
<tr>
<td>Market survey</td>
<td>Food sources and prices</td>
<td>Retail outlets in three sites</td>
</tr>
<tr>
<td>Semi-structured interviews</td>
<td>Reasons for IYCF and main influences</td>
<td>N = 42 mothers of children 0–23 months</td>
</tr>
<tr>
<td>Food attributes exercise</td>
<td>Perceptions about foods</td>
<td>N = 23 mothers of children 6–23 months</td>
</tr>
<tr>
<td>Opportunistic observations</td>
<td>Perceptions and practices</td>
<td>N = 21 (traditional birth attendants and village doctors)</td>
</tr>
<tr>
<td>Media scan (Nielsen)</td>
<td>Media habits (secondary data)</td>
<td>Demographic and Health Surveys (DHS) and Bangladesh Media and Demographic Survey 2008</td>
</tr>
<tr>
<td>Additional analysis of</td>
<td>IYCF practices and use of animal source foods (secondary data)</td>
<td>N = 2858 mothers of children aged 0–35 months</td>
</tr>
<tr>
<td>Demographic and Health Survey (2007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health care workers (BRAC)</td>
<td>Perceptions</td>
<td>N = 69 (formal and informal providers)</td>
</tr>
<tr>
<td>Baseline survey (IFPRI)</td>
<td>Household survey</td>
<td>N = 2000 mothers of children &lt;24 months</td>
</tr>
<tr>
<td>Ongoing research</td>
<td></td>
<td></td>
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<tr>
<td>Doctors survey</td>
<td>KAP of IYCF and media habits</td>
<td>N = 150 doctors in five regions</td>
</tr>
<tr>
<td>Handwashing formative research (ICDDR,B)</td>
<td>Barriers, motivations and rapid trial</td>
<td>Qualitative (n = 300), qualitative (n = 25) and trials of practices (n = 80 mothers of children aged 6–23 months)</td>
</tr>
<tr>
<td>Programme monitoring</td>
<td>Home visits and media reach</td>
<td>N = variable</td>
</tr>
<tr>
<td>Midline surveys (IFPRI)</td>
<td>IYCF, coverage and perceptions</td>
<td>N = 453 children aged 6–23 months (2012)</td>
</tr>
</tbody>
</table>

N = 2000 children aged <24 months (2013)

ICDDR,B, International Centre for Diarrhoeal Disease Research, Bangladesh; IFPRI, International Food Policy Research Institute; IYCF, infant and young child feeding; KAP, knowledge, attitudes and practices.

### Box 2. Programme target behaviours – major indicators*

1. Early initiation of breastfeeding (within 1 h)
2. Exclusive breastfeeding under 6 months of age
3. Continued breastfeeding at 1 year
4. Timely introduction of complementary foods (6–8 months)
5. Minimum dietary diversity
6. Minimum meal frequency
7. Minimum acceptable diet
8. Consumption of iron-rich foods

*WHO definition. See WHO 2008.
to conduct additional formative research exploring caregivers’ knowledge and practices of handwashing before child feeding, as well as sources of information on handwashing and preferred channels for messages. Methods included a household survey ($N = 300$), video data collection on 12 caregivers of children with a mean age of 15 months, an exercise for ranking motivations for handwashing with six groups, 24 in-depth interviews with caregivers of children with a mean age of 16 months and six focus group discussions. The household survey and qualitative studies were conducted in 50 rural villages in three purposively selected districts in different regions of the country (Manikganj District, Dinajpur and Chittagong). Results are reported in Nizame et al. (2013).

**Monitoring mechanisms and rapid small studies 2010–2014**

Monitoring focused on both delivery of community interventions (especially household visits) and media reach and recall. Data regarding community interventions were collected through three channels: routine service registers maintained by BRAC including indicators on community mobilization, home visits and mothers’ IYCF practices; sample surveys by BRAC’s independent monitoring wing; and random sample home visits conducted by A&T focusing on BRAC home visits, community mobilization, IYCF practices and media recall.

From 2010 onwards, A&T hired media placement companies to track TV viewing habits, via devices embedded in homes, in a random sample of households as part of a routine industry survey that calculates media reach for advertising and marketing companies. Data were triangulated with the recall-aided questions in the IFPRI and A&T surveys to estimate coverage and recall of the media messages.

Alive & Thrive carried out several small studies after programme launch to examine gaps highlighted by the baseline or that emerged during monitoring or to field test evolving strategies. Studies included a survey of doctors’ knowledge, attitudes and practices related to providing IYCF support to mothers and their media habits ($N = 150$). Other research included a pilot test of communication strategies for media dark areas, tests of options for short duration training and in-kind incentives and field trials for participatory community approaches in Sylhet and Habiganj.

**Box 3. Programme evolution/scale-up milestones**

- Field test of community strategies in four BRAC programmes: September 2009 to January 2010
- GOB national alliance formation and issuing of a national communication plan: December 2009 to March 2010 (the alliance continues)
- Community component launched in BRAC EHC programme in 22 sub-districts: August to December 2010
- Media campaign launch and intensification: December 2010 to March 2011
- Campaign materials on handwashing before feeding developed (based on additional formative research): April 2011 to July 2012
- Community component reaches 50 sub-districts in BRAC’s EHC programme: August 2011
- Final field testing and revisions of training module and job aids, rebranded as GOB materials and disseminated nationally: January 2011 to November 2011
- Interpersonal counselling scaled up through national government providers and NGO maternal newborn and child health and UK Aid foreign aid agency (DFID)-funded livelihoods programmes: August 2011 to December 2013
- Media dark strategy designed and tested and community events launched in targeted low reach villages: February 2012 to June 2014
- Media campaign developed and print materials launched for handwashing before feeding: October 2012
- Media campaign for doctors developed and launched: January 2012
- Interpersonal counselling scaled up through GOB Health and Family Welfare workers: March 2013 to mid-2014

International Food Policy Research Institute conducted two midline household surveys. The 2012 survey measured WHO standard indicators for complementary feeding practices, exposure to home visits (by two types
of frontline workers) and recall of TV spots broadcast by the programme. The sample included 462 households having children 6–23 months of age selected randomly from 100 villages in 10 programme sub-districts. The 2013 survey included infants below 6 months (as well as older children) and looked at all IYCF-recommended WHO core indicators for breastfeeding and complementary feeding, plus the coverage indicators. The sample included 500 households from intensive\(^1\) programme areas and 500 from non-intensive areas in 20 sub-districts.

**Database on scaling up – 2011 onwards**

Implementation partners (members of the National IYCF Alliance) shared information quarterly on their community-based and facility-based IYCF programmes. GOB mapped the location of these stakeholders, and A&T assisted with maintaining a database on the cumulative number of health workers and trainers provided with training. Information was shared at Alliance meetings.

**Results**

**Programme implications of situation analysis**

The existence of supportive national policies on child nutrition in Bangladesh meant that investments were not needed in this area and advocacy should focus on stimulating and supporting implementation of existing policies and guidelines. A&T also saw an urgent need for harmonizing efforts of multiple implementing NGOs and donors working in different geographic areas of the country. There was a clear opportunity to form a national alliance under the GOB’s IPHN to leverage a high level of interest in IYCF and strengthen sustainability. As part of scale-up efforts, A&T developed a national training module for the government’s frontline workers. Government staff were trained by national and master trainers who were in turn trained by A&T at three government training centres in Dhaka and at one NGO training site (Lamb Hospital).

Advocacy for, and evidence of the effectiveness of interpersonal counselling, had been strong over several years, but large-scale coverage of support for mothers was very limited. A&T saw the need to introduce strategies going beyond government health services. BRAC was the only NGO with scaled-up presence in the country and had a ready-made cadre of multi-purpose community volunteers. They were a natural partner for introduction of new strategies.

Prior to 2009, promotion of breastfeeding had received far more emphasis in Bangladesh than promotion of optimal complementary feeding practices. While there was public awareness about the importance of exclusive breastfeeding for the first 6 months, practice was still not widespread. A&T therefore decided to focus on converting high awareness of breastfeeding to an emphasis on specific desirable practices and building a basic understanding about complementary feeding.

Secondary evidence clearly pointed to the importance and feasibility of promoting home-based foods. Processed and/or fortified foods for children were not feasible as a nationally scalable strategy because of limited capacity for quality control and strong opposition from highly respected and influential IYCF advocates in the country. Household food insecurity was estimated to affect a quarter of the population, and three of four households were found to have animal source foods for child feeding (NIPORT 2009).

**Programme implications of formative research on IYCF practices**

Formative research revealed that the major barrier to exclusive breastfeeding was mothers’ perception of ‘insufficient milk’. A&T strategies therefore emphasized counselling on breastfeeding skills and simple remedies to prevent and overcome common difficulties...
Providers were trained to support mothers in accurately self-assessing the adequacy of their breast milk production and in understanding how to maintain adequate breast milk supply.

Formative research also highlighted the importance of promoting animal source foods. Even when available in the home, these were not being given to young children. The perception of poor appetite was widespread, leading mothers to lose confidence in proper complementary feeding. A&T messages discouraged giving children junk food, which was ubiquitous, and promoted simple strategies for motivating fussy eaters: encouraging food variety and age-appropriate texture, reducing watery and low-nutrient density snacks foods and spending more time feeding. Most mothers were available to spend time feeding children as outside employment is low and infant care is considered the mothers’ main occupation, according to rural social norms.

For mothers, motivating factors for changes in IYCF practices included benefits for child’s brain and physical development and safety or protection from illnesses, perception of positive child responses (‘child likes it’), convenience and satisfaction in being able to breastfeed adequately or motivate a child to eat enough quantity of complementary foods.

Alive & Thrive saw the importance and feasibility of developing a single national communication strategy. Results of the formative research and reviews of the DHS showed that patterns of good vs. weak IYCF practices were similar in urban and rural areas. Specifically, timely initiation, duration of exclusive breastfeeding and diversity of complementary foods were low in both urban and rural areas. The rapid trials of improved practices (TIPs) showed that mothers in urban and rural areas had similar reasons for common practices and similar motivations for adopting improved behaviours. Mass media reach and habits initially seemed largely the same, but more TV channels were available in urban areas. A&T decided to use mass media and community mobilization on a large scale. Secondary audiences who could encourage mothers (family members, health workers and neighbours) could also be reached rapidly through mass media.

Programme implications of the media audit

The media audit provided evidence that TV should be the main channel for high reach/coverage at national scale. A loyal viewership (68% of households watching TV at least once a week), cutting across economic and education levels, and a single main language and cultural context were crucial factors. However, the audit also showed that media habits change rapidly, so media placements needed to be adjusted based on ongoing assessments. The media audit demonstrated that Bangladesh has effectively controlled mass media advertising of breast milk substitutes, but the situation needed ongoing monitoring.

Programme implications of the 2010 baseline survey

Alive & Thrive’s baseline survey confirmed the relative importance of different IYCF practices for programme emphasis. The survey also confirmed that even poor families consumed a diverse diet, including animal source foods, as well as vegetables and fruits – so that home-based foods could be promoted as part of the IYCF strategy.

Mothers said that health professionals and family members were their primary sources of support when faced with problems with infant feeding. Food purchases were primarily the responsibility of male members of the family. This validated A&T’s decision to target multiple influential audiences.

Although BRAC workers were found to be present in communities in many areas, baseline coverage of home visits to mothers was not very high, and there was substantial variability across sub-districts. Overall, about a quarter of respondents had ever been visited at home by a BRAC frontline health volunteer (Shasthya Sebika). Contact between households and Shasthya Sebika went up to over 60% in some areas. A smaller proportion of respondents had been visited by a BRAC health worker (Shasthya Kormi) at 11.3%; 12% attended a health forum facilitated by a Shasthya Kormi.

BRAC’s capacity to manage and organize mobilization of frontline workers on a large scale was strong, with great potential for strengthening home visits and
community mobilization. BRAC decided to follow the example of their community-based programmes (TB Dots; oral rehydration therapy; and maternal, newborn and child health) to provide performance-based monetary incentives to volunteers rather than a fixed salary to conduct home visits (one per 250–300 households) and supported them with full-time mentors (IYCF promoters) with one mentor per 10 volunteers. Volunteers received a cash incentive (totaling US$6 to US$8 per month on average) based on each eligible mother who practised the IYCF behaviours. This motivated volunteers to counsel almost every eligible woman in their respective areas and work on problem-solving for changing behaviours rather than only giving messages.

**Programme implications of monitoring systems and small studies 2010–2014**

Feedback from monitoring visits revealed that mothers often complained that they were unable to feed children because of ‘poor appetite’. This did not refer to ‘sick’ children only, or frequently sick children. A&T hypothesized that one reason for low appetite might be sub-clinical enteropathic infections from contaminated complementary foods due to infrequent washing of hands with soap before feeding children (Islam et al. 2013). This led to the decision to conduct additional formative research on handwashing before child feeding, in order to provide more emphasis on the behaviour within the programme.

The monitoring system helped to highlight which programme sub-districts were lagging in enlisting eligible households, in providing home visits and in improving IYCF indicators. A&T took special steps to ensure high coverage and quality counselling in home visits while scaling up:

- BRAC established 16 parallel training centres across all regions for meeting the demand for frontline workers and ongoing refresher training.
- Managers ensured full staffing of frontline workers in programme areas, and vacancies were filled.
- Supervision checklists were routinely collected and discussed.
- Mobile phone contacts were established between volunteers and salaried staff.

The focus of community mobilization shifted based on monitoring data of BRAC and A&T. For example, in the latter half of the programme period, fathers, religious leaders and doctors/local opinion leaders (combined group) were prioritized.

Results of knowledge, attitudes and practices surveys of doctors and their media habits in 2012 showed that doctors were not providing even basic counselling about child nutrition to mothers. They did not have the knowledge, skills or motivation for improving IYCF practices. There was some evidence that they may even have been reinforcing poor practices – for example, recommending breast milk substitutes for perceived insufficient milk and encouraging ‘soft foods’ that are low in energy and nutrient density for infants under 1 year old. The survey showed that a large proportion did not believe it was their responsibility to counsel mothers on IYCF. It also showed that doctors could be reached with high coverage through print media and TV.

Alive & Thrive decided IYCF counselling needed to be urgently mainstreamed within national health services. GOB leadership was important for introducing IYCF counselling during antenatal care and immunization contacts and also at sick child visits. Standards of care for maternities, training on how to initiate breastfeeding and special support for C-section deliveries were needed. A&T provided a partnership grant to the Obstetrical and Gynecological Society of Bangladesh (OGSB) to support revisions to the pre-service curriculum. The programme also launched a mass media campaign through inserts in newspapers for 20 months starting in October 2012.

**Programme implications from formative research on handwashing**

The household survey on handwashing revealed that 95% of participants had soap in their homes but only 37% had soap present at the place for handwashing before food preparation (Nizame et al. 2013). Participants connected food contamination with the presence of dust/dirt and also with germs but did not think that hands could be a vehicle for germs if no dirt were visible. Most (60%) of surveyed respondents agreed with the statement that ‘the unavailability of soap and
water near the cooking place was a physical barrier to handwashing before food preparation.

Alive & Thrive tests introducing handwashing stations to households for use at the location of food preparation showed practices improved with both home-made stations and ready-made project-provided stations. However, providing stations on a large scale was not sustainable (Biswas et al. 2014). The same study also showed that complementary feeding indicators improved alongside handwashing indicators when a single integrated package of interventions was implemented (Unicomb et al. 2013).

Alive & Thrive decided that home visits should include helping families to establish and maintain handwashing stations close to the place of child feeding rather than focusing on the message ‘wash your hands with soap’. Mass media and community mobilization were used to create an enabling environment by changing perceptions about using soap as the norm. Communication materials and a TV spot focused on convenience – establishing a handwashing close to the place of food preparation. A training session on handwashing stations was also inserted in the national IYCF training manual.

**Programme implications of the midline surveys in 2012 and 2013**

The baseline survey in 2010 and early midline in 2012 showed that IYCF TV spots were seen by the same per cent of rural mothers in intensive and non-intensive areas, and coverage was about 50%. Opportunistic media recall surveys in 2012 (attached to other A&T assessments) conducted in Sylhet (eastern region), Manikgonj (central region) and Dinajpur (northern region) also showed that a significant number of communities did not view TV because of electricity shortages and exclusion from services due to various reasons, and this was contributing to low TV viewership.

Alive & Thrive tested a supplementary communication strategy of exposing these communities to the same TV spots through mobile video shows and interactive Q&A sessions (conducted by rural marketing agencies) in order to reach a wide cross-section of community members and opinion leaders in low-electricity communities. The materials included A&T messages contained in *Meena* animated films and the seven TV spots being broadcast through national TV. Each material was played, and key messages were then discussed by trained facilitators. Difficulties in practising the actions were also discussed. A small feasibility trial in 19 randomly allocated low electricity villages confirmed that even a single round of such an approach would raise message recall and knowledge of correct practices. Based on this, the ‘media dark’ strategy was mainstreamed in the A&T programme.

The 2013 midline survey showed improvements in TV exposure above 2010 and 2012 levels in both A&T programme areas (Menon et al. 2014). In intensive areas, the improvement in 2013 was slightly greater where the media dark strategy was implemented for hard-to-reach and low-electricity communities.

The 2012 midline survey of mothers with 6- to 23-month-old children showed only 45–50% coverage of home visits in targeted areas. From 2012 to 2014, coverage of home visits was consistently higher and increased over time in areas receiving more intensive inputs. Midline survey results in 2013 and the endline in 2014 found that the reach of BRAC frontline workers had risen to over 80% in A&T intensive areas.

At the 2013, midline five of the eight key IYCF indicators showed significant improvements over the 2010 baseline levels in both programme intensive and non-intensive areas, and the impacts were greater in intensive areas. From 2010 at baseline to 2013, IYCF practices improved in intensive areas [double difference (DD) compared with non-intensive areas] as follows: early initiation of breastfeeding from 63.5% to 91.9% (DD of 18.7), exclusive breastfeeding from 48.5% to 83.4% (DD of 24.6) and iron-rich foods from 39.5 to 72.2 (DD of 20.9).

Problems in IYCF still remained, including not feeding during illness and use of sugary drinks and foods and salty snacks.

The processes that were associated with improvements in practices included high levels of exposure to TV spots on IYCF in both intensive and less intensive programme areas and, in intensive areas, higher frequency of home visits by trained IYCF workers (Saha et al. 2013). In A&T-intensive areas, frontline workers were named more often as the primary sources of IYCF...
information than family members and neighbours – a change from the 2010 baseline survey.

Discussion

Ingredients for scale

In a review of scaling up innovations across development sectors, Linn (2012) concluded that among the essential ingredients of successful scale-up are a commitment to scaling up from the start, systematically planned steps to achieve scale in the programme design process, agility to adapt the approach because successive stages of scale-up require different inputs, the strategic use of data to manage these turning points and partnerships that are built for long-term sustainability.

Perez-Escamilla et al. (2012) found that facilitation of scale-up of breastfeeding programmes in Africa, Asia, Latin America and the Caribbean involved multiple components that worked in close harmony. Evidence-based advocacy was required for shifting political will to enact legislation and policies; human and financial resources were important for ensuring a large cadre of trained frontline providers to support mothers, and data that were fed back for making programme adjustments were valuable to ensuring quality during scale-up. Victora et al. (2012) noted that successful scale-up of maternal nutrition programmes required making the problem visible to decision makers; evidence-based programme design and large-scale implementation capacities were essential; partnerships among governmental and private (commercial and nonprofit) agencies facilitated the process; and scale-up could be accelerated by generating demand within the target population.

In Bangladesh, A&T’s process of using data from multiple sources to design and continually adjust strategies while rapidly scaling up a national programme was another ingredient that resulted in significant changes in IYCF practices. Selection of key practices for programme focus was a first important step. A&T focused on converting high awareness on breastfeeding to desirable practices and building a basic understanding about complementary feeding.

Achieving behaviour change on a large scale

The use of a sound theoretical basis to design behaviour change interventions and engaging complementary channels to reach diverse audiences were also important. The programme employed a socio-ecological model of behaviour change (McLeroy et al. 1988), addressing multiple factors found by the formative research studies (conducted in different regions of the country and among national thought leaders) to be major determinants of individual IYCF practices. The intervention strategy engaged various sources of influence on mothers through specifically tailored face-to-face contacts (through advocacy dialogue, community meetings/forums, home visits and clinic visits) and mass media (TV spots on father’s support and print media plus TV spots for health providers). Religious leaders constituted a prime channel for reinforcing information within communities. Children were a secondary audience, reached through the Meena animated film series and in popular TV programmes, as part of a longer-term strategy to educate the next generation and also as a potential route for delivering messages in the home.

A training programme for community volunteers and health workers was combined with supportive supervision, monthly meetings, quarterly refresher training, monitoring feedback and monetary incentives to both improve skills and incentivize performance aimed at solving problems and using meaningful motivations for mothers and families, not just completing scheduled home visits for delivering messages.

Strategic planning for scale from the start

Alive & Thrive selected partners and existing platforms to scale up rapidly within and outside BRAC. In expanding small-scale programmes, organizations may face challenges related to building management capacity (Cooley & Kohl 2006). In Bangladesh, however, A&T was able to utilize the structures and experience of BRAC with limited additional investment in field offices and orientation to multi-channel communication strategies. Planning for scale involved setting up administrative systems within BRAC to meet the needs of multiple training sites, hiring additional staff in key posts and building capacity for recordkeeping and information flows focused on a few key indicators for monitoring.
Other scale-up strategies included systematic development of an evidence-based package of tools and government (or multiple stakeholders) branding of the package for broader ownership and uptake. The national IYCF communication plan framework and document developed by the IYCF Alliance with A&T and UNICEF support was also branded and distributed by the government and adopted by a range of stakeholders. A&T also made adoption convenient by providing seed money, timely technical support and free materials and training of trainers to government and NGOs.

Facilitating adoption by multiple implementers

After launching the programme in 2010, A&T programme components were streamlined starting in 2012 as part of the transfer process to new implementing partners. For example, training of frontline workers was reduced from 5 to 3 days. Post-training supervision checklists were reduced from over 25 items each for breastfeeding and complementary feeding to a single two-sided sheet with 8–10 items for observing counselling content and technique. The number of separate community mobilization forums was reduced from 8 (religious leaders, youth/adolescents, school teachers, traditional birth attendants (TBAs), other NGO workers, village elite, local government leaders and village doctors) to 3 (doctors, combined group of local opinion leaders and fathers of children aged 6–23 months).

Programme scale and effectiveness increased over time because of monitoring and purposeful adjustment of strategies that led to new implementing partners. When the 2012 midline survey showed that mothers continued to consult doctors for IYCF difficulties, A&T increased its emphasis on reaching doctors, through both in-service and pre-service training. New communication channels were employed (newspaper inserts) to reach medical doctors; the national OGSB was selected as a strategic partner to lead the strengthening of pre-service medical and nursing curricula.

The formation of the National IYCF Alliance of multiple stakeholders by A&T and UNICEF under GOB/IPHN facilitated expansion of the IYCF programme beyond BRAC to new implementers. The transfer of approaches, tools and skills nationwide was carried out through this central government-led hub. Collaboration with UNICEF (GOB’s primary external technical support agency) and advocacy with donors such as DFID and USAID helped lay the groundwork for sustainability. In the second year of implementation, the country’s national nutrition programme (supported by multiple donors) was reorganized as the National Nutrition Service, and with A&T’s inputs, IYCF became a top priority in plans for mainstreaming through government health and family planning services.

Scale-up processes and pathways

Scale-up took place in several ways. Partnerships led to the geographic expansion of the A&T community model and tools within different BRAC programme divisions and outside BRAC (BRAC 2014). The government, UNICEF and the National IYCF Alliance were identified by A&T as key players in scaling up. Within the BRAC’s EHC programme, the A&T programme expanded from two sub-districts in 2009 to 22 in 2010; another 28 sub-districts were added in 2011, for a total of 50 A&T-supported BRAC/EHC sub-districts (Haque et al. 2012). In 2014, the A&T package of community interventions was expanded to another 114 BRAC/EHC sub-districts with funds from DFID. Other BRAC programmes, particularly for urban and rural Maternal Newborn and Child Health (MNCH), were expanded from one sub-district in 2012 to a total of 94 sub-districts in 14 districts in 2014. Expansion of non-BRAC stakeholder programmes began in 2012 and continued until 2015. Two examples where A&T advocated for and later helped design the adaptation for new geographic areas and types of programme platforms are the DFID-funded Livelihoods programmes in hard-to-reach and urban poor communities and the USAID-supported Feed the Future programme.

To increase the commitment of new stakeholders to IYCF, A&T’s advocacy component engaged national medical associations of paediatricians and Ob/Gyn practitioners, as well as donors and senior government officials. Journalists were invited to raise awareness by reporting on the risks of stunting and related IYCF government programmes and policies.

Contextual factors

Successful scale-up was facilitated in Bangladesh by contextual factors. Publicity around the global Scale
Up Nutrition (SUN) movement movement stimulated involvement in IYCF by new donors. Different constituencies responded for different reasons. Government historically had progressive policies (e.g. 6 months of maternity leave and International Code of Marketing of Breast-milk Substitutes) and strategies (National Strategy for IYCF and National Plan of Action) but stagnant indicators (NIPORT 2005; NIPORT 2009). Government also needed a quick replacement for the recently disbanded National Nutrition Programme.

Breastfeeding was well accepted in the newborn child mortality community as a newborn and infant mortality-reducing intervention. Among nutritionists, there was interest in lowering high levels of underweight, stunting and wasting in the country through the IYCF component. There was an interest in learning more about programme strategies to address child malnutrition, as several projects were working towards a goal of reducing malnutrition and A&T was the only one solely dedicated to improving IYCF practices. Donors such as DFID and medical associations such as OGSB wanted to engage in a strongly evidence-based programme with high pay-offs. Early results from the midline surveys by IFPRI provided credible evidence (from a rigorously designed external evaluation) of significant impact.

The National IYCF Alliance – comprising A&T, BRAC, UNICEF and the government as its nucleus plus over 20 other stakeholders – led to building up resources for scale and is now a formal structure of the government of Bangladesh.

Challenges faced during scale-up included (1) lack of demand due to widespread gaps in understanding among communities and health workers of complementary feeding beyond introduction at 6–8 months; (2) lack of capacity, leadership and confidence including concerns among implementing partners that mainstreaming IYCF into existing programme platforms might not work because of work overload and lack of technical focus; (3) a limited number of experienced nutrition programme implementers with the necessary practical training; (4) unfamiliarity among implementers with WHO’s IYCF indicators; (5) the need for training and supervising a large number of health care providers and community volunteers in the labour-intensive interpersonal component; (6) a substantial number of the population residing in ‘media dark’ areas; and (7) one in four households facing economic constraints. Donors were reluctant to make adequate financial commitments without firm evidence of results from the endline survey in 2014.

Conclusion

Key to scale-up of A&T’s IYCF interventions in Bangladesh included early evidence that behaviour change interventions were working, partnership with a strong community-based NGO, the formation of alliances with like-minded stakeholders, availability of funds and technical support from multiple donors, feasible programme implementation options, well-defined interventions and indicators, and streamlined processes and tools to aid implementation. Formation of synergistic partnerships for sustainability and scale – particularly the IYCF Alliance, including governmental, non-governmental and donor organizations – ensured complementary resources to support IYCF activities.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

TS, JB, RS and AJ contributed to writing different sections. SR, RH and KA provided concepts, interpretation and facts and figures for the document.

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Evidence-based evolution of an integrated nutrition-focused agriculture approach to address the underlying determinants of stunting

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Abstract
Despite progress in reducing hunger and malnutrition since the 1990s, many still suffer from undernutrition and food insecurity, particularly women and young children, resulting in preterm birth, low birthweight and stunting, among other conditions. Helen Keller International (HKI) has addressed malnutrition and household food insecurity through implementation of an Enhanced Homestead Food Production (EHFP) programme that increases year-round availability and intake of diverse micronutrient-rich foods and promotes optimal nutrition and hygiene practices among poor households. This paper reviews the evolution and impact of HKI’s EHFP programme and identifies core components of the model that address the underlying determinants of stunting. To date, evaluations of EHFP have shown impact on food production, consumption by women and children and household food security. Sale of surplus produce has increased household income, and the use of a transformative gender approach has empowered women. EHFP has also realized nutrition improvements in many project sites. Results from a randomized control trial (RCT) in Baitadi district, Nepal showed a significant improvement in a range of practices known to impact child growth, although no impact on stunting. Additional non-RCT evaluations in Kailali district of Nepal, demonstrated a 10.5% reduction in stunting and in the Chittagong Hill Tracts in Bangladesh, revealed an 18% decrease in stunting. Based on evidence, the EHFP has evolved into an integrated package that includes agriculture, nutrition, water/hygiene/sanitation, linkages to health care, women’s empowerment, income generation and advocacy. Closing the stunting gap requires long-term exposure to targeted multi-sectoral solutions and rigorous evaluation to optimize impact.

Keywords: stunting, nutrition-sensitive agriculture, homestead food production.

Introduction
Despite progress in reducing global hunger and malnutrition over the past 25 years, factors such as food price increases, sporadic social and political unrest and increasing inequity have resulted in a stagnation of this progress with many people still suffering from hunger, malnutrition and household food insecurity. According to the Food and Agriculture Organization (FAO), 842 million people in the world still do not have enough to eat, with most of those living in Asia. Asia has the largest number of hungry people – over 550 million (The State of Food Insecurity in the World 2014).

Women and young children remain the most vulnerable to hunger and food insecurity. Undernutrition is responsible for 45% of all under five child deaths or 2.6 million child deaths each year (WHO 2014; Black et al. 2013). Hidden hunger, including iron, vitamin A and zinc deficiencies is also still highly prevalent in Asia and has long-term developmental consequences contributing to the burden of child mortality, poor birth outcomes and lower productivity in affected populations.

According to a recent estimates of child malnutrition, 50 million children under 5 years of age are wasted (too thin for their height) and 159 million children under five (24%) are stunted (too short for their age) in the world.
today (UNICEF et al. 2015). Although global prevalence of stunting decreased from 33% in 2000, the numbers remain alarmingly high. The largest percentage (56%) and number of stunted children (96 million) live in Asia (UNICEF et al. 2012).

Stunting can begin before birth. Because most of the growth faltering occurs well before the age of 2 years, it is imperative for programmes to focus interventions that address the causes of child growth during the first 1000 days – from conception through age two – in order to have an impact on stunting. Stunted children become stunted adults who will never realize their full developmental potential. Severe stunting is associated with an IQ loss of 5–10 points (Strauss & Thomas 1998). Low birth weight babies have been found to have IQs five points lower than non-low birth weight babies (UNICEF 1998).

The Framework for action to achieve optimal fetal and child nutrition and development illustrated in the 2013 Lancet series, identifies household food security (including availability, economic access and use of food), feeding and caregiving resources and practices (including maternal, household and community levels) and access to and use of health services as well as a safe and hygienic environment (i.e. food, care and health) as key determinants of optimal child nutrition, growth and development (Black et al. 2013). The Lancet Series also proposed 10 interventions that if implemented at 90% coverage could prevent one million under five child deaths per year, but would avert only 20% of global stunting (Bhutta et al. 2013; Ruel et al. 2013). Clearly, additional evidence is needed to design an integrated package to achieve a more significant impact on reducing stunting. The interventions found in Box 1 have been categorized as nutrition specific, with direct pathways to nutrition outcomes, and nutrition sensitive, with indirect pathways to nutrition outcomes.

### Box 1. Interventions

#### Nutrition Specific

- Promote appropriate breastfeeding and complementary feeding
- Micronutrient supplementation
- Management of acute malnutrition (including screening and referral)
- Balanced energy and protein supplements to women

#### Nutrition Sensitive

- Agriculture & food security
- Social safety nets
- Women’s empowerment
- Water, sanitation & hygiene
- Health and family planning services
- Early child development & child protection programmes

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Evolution of an integrated programme model that links agriculture to nutrition for food security and nutrition outcomes

Over a 25-year period, Helen Keller International (HKI) has developed an integrated nutrition-specific and nutrition-sensitive programme model that uses agriculture as the delivery platform through which disadvantaged households receive a package of services to improve nutritional status among the most vulnerable – young children and pregnant and lactating women. The programme, called Enhanced Homestead Food Production (EHFP), is designed for implementation in rural food insecure areas. It now includes agriculture, nutrition, health, gender and income generation strategies that simultaneously promote optimal nutrition, care and health practices and establishes a system for year-round food availability and intake of diverse micronutrient rich foods. The model marries production of plant and animal source foods (through home gardens, small animal rearing and agriculture support mechanisms) with nutrition education and behaviour change communication using the essential nutrition actions (ENA) framework, highlighting promotion of optimal breastfeeding and complementary feeding (Guyon et al. 2009; WHO 2013). Ensuring that adequate water, hygiene and sanitation interventions are promoted, including uptake of essential hygiene actions (EHA), is also key to optimize the programme’s success. The EHFP model targets women, especially pregnant women and those with children under 2 years of age, and empowers them as the primary beneficiaries of training, services and inputs. The model establishes Village Model Farms (VMF) by providing additional training and inputs so the VMF can serve as a sustainable support mechanism for the 10–20 household farmers in her group and become a small private enterprise selling future inputs to the community. A monitoring (multi-stage cluster random selection of households every 3–4 months) and evaluation system that collects key process and impact data for continual adjustment and programme improvement is integral to the design as well. The EHFP model has evolved over more than 25 years in response to evidence collected by HKI and others and now addresses six of the 10 Lancet Series nutrition-specific and nutrition-sensitive interventions (in bold in Box 1), with mechanisms in place for identification and referral of acute malnutrition cases as well.

Developing the basic homestead food production programme model

The programme was initiated in 1988 as a pilot home gardening project in Bangladesh to improve year-round production and consumption of vitamin-A rich fruits and vegetables among children under 5 years of age after a national blindness survey revealed that households with gardens were less likely to have children with night blindness (HKI & Institute for Public Health and Nutrition 1983). Based on the pilot evaluation results, the project model was fine-tuned to include improved gardening techniques for year-round production and nutrition education to ensure optimal consumption for women and young children, and expanded to additional households. A major improvement to the programme model occurred during the late 1990s, when evidence revealed that the bioavailability of vitamin A and other micronutrients from plant source foods was lower than originally thought – as conversion factors for estimating vitamin A obtained from plant foods were revised from 6:1 to 21:1 for a mixed diet (12:1 for fruits and 26:1 for vegetables) (μg β-carotene: retinol activity equivalent) (West et al. 2002; de Pee & Bloem 2007). In response, the model was revised to include small animal husbandry – mostly poultry, together with promotion of meat and egg consumption among women and young children and named the Homestead Food Production (HFP) programme. Breastfeeding and appropriate complementary feeding counselling (using HFP produce) were also incorporated in order to target infant and young child feeding practices. Later, in response to the Avian Influenza outbreak, diversified sources of animal protein were encouraged by testing an aquaculture option in Cambodia and Indonesia. Participants in Bangladesh could also opt to rear pigs or goats in addition to chickens. During these years observational, monitoring and
evaluation results from various projects in Asia also informed the programme process and implementation procedures. For instance, the sequence of activities, the duration of exposure to training, technical support and supervision, the kind and amount of agriculture inputs and the key communication materials and messages were all refined.

**Enhancing the nutrition-sensitive component**

In 2007, based on the demonstrated impact of the ENA approach to improve delivery of nutrition-specific interventions to mothers and young children, HKI revised the HFP model to incorporate ENA as the basic framework for nutrition improvement and renamed it the EHFP programme (USAID 2006; Guyon et al. 2009). The new approach included using behaviour change communications approaches to promote key doable actions at every opportunity to enhance uptake: maternal nutrition; early initiation of breastfeeding; exclusive breastfeeding for 6 months; the introduction of adequate complementary foods at 6 months, including the animal-source foods that are increasingly being shown as crucial for child growth; continued breastfeeding through 2 years or beyond; nutritional care for the sick child; the integrated control of anaemia and intake of key micronutrients (Dewey & Adu-Afarwuah 2008). Capacity building of and stronger links to the government health sector at health facilities and in communities was undertaken in order to ensure consistency and accuracy of key nutrition messages and to ensure adequate support for health services, better care and referrals particularly for pregnant women and malnourished and sick children.

**Improving household income generation from HFP**

Based on a need expressed (during monitoring and supervision visits) by participating women who found that they had remaining produce after household use, HKI added a small marketing component to create linkages and provide training for the sale of excess produce and animal products. This was undertaken with the understanding that even small income in the hands of women can benefit maternal and child nutrition and health (Engle 1993; Roushdy 2004; Quisumbing & Maluccio 2000). Programme monitoring and evaluation (pre and post cross-sectional surveys comparing intervention and control group) data (Table 1) have shown that this

| Table 1. Proportion of households in Bangladesh and Cambodia that spent income earned by selling garden produce, poultry and egg on various items at endline. |
|---|---|---|---|
| Household commodities | Bangladesh* (in last 2 months) | Cambodia (in last 1 month) |
| Food | 70 | 46 | 92 | 82 |
| Education | 30 | 26 | 1 | 3 |
| Productive/reinvestment | 22 | 25 | 1 | 3 |
| Clothes | 14 | 22 | 0 | 3 |
| Saving | 11 | 24 | 0 | 0 |
| Medicine | 8 | 0 | 2 | 6 |
| Housing | 1 | 3 | 0 | 0 |
| Amusement | 1 | 2 | 0 | 0 |
| Social activities | 0 | 1 | 1 | 2 |
| Other | 0 | 0 | 3 | 1 |

*In Bangladesh, respondents could choose as many commodities as applied. Tahakder et al., 2010
income is in fact often used to purchase high quality and other needed food items or to pay for health and education costs (Talukder et al. 2010). All EHFP programmes now include marketing education and training for participants.

**Enriching gender equity within EHFP**

Although EHFP has been women-centred from the beginning, monitoring and evaluation data across projects indicated a need to strengthen the approach to better empower women in decision making, to increase male participation in childcare and other traditional women’s tasks and to encourage support for mothers from influential family and community members. The Nurturing Connections© manual was created by HKI (in Bangladesh) to implement a transformative gender approach within EHFP (Kotze et al. 2014). The approach consists of a range of participatory activities where all main decision-makers of the household acquire communication and negotiation skills to discuss and challenge traditional norms that impact nutrition, health and overall well-being of the households.

**Addressing WASH through EHFP**

The inclusion of EHA and a stronger water, sanitation and hygiene (WASH) component was a further refinement to the model after the Nepal Action Against Malnutrition through Agriculture (AAMA) research project showed less impact on improving child nutritional status and growth than expected (McNulty et al. 2013). In addition to the handwashing and diarrhea prevention that already existed in the model, EHA added the creation of handwashing stations, disposal of feces, de-worming, water purification and proper food storage to the EHFP.

Most recently, HKI has incorporated activities to address environmental enteropathy based on evidence from a randomized control trial (RCT) in Zimbabwe indicating that environmental enteropathies could impact stunting even in the absence of diarrhea (Humphrey 2014). An earlier study conducted with Zimbabwean toddlers found that the greatest cause of intestinal damage, as measured by *Escherichia coli*, was because of ingestion of chicken feces (Ngure et al. 2013). HKI therefore tested the use of safe and sanitary play areas in Nepal (as was used in the SHINE study), but found that mothers were resistant to the idea that dirt and chicken feces made children sick so there was little interest in uptake despite intensive behaviour change messaging. Instead more than 60 000 chicken coops have been built and are being utilized in project areas (Save the Children & HKI 2014). Further formative research is needed to determine messaging and strategies to improve use of the play areas.

**Better targeting to optimize impact**

The AAMA results, along with the Scaling Up Nutrition Movement and the 2013 Lancet series papers, led HKI to prioritize targeting the programme to households with children under 2 years of age and pregnant women in order to address the growth faltering within the 1000-day window (Scaling up Nutrition 2012; Ruel et al. 2013; Bhutta et al. 2013; Adair et al. 2013). The programme focused even more attention on nutrition services related to interventions that span this critical window from pregnancy into the first 2 years of life (World Bank 2006).

**The EHFP programme impact pathways**

Through identification of gaps and testing of new strategies, the components of EHFP have evolved to more comprehensively address the underlying food, health and care determinants of stunting. The current integrated model is expected to improve maternal and child nutritional outcomes through several pathways, namely: (1) increased access to and consumption of micronutrient-rich fruits, vegetables and poultry or small animal products, (2) improved breastfeeding and complementary feeding practices, (3) increased use of public health services by mothers and children, (4) increased income through the sale of surplus products from the home gardens and small animal husbandry, and (5) empowered mothers by improving their knowledge and skills and influence over household decision making. The model has added a sixth pathway in order to reduce infections (particularly diarrhea disease and intestinal

worms) namely (6) improved water, sanitation and hygiene (WASH) practices.

The Suaahara project, implemented in disadvantaged areas of Nepal, reflects the current model for HKI’s EHFP programme, incorporating critical research findings from AAMA and other research to try to optimize the impact on stunting. The Suaahara project is a 5-year USAID funded project with Save the Children and other partners and uses the ENA framework to improve nutrition; maternal, newborn and child health (MNCH) services; reproductive health/family planning services; WASH and home-based food production in 41 districts throughout the country. Figure 1 below describes the Suaahara EHFP Programme Impact Pathways.

**Impact of HKI’s EHFP on determinants of stunting**

EHFP across the Asia-Pacific region has improved household garden and animal husbandry practices, food production, consumption and dietary diversity among women and young children. EHFP has also been shown to improve uptake of essential nutrition and hygiene actions by mothers and other caretakers, improve linkages to the health sector and enhance women’s decision making power in the household. EHFP has been shown to reduce anaemia and nightblindness (vitamin A deficiency) prevalence among young children and women of reproductive age in some projects and has improved women’s nutrition; however, more evidence on its impact on child growth is needed.

A review of EHFP programme evaluations (pre and post cross-sectional surveys comparing intervention and control group) from 2003 to 2007 in Bangladesh, Nepal, Cambodia, Indonesia and the Philippines indicates that HKI’s EHFP has positively impacted poor households’ year round food production and availability, particularly for women and children 6–59 months of age (Talukder et al. 2010). As illustrated in Fig. 2 below, programme evaluation research by HKI in Bangladesh and Cambodia showed that as gardening practices
improved from traditional gardening (seasonal with limited crops grown) to developed gardening promoted by HKI (year round production with a variety of crops grown at all times), the quantity and number of vegetables varieties grown increased, as did consumption of vegetables by children. The diversity of vegetable consumption by young children in the week before the survey was four types eaten when households practiced traditional gardening compared with 13 types eaten when households practiced developed gardening. Frequency of consumption of vegetables by children was 1.6 times higher among children in households with developed gardens relative to traditional gardens. Consumption of vitamin A rich foods among children was also improved (Talukder et al. 2010).

The results also demonstrated an increase in women’s level of influence in household decision-making along

![Graph](image)

**Intra-household Influence of Married Beneficiaries**

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<tr>
<td>Confident to stand in as household bread winner if needed</td>
<td>4%</td>
<td>14%</td>
<td>5%</td>
<td>8%</td>
<td>3%</td>
<td>7%</td>
<td>13%</td>
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<tr>
<td>Comfortable expressing different opinion from spouse</td>
<td>95%</td>
<td>81%</td>
<td>92%</td>
<td>86%</td>
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<td>Can freely discuss household money matters with spouse</td>
<td>4%</td>
<td>1%</td>
<td>3%</td>
<td>5%</td>
<td>9%</td>
<td>4%</td>
<td>1%</td>
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<tr>
<td>Spouse is higher priority than themselves in Hh food consumption</td>
<td>7%</td>
<td>1%</td>
<td>2%</td>
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<td>Can discuss contraception with spouse</td>
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**Fig. 2.** Type of garden related to production and consumption of vegetables in Bangladesh (2003–2005) and Cambodia (2005–2007) at endline (consolidated).

**Fig. 3.** Women’s Empowerment Making Markets Work for Women Final Report. 2012.
with increased household income controlled by women (Talukder et al. 2010).

An external evaluation (comparing current HFP households, former HFP households and controls) in Bangladesh confirmed that through HFP women’s influence in the household improved across all parameters as women were empowered with increased knowledge and skills and also were able to control a small amount of income from sale of excess EHFP produce (Bushamuka et al. 2005). A more recent evaluation of the pilot project, Making Markets Work for Women (M2W2), an EHFP and livelihood intervention with 450 extremely poor landless women in Bangladesh, confirms these findings (HKI 2012). As seen in Fig. 3 below, endline data revealed that respondents had higher levels of comfort with expressing opinions and discussing money matters and family planning issues than at baseline. Additionally, a recent qualitative assessment has indicated that households participating in Nurturing Connections as part of EHFP share household food more equitably, pregnant and lactating women receive support for domestic duties from other household members, and household members engage more in joint decision-making regarding food purchases and use of income (HKI-Bangladesh 2015).

An external review/secondary data analysis of HKI’s EHFP in Bangladesh by the International Food Policy Research Institute (IFPRI) revealed that the programme increased diversity and quantities of food produced and consumed, and also increased women’s involvement in household decision making, noting, ‘there is sufficient evidence to conclude that (EHFP) is improving household food security, and in some cases nutrition and other intermediary outcomes’ (Iannotti et al. 2010). Intake of micronutrient rich fruits and vegetables by mothers and young children among poor families in Bangladesh improved substantially in just 1 year, as a result of additional production year round and promotion and instruction of how to prepare the foods for children (Talukder et al. 2000). Evaluations of other nutrition-sensitive agriculture interventions support these findings, showing consistent improvements in the volume and diversity of vegetables and fruits produced, diversity of foods consumed and women’s involvement in family decision-making, all of which are determinants for child health (Masset et al. 2012).

To address the dearth of evidence on nutrition-sensitive agriculture interventions impact on nutrition status, HKI designed a study to assess the impact of the EHFP model on child nutrition and growth (anthropometry), as well as women’s nutritional status. As part of a USAID-funded Child Survival Innovations Project, HKI implemented two EHFP studies in Nepal (AAMA Project) from 2009 to 2012 in Baitadi and Kailali districts that addressed the food, health and care causes of malnutrition in the area. The project, covering approximately 11 000 households, was an integrated EHFP model including home gardens, poultry-rearing, ENA behaviour change communication led by community health workers, a hygiene component and activities to improve linkages to health services.

The main research study within the AAMA project was a cluster RCT that assessed more than 2000 families with children 12–48 months of age at baseline and endline in intervention and control areas. Results showed that there was a significant improvement in
household food security (using the Household Food Insecurity Access Scale; Coates et al. 2007) among intervention households compared with controls, with the greatest difference realized among severely food insecure households. EHFP improved early initiation of breastfeeding, exclusive breastfeeding, complementary feeding practices, hygiene practices of mothers and children and had a significantly positive impact on children’s/mother’s participation in preventative health services as well. At endline, anaemia was significantly lower among mothers and children in the intervention (EHFP) group, and mothers participating in the EHFP were significantly less likely to be underweight (BMI < 18.5 kg/m²) than those who were not in the programme. However, there was no impact seen on child anthropometry (Haselow & Osei 2014).

The study did show that an integrated agriculture-nutrition focused intervention can play an important role in improving determinants of stunting such as household food security, maternal hand-washing and child feeding practices, as well as reducing anaemia among women and children and decreasing maternal underweight.

The Kailali district project was not a cluster randomized controlled trial, but did use an intervention–comparison evaluation design. Difference in difference analysis between intervention and control groups showed a reduction of 10.25% (P value 0.008) in stunting between baseline and endline. Furthermore, the M2W2 evaluation in Bangladesh demonstrated a reduction in stunting among participating households (see Fig. 4 below). The baseline and endline surveys revealed that 54% of children suffered stunting at baseline and, of those, 19% were severely stunted. By endline stunting had been reduced to 36%, and severe stunting was reduced to 16% (HKI 2013). However, there was no control group for the project and because of the census methodology utilized – some of the same children were measured in households at base and endline, which could lead to ageing effects, distorting the true impact.

Despite these positive results from EHFP, data across nutrition-sensitive agriculture programmes have shown inconsistent impact on nutritional status of children, and in particular they have shown little impact on child growth. Some reasons for this may be that few evaluations of agriculture programmes have included nutritional indicators, and those that have, have not utilized sufficiently rigorous evaluation designs in order to detect change (Masset et al. 2012). In addition, both the duration of the exposure to the intervention before evaluating the impact and targeting of the intervention may have been suboptimal. Programmes may not have addressed all of the aspects included in the three determinants of malnutrition adequately, namely food, care and health (including adequate attention to ensuring clean water and proper sanitation and hygiene) (UNICEF 1997). Finally, the indicators used to measure the determinants may not have been specific enough to capture an association with stunting (i.e. ownership of toilet vs. use of toilet). In the case of the AAMA trial mentioned above, reasons for lack of impact seen on child growth may be that the design was cross-sectional rather than longitudinal, the age range of children studied may have been too broad and too old and the duration of exposure to the intervention may have been too short to show impact. In addition, the WASH component of the integrated model may not have been adequate to control infection.

**Lessons learned from implementing a nutrition-focused agriculture programme model**

HKI’s EHFP programme has been replicated and adapted to the local context to reach over 1.2 million households in Bangladesh, Cambodia, Indonesia, Nepal, the Philippines and Vietnam as well as to three countries in Africa. Adapting and scaling the programme to incorporate evidence that leverages impact on the underlying determinants of stunting have led to the following key learnings summarized in Box 2 and expanded below:

1. Agriculture is critically important but not enough to improve nutrition of vulnerable populations in food insecure areas. For agriculture interventions to optimize nutrition outcomes of the most vulnerable, they should be designed through a nutrition lens, addressing local food, care and health determinants of malnutrition. This requires working with partners across sectors to ensure all aspects of the local determinants of undernutrition are adequately addressed.
(2) It is crucial to target pregnant women and women with children under 2 years of age. This targeting focuses attention on the critical 1000-day developmental window and builds women’s knowledge and confidence to make good nutrition and health choices for their children and themselves.

(3) Geographic targeting is also important considering the cost of inputs and training required: nutrition focused agriculture programmes have the greatest impact when implemented in food insecure areas among disadvantaged households.

(4) In order to maximize health and nutrition outcomes for women and children, programmes should be designed to empower women in their important role as the gatekeepers of household food security, food production, and hygiene and child nutrition. This also means educating and enlisting other influential members of the household, such as mothers-in-law and husbands, to provide both emotional and physical support.

(5) The design and adaptation of the integrated programme delivery model should be based on evidence from the project area.

(a) An equity analysis should be performed to provide an understanding of the social/gender dimensions that must be addressed to implement effective programmes that reduce gender/social barriers and enable men and women to better access resources, livelihood opportunities and improved nutrition and food security.

(b) The behaviour change communication strategy should be based on formative research and tested to facilitate lasting change. The research should include an analysis of the barriers and facilitators for improved nutrition and should be used to develop a strategy for positive change regarding agriculture, nutrition, health, WASH and livelihoods behaviours. The messages should be consistent and reinforced through multiple channels (interpersonal communication, community mobilization, mass media) at all levels.

(c) A practical training package for agriculture, nutrition and health should be adapted to the local context and tested. The training content should be updated to include state of the art information and appropriate technology in nutrition, health, WASH and agriculture that could be usable and available in the project area. Agriculture practices and planning should address climate change issues in the target area.

(6) Have an entry and exit strategy. Participatory and learning methods are essential for community entry and to ensure full participation and ownership among stakeholders. There should be an initial and ongoing support mechanism built into the programme model with a qualified technical and management team available to build capacity of local resources in order to ensure households can receive the support they need, and be prepared to continue without much assistance.

(7) A local source for continued agriculture inputs and support is important for access (particularly in more remote areas), affordability and sustainability of the agriculture component. It is best when these are civic-minded, community-selected households that receive additional training and can establish a VMF as a private household enterprise.

(8) Building multi-sector collaboration at national, regional and local level is important to maximize nutrition outcomes and use limited resources wisely. Locally, this also means that links to existing agriculture resources, both private and public sector, and to markets must be established in the project. Strong links to the existing health, nutrition and WASH resources should be embedded in the project, as well as working closely with local authorities to support community improvements and leverage additional resources.

(9) A monitoring and evaluation system that provides continuous learning is necessary when adapting the model successfully and sustainably to new areas, environments and cultures. Nutrition indicators should be included in any intervention with the aim of improving nutrition, including agriculture projects. A rigorous evaluation designed specifically to assess impact on nutrition is important in order to build the evidence base for integrated approaches.

(10) Documentation, publication and dissemination are critical to advocate for policies that support integrated nutrition-specific and -sensitive approaches and to compel donors to invest in these kinds of interventions for poor communities.
Toward a more comprehensive strategy to close the stunting gap

In light of the 80% gap that remains in reducing child stunting based on the Lancet series estimation, more work is needed to design an integrated nutrition-specific and nutrition-sensitive strategy that intensifies the current known solutions, improves targeting and/or includes additional interventions that may leverage impact on stunting. This will also require that all sectors, public and private, form effective partnerships and do their part to deliver quality services to disadvantaged communities and households.

HKI is continuing to assess and refine the integrated EHFP model to help fill the gap. We are currently undertaking a number of studies to look at various aspects of the model, including several RCTs to assess its impact on child growth. This will also require that all sectors, public and private, form effective partnerships and do their part to deliver quality services to disadvantaged communities and households.

HKI is continuing to assess and refine the integrated EHFP model to help fill the gap. We are currently undertaking a number of studies to look at various aspects of the model, including several RCTs to assess its impact on child growth. This will also require that all sectors, public and private, form effective partnerships and do their part to deliver quality services to disadvantaged communities and households.

HKI is currently engaged in a study in Bangladesh to enroll women at marriage and assess the impact of EHFP on maternal nutrition and child growth. More research is needed on the impact of stunting beginning at the first day of the 1000-day period mark, and the impact of reaching adolescent girls and women before they are pregnant.

In many cases, the short length of exposure to nutrition-sensitive interventions may not be adequate to determine changes in stunting in field conditions. Because of project and research funding cycles, few, if any, evaluations take place for extended periods of time. HKI has recently initiated long-term projects (more than 5 years) involving rigorous evaluation and surveillance mechanisms in Cambodia and in Bangladesh to look at impact over time.

Another important need is to refine measures that have already been identified in previous studies in the areas of diarrhea, WASH and food consumption so that the correct indicators on compliance and uptake are measured. For instance, measuring the presence of a latrine or availability of soap and water at households is not adequate to assess whether people actually use the latrine or wash hands after defecation and before cooking/eating, which will increase exposure and repeat parasitic infections.

Additionally, the body of evidence should include both monitoring and evaluation data to better understand where issues of uptake and compliance happen so that programme models, such as HKI’s EHFP, can

<table>
<thead>
<tr>
<th>Box 2. Key learning to leverage impact of nutrition-focused agriculture programmes</th>
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<tbody>
<tr>
<td>1. Collaborate with local partners across sectors to ensure all food, health and care determinants of undernutrition are adequately addressed</td>
</tr>
<tr>
<td>2. Target interventions to pregnant women and women with children under two years of age to best address child growth</td>
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<tr>
<td>3. Implement in food insecure areas among disadvantaged households</td>
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<tr>
<td>4. Ensure the programme design empowers women</td>
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<tr>
<td>5. Base the programme design and adaptation to the local context on evidence</td>
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<tr>
<td>6. Have a programmatic entry and exit strategy</td>
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<tr>
<td>7. Ensure there is a local source for continued agriculture inputs and support</td>
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<tr>
<td>8. Work to build multi-sector collaboration at national, regional and local levels</td>
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<tr>
<td>9. Provide continuous learning through an effective monitoring and evaluation system</td>
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<tr>
<td>10. Document, publish and disseminate findings to advocate for policy and resource support</td>
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</table>
be refined to achieve a greater impact. A greater number of comprehensive, rigorous programme evaluations conducted, which are long term and longitudinal, must be designed and funded to ensure that the fight to reduce stunting is based on evidence.

Finally, one of the areas warranting further investigation is the relationship between maternal depression and exposure to stressful events during and post pregnancy as contributing factors to child nutrition and growth. A recent meta-analysis revealed that maternal depression was linked to child stunting and underweight in developing countries (Surkan et al. 2011). Other studies found that stressful events occurring during the first and second trimesters of pregnancy increased risk of preterm birth and perceived stressful events during first trimester were associated with a 99.09-g decrease in infant birthweight (Glynn et al. 2008; Littleton et al. 2010; Zhu et al. 2010). Exposure to stress and anxiety remains to be evaluated as part of nutrition-sensitive interventions, and measures to do so will need to be adapted to the developing country context. Additional areas that might contribute to a more effective approach to reduce stunting include strategies to improve resilience specifically of disadvantaged communities and households and better convergence of nutrition-sensitive interventions by multi-sectoral stakeholders in these communities.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

NJH drafted the manuscript, AS contributed to the writing and AP provided valuable information for key sections. All authors reviewed, edited and approved the final submission.

References


Estimating the cost of delivering direct nutrition interventions at scale: national and subnational level insights from India

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Abstract

India’s national nutrition and health programmes are largely designed to provide evidence-based nutrition-specific interventions, but intervention coverage is low due to a combination of implementation challenges, capacity and financing gaps. Global cost estimates for nutrition are available but national and subnational costs are not. We estimated national and subnational costs of delivering recommended nutrition-specific interventions using the Scaling Up Nutrition (SUN) costing approach. We compared costs of delivering the SUN interventions at 100% scale with those of nationally recommended interventions. Target populations (TP) for interventions were estimated using national population and nutrition data. Unit costs (UC) were derived from programmatic data. The cost of delivering an intervention at 100% coverage was calculated as (UC*projected TP). Cost estimates varied; estimates for SUN interventions were lower than estimates for nationally recommended interventions because of differences in choice of intervention, target group or unit cost. US$5.9bn/year are required to deliver a set of nationally recommended nutrition interventions at scale in India, while US$4.2bn are required for the SUN interventions. Cash transfers (49%) and food supplements (40%) contribute most to costs of nationally recommended interventions, while food supplements to prevent and treat malnutrition contribute most to the SUN costs. We conclude that although such costing is useful to generate broad estimates, there is an urgent need for further costing studies on the true unit costs of the delivery of nutrition-specific interventions in different local contexts to be able to project accurate national and subnational budgets for nutrition in India.

Keywords: nutrition, health, cost, scaling up, India, South Asia.

Introduction

India is currently not on track to meet Millennium Development Goals 1 (eradicate extreme hunger and poverty) and 4 (reduce child mortality) and carries an exceptionally high proportion of the global burden of undernutrition. In 2005–2006, nearly half of all children under 5 years of age in India were stunted (International Institute for Population Sciences 2007). A high prevalence, coupled with a large population size, make India home to the largest number of undernourished children in the world – estimated at over 58 million in 2006. Undernutrition among women and children is determined by a diverse set of factors that include immediate, underlying and basic determinants (Black et al. 2013). Strategies to improve nutrition, therefore, include a set of interventions to target immediate determinants of poor diet and illnesses, typically delivered through community-based nutrition programmes or health systems, called ‘nutrition-specific’ interventions (Bhutta et al. 2013a). Interventions to strengthen the underlying determinants of food insecurity, poverty, women’s status, and sanitation, called ‘nutrition-sensitive’ interventions, are also recommended, but less evidence is available on their effectiveness (Ruel et al. 2013). It is, therefore, well-accepted now that scaling up a set of nutrition-specific interventions must be part of any strategy to combat undernutrition, while efforts continue on identifying the best combination of nutrition-sensitive interventions for any context. In India, where
nutrition policy already includes several recommended nutrition-specific interventions, prior research has identified that the gaps to delivering nutrition-specific interventions lie primarily in areas of implementation and monitoring (Avula et al. 2013). Among other actions necessary to support adequate implementation is adequate financing, and therefore, one of the critical questions that must be asked is ‘How much will it cost?’

In public health nutrition, cost analyses are typically undertaken to offer estimates of the financial resources required to provide a service or intervention to a specific population. Costing studies help to identify the levels, types and composition of costs, as well as the overhead and infrastructure that are required to expand the coverage of an intervention. They can also isolate regions where interventions are challenging to implement and where additional resources may be required to effectively expand coverage to reach the target population. This information is critically important to programme planning and implementation. The inclusion of cost–benefit analysis can also help policymakers prioritize interventions that will have the greatest impact in situations where resources are limited (Stenberg et al. 2015). In addition, costing analyses aid in standardizing programme domains, accountability and incentives (Fiedler & Macdonald 2009).

In 2010, the World Bank spearheaded a study, Scaling up Nutrition: What will it Cost? (SUNWWIC) (Horton et al. 2010), to estimate the total cost of scaling up a package of 10 direct nutrition interventions from current coverage levels to full coverage in 36 countries that represent 90% of the global stunting burden and 32 additional smaller countries that also have high rates of child undernutrition. Following this, the second paper of the 2013 Lancet Series on Maternal and Child Nutrition provided further analyses on the cost of implementing 10 direct nutrition interventions at scale in 34 countries that carry the highest global burden of undernutrition (Bhutta et al. 2013b). Other authors have recently elaborately furthered the costs required for a full investment in breastfeeding promotion on a global scale (Holla et al. 2013). These studies all succeed in approximating the required financing to scale up important nutrition activities at the global level. They also underscore the importance of investing in nutrition and raise awareness of the need for additional resources. However, these global cost estimates do not typically capture local contexts, nuances and priorities of the individual countries. There is, therefore, a clear need for more tailored cost estimates that account for important factors such as local unit costs, synergies between interventions and optimal delivery platforms at the national and subnational level. This need is particularly pronounced in India, given its persistently high burden of undernutrition and recent findings on suboptimal coverage levels of most nutrition activities (Avula et al. 2013).

Within this context of costing and cost-effectiveness in the area of nutrition, the objectives of this study are to use the SUNWWIC methodology and use local costing data and information on delivery platforms and target populations to calculate and compare the cost of delivering two sets of interventions at scale. The first is the set of the 10 SUN interventions using the most recent population data, and the second is a set of 14 nutrition interventions that are encompassed in India’s policy framework and also supported by recommendations from a large network of stakeholders in India, the Coalition for Food and Nutrition Security in India (The Coalition for Sustainable Nutrition Security 2010). We call this set of interventions the ‘India Plus’ actions.

### Key messages

- US$5.9bn/year is required to deliver 14 essential nutrition interventions at full coverage across India.
- Cash transfers to women to support breastfeeding accounts for the largest proportion of the total cost, followed by supplementary food targeted at children under two.
- The lowest cost interventions include counselling for promoting breastfeeding, iron-folic acid supplements for pregnant and breastfeeding women, vitamin A supplementation, deworming and insecticide treated nets for pregnant women in malaria-endemic areas.
- Scaling up costs vary considerably even within India – states in the Indo-Gangetic area require the greatest outlay because of larger target population sizes.
- We estimate that planners can use a rule of thumb of US$140 per child 0–24 months of age per year as an average cost to budget for interventions covered in this framework but caution that more research is needed on unit costs of several interventions.

Table 1 provides a broad comparison of the two sets of interventions analysed in this paper.

**Aim and scope**

This paper strives to estimate the costs of implementing a set of specific nutrition actions in financial or budgetary terms. It does not venture to calculate the full social resource requirements that also incorporate the opportunity costs of time committed by beneficiaries accessing the services. While this latter approach is more comprehensive, it involves the collection of primary data, which is beyond the scope of the current study. Furthermore, this paper also does not focus on cost-effectiveness analyses or cost–benefit analyses. Rather, it focuses on providing the best possible estimates of the cost of implementing each intervention at full coverage but does not predict the corresponding health and nutrition outcomes that are expected to result from the scale up of services.

The cost estimates in this paper are restricted to direct, nutrition-specific interventions, primarily delivered through programmes implemented by the Ministry of Health and Family Welfare and the Ministry of Women and Child Development (see Avula et al. 2013 for further detail) and broadly agreed upon by a national technical stakeholder coalition (Swaminathan 2009). We do not include nutrition-sensitive interventions

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**Table 1. A comparison of the Scaling Up Nutrition (SUN) and India Plus interventions**

<table>
<thead>
<tr>
<th>SUN interventions</th>
<th>India Plus interventions</th>
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<tbody>
<tr>
<td>Behaviour change interventions</td>
<td>Counselling for mothers during pregnancy</td>
</tr>
<tr>
<td>Community nutrition programmes for behaviour change</td>
<td>Counselling for optimal breastfeeding to caregivers of children 0–6 months</td>
</tr>
<tr>
<td>communication for caregivers of children 0–59 months of age</td>
<td>Counselling for complementary feeding and hand washing to caregivers of children 0–6 months</td>
</tr>
<tr>
<td>Micronutrient and deworming interventions</td>
<td>Vitamin A supplementation for children 6–59 months</td>
</tr>
<tr>
<td>Vitamin A supplementation for children 6–59 months</td>
<td>ORS and therapeutic zinc supplements for treatment of diarrhoea for children 2–59 months</td>
</tr>
<tr>
<td>Zinc supplementation for children 6–59 months</td>
<td>Deworming for children 12–59 months</td>
</tr>
<tr>
<td>Deworming for children 12–59 months</td>
<td>Deworming for adolescents 11–18 years</td>
</tr>
<tr>
<td>Iron-foolic acid supplements for pregnant women</td>
<td>Iron supplements for children 6–59 months</td>
</tr>
<tr>
<td>Iron-foolic acid supplements for pregnant and lactating women</td>
<td>Iron-foolic acid supplements for adolescents 11–18 years</td>
</tr>
<tr>
<td>Multiple micronutrient powders for children 6–23 months not receiving fortified food</td>
<td>No comparable intervention</td>
</tr>
<tr>
<td>Iron fortification of staple foods for general population</td>
<td></td>
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<tr>
<td>Salt iodization for general population</td>
<td></td>
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<tr>
<td>Complementary and therapeutic feeding interventions</td>
<td>Complementary food supplements for children 6–36 months of age</td>
</tr>
<tr>
<td>Complementary food for prevention or treatment of moderate malnutrition for children 6–23 months</td>
<td>Supplementary food rations for pregnant and lactating women for 6 months after delivery</td>
</tr>
<tr>
<td>Severe Acute Malnutrition treatment</td>
<td>Additional food rations for severely malnourished (WAZ &lt; –3) children 6–59 months</td>
</tr>
<tr>
<td>Others</td>
<td>Insecticide-treated nets for pregnant women in malaria-endemic areas</td>
</tr>
<tr>
<td>No comparable intervention</td>
<td>Cash transfers to women for the first 6 months after delivery</td>
</tr>
</tbody>
</table>

SUN, Scaling Up Nutrition; ORS, oral rehydration salts; WAZ, Weight-for-Age Z score; WHZ, Weight-for-Height Z score. Source: Compiled by authors
(e.g. nutrition-sensitive social protection programmes, programmes to improve agricultural productivity in a nutrition-sensitive manner or to improve sanitation). There is agreement that such interventions can help to improve nutrition outcomes in the long run, but the evidence base is weaker in comparison with nutrition-specific interventions, delivery platforms are less clear and costing data are sparse.

This paper is a summarized version of a longer policy-focused report on the costing of nutrition-specific interventions in India, which is available elsewhere (Menon et al. 2015).

Methods

Costing approach

The ‘program experience’ approach is used to calculate the costs of delivering both sets of activities at full coverage (Horton et al. 2010). This method utilizes unit cost data for each intervention from actual programmes that are in operation and considers the context and channels through which they are delivered.

To calculate the cost of providing interventions at full coverage, we performed the following steps: (1) described each intervention to be costed; (2) defined the target population of each intervention; (3) estimated the size of the target population in 2014 for each intervention; (4) specified the platform or channel(s) through which each intervention or activity will be delivered; (5) obtained local unit cost data for India Plus interventions from relevant sources within India or from programmatic settings in South Asia that could be applicable; (6) for each intervention, multiplied the size of the target population by the unit cost to arrive at a total cost of implementing each intervention at full coverage; and (7) perform necessary adjustments for inflation. The Government of India has explicitly committed to ‘universalize’ the costed nutrition interventions, and therefore, we define ‘full coverage’ as 100% of the target population for all interventions except in the case of treatment of severe acute malnutrition, which we set to 80%. This is in keeping with SUNWWIC methods and is based on the reality that it is exceptionally challenging to surpass 80% coverage at scale. We first conducted all calculations at the national level and then estimated costs at the state level for all 35 Indian states and union territories using state-specific target population estimates.

The intervention descriptions, target population and delivery channel are specified in Tables 2 and 3. Subsequently, we describe the data sources for the size of the target populations and the unit costs of interventions.

Data sources

1. Target populations: We used India’s 2011 Census and accompanying Sample Registration System as the main source of data for estimating the size of each target population in 2014, as it is the most credible source of demographic information in the country. More specifically, we used data on the aggregated population, age-specific strata for males and females, the crude birth rate and the derived average population growth rate that is reported in the Sample Registration System bulletins and vital statistics sections by the Ministry of Home Affairs. Our secondary data source was the third series of the National Family Health Survey, which we used to derive estimates of the prevalence of stunting, wasting, underweight, severe wasting and severe underweight among children under 5 years of age (International Institute for Population Sciences 2007). Finally, we used data from the 68th round of the National Sample Survey on employment and unemployment to estimate the percentage of women aged 18–50 years who work in the government sector. The sources of data for the target population estimates for the SUNWWIC and India-Plus were the same, but because target populations vary between the two sets of interventions, they were estimated appropriate to the intervention.

2. Unit costs: In performing the analyses to estimate the SUN costs, we used the same unit costs as for the 10 core SUN interventions used in SUNWWIC

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Description</th>
<th>Assumptions</th>
<th>Target Population</th>
<th>Unit cost (US$)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Counselling actions</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Counselling during pregnancy</strong></td>
<td>Promotion of optimal nutrition during pregnancy although an average of 3.5 individual/group contacts during pregnancy</td>
<td>Assumes an average of 4.1 face-to-face visits per pregnant woman at US$0.43 per visit.</td>
<td>Pregnant women</td>
<td>$1.76 per pregnant woman per year</td>
<td>(Khan et al. 2014)</td>
</tr>
<tr>
<td><strong>Counselling for breastfeeding</strong></td>
<td>Promotion of optimal breastfeeding practices through an average of 11.7 individual/group contacts between 0–6 months of age</td>
<td>Assumes an average of 15.2 face-to-face visits between 0–6 months at US$0.11 per visit.</td>
<td>Caregivers of children 0–6 months of age</td>
<td>$1.67 per child 0–6 months of age per year</td>
<td>(Khan et al. 2014)</td>
</tr>
<tr>
<td><strong>Counselling for complementary feeding and hand washing</strong></td>
<td>Promotion of optimal IYCF and hand-washing practices through an average of 11.6 individual/group contacts between 6–12 months of age, and 13.5 contacts between 12–24 months of age</td>
<td>Assumes an average of 13.3 face-to-face visits per child between 6–12 months of age at US$0.56 per visit, and an average of 12.2 face-to-face visits per child between 12–24 months of age at US$0.23 per visit.</td>
<td>Caregivers of children 6–24 months of age</td>
<td>$7.47 per child 6–12 months of age per year $2.80 per child 12–24 months of age per year</td>
<td>(Khan et al. 2014)</td>
</tr>
<tr>
<td><strong>Supplementation</strong></td>
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<tr>
<td><strong>Complementary food supplements</strong></td>
<td>Daily food supplements between 6–36 months of age</td>
<td>Assumes provision of a daily ration at Rs.6 (US$0.097) per day.</td>
<td>Children 6–36 months of age</td>
<td>$14.52 per child 6–12 months of age per year $29.03 per child 12–26 months of age per year</td>
<td>(Ministry of Women and Child Development 2012)</td>
</tr>
<tr>
<td><strong>Supplementary food rations</strong></td>
<td>Daily food supplements for the second and third trimesters (i.e. approx. 6 months) of pregnancy and 6 months after birth</td>
<td>Assumes provision of a daily ration for pregnancy and after delivery</td>
<td>Pregnant and lactating women for 6 months after delivery</td>
<td>$16.93 per pregnant woman per year; $16.93 per mother of a child 0–6 months of age per year</td>
<td>(Ministry of Women and Child Development 2012)</td>
</tr>
<tr>
<td>Intervention</td>
<td>Description</td>
<td>Assumptions</td>
<td>Target Population</td>
<td>Unit cost (US$)</td>
<td>Source</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>--------</td>
</tr>
<tr>
<td>Additional food rations for severely malnourished children</td>
<td>Provision of an additional daily food supplement for 3 months for children who are severely malnourished</td>
<td>Assumes provision of a daily ration for 3 months at Rs 9 (US $0.145) per day.</td>
<td>Children 6-59 months of age with WAZ &lt; -3</td>
<td>$13.06 per severely underweight child 6-36 months of age per year</td>
<td>(Ministry of Women and Child Development 2012)</td>
</tr>
<tr>
<td>Micronutrient and deworming</td>
<td>IFA supplements for pregnant and breastfeeding women</td>
<td>Provision of daily IFA supplements for women</td>
<td>Pregnant and lactating women for 6 months after delivery</td>
<td>$0.72 per pregnant woman per year; $0.51 per mother of a child 0-6 months of age per year</td>
<td>(Micronutrient Initiative 2011)</td>
</tr>
<tr>
<td>IFA supplements and deworming for adolescents</td>
<td>Provision of IFA supplements through the school system</td>
<td>Assumes weekly provision of IFA tablets and semi-annual deworming prophylaxis</td>
<td>Adolescents 11-18 years of age</td>
<td>$0.40 per adolescent 11-18 years of age per year</td>
<td>(UNICEF 2011)</td>
</tr>
<tr>
<td>Iron supplements for children</td>
<td>Provision of daily iron supplements for children 6-59 months of age</td>
<td>This is the GOI’s current expenditure on iron supplementation per beneficiary</td>
<td>Children 6-59 months of age</td>
<td>$0.37 per child 6-36 months of age per year</td>
<td>(Micronutrient Initiative 2011)</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>Supplements for children</td>
<td>Assumes two rounds of vitamin A supplementation per child per year</td>
<td>Children 6-59 months of age</td>
<td>$0.07 per child 6-59 months of age per year</td>
<td>(Micronutrient Initiative 2011)</td>
</tr>
<tr>
<td>ORS and therapeutic zinc supplements for treatment of diarrhoea</td>
<td>Daily ORS and zinc for 14 days during/ following an episode of diarrhoea</td>
<td>Assumes each child 2-59 months of age has an average of three episodes of diarrhoea per year, two ORS sachets are required to treat each episode of diarrhoea, zinc is</td>
<td>Children 2-59 months of age with diarrhoea</td>
<td>$0.64 per child 2-59 months of age per year</td>
<td>(Micronutrient Initiative 2011)</td>
</tr>
</tbody>
</table>

(Continues)
<table>
<thead>
<tr>
<th>Intervention</th>
<th>Description</th>
<th>Assumptions</th>
<th>Target Population</th>
<th>Unit cost (US$)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deworming</td>
<td>Deworming tablets for children</td>
<td>Assumes two rounds of deworming per child per year</td>
<td>Children 12–59 months of age</td>
<td>$0.23 per child 12–59 months of age per year</td>
<td>(Ministry of Health and Family Welfare 2012)</td>
</tr>
<tr>
<td>Treatment of severe acute malnutrition</td>
<td>Facility-based treatment for children with severe acute malnutrition</td>
<td>Assumes that the incident cases of SAM per year is twice the prevalence of severe wasting; 15% of these children will receive inpatient treatment; average duration of treatment is 12.5 days</td>
<td>Children 6–59 months of age with a WHZ &lt; -3</td>
<td>$107.38 per case treated per year</td>
<td>(Ministry of Health and Family Welfare 2011)</td>
</tr>
<tr>
<td>Insecticide-treated nets</td>
<td>Provision of insecticide treated bed nets to pregnant women for prevention of malaria in malaria-endemic areas</td>
<td>Endemic areas include: Chhattisgarh, Jharkhand, Odisha, West Bengal, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura; and Andaman and Nicobar Islands</td>
<td>Pregnant women</td>
<td>$4.84 per pregnant woman per year</td>
<td>(UNICEF 2013)</td>
</tr>
<tr>
<td>Cash transfers to women</td>
<td>Monthly cash stipend provided to breastfeeding mothers</td>
<td>Includes the cost of the benefit and incentives. The benefit is provided for 6 months after delivery. Excludes women working in the government sector per year</td>
<td>Breastfeeding mothers for the first 6 months after delivery</td>
<td>$103.22 per eligible woman</td>
<td>(Ministry of Law and Justice 2013)</td>
</tr>
</tbody>
</table>

IYCF, infant and young child feeding; IFA, iron-folic acid; GOI, Government of India; ORS, oral rehydration salts. Source: Compiled by authors.
For the India Plus interventions, we estimated local unit costs from a variety of sources. These are described subsequently.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Assumptions</th>
<th>Unit cost (US$) per year</th>
<th>Cost (US$ million) per year</th>
<th>Share in cost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community nutrition programmes for behaviour change communication</td>
<td>Assumes two children under 5 per household</td>
<td>$15.00 per household per year (or $7.50 per child under 5 years of age)</td>
<td>891.42</td>
<td>21.11</td>
</tr>
<tr>
<td>Vitamin A supplementation</td>
<td>Assumes two doses per year</td>
<td>$1.20 per child 6–59 months of age per year</td>
<td>129.79</td>
<td>3.07</td>
</tr>
<tr>
<td>Zinc supplementation</td>
<td>Allows for two to three rounds of zinc supplementation per child per year</td>
<td>$1.00 per child 6–59 months of age per year</td>
<td>5.54</td>
<td>0.13</td>
</tr>
<tr>
<td>Multiple micronutrient powders</td>
<td>Assumes each child will receive 60 sachets. Target population does not include children receiving complementary food for the prevention of moderate malnutrition.</td>
<td>$3.60 per child 6–23 months of age per year</td>
<td>4.84</td>
<td>0.11</td>
</tr>
<tr>
<td>Deworming</td>
<td>Assumes two rounds per year</td>
<td>$0.50 per child 12–59 months of age per year</td>
<td>59.43</td>
<td>1.41</td>
</tr>
<tr>
<td>IFA supplements</td>
<td>Assumes that pregnant women will receive IFA supplements for the last two trimesters of pregnancy</td>
<td>$2.00 per pregnancy</td>
<td>56.37</td>
<td>1.33</td>
</tr>
<tr>
<td>Iron fortification of staple foods</td>
<td>General population</td>
<td>$0.20 per person per year</td>
<td>255.07</td>
<td>6.04</td>
</tr>
<tr>
<td>Salt iodization</td>
<td>General population</td>
<td>$0.05 per person per year</td>
<td>63.77</td>
<td>1.51</td>
</tr>
<tr>
<td>Complementary food for prevention or treatment of moderate malnutrition</td>
<td>Assumes ~250 kcal/day should be provided to each targeted child on a daily basis, because the prevalence of wasting (WHZ &lt; -2) is &gt; 10%</td>
<td>$51.10 per child per year</td>
<td>1649.4</td>
<td>39.06</td>
</tr>
<tr>
<td>Treatment of SAM using a Community-based Management of Acute Malnutrition</td>
<td>Prevalence of severe wasting is doubled to estimate the incidence of SAM cases over a one-year period. Assumes that if all other interventions are delivered first, the prevalence of SAM will decrease by 50%. Full coverage is then defined as 80% of this remainder.</td>
<td>$200 per child treated</td>
<td>1107.51</td>
<td>26.22</td>
</tr>
</tbody>
</table>

All SUN interventions: 4223.14 100

IFA, Iron-folic acid; SAM, severe acute malnutrition; SUN, Scaling Up Nutrition; WHZ, Weight-for-Height Z score. Source: Author’s estimates using population data from Indian Census 2011 and unit cost data from SUNWWIC.
communication programmes in India. Therefore, our unit cost estimates for the counselling activities were based on a recent study that estimated the implementation costs of the Alive and Thrive (A&T) initiative in Bangladesh (Khan et al. 2014). A&T aims to improve infant and young child feeding practices at scale through the use of intensive community-based interpersonal counselling and national media campaigns. The authors of the costing study calculated costs per visit for the face-to-face interpersonal counselling sessions, which includes the costs of staff, logistics and supplies, travel, incentives, monitoring and materials. We multiplied this cost per visit by the estimated number of visits each beneficiary would receive per year to arrive at the total annual cost per beneficiary of counselling during pregnancy, counselling for breastfeeding and counselling for complementary feeding and hand washing. We note that the delivery platform in the case of the A&T initiative in Bangladesh is very similar to existing government community health outreach platforms in India.

b. Supplementary food: We used the Ministry of Women and Child Development’s 2013 revised norms for the supplementary nutrition components of the Integrated Child Development Services (ICDS) programme to estimate the cost per beneficiary for supplementary food rations for children 6–36 months of age, pregnant and lactating women and severely malnourished children (Ministry of Women and Child Development 2012). There are currently no clear estimates of the actual costs of producing, delivering and promoting the consumption of high-quality supplementary foods in the Indian context or in South Asia.

c. Micronutrient supplementation and other commodities: Estimates of the unit costs of iron-folic acid (IFA) supplements for pregnant women, iron supplementation for children, vitamin A supplementation for children and therapeutic zinc supplements were based on detailed unit cost estimates provided in the Micronutrient Initiative’s 2007–2011 National Micronutrient Investment Plan for India (Micronutrient Initiative 2011). These estimates include the costs of physical inputs as well as the delivery costs, including training, information, education and communication materials, and programme monitoring and evaluation. The combined unit cost of weekly IFA supplements and semi-annual deworming prophylaxis for adolescents was obtained from a 2011 report by UNICEF India titled The Adolescent Girls Anaemia Control Program: Breaking the Inter-Generational Cycle of Undernutrition in India with a focus on Adolescent Girls (UNICEF 2011). The unit cost of providing two rounds of deworming to children 12–59 months of age was calculated from data in India’s National Rural Health Mission’s Project Implementation Plan (Ministry of Health and Family Welfare 2012). We also used the National Rural Health Mission’s Project Implementation Plan to obtain unit cost estimates of oral rehydration salts and assumed that each child 2–59 months of age would have an average of three episodes of diarrhoea per year. The estimated cost of an insecticide treated bed net was provided by UNICEF (UNICEF 2013).

d. Treating severe acute malnutrition: We estimated the per beneficiary cost of facility-based treatment of severe acute malnutrition using the Ministry of Health and Family Welfare’s 2011 Operational Guidelines and assumed an average stay of 12.4 days in the treatment facility (Ministry of Health and Family Welfare 2011). India does not currently have guidelines for community-based management of acute malnutrition, and thus, unit cost estimates can only be derived for facility-based treatment.

e. Cash transfers to women in the first 6 months after delivery: India’s 2013 Food Security Bill (Ministry of Law and Justice 2013) currently includes a ‘maternity benefit’ for breastfeeding mothers, which is a cash transfer to women for the first 6 months after the delivery of an infant. It is targeted to those who are not employed in government, because maternity leave benefits for government employees is already in place. Receipt of the cash transfer is conditional on fulfilling the use of basic health care and breastfeeding exclusively. Although this programme has not
been evaluated for impact on health outcomes, it was included in the costing exercise given prior literature on the potential for conditional cash transfer programmes to help support nutrition improvements (Ruel et al. 2013) and the inclusion of this intervention in India’s policy framework.

All unit cost estimates, the source of data, and relevant assumptions for the India Plus interventions are summarized in Table 2.

### Results

The total annual cost of implementing the 10 core SUN interventions at full coverage, nationwide, was estimated to be US$4.22bn (Table 3). The total annual cost of implementing the complete set of India Plus interventions at full coverage throughout India is US$5.93bn (Table 4). The largest proportion of the total India Plus cost, approximately US$2.9bn and US$2.3bn, is for the cash transfers to women to support breastfeeding and supplementary food rations, respectively; these two costs together cover >80% of the total cost estimates. This is followed by health interventions (including inpatient treatment of severe acute malnutrition), counselling actions and micronutrient supplements and deworming, which account for the 4, 5 and 3% share of the total cost, respectively. Comparisons between costs of the SUN interventions and India Plus interventions are shown in Fig. 1; they illustrate that the SUN interventions cost more than the India Plus actions for all of the four comparable categories stated in Table 1 but that India Plus costs more for the supplementary food interventions.

There is considerable variability in the costs for delivering the India Plus interventions at scale in the different states across India (Table 5), with variability in cost estimates primarily driven by differences in target populations. The cost of implementing all India Plus interventions in the state of Uttar Pradesh will amount to just under of US$1.2bn, which is 20% of the total India Plus cost estimate. Costs for Uttar Pradesh are driven up primarily by the existing population and high fertility rates as well as by the state’s poor performance on nutrition, which amplifies the costs for treatment of severe acute malnutrition. Similarly, in other states such as Bihar, Madhya Pradesh, Rajasthan and Maharashtra where wasting rates and population sizes are high,

<table>
<thead>
<tr>
<th>Action</th>
<th>Cost (US$ million) per year</th>
<th>Share in cost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counselling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counseling during pregnancy</td>
<td>49.61</td>
<td>0.84</td>
</tr>
<tr>
<td>Counselling for breastfeeding</td>
<td>17.87</td>
<td>0.30</td>
</tr>
<tr>
<td>Counselling for complementary feeding and hand washing</td>
<td>219.56</td>
<td>3.70</td>
</tr>
<tr>
<td>Supplementation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complementary food supplements for children 6–36 months of age</td>
<td>1526.01</td>
<td>25.73</td>
</tr>
<tr>
<td>Supplementary food rations for pregnant and lactating women</td>
<td>658.35</td>
<td>11.10</td>
</tr>
<tr>
<td>Additional food rations for severely malnourished children</td>
<td>111.04</td>
<td>1.87</td>
</tr>
<tr>
<td>Micronutrient and deworming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron-folic acid supplements for pregnant and breastfeeding women</td>
<td>19.83</td>
<td>0.33</td>
</tr>
<tr>
<td>IFA supplements and deworming for adolescents</td>
<td>40.19</td>
<td>0.68</td>
</tr>
<tr>
<td>Iron supplements for children 6–36 months of age</td>
<td>40.02</td>
<td>0.67</td>
</tr>
<tr>
<td>Vitamin A supplementation</td>
<td>7.57</td>
<td>0.13</td>
</tr>
<tr>
<td>ORS and therapeutic zinc supplements for treatment of diarrhoea</td>
<td>70.99</td>
<td>1.20</td>
</tr>
<tr>
<td>Deworming</td>
<td>22.41</td>
<td>0.38</td>
</tr>
<tr>
<td>Health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment of severe acute malnutrition</td>
<td>222.98</td>
<td>3.76</td>
</tr>
<tr>
<td>Insecticide treated nets for pregnant women in malaria-endemic areas</td>
<td>24.76</td>
<td>0.42</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash transfers to women in the first 6 months after delivery</td>
<td>2899.73</td>
<td>48.89</td>
</tr>
<tr>
<td>Total</td>
<td>5930.91</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: Author’s estimates

delivering interventions at scale will cost in excess of US$400m per year.

Finally, our estimates for India Plus costs lead to an average estimated cost per child (0–24 months) per year of US$54.2 for food supplements, US$68.4 for cash transfers, US$6.8 for a full package of counselling, US$4.7 for micronutrient supplementation and deworming, US$5.9 for health interventions (excluding immunizations). This leads to a cost of US$140 per child per year.

Discussion

In this costing exercise, we set out to estimate a set of costs for delivering at scale a range of preventive, promotive and therapeutic interventions for nutrition in India’s diverse landscape. Using the SUNWWIC unit costs and India-specific target populations, we estimated that about US$4.2bn would be needed to deliver at scale the SUN interventions in India. Using a more tailored, but expanded, set of interventions already in India’s policy landscape and a set of unit costs tailored to the Indian/South Asian context, we find that costs would be about US$5.9bn cost for the set of actions we labelled ‘India Plus’. We find that the costs and the differences in total costs between the two methods vary depending on the interventions chosen, unit costs and target populations. We only estimated state-specific costs for the India Plus set of interventions and find there that the costs are driven both by population size and the levels of undernutrition in each state. Costs are highest for Uttar Pradesh, followed by Bihar, Maharashtra, Rajasthan and other states. For the India Plus interventions, our findings indicate that the supplementary food and cash transfers to women together account for over 80% of the total estimated costs.

Overall, the costs estimated in this paper tally reasonably well with estimates from previous reviews and studies. For instance, in SUNWWIC, the World Bank (Horton et al. 2010) estimates that the total additional costs of all 10 SUN interventions is about US$5.9bn for South Asia (Afghanistan, Bangladesh, India, Nepal and Pakistan), and in the Lancet, (Bhutta et al. 2013a) the figure estimated is US$4.8bn.
Table 5. State-wise costs of India Plus actions at scale

<table>
<thead>
<tr>
<th>Million</th>
<th>Total population (person)</th>
<th>Counselling (US$)</th>
<th>Supplementation (US$)</th>
<th>Micronutrient and deworming (US$)</th>
<th>Health (US$)</th>
<th>Cash transfers to women (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indo-gangetic plains (Subtotal)</td>
<td>427.7</td>
<td>108.3</td>
<td>903.9</td>
<td>90.6</td>
<td>102.1</td>
<td>1197.1</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>199.6</td>
<td>51.4</td>
<td>426.8</td>
<td>42.7</td>
<td>32.5</td>
<td>616.9</td>
</tr>
<tr>
<td>Bihar</td>
<td>103.8</td>
<td>30.1</td>
<td>266.5</td>
<td>25.5</td>
<td>33.9</td>
<td>324.0</td>
</tr>
<tr>
<td>West Bengal</td>
<td>91.3</td>
<td>17.7</td>
<td>140.7</td>
<td>15.0</td>
<td>17.8</td>
<td>164.2</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>33.0</td>
<td>9.0</td>
<td>75.8</td>
<td>7.4</td>
<td>17.9</td>
<td>91.9</td>
</tr>
<tr>
<td>Central states (Subtotal)</td>
<td>252.5</td>
<td>60.8</td>
<td>475.2</td>
<td>46.7</td>
<td>62.0</td>
<td>587.1</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>72.6</td>
<td>20.1</td>
<td>162.4</td>
<td>15.3</td>
<td>29.2</td>
<td>216.8</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>112.4</td>
<td>24.3</td>
<td>186.2</td>
<td>18.7</td>
<td>14.9</td>
<td>207.2</td>
</tr>
<tr>
<td>Chhattisgarh</td>
<td>25.5</td>
<td>6.9</td>
<td>52.8</td>
<td>5.2</td>
<td>7.8</td>
<td>70.9</td>
</tr>
<tr>
<td>Odisha</td>
<td>41.9</td>
<td>9.5</td>
<td>73.8</td>
<td>7.4</td>
<td>10.1</td>
<td>92.2</td>
</tr>
<tr>
<td>Western (Subtotal)</td>
<td>182.1</td>
<td>45.3</td>
<td>356.9</td>
<td>35.1</td>
<td>31.4</td>
<td>454.8</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>68.6</td>
<td>19.2</td>
<td>152.6</td>
<td>14.9</td>
<td>16.6</td>
<td>200.6</td>
</tr>
<tr>
<td>Gujarat</td>
<td>60.4</td>
<td>14.0</td>
<td>113.8</td>
<td>11.1</td>
<td>9.8</td>
<td>143.3</td>
</tr>
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<td>Haryana</td>
<td>25.4</td>
<td>6.5</td>
<td>49.0</td>
<td>4.8</td>
<td>3.6</td>
<td>61.6</td>
</tr>
<tr>
<td>Punjab</td>
<td>27.7</td>
<td>5.6</td>
<td>41.6</td>
<td>4.3</td>
<td>1.4</td>
<td>49.3</td>
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<tr>
<td>Southern (Subtotal)</td>
<td>252.8</td>
<td>50.0</td>
<td>375.7</td>
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<td>33.2</td>
<td>464.5</td>
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<tr>
<td>Andhra Pradesh</td>
<td>84.7</td>
<td>16.6</td>
<td>123.1</td>
<td>12.9</td>
<td>6.6</td>
<td>160.5</td>
</tr>
<tr>
<td>Karnataka</td>
<td>61.1</td>
<td>13.1</td>
<td>101.7</td>
<td>10.2</td>
<td>9.1</td>
<td>126.8</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>72.1</td>
<td>13.8</td>
<td>103.1</td>
<td>10.7</td>
<td>14.3</td>
<td>123.8</td>
</tr>
<tr>
<td>Kerala</td>
<td>33.4</td>
<td>6.3</td>
<td>45.7</td>
<td>4.8</td>
<td>3.0</td>
<td>51.3</td>
</tr>
<tr>
<td>Goa</td>
<td>1.5</td>
<td>0.3</td>
<td>2.0</td>
<td>0.2</td>
<td>0.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Northern (Subtotal)</td>
<td>29.5</td>
<td>7.4</td>
<td>56.2</td>
<td>5.8</td>
<td>4.5</td>
<td>58.8</td>
</tr>
<tr>
<td>Jammu and Kashmir</td>
<td>12.5</td>
<td>3.6</td>
<td>26.9</td>
<td>2.8</td>
<td>1.9</td>
<td>25.2</td>
</tr>
<tr>
<td>Uttarakhand</td>
<td>10.1</td>
<td>2.4</td>
<td>18.4</td>
<td>1.9</td>
<td>1.5</td>
<td>21.3</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>6.9</td>
<td>1.4</td>
<td>10.9</td>
<td>1.1</td>
<td>1.1</td>
<td>12.3</td>
</tr>
<tr>
<td>North eastern (Subtotal)</td>
<td>44.5</td>
<td>11.2</td>
<td>90.0</td>
<td>9.1</td>
<td>13.1</td>
<td>104.2</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>3.0</td>
<td>1.1</td>
<td>8.6</td>
<td>0.8</td>
<td>2.9</td>
<td>8.0</td>
</tr>
<tr>
<td>Tripura</td>
<td>3.7</td>
<td>0.8</td>
<td>6.1</td>
<td>0.6</td>
<td>1.1</td>
<td>5.9</td>
</tr>
<tr>
<td>Manipur</td>
<td>2.7</td>
<td>0.6</td>
<td>4.5</td>
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</tr>
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</table>

Source: Author’s estimates

While major studies at the global level (Horton et al. 2010; Bhutta et al. 2013b; Darmstadt et al. 2008) focused on providing costs for multiple interventions for South Asia as a whole, other focused studies (Fiedler & Macdonald 2009; Neidecker-Gonzales et al. 2007; Bhutta et al. 2013a) have provided country-specific costs for micronutrients, behavioural change communication, vaccination and fortification. To our knowledge, this study is the first to have estimated costs for multiple interventions at the subnational level.
Sensitivity of estimates to unit costs and target populations

Cost estimates are highly sensitive to unit costs, which are highest for food supplementation and cash benefits. As with other studies, our estimates reaffirm that unit costs for micronutrients and deworming are lowest among the spectrum of interventions, and therefore, yield the lowest total intervention costs. Nevertheless, even unit costs can vary across countries and within, and total costs can therefore be sensitive to this variability. For example, Nepal’s National Vitamin A programme reports a unit cost of US$0.04 per capsule, which is US$0.03 less than the unit cost used in this study but excludes the costs of training, personnel and promotion (Neidecker-Gonzales et al. 2007). Adding in those costs increases the unit cost to US$0.82. In another example, the SUNWWIC (Horton et al. 2010) estimate for unit costs for counselling is US$7.5 per child per year on average, while we used unit costs of US$1.76 for pregnancy-related counselling, 1.67 for breastfeeding counselling (0–6 months), 7.47 for complementary feeding counselling (6–12 months) and 2.8 for counselling between 12–24 months, yielding a total cost that is lower than the SUNWWIC estimate. Another study on the costs of providing counselling have used a slightly higher unit cost than SUNWWIC on account of factoring in an additional cost to training workers of US$0.20 per child per year (Holla et al. 2012). We believe the unit costs applied in our study are likely the most applicable for the South Asian context as they draw on a detailed costing study that assesses the financial and economic costs of delivering a package of counselling services in a delivery platform that is similar to health systems in South Asia.

One of the most challenging areas for estimating unit costs is the cost of delivering a high-quality nutritional supplement as part of the supplementary nutrition programme. Global recommendations for interventions support the inclusion of a food supplement or cash transfer along with counselling for behaviour change (Bhutta et al. 2013b). However, the cost of providing a high-quality supplementary food is not well-studied. Cost estimates for South Asian countries in SUNWWIC are based on a complementary food developed by the World Food Program (called India ready-to-use food) at US$0.13 per child per day (Horton et al. 2010), whereas India Plus estimates are based on cost norms of US$0.097 per child per day for the ICDS supplementary nutrition programme, as budgeted by the government of India. In the context of the India Plus estimates, we chose to use the government of India’s stated cost norms for supplementary food in the ICDS programme. We recognize, however, that the cost norm of US$0.097 (INR 6) per child per day (Ministry of Women and Child Development 2012) may be unlikely to deliver a high-quality supplementary food that also meets available guidance on the quality of supplementary foods for complementary feeding. The government of India cost norms for supplementary nutrition aim to deliver 500 kcal in calories and 12–15 grammes in protein, for 300 days a year, to children 6–36 months, at US$29 per beneficiary per year through the ICDS programme. The SUNWWIC complementary food supplements cost a total of US$51.1 per child per year to provide 260 kcal (per day) to moderately malnourished children in India. It would be prudent, given the variability in what the current cost norms are likely to be able to deliver across India, for a careful review of the composition, quality and nutritional appropriateness of the supplementary foods intended to be provided in India. Further research on the true unit costs of provision of a palatable, safe, high-quality food supplement in India and other South Asian countries is thus strongly merited.

In the India Plus estimates, complementary food supplements, even using the slightly lower cost norms as noted above, will cost US$1.5bn per year. The internationally comparable intervention in the SUNWWIC costing is ‘complementary food for prevention or treatment of moderate malnutrition’. One major area of difference between the SUNWWIC and the India Plus estimates we derived is that the ICDS targets all children aged 6–36 months for food supplements irrespective of their nutritional status, whereas SUN interventions are targeted to children 6–23 months with a weight-for-age z-scores of less than −2. This leads to differences between the two costing approaches because of target population definitions. The target population for the SUN intervention is narrower and hence smaller than the universal age-based targeting in the ICDS programme. Research in other contexts suggests that a blanket
age-targeted programme for supplementary food is likely to have greater community-wide impacts on undernutrition (Ruel et al. 2007). Even though the SUNWWIC intervention accommodates for targeting errors by assuming twice the prevalence of weight-for-age z-scores $< -2$, the resultant target populations using the SUNWWIC and India Plus methods are 32.2 and 57.9 million children, respectively. These vastly different target populations yield different total costs depending on the unit cost applied. If one applies the US$29 India Plus unit cost to the SUNWWIC target population, the total cost is approximately US$0.93bn, which is much less than the US$1.65bn figure using the SUNWWIC unit cost. On the other hand, applying the SUNWWIC cost of supplementary food ($0.13 per child per day) would lead to a total higher cost of US$2.96bn for the India Plus estimate given the different target groups.

Our estimates suggest that, at US$2.9bn per year, the universally targeted cash transfers to women to support breastfeeding are the highest cost intervention to deliver at scale. These estimates too are subject to unit cost and target population variability, however. For example, one recent estimate in India (Holla et al. 2012) suggests that delivering cash transfers of US$2 per day for 6 months to a target population of women from households living below the poverty line in South Asia would cost US$4.8bn a year. A key difference between this estimate and what is currently budgeted in the government norms for maternity benefits is the unit cost – US$360 per woman for the Holla et al. estimate compared with about US$100 per woman. In this particular example, either a small increase in per day transfers for a universal intervention or a much higher transfer amount for a more targeted intervention will both have significant implications for total financial outlays.

**Limitations**

Our approach to deriving estimates of the total cost of delivering nutrition-specific interventions in India is not without some limitations. Although there will likely be differences in costs of delivery between and within different states, the lack of detailed costing studies precludes an accounting for local unit cost variations in our state-specific estimates. Key factors that influence the cost of delivery and likely vary by state include: the level of existing infrastructure, the quality and effectiveness of existing delivery platforms, population density, the target population’s accessibility to and utilization of delivery platforms and the potential need for outreach programmes. For example, interstate variations in delivering a package of IFA supplements, deworming tablets and nutrition counselling as part of the adolescent anaemia programme ranged from US$0.11 per girl per year in Tamil Nadu vs. US$0.58 in Rajasthan (UNICEF 2011). Furthermore, some of our unit costs are based on relatively small programmes in comparison with the scale of operations in India, especially in some of the larger states within India. Our analyses assume constant economies of scale in expanding the coverage of these; however, in reality, there are likely to be cost savings when implemented on a large scale. In this paper, we also do not attempt to estimate gaps between projected costs and actual expenditures, primarily because actual expenditures are difficult to track for all essential nutrition interventions.

Another limitation for interpreting the estimates derived here is data availability for the target population estimates used in deriving costs of treatment for severe acute malnutrition. The primary source of data for nutrition indicators is the National Family Health Survey (International Institute for Population Sciences 2007) from 2005–2006, which is now outdated by 10 years. Recent estimates, only provisionally released by the government of India (Ministry of Women and Child Development 2015), suggest that wasting rates in India may well have gone down by several percentage points, which would, in turn, lead to significant reductions in the numbers of severely malnourished children (International Food Policy Research Institute 2014). This will have significant financial implications for the costing of treatment of severe acute malnutrition, one of the more expensive interventions.

Another limitation of our estimates are that we have not accounted for the cost of formative research or mass media campaigns for behaviour change communications to promote appropriate infant and young child feeding practices. The literature suggests that the costs of mass media can be quite high (US$1–5 per beneficiary at 1992 prices) and could likely increase behavioural change communication outlays considerably (Horton 1992). However, these costs will need to be
estimated either at the state level or the regional level, given the diversity across India.

Finally, we have not extended the costs derived from this study to their natural progression – a cost–benefit analysis. However, a recent paper on cost–benefit analyses for nutrition interventions indicate that benefit–cost ratio estimates (US$ gains for each US$1 invested) range from 12.9 to 18.4 for Nepal and Bangladesh and 28.9 to 38.6 for Pakistan and India, respectively (Hoddinott et al. 2013). At the same time, a recent review on the cost-effectiveness of nutrition and early childhood interventions highlights the limited availability of cost-effectiveness studies and notes that even for available studies, comparability of cost-effectiveness is often limited due to differences in outcomes studied and limited use of common outcome measures across studies (Batura et al. 2014).

In conclusion, the need to invest fully for nutrition in India and indeed in all South Asian countries is urgent. This study has estimated the financial commitments required to deliver at scale a set of interventions already within the policy frameworks in India, a country that contributes the largest number of stunted children in the South Asia region. The financial requirements for delivering these interventions vary within India, and prioritization of financing for nutrition across India will need to consider the gaps between projected costs for each state, current expenditures and the availability of national-level and state-level finances to deliver fully for nutrition. Further research is essential to re-estimate some of these costs based on updated unit costs for supplementary feeding, updated target population estimates for severe acute malnutrition and any other updates to interventions and related unit costs.

**Acknowledgements**

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**Conflicts of interest**

The authors declare that they have no conflicts of interest. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions, policy or views of IFPRI or FEWS NET. Any errors are our own.

**Contributions**

PM conceptualized and provided leadership for the study, provided interpretation of data and results and revised the manuscript critically for important intellectual content. CM lead the acquisition and analysis of the data and drafted the manuscript. SC supported data acquisition, analysis, manuscript drafting and revision.

**Abbreviations and Acronyms:** BCC, Behavioral Change Communication; GOI, Government of India; ICDS, Integrated Child Development Services Program; IEC, Information, Education and Communication; IFA, Iron-folic acid; IYCF, Infant and Young Child Feeding; NFHS-III, National Family Health Survey-III; NRHM, National Rural Health Mission; POSHAN, Partnerships and Opportunities to Strengthen and Harmonize Actions for Nutrition in India; SAM, Severe Acute Malnutrition; SRS, Sample Registration System; SUN, Scaling up Nutrition; SUNWWIC, Scaling up Nutrition: What will it Cost?; UNICEF, United Nations Children’s Fund; WAZ, Weight-for-Age Z score; WHZ, Weight-for-Height Z score; NSS, National Sample Survey; US$, United States Dollar; INR, Indian National Rupee

References


The costs of stunting in South Asia and the benefits of public investments in nutrition

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Health, Nutrition and Population Global Practice, World Bank, Washington, District of Columbia, USA

Abstract
South Asia is home to the largest number of stunted children worldwide: 65 million or 37% of all South Asian children under 5 were stunted in 2014. The costs to society as a result of stunting during childhood are high and include increased mortality, increased morbidity (in childhood and later as adults), decreased cognitive ability, poor educational outcomes, lost earnings and losses to national economic productivity. Conversely, investing in nutrition provides many benefits for poverty reduction and economic growth. This article draws from analyses conducted in four sub-Saharan countries to demonstrate that investments in nutrition can also be very cost-effective in South Asian countries. Specifically, the analyses demonstrate that scaling up a set of 10 critical nutrition-specific interventions is highly cost-effective when considered as a package. Most of the interventions are also very cost-effective when considered individually. By modelling cost-effectiveness of different scale-up scenarios, the analysis offers insights into ways in which the impact of investing in nutrition interventions can be maximized under budget constraints. Rigorous estimations of the costs and benefits of nutrition investments, similar to those reported here for sub-Saharan countries, are an important next step for all South Asian countries in order to drive political commitment and action and to enhance allocative efficiency of nutrition resources.

Keywords: stunting, South Asia, cost-effectiveness, nutrition interventions, economic productivity.

Introduction
South Asia is home to the largest number of stunted children worldwide (Fig. 1). Sixty-five million or 37% of all children under 5 were stunted in South Asia in 2014 (UNICEF et al. 2015). Undernutrition is an underlying cause of 3.1 million child deaths annually, which accounts for 45% of all deaths in children under 5 (Black et al. 2013). Chronic malnutrition (stunting) alone is responsible for between 15% and 17% of all deaths in children under 5 worldwide and approximately 400000 deaths in South Asia (Black et al. 2013). Undernourished children are more likely to die from common childhood illnesses such as diarrhoea, measles, pneumonia, malaria or HIV/AIDS (Black et al. 2013). Stunting has detrimental effects on the brain by causing deviations in the temporal sequence of brain maturation, which in turn disturb the formation of neural circuits (Udani 1992) and result in cognitive deficits (Kar et al. 2008). Stunted children are more likely to start school late, to repeat a grade or to drop out of school (Mendez & Adair 1999; Daniels & Adair 2004). Martorell et al. (2010) have shown that adults who were stunted at age 2 completed 1 less year of schooling. Adair et al. (2013) estimated that improving linear growth for children under 2 by one standard deviation adds about half a grade of school attainment.

Although progress has been made in reducing stunting in South Asia to 37% of children under 5, this rate is still unacceptably high. Every country in the region has observed reductions in the prevalence of stunting over the past two decades – the average annual rate of reduction is 1.7% for the region as a whole, but it varies across countries from about 1.1% in Pakistan to about 3% in the Maldives (UNICEF et al. 2015). However, given the current high levels of undernutrition and its slow rate of reduction during the most recent decade, most South Asian countries are unlikely...
to achieve the Millennium Development Goal for nutrition (target 2 of Millennium Development Goal 1) of halving, between 1990 and 2015, the proportion of children who are underweight.

Although South Asia is in many ways poised for economic transformation, the hidden burden of undernutrition slows prosperity in a number of ways. Childhood stunting costs developing countries billions of dollars in future revenue losses through reduced economic productivity, particularly through lower wages, lower physical and mental capabilities and more days away from work as a result of illness. Adult height is known to be related to productivity, and final height is determined in large part by nutrition from conception to age 2 (Behrman & Rosenzweig 2001). Not only are taller adults more physically capable and strong (which is especially important for manual labour), but greater height may also be a proxy measure of other dimensions of human capital such as social skills and cognitive ability (Hoddinott et al. 2013). The median increase in hourly wages per 1 cm of additional height was 4.5% from a survey of eight low-income and middle-income countries (Horton & Steckel 2013) and 0.55% from a study of eight high-income countries (Gao & Smyth 2010). Horton & Steckel (2013) estimated losses from all forms of malnutrition of up to 11% of gross domestic product (GDP) in Africa and Asia each year. Adults, who were stunted as children earned 20% less than comparable adults who were not stunted (Grantham-McGregor et al. 2007), were 30% more likely to live in poverty and were less likely to work in skilled labour (Hoddinott et al. 2011).

There is a strong and growing body of evidence identifying interventions that are effective and feasible to implement at scale (World Bank 2006; Lancet 2008 and 2013). The first 2 years of life – the first 1000 days between conception and age 2 – are the critical period for growth and development, while growth at older ages does not have the same effect on adult height and brain development (Black et al. 2013). Therefore, investments during this period of development have the highest returns (Heckman & Masterov 2004), and investing in early childhood nutrition interventions offers a window

**Key messages**

- South Asia is home to the largest number of children stunted worldwide.
- Stunting leads to increased mortality and morbidity, poor educational outcomes, lost earnings and reductions in national economic productivity, yet nutrition investments are among the most cost-effective development actions.
- Analysis of four sub-Saharan countries finds that the scaling up of a set of 10 key nutrition interventions is highly cost-effective and most are very cost-effective when considered individually.
- Rigorous estimations of the costs and benefits of nutrition investments are an important next step in all South Asian countries in order to drive political commitment and action.
of opportunity to permanently lock-in human capital. Indeed, the Copenhagen Consensus Center has identified nutrition interventions as one of the most cost-effective development actions. The centre has estimated that reducing by 40% the number of children who are stunted by 2030 would return $45 for every dollar spent (Copenhagen Consensus Center 2015; Hoddinott et al. 2013). However, investment in nutrition in South Asia remains inadequate. The key questions that need to be answered to mobilize the political will and accelerate action to reduce stunting in South Asia are ‘How much will it cost to scale up nutrition interventions?’ and ‘What will these investments buy?’ However, at present, there are no rigorous estimates of the costs and benefits of nutrition investments in South Asia.

This article presents preliminary estimates of costs and cost-effectiveness of investing in high-impact evidence-based nutrition interventions in four countries in sub-Saharan Africa to show what investing in nutrition can buy in terms of averted deaths, cases of stunting and disability-adjusted life years (DALYs) averted.1 By modelling cost-effectiveness of different scale-up scenarios, we offer insights into ways in which the impact of investing in prevention of stunting can be maximized under budget constraints.

**Methods**

The preliminary results presented next are part of a larger effort to assess the cost and cost-effectiveness of investing in nutrition in sub-Saharan Africa.2 Scale-up costs were estimated for 10 interventions in four African countries: Democratic Republic of the Congo (DRC), Mali, Nigeria and Togo.

**Interventions included and rationale for selection**

The 10 nutrition-specific interventions considered are a modified package of the interventions included in the 2008 and 2013 Lancet series on Maternal and Child Undernutrition (Table 1). Some interventions, such as deworming and iron fortification of staple foods, which were included in the 2008 Lancet series but no longer listed in the 2013 Lancet series, are included here as they remain relevant. Others, such as calcium supplements for women or prophylactic zinc supplementation, are excluded because delivery mechanisms are not available in developing countries and/or there are no clear World Health Organization (WHO) protocols or guidelines for large-scale programming. In other cases, the capacity for scaling up the interventions is limited. Only those nutrition-specific interventions that have strong evidence of effectiveness have a WHO protocol, and a feasible delivery mechanism for scale-up is included.

**Data**

Unit costs for each intervention were obtained from published sources or from in-country stakeholders including governmental agencies, development partners and non-governmental organizations implementing activities related to nutrition during in-person interviews and remote follow-up. Costing methodology followed the programme experience approach where the unit cost (cost per beneficiary) was calculated based on the budget/expenditure estimates of agencies implementing the interventions in each country. This approach generates unit cost data that capture all aspects of service delivery, including the costs of commodities, transportation and storage, personnel, training, supervision, monitoring and evaluation, relevant overhead and wastage for each intervention from actual programmes that are already in operation. Although the programme experience approach tends to yield cost estimates higher than those of the ingredient-based approach, these estimates more accurately reflect real programmatic experience, including inefficiencies in service delivery. It should, however, be noted that the calculated costs are reported in financial or budgetary terms. They do not capture the full social resource requirements, which account for the opportunity costs of the time committed by beneficiaries accessing the services.

Programme coverage data were obtained from the most recent Demographic and Health Survey (DHS), Multiple Indicator Cluster Survey or Standardized Monitoring and Assessment of Relief and Transitions survey.

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1A DALY is equivalent to a year of healthy life lost due to a health condition. The DALY, developed in 1993 by the World Bank, combines the years of life lost from a disease and the years of life spent with disability from the disease.

2This work is ongoing by the World Bank with the support of the Bill and Melinda Gates Foundation.
in each country. Nutrition status, health and other demographic data were obtained from the most recent DHS or Multiple Indicator Cluster Survey. Population data were obtained from the most recent available national census and supplemented, if needed, by the DHS data (e.g. distribution of children under 5 in different age categories: 0–6, 0–24, 6–24 and 6–50 months).

We have assumed a linear relationship between the cost and coverage with no economies or diseconomies of scale at the country level. ‘Full coverage’ is defined as 100% of the target population for all interventions except for community-based treatment of severe acute malnutrition, for which full coverage is assumed to be 80%.

### Estimating intervention costs

The cost for the scale-up of each intervention was calculated as follows: \( Y = (x_1 + x_2) - x_3 \) where \( Y \) is the annual public investment required to scale-up to full coverage; \( x_1 \) is the additional total cost to scale-up to full coverage; \( x_2 \) is the additional cost for capacity development, monitoring and evaluation, and technical assistance; and \( x_3 \) is the cost covered by households living above poverty line for selected interventions.

### Estimating benefits from interventions

The expected benefits from scaling up nutrition interventions are calculated in terms of (1) DALYs averted, (2) number of lives saved and (3) cases of childhood stunting averted. The projected number of lives saved and the cases of childhood stunting averted are calculated using the Lives Saved Tool (LiST), which models reductions in mortality and prevalence of under-5 stunting resulting from changes in intervention.
Based on the lives saved and cases of stunting averted estimated using LiST, DALYs are estimated following the established convention of counting one life saved as 33.3 discounted DALYs averted and one case of stunting as 0.23 discounted DALY averted (Bhutta et al. 2009). This method discounts the DALYs at 3% following the WHO–Choosing Interventions that Are Cost-effective (CHOICE) methodology (WHO 2003). Because of limitations of the LiST tool, estimates for the number of lives saved and DALYs averted are based on only six of the 10 interventions, and cases of childhood stunting averted are based on only four of the 10 interventions. As such, the estimates presented here are likely to underestimate the number of lives saved and cases of childhood stunting averted.

Estimates of benefits were combined with information on costs to produce the cost-effectiveness measures for each intervention as well as for the overall package of interventions. The measures for cost-effectiveness of nutrition-specific interventions are calculated in terms of cost per DALY averted, cost per life saved and cost per case of stunting averted. The evaluation of cost-effectiveness ratio in terms of DALYs averted is based on societal willingness to pay thresholds based on GDP per capita, using the categorization developed by WHO-CHOICE (WHO 2014). An intervention is considered to be ‘very cost-effective’ if the cost per DALY averted is less than GDP per capita; it is considered to be ‘cost-effective’ if it is between one and three times GDP per capita; and it is considered ‘not cost-effective’ if it exceeds three times GDP per capita (WHO 2014).

In each country, we estimated the cost and impact of scaling up the high-impact intervention at the national level (full national coverage). Given resource constraints, few countries are able to effectively scale-up all 10 nutrition-specific interventions to full national coverage immediately. We therefore model potential partial scale-up scenarios with lower overall costs, based on considerations of burden of stunting, potential for impact, costs and capacity for implementation in the specific country. Three approaches are considered: (1) scaling up only in the regions with the highest burden of malnutrition; (2) scaling up only a subset of interventions nationwide; and (3) scaling up a subset of interventions only in the regions with the highest burden of malnutrition.

Results

Table 2 provides estimates of the total costs and impacts of scaling up all 10 interventions to full coverage for the four countries. The costs to scale-up vary substantially across countries, ranging from US$13m in Togo to US $837m in Nigeria. The differences in the scale-up costs are a result of variation in the number of beneficiaries, baseline coverage of the interventions and in unit costs. Based on the modelling results, the investments would save 115 000 DALYs in Togo, 509 000 DALYs in Mali, 2.6 million DALYs in the DRC and 6.3 million DALYs in Nigeria. For each country, the scale-up would also save between 3000 and 180 000 lives and prevent between 60 000 and 3 million cases of stunting annually. Based on the WHO-CHOICE criteria of cost-effectiveness, investing in the scale-up of the full intervention package is estimated to be very cost-effective in each of the four countries.

Most of the interventions – with the exception of the public provision of complementary food for the prevention of moderate acute malnutrition – are ‘very cost-effective’ when considered individually (Table 3). Across all four countries, community nutrition programmes for growth promotion, vitamin A supplementation, therapeutic zinc supplementation with ORS, iron–folic acid supplementation, the public provision of complementary food for the prevention of moderate acute malnutrition and community-based management of severe acute malnutrition are cost-effective, with a cost per DALY averted that is much higher than the other interventions. It is above

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Footnotes:

3For details on the tool, see http://www.livesavedtool.org/.
4The six interventions are community nutrition programmes for growth promotion, vitamin A supplementation, therapeutic zinc supplementation with ORS, iron–folic acid supplementation, the public provision of complementary food for the prevention of moderate acute malnutrition and community-based management of severe acute malnutrition.
5The four interventions are community nutrition programmes for growth promotion, vitamin A supplementation, iron–folic acid supplementation and the public provision of complementary food for the prevention of moderate acute malnutrition.
Table 2. Costs and benefits of investing in a package of 10 (Lancet ±) nutrition-specific interventions in DRC, Mali, Nigeria and Togo (US dollars)

<table>
<thead>
<tr>
<th>Country region (year)</th>
<th>Annual public investment required</th>
<th>DALYs averted</th>
<th>Lives saved</th>
<th>Cases of stunting averted</th>
<th>Cost per DALY averted</th>
<th>Cost per life saved</th>
<th>Cost per case of stunting averted</th>
<th>WTP threshold (GDP per capita)</th>
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<td>4929</td>
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<td>454</td>
</tr>
<tr>
<td>Mali (2015)</td>
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<td>509 000</td>
<td>14 000</td>
<td>260 000</td>
<td>178*</td>
<td>6276</td>
<td>344</td>
<td>715</td>
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<td>837 M</td>
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<td>141</td>
<td>4865</td>
<td>292</td>
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</tr>
<tr>
<td>Togo (2015)</td>
<td>13 M</td>
<td>115 295</td>
<td>3000</td>
<td>60 000</td>
<td>127*</td>
<td>4635</td>
<td>238</td>
<td>636</td>
</tr>
</tbody>
</table>

Sources: Shekar et al. 2014, 2015a, 2015b, 2015c. DALY, disability-adjusted life year; DRC, Democratic Republic of the Congo; GDP, gross domestic product; WTP, willingness to pay. M denotes million, and B denotes billion. DALYs are discounted at 3%. *Very cost-effective; †Cost-effective; and ‡Not cost-effective according to WHO-CHOICE criteria. See WHO 2014.

the ‘very cost effective’ threshold of GDP per capita in two of the four countries.

Finally, we compared the full national coverage scenario with more limited scale-up scenarios that (1) target only the regions with highest burden of stunting,7 (2) scale-up only the most cost-effective interventions or (3) scale-up the most cost-effective interventions in the highest burden regions. Table 4 shows that in all four countries, scaling up all interventions except the public provision of complementary feeding was the most cost-effective strategy (cost per DALY ranging from $79 in Togo to $109 in Nigeria). The differences between the costs per DALY averted of the scale-up of this subset of intervention nationwide and only in high burden regions were very small. The scale-up in high burden regions had lower cost per DALY only in Togo ($78 compared with $79 for the full national coverage scale-up).

Discussion

This paper contributes to the existing literature on the cost of scaling up nutrition interventions (World Bank 2010; Hoddinott et al. 2013; Bhutta et al. 2013). It expands it by considering the cost-effectiveness of those investments at the country level for four African countries. Our analysis suggests that investing in the same set of interventions in South Asia is likely to be very cost-effective.

The results show that investing in expanding the coverage of high-impact interventions is very cost-effective, with costs per DALY averted well below the established willingness to pay threshold. Those findings are consistent with the existing literature. Hoddinott et al. (2013) estimated that expanding the coverage of nutrition intervention would yield a benefit–cost ratio of 18:1. In other words, that $1 invested in nutrition produces $18 worth of benefits.

When examined individually, most of the interventions considered here are shown to be very cost-effective according to well-established criteria. The exception is the public provision of complementary food for the prevention of moderate acute malnutrition. Even though it is cost-effective in two countries (DRC and Mali) and very cost-effective in the other two (Nigeria and Togo), it is nevertheless between two and eight times more costly per DALY averted than the next least cost-effective intervention. Therefore, in countries like the four examined here, where fiscal and capacity constraints will limit scale-up, certain expensive interventions – such as the public provision of complementary foods – may be a lower priority. Furthermore, issues of governance, accountability and supply logistics will all put pressure on the cost and complicate the scale-up of the public provision of complementary foods.

The cost per DALY and other outcomes were consistent in magnitude but varied slightly across the four countries. Overall, the cost per outcome was the
highest in Mali ($178 per DALY averted, $6276 per life saved and $344 per case of stunting averted) and lowest in Togo ($127 per DALY averted, $4635 per life saved and $238 per case of stunting averted). The differences between countries are driven mostly by the differences in unit costs of the specific interventions and, to a much smaller extent, by the differences in the baseline coverage in and, consequently, cost of filling the coverage gaps and its impact on morbidity and mortality.

Scaling up high-impact interventions (that is, excluding the public provision of complementary feeding) was the most cost-effective strategy. Whether these interventions were scaled up nationwide or only in the highest burden regions did not affect their cost-effectiveness by much. However, there was a large total cost differential between the two scenarios, and therefore in most cases, the selection between the two

Table 3. Cost per DALY averted for nutrition-specific interventions in four African countries (US dollars)

<table>
<thead>
<tr>
<th>Intervention§</th>
<th>Cost per DALY averted (US dollars)</th>
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</table>

Table 4. Scale-up scenarios for 10 nutrition-specific interventions in four African countries (US dollars)

<table>
<thead>
<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total in millions</td>
<td>Cost per DALY averted</td>
<td>Total in millions</td>
<td>Cost per DALY averted</td>
</tr>
<tr>
<td>Full scale-up of all 10 interventions nationwide</td>
<td>371</td>
<td>143</td>
<td>64</td>
<td>178</td>
</tr>
<tr>
<td>Full scale-up in highest burden regions</td>
<td>135</td>
<td>173</td>
<td>44</td>
<td>212</td>
</tr>
<tr>
<td>High-impact interventions* nationwide (excludes public provision of complementary food)</td>
<td>279</td>
<td>133</td>
<td>24</td>
<td>71</td>
</tr>
<tr>
<td>High-impact interventions* in highest burden regions (excludes public provision of complementary food)</td>
<td>97</td>
<td>134</td>
<td>18</td>
<td>75</td>
</tr>
</tbody>
</table>

Sources: Shekar et al. 2014, 2015a, 2015b, 2015c. DALY, disability-adjusted life year; DRC, Democratic Republic of the Congo. DALYs are discounted at 3%. *Because of methodological limitations, we were not able to calculate DALYs averted, lives saved or cases of stunting averted from four interventions: multiple micronutrient powders, deworming, iron fortification of staple foods and salt iodization. §§DALY estimates for iron–folic acid supplementation are calculated for DALYs averted among pregnant women. They do not include the DALYs averted among mothers who received these supplements. *Very cost-effective; †Cost-effective; and ‡Not cost-effective according to WHO-CHOICE criteria. See WHO 2014.
scale-up scenarios hinges mainly on the availability of public resources for scaling up nutrition interventions. These results are not counterintuitive. However, they demonstrate that data-based planning that incorporates both local need, current coverage of interventions and economic analysis is needed to ensure that investment in nutrient has the greatest possible impact. This is particularly important given the severe resource constraints faced by countries with high burdens of malnutrition.

At present, rigorous country estimates of the costs and benefits of nutrition investments similar to those available for some sub-Saharan countries do not exist for South Asia. The one analysis in Bangladesh estimated that the $1.3–1.7bn cost of implementing a comprehensive package of interventions to improve health status of child under 2 years of age was much smaller than the $10bn loss to GDP because of productivity losses resulting from inaction (Howlader et al. 2012). Quality cost-effectiveness studies for additional countries are needed to build the body of evidence needed to influence policymakers. The existing evidence from other regions has not been enough to expand programmes to improve early childhood nutrition.

Scaling up preventive interventions that include micronutrient supplements for both children and pregnant women is particularly important in the context of South Asia, which is home to persistently high levels of micronutrient deficiencies (iron, vitamin A and iodine). Coverage rates of micronutrient supplement programmes are low: only 24% of pregnant women take iron–folic acid supplements during pregnancy; only 68% of children age 6–59 months receive vitamin A supplementation; and only 70% of the South Asia population uses iodized salt (International Food Policy Research Institute 2014). Similarly, the prevalence of low birthweight (LBW; a birthweight of less than 2.5kg) is higher in Asia than elsewhere, predominantly because of undernutrition of the mother prior to and during pregnancy and/or being underage (<18 years old) when entering marital union and/or pregnancy. An estimated 25–30% of all infants in South Asia are born with LBW, accounting for half of all LBW babies in the developing world (UNICEF et al. 2015).

Although the results reported here are limited to ‘nutrition-specific’ interventions delivered through the health sector, multisectoral ‘nutrition-sensitive’ actions through agriculture sector, social protection, water and sanitation and poverty reduction programmes have the potential to strengthen nutritional outcomes in several ways (Ruel et al. 2013; World Bank 2013). These interventions address malnutrition in more indirect ways, and there is currently very limited guidance on costing for nutrition-sensitive interventions for at least two reasons. First, evidence on effectiveness of ‘nutrition-sensitive’ interventions with respect to nutritional outcomes is limited. Second, compared with nutrition-specific interventions, estimating and attributing the costs of nutrition-sensitive interventions is more complex because these interventions have multiple objectives, improved nutrition outcomes being only one of them. Notwithstanding these limitations, the availability of costing information is crucial to assess cost-effectiveness of these interventions and is needed to engage other sectors in planning for nutritional effects.

Conclusions

Despite overwhelming evidence of the debilitating costs of stunting, minimal resources are allocated to stunting reduction in South Asia, and where resources are allocated, these are often not focused on scaling up the most cost-effective interventions. This is largely because stunting in South Asia continues to be invisible to and unrecognized by families, communities and especially policymakers. An appreciation of the economic costs described here can help to make stunting a more ‘visible’ challenge to development. Rigorous estimations of the costs, benefits and cost-effectiveness of

8There are two schools of thought as to why there is currently very little evidence. Some believe that there is little evidence of impact of agricultural interventions on nutrition outcomes because indeed they have no effect. This is referred to as the ‘agriculture–nutrition disconnect’. Another school of thought is that very few agricultural interventions have been designed such as to have an impact on nutrition and so the lack of evidence is inevitable. However, if these interventions were indeed designed to have an impact on nutrition, they could become critical mechanisms for building the evidence base for nutrition-sensitive programming.
nutrition investments need to be an important next step in all South Asian countries in order to drive political commitment and action and to maximize allocative efficiencies. Knowing how many interventions would cost to scale-up, what results these might deliver, and how to maximize the effectiveness of the investments provides governments with guidance to prioritize the most cost-effective interventions as well as with cost-effective ways of scaling up the interventions over time, thereby maximizing both technical and allocative efficiencies. Furthermore, these rigorous analyses are necessary to leverage new financing from both domestic budgets and overseas development aid.

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**Conflicts of interest**

The authors declare that they have no conflicts of interest.

**Contributions**

MS conceptualized and led the project. MS, JDE and JK designed the research. JDE and JK conducted the analysis and wrote the paper. All authors edited and approved the final paper.

**References**


Understanding the null-to-small association between increased macroeconomic growth and reducing child undernutrition in India: role of development expenditures and poverty alleviation

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Abstract

Empirical evidence suggests that macroeconomic growth in India is not correlated with any substantial reductions in the prevalence of child undernutrition over time. This study investigates the two commonly hypothesized pathways through which macroeconomic growth is expected to reduce child undernutrition: (1) an increase in public developmental expenditure and (2) a reduction in aggregate income-poverty levels. For the anthropometric data on children, we draw on the data from two cross-sectional waves of National Family Health Survey conducted in 1992–1993 and 2005–2006, while the data for per capita net state domestic product and per capita public spending on developmental expenditure and headcount ratio of poverty were obtained from the Reserve Bank of India and the Government of India expert committee reports. We find that between 1992–1993 and 2005–2006, state-level macroeconomic growth was not associated with any substantial increases in public development expenditure or substantial reductions in poverty at the aggregate level. Furthermore, the association between changes in public development expenditure or aggregate poverty and changes in undernutrition was small. In summary, it appears that the inability of macroeconomic growth to translate into reductions in child undernutrition in India is likely a consequence of the macroeconomic growth not translating into substantial investments in development expenditure that could matter for children’s nutritional status and neither did it substantially improve incomes of the poor, a group where undernutrition is also the highest. The findings here build a case to advocate a ‘support-led’ strategy for reducing undernutrition rather than simply relying on a ‘growth-mediated’ strategy.

Keywords: stunting, undernutrition, economic growth, poverty, development expenditure, growth-mediated strategy, support-led strategy, India.

Introduction

It is clear that while there exists an inverse ecological association between levels of per capita income and prevalence of child undernutrition (Smith & Haddad 2002; Haddad et al. 2003; Smith & Haddad 2015), results from studies examining the association between changes in per capita income and child undernutrition have been null to small, both across countries (Heltberg 2009; Vollmer et al. 2014) and across states in India (Subramanyam et al. 2011). Furthermore, regardless of whether ecological studies are cross-sectional or repeated cross-sectional, they cannot quantify the association between aggregate macroeconomic growth and the risk of undernutrition at the child level (Subramanyam et al. 2011; Vollmer et al. 2014), which suggests the need for more studies to investigate this relationship in a multilevel framework. The null-to-small association between macroeconomic growth and reductions in child undernutrition in India conducted within a multilevel framework (Subramanyam et al. 2011) begs further investigation, given the overwhelming reliance on a ‘growth-mediated’ strategy to improving population health (Dreze & Sen 1989; Dreze & Sen 2013; Subramanian et al. 2016). It
should be acknowledged that even though the association between increases in macroeconomic growth measured at the state level and decreases in the likelihood of child undernutrition is small, there does exist an inverse association between household wealth measured through asset index at the micro level and the likelihood of child undernutrition (Subramanyam et al. 2011). Some caution is necessary to naively interpret such a gradient as evidence of the effect of macroeconomic growth, especially because the association between macroeconomic growth and likelihood of child undernutrition in India was found to be small-to-null even without adjusting for micro/household wealth (Subramanyam et al. 2011). Furthermore, it has also been shown that household wealth index growth and standard measures of economic growth (often based on consumption-based income measures) are not correlated and remain largely unaffected by trends in macroeconomic performance (Harttgen et al. 2013).

Consequently, employing ecological and multilevel analysis, we aim to advance the literature by exploring the role of two primary pathways through which increases in macroeconomic growth could substantially translate into reducing the burden of child undernutrition. First, increased macroeconomic growth could potentially lead to increased public development expenditure (especially in social and health sectors) that in turn can lead to reductions in child undernutrition. Second, increased macroeconomic growth can also directly reduce child undernutrition by improving the material standards of living of the majority of the population, i.e. raising income levels and/or substantially reducing number of people living in poverty. In the absence of substantial investments in public development expenditures that matter for health or substantial reductions in poverty, it will not be surprising for macroeconomic growth not to be associated with the reductions in child undernutrition in India. Hence, in this study, we investigate (1) whether macroeconomic growth led to increases in public development expenditure, and reductions in incidence of poverty across Indian states, and (2) whether changes in public development expenditure and poverty incidence were associated with reductions in undernutrition in children under the age of 3 years. If these two effects are not significant, then one might hypothesize that not only macroeconomic growth in India is not associated with undernutrition but also the association between ‘changes’ in poverty and public development expenditure with undernutrition is negligible.

**Methods**

**Data**

The data for this analysis are obtained from the National Family Health Surveys (NFHS) of India. The NFHS is part of the Demographic and Health Surveys programme that provides technical assistance to more than 300 surveys on health and population issues in over 90 developing countries (http://www.dhsprogram.com). NFHS-3 (2005–2006), the third in the series of these national surveys, was preceded by NFHS-2 in 1998–1999 and NFHS-1 in 1992–1993. With a focus on maternal and child health, NFHS adopts a multi-stage, systematic and stratified sampling design to provide national and sub-national information on fertility, family planning, maternal and child health, gender, HIV/AIDS, malaria and nutrition (see IIPS 1995; IIPS and Macro International, 2007 for details on data collection and methodologies in the survey). In our analysis, owing to unavailability of comparable data across the three

**Key messages**

- Increases in macroeconomic growth have not been accompanied by substantial increases in public developmental spending or reduction in aggregate poverty headcount ratio in India.
- Association between increases in public development expenditure or poverty headcount ratios and changes in child undernutrition, in particular, child stunting, is small to null.
- Reducing the burden of undernutrition in India cannot be accomplished solely relying on a growth-mediated strategy, and a concerted support-led strategy is required.
surveys, we could use only the first (1992–1993) and the third (2005–2006) NFHS surveys. NFHS 1992–1993 and NFHS 2005–2006 cover 48 959 and 51 555 children (including 3680 and 2876 death cases), respectively, and we undertook the following step-wise filtration process to arrive at our final sample for analysis. In the first step, we dropped the cases with missing information (including death cases) on height or weight of the children (19 692 and 7685 cases in NFHS 1992–1993 and 2005–2006, respectively). To ensure comparability with previous research, we restricted the analysis to children aged below 3 years, which leads to a further reduction in the sample size by 6935, and 17 592 cases, respectively. It may be noted that under the first wave of NFHS, anthropometric information was not ascertained from certain sample regions and states. Specifically, the survey did not ascertain information on children’s height-for-age in the states of Andhra Pradesh, Himachal Pradesh, Madhya Pradesh, Tamil Nadu and West Bengal. Because our analysis focuses on state-specific dynamics (as explained in detail later), to maintain comparability across the two surveys, we excluded these states in the 2005–2006 survey. Due to unavailability of information regarding public developmental expenditure, which is one of the key variables of interest, we had to exclude the states of Mizoram, Nagaland and Tripura from the two waves. Also, in the year 2000, two states – Uttar Pradesh and Bihar – were bifurcated; therefore, to maintain comparability across the two surveys (one pre 2000 and one post), we treated the two states as undivided by combining the new states Jharkhand and Uttarakhand with their corresponding parent states – Bihar and Uttar Pradesh. We finally arrived at the following pooled sample: stunting – 37 256 cases, underweight – 38 817 cases and wasting – 37 073 cases. We also include the following covariates for analysis from the NFHS: age, sex (value of 1 for boy and 0 for girl), birth order of the child; maternal age at child birth, maternal and paternal education, marital status (value of 1 if married and 0 otherwise); social group – caste and religion (explained later); and household asset-based wealth index ranking, and place of residence (value of 1 for rural and 0 otherwise).

Recently, the Government of India and UNICEF have released the results of Rapid Survey on Children (RSOC) conducted during 2013–2014 to strengthen the data system on children and women, based on a nationwide household cum facility-based survey in 28 states and Delhi. This survey has a focus on the well-being of children below 6 years and their mothers covering aspects of child health and development maternal health and health care and school/college attendance among persons aged 5–24 years. However, it may be noted that the unit level data from the RSOC survey is unavailable (at the time of writing the paper) in the public domain to facilitate an individual level analysis. Therefore, we only present some inferences based on ecological analysis of the RSOC data as Supporting Information tables.

Additional data to characterize the state level per capita net domestic product (PCNSDP), public developmental expenditure [per capita state developmental expenditure (PCDE)] and poverty headcount ratio (HCR) are based on the official sources. The information on PCNSDP is prepared by the Central Statistical Organization of the Ministry of Statistics and Program Implementation, Government of India. The information on PCNSDP is also made available in the Reserve Bank of India, which is used in our analysis, for the years 1993–1994, 2005–2006 and 2013–2014 corresponding to the two NFHS waves and the RSOC survey. The information on PCDE is compiled by the Reserve Bank of India and is provided in its annual publication on state finances (available at https://www.rbi.org.in). Information on poverty HCR – defined as percentage of population below the official poverty line – is obtained from the report of the Government of India (Government of India 2009). These estimates are based on the data from the private household consumer expenditure and collected by the National Sample Survey Organization, and we used the state-level data for these variables. As mentioned earlier, owing to unavailability of comparable HCR estimates for the year 1998–1999, we could not include the NFHS second wave information in our pooled repeated cross-sectional data analysis. We have also used poverty estimates from the private consumer expenditure survey data for 2011–2012 to facilitate an ecological analysis using the RSOC data on child undernutrition across Indian states.

Outcomes, exposure and covariates

Undernutrition among children is based on anthropometric data (physical indices) made available through
NFHS (we also use data from the RSOC to verify our results). The anthropometric measures describe nutritional status of children with respect to three dimensions: height-for-age (stunting), height-for-weight (wasting) and weight-for-age (underweight). While our focus is predominantly on chronic undernutrition – stunting, we also verify our findings with the other two measures as well. A child is considered stunted, wasted or underweight if he or she falls two standard deviations below the median score for children of the same age and gender in the reference population on their respective anthropometric scores. The median score of the reference population is based on an internationally accepted World Health Organization Child Growth Standards, which is applied in both the NFHS waves and helps identify if a child is undernourished. The computation of z-score is performed using the STATA user-written programme zscore06 by Leroy (2011). It may be noted that unlike WHO’s igrowup programme, none of the z-scores are calculated if child age is missing. For STATA commands related to the calculation of anthropometric z-scores using the WHO (2006) child growth standards, see http://www.ifpri.org/staffprofile/jef-leroy.

Per capita net state domestic product, PCDE and state poverty HCR are the key socio-economic indicators of interest. PCNSDP is expressed in Indian Rupees (INR) and is a fundamental indicator of a state’s income and economic progress. To adjust for price variations over the years, PCNSDP is expressed in 2004–2005 constant prices and normalized to 5000 to get the estimates in units of INR 5000. For 2005, the PCNSDP of the two new states (Uttarakhand and Jharkhand) was combined with its parent state (Uttar Pradesh and Bihar, respectively) by using the information on population size and PCNSDP of these states. The PCDE (in INR) is expressed in 2004–2005 prices and normalized to 2000 to get estimates in units of INR 2000. Similar to PCNSDP, for the year 2005, the PCDE of new states (Uttarakhand and Jharkhand) was combined with its parent state (Uttar Pradesh and Bihar, respectively) by using the information on population size and PCNSDP of these states. Expenditures of the state governments in India are categorized into developmental and non-developmental expenditure, and developmental expenditure of the state is defined as revenue and capital expenditure on social and economic services. The resources for the same are also generated through contribution of the central government or by means of loans and advances to the state. Developmental expenditure on social services generally covers areas such as health, education, water supply, sanitation, housing, social security and welfare of marginalized and vulnerable subgroups such as the Scheduled Castes and Tribes – SC/ST. Under economic services, developmental spending is largely on agriculture and allied activities, rural development, irrigation, energy, transport and communication.

For analytical purposes, maternal age at child birth was divided into five categories: less than 17 years (reference category), 17–19, 20–24, 25–29 and more than 29 years. Mother’s marital status was scored 1 if she was living with her husband and 0 (i.e. single) if she was widowed, divorced or separated. Education of mother and father was categorized using the customary classification in the Indian educational system as follows: illiterate – no formal schooling (reference category), primary – up to 5 years of schooling, secondary – up to 10 years of schooling and higher – more than 10 years of schooling. Social group affiliation is categorized as scheduled caste, scheduled tribe and others (reference category). Typically, the ‘others’ subgroup (reference category) – for caste – is considered to be relatively advantaged in terms of general socio-economic conditions: in fact, there are specific legal, constitutional and policy provisions for promotion of social and economic welfare among the scheduled caste and scheduled tribe population. Further, households were classified based on religious affiliation (Hinduism, Islam and others). To account for economic status of the households, we used the asset-based wealth index derived through principal component analysis (Filmer & Pritchett 2001; IIPS Macro-International 2007). Descriptive statistics for all the key variables are provided in Table S1.

**Analysis**

We use alternative model specifications to understand how macroeconomic growth translated to increased PCDE and poverty reduction, and in turn, how the latter two economic development indicators
influenced child undernutrition across Indian states. We employed two types of analysis: an aggregate cross-sectional analysis at the state level for each time period and an aggregate repeated cross-sectional analysis (using states as a fixed effect). While the former estimates the association between two variables at a given level, the latter estimates whether change in one variable is associated with a change in another. The latter specification is the one that we use for interpretation.

Further, we also estimated multilevel logistic regression models with a log link function to exploit the latent association between economic variables at aggregate levels and undernutrition at the individual level. The model estimation is based on penalized quasi-likelihood procedures with first-order Taylor linearization (Rasbash et al. 2009). The results are presented both for unadjusted model (not controlled for the entire set of potential covariates but clustered at the primary sampling unit level) and the fully adjusted models (which includes controls for set of socio-economic variables as well). We report the odds ratios along with 95% confidence intervals.

In the modelling exercise we adopt a stepwise approach, wherein first, we estimate the association of each indicator of child undernutrition with PCNSDP, PCDE and HCR separately, adjusted for age and sex of the child; subsequently, all the socio-economic covariates are included to present results from the fully adjusted model. As a general rule, wherever we employ time as the predominant unit of analysis, i.e. change in change models, we control for state-fixed effects. While the main text presents estimates based on unweighted regressions, we also perform the analysis using specified sampling weights and arrive at similar conclusions. Data management was performed in Stata 13.0 version, whereas the multilevel models were implemented using runmlwin programme developed for the use of MLwiN (2.31 version) statistical software within Stata (Leckie and Charlton 2013, StataCorp 2013).

Given our focus on chronic undernutrition, the results are discussed in detail for stunting, while results for underweight and wasting are presented in Supporting Information tables.

Results

Descriptive patterns

Per capita net state domestic product, PCDE and HCR varied widely across the Indian states between 1993 and 2005 (Table 1). Bihar and Goa had the lowest and highest PCNSDP, respectively, at both time periods. Gujarat registered the highest average annual PCNSDP growth of 7.5% over the period, while Assam registered the lowest: 1.4%. Interestingly, in 1993, the PCDE spending in Bihar was about one-sixth of PCDE in Goa, and this ratio further decreased to one-tenth in 2005. In 1993, six states had poverty HCR exceeding 50%, and despite macroeconomic growth, Odisha and Bihar continued to have more than half of its population below the poverty line: 57% and 54%, respectively.

The correlation between PCNSDP and PCDE in 1993 and 2005 was 0.356 (P-value 0.161) and 0.496 (0.043), respectively (Fig. 1). During the same time period, the strength of the correlation between PCNSDP and poverty HCR was −0.713 (0.001) and −0.521 (0.023), respectively. However, the correlation between PCDE and poverty HCR was statistically insignificant [correlation 1993: −0.124 (0.635) and 2005: −0.387 (0.125)], and interestingly, there was no correlation across the changes in these three developmental variables either (right-side panel of Fig. 1).

The levels of childhood stunting were very high across most of the Indian states, and there was no perceptible decline during 1990s (Table 1). In 1993, the magnitude of stunting ranged from 59.4% (57.2–61.6) in Bihar to 31.9% (27.0–36.8) in Manipur. Between 1993 and 2005, only marginal improvements in stunting prevalence are noted. The ratios of change in stunting prevalence to changes in the three developmental variables are also low. In 12 out of the 17 states, 1% increase in PCNSDP was associated with 0 to 0.2 percentage point reduction in stunting prevalence (Table S3). Nine out of 17 states had similar values for public development expenditure, and 11 out the 17 states had an increase of approximately 1 percentage point in stunting for a percentage point increase in poverty ratio.
Macroeconomic growth, public developmental expenditure and poverty

Table 2 and Fig. 1 present the results from the analysis in levels as well change over time to determine if macroeconomic growth during the period resulted in increased PCDE and poverty reduction.

State income and development expenditure

In case of levels (Table 2 model 1), the coefficient estimates for PCNSDP is 0.35 (0.27; 0.44) implying that an increase in PCNSDP by INR 5000 is associated with an increase of INR 700 in PCDE. In other words, one rupee increase in PCNSDP is associated with 0.14 rupee increase in PCDE. The middle panel in Fig. 1 provides the graphical representation of this correlation between the two variables, and the relationship seems to have strengthened both in magnitude and statistical significance, from 1993 [0.356 (0.161)] to 2005 [0.496 (0.043)]. Not surprisingly, this improvement in the relationship over time is captured in the change on change model (Table 2 right-side panel) albeit the magnitude is smaller compared with the levels and also revealed in Fig. 1 (right-side panel): 0.536 (0.027).

State income and poverty

Similarly, the results also reveal a statistically significant but small association between levels of PCNSDP and poverty HCR. The estimates from levels model show that an increase in PCNSDP by INR 5000 is associated with a reduction of 2.1 (−3.51; −0.77) percentage points in HCR, while the change in change model reveals no considerable relationship (model 2 in Table 3). Also, this association seems to have weakened over the two time periods, which is represented in the top panel of Fig. 1: 1993 [−0.713 (0.001)] and 2005 [−0.521 (0.023)]. It is noteworthy to mention that the relationship between HCR and PCDE has not been significant either in levels or change over time.

In sum, Table 2 and Fig. 1 indicate that while the association between PCNSDP and PCDE has strengthened in recent years (though modestly), it is the opposite for PCNSDP and HCR. This phenomenon is also reflected in the change in change models, where


<table>
<thead>
<tr>
<th>States</th>
<th>Stunting (%)</th>
<th>PCNSDP (INR)</th>
<th>PCDE (INR)</th>
<th>Poverty HCR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arunachal Pradesh</td>
<td>56.5</td>
<td>34.3</td>
<td>18 910</td>
<td>26 759</td>
</tr>
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<td>Assam</td>
<td>56.0</td>
<td>41.0</td>
<td>14 601</td>
<td>17 050</td>
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<td>Bihar</td>
<td>59.4</td>
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<td>7749</td>
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<td>Delhi</td>
<td>47.7</td>
<td>43.0</td>
<td>41 659</td>
<td>69 128</td>
</tr>
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<td>Goa</td>
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<td>26.2</td>
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<td>80 844</td>
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</tr>
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<td>43.5</td>
<td>23 919</td>
<td>40 627</td>
</tr>
<tr>
<td>Jammu and Kashmir</td>
<td>44.2</td>
<td>32.7</td>
<td>17 262</td>
<td>22 406</td>
</tr>
<tr>
<td>Karnataka</td>
<td>47.2</td>
<td>40.8</td>
<td>17 034</td>
<td>29 295</td>
</tr>
<tr>
<td>Kerala</td>
<td>32.8</td>
<td>27.4</td>
<td>18 897</td>
<td>34 837</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>46.4</td>
<td>43.9</td>
<td>24 918</td>
<td>40 671</td>
</tr>
<tr>
<td>Manipur</td>
<td>31.9</td>
<td>29.3</td>
<td>14 204</td>
<td>19 479</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>53.3</td>
<td>42.7</td>
<td>15 057</td>
<td>25 642</td>
</tr>
<tr>
<td>Odisha</td>
<td>50.3</td>
<td>43.7</td>
<td>12 009</td>
<td>18 194</td>
</tr>
<tr>
<td>Punjab</td>
<td>43.7</td>
<td>36.5</td>
<td>26 096</td>
<td>34 096</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>46.1</td>
<td>39.1</td>
<td>12 256</td>
<td>19 445</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>59.2</td>
<td>51.6</td>
<td>10 815</td>
<td>13 445</td>
</tr>
</tbody>
</table>

the relationship with PCNSDP is stronger for PCDE compared with HCR (Fig. 1).

Public expenditure, poverty and stunting

Public expenditure and stunting

To test the association between PCDE and stunting, we undertake the following analysis in the same order: (1) employ ecological models – level on level and change on change and (2) multilevel modelling – unadjusted and adjusted (see Fig. 2). In the ecological model (Table 3), only in case of cross-sectional regressions, we find a statistically significant association between PCDE and stunting. An increase of two thousand rupees in PCDE is associated with 5.4 (−7.15; −3.66) percentage point reduction in stunting prevalence (levels model 2), while there is no statistically significant relationship in the change on change model (right-side panel), which


is in line with the existing recent literature mentioned earlier. Similarly, the multilevel logistic model (Table 4 model 2) that adjusts for age and sex of the child as well as the survey year neither provides evidence for statistical relationship between the two variables. We arrive at similar conclusions even after adjusting for other individual and socioeconomic status (SES) correlates (right-side panel).

**Poverty and stunting**

We follow the same sequence as in PCDE by first analysing the relationship between HCR and stunting through (1) ecological models – levels and change on change and (2) multilevel models – unadjusted and adjusted and broadly find similar patterns. Model 3 in Table 3 (levels model) shows that one percentage point increase in HCR is associated with 0.55 (0.40; 0.70) percentage point higher prevalence of stunting, while in the change-on-change model, the relationship turns out to be insignificant. In the multilevel logistic models adjusted for age and sex of the child as well as the survey year, there is no evidence of relationship between HCR and stunting (Table 4, model 3). As with PCDE, we arrive at similar conclusions even after adjusting for other individual and SES correlates. Largely, the results from Tables 3 and 4 indicate that growth in PCNSDP or increments in PCDE or reductions in poverty did not necessarily translate to significant reductions in the prevalence of stunting.

---


<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variable</th>
<th>Levels</th>
<th>Change in change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PCNSDP</td>
<td>PCDE</td>
</tr>
<tr>
<td>1</td>
<td>PCDE</td>
<td>0.35**</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.04)</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>HCR</td>
<td>–2.14**</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.70)</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>HCR</td>
<td>–</td>
<td>–6.70**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
<td>(1.40)</td>
</tr>
</tbody>
</table>

PCNSDP, per capita net state domestic product; PCDE, per capita state developmental expenditure; HCR, headcount ratio. Ecological models: standard error of the coefficient is reported in (parenthesis). All the models include an intercept term. The levels analysis is based on 34 observations available from 17 states observed at two points of time (1993 and 2005). The change in change analysis is based on 17 observations from 17 states. PCNSDP is expressed in units of Rs. 5000, whereas PCDE is expressed in units of Rs. 2000. **P < 0.01 and *P < 0.05.


<table>
<thead>
<tr>
<th>Ecological</th>
<th>Dependent variable</th>
<th>Levels</th>
<th>Change in change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PCNSDP</td>
<td>PCDE</td>
</tr>
<tr>
<td>1</td>
<td>Stunting prevalence</td>
<td>–1.92**</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.45)</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>Stunting prevalence</td>
<td>–</td>
<td>–5.41**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
<td>(0.89)</td>
</tr>
<tr>
<td>3</td>
<td>Stunting prevalence</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

PCNSDP, per capita net state domestic product; PCDE, per capita state developmental expenditure; HCR, headcount ratio. Standard error of the coefficient are reported in (parenthesis). **P < 0.01 and *P < 0.05.
As a part of sensitivity check, we also report the socio-economic covariate-specific odds ratio from the fully adjusted models for stunting in Table S6. The result shows that the associations between key socio-economic variables and stunting outcomes are consistent and in expected direction: children from the highest wealth quintile were 51% less likely to be stunted [odds ratio 0.49 (0.44; 0.55)]. Similarly, we also find a gradient in the individual risk of stunting across levels of maternal and paternal education (Subramanyam et al. 2011). We also perform similar econometric analysis to examine the association of these developmental variables with two other indicators of child undernutrition viz. underweight and...
wasting and arrive at similar conclusions regarding the associations (Table S7–S8).

In sum, the results from our analysis suggest that although there is an association among levels of PCNSDP, PCDE and HCR, the change-on-change analysis clearly indicates that macroeconomic growth did not necessarily translate to substantial increments in PCDE or huge reductions in poverty incidence. Also, the results indicate that public developmental spending expenditure or poverty, in turn, had no significant influence on the prevalence of stunting (see Fig. 2). Interestingly, the ecological analysis (Table S10 and S11) using NFHS 2005–2006 and RSOC 2013–2014 data emerges with similar conclusions regarding the association between child undernutrition and developmental variables (also see Figures S5–S8). However, due to unavailability of individual unit-level data from the RSOC survey as well as lack of comparable ecological data from the NFHS 1992–1993, we are unable to draw any further conclusions regarding these associations in recent years.

**Discussion**

While it is generally believed that macroeconomic growth, through poverty alleviation and increased public investments in developmental services, can help reduce incidence of stunting (Haddad et al. 2003; Black et al. 2008; UNICEF 2013; Smith & Haddad 2015), our study results confirm that macroeconomic growth in Indian states did not necessarily translate into increased public development expenditure or substantial reduction in poverty between 1992 and 2005. At the same time, we did not find a robust relationship between changes in public development expenditure and reductions in stunting or reductions in aggregate poverty and stunting either. In other words, the channel through which macroeconomic growth is generally expected to positively influence stunting has been ineffective perhaps owing to low spillover effect from macroeconomic growth to public development expenditure and poverty reduction.

It is plausible that our results in some measure might be influenced by certain data constraints. First, because of unavailability of information on household incomes, we used socio-economic ranking as a proxy, yet data on income could provide insights on the direct impact of macroeconomic growth on household incomes and consequently on child stunting, although our findings are robust even in parsimonious models with no consideration of other variables. Second, owing to data inconsistencies and unavailability, we could not include all states of India in our analysis – but this elimination does not induce any kind of selection bias as our criteria of

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variable</th>
<th>PCNSDP</th>
<th>PCDE</th>
<th>HCR</th>
<th>PCNSDP</th>
<th>PCDE</th>
<th>HCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stunting prevalence</td>
<td>1.059**</td>
<td>–</td>
<td>–</td>
<td>1.069**</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.02, 1.10)</td>
<td>–</td>
<td>–</td>
<td>(1.04, 1.11)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>Stunting prevalence</td>
<td>–</td>
<td>1.121*</td>
<td>–</td>
<td>–</td>
<td>1.095</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
<td>(1.01, 1.25)</td>
<td>–</td>
<td>–</td>
<td>(0.98, 1.22)</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>Stunting prevalence</td>
<td>–</td>
<td>–</td>
<td>1.005</td>
<td>–</td>
<td>–</td>
<td>1.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–</td>
<td>–</td>
<td>(1.00, 1.01)</td>
<td>–</td>
<td>–</td>
<td>(1.00, 1.01)</td>
</tr>
</tbody>
</table>

Ecological models: standard error of the coefficient is reported in (parenthesis). All the models include an intercept term. The analysis is based on 34 observations available from 17 states observed at two points in time 1993 and 2005. Multilevel models: 95% confidence interval for the odds ratios is reported in (parenthesis). All models include an intercept term. Models also adjust for age and sex of the child and survey year. The models with SES variables adjust for the following socio-economic variables: birth order, maternal co-residence, mother’s age at child birth, maternal and partner education, social group, religion, wealth quintile and place of residence. The (unweighted) analysis is based on 37 256 pooled observations available from 17 states in National Family Health Surveys (NFHS) 1992–1993 and 2005–2006. PCNSDP is expressed as multiple of 5000, and PCDE is expressed as multiple of 2000. PCNSDP, per capita net state domestic product; PCDE, per capita state developmental expenditure; HCR, headcount ratio; SES, socioeconomic status. **P < 0.01 and *P < 0.05.
exclusion was not with respect to any specific pattern of income or undernutrition. Third, we rely on measurement of macroeconomic growth, public developmental spending and poverty incidence at two distinct points in times. While there is no reason to expect major fluctuations in the trend, a panel dataset would be ideal to capture the inter-temporal effects of growth, poverty and developmental spending on child stunting better tracking the same units of observations over time. Finally, it is worthwhile to note that public development expenditure as well as state per capita income only serves as a reasonable proxy for determinants such as investments in health and sanitation and overall household incomes. However, it is plausible that some of the investments and changes related with households may not be well captured through these proxy determinants. This also implies that the respective regression coefficients of these variables are perhaps not completely immune to any kind of attenuation bias. Relatedly, the explanatory variables are also likely to be measured with error that could attenuate the association.

Interestingly, recent findings from RSOC (2013–2014) indicate a decline in prevalence of stunting (children below 5 years) from 48.0% in 2005–2006 (NFHS-3) to 38.8% in RSOC 2013–2014 (UNICEF and Government of India 2015). In this regard, the ecological analysis using NFHS 2005–2006 and RSOC 2013–2014 suggests possible improvement in the association between anthropometric failure and developmental variables although this could not be confirmed from the graphical analysis (S5–S8). Nevertheless, it may be noted that there have been some important changes in the policy environment in India post-2005–2006 with increased public investment on developmental programmes such as the National Rural Health Mission, National Rural Employment Guarantee Act, etc. Hence, with new individual level data on child undernutrition and other socio-economic covariates, it would be necessary to revisit the dynamics of the relationship.

Overall, the results from our analysis unravel a few worrisome aspects related to nutritional health and development in India. First is the concern regarding low levels of PCDE to PCNSDP ratio, particularly in states with high burden of stunting (Figure S5) combined with disparities in quality and efficiency of developmental spending across the states (Varadharajan et al. 2013). In most Indian states, unfavourable political economy coupled with institutional inefficiencies act as impediments for socio-economic public investments and attenuates the effectiveness of direct interventions aimed at nutritional health. The noted exceptions are Kerala and Tamil Nadu, where the political economy environment promotes development of policy frameworks to support interventions, and the quantity and quality of public spending in social sectors positively influence human development (Dreze & Sen 1989; Mehrotra 2006; Muraleedharan et al. 2011). For most other states, while the numbers may not always suggest unhealthy development expenditure to growth ratio, whether they translate to improved socio-economic outcomes is debatable. The prominent examples are the universal programmes for food supply (Public Distribution System) and nutritional supplementation programme (Integrated Child Development Services and Mid-day School Meal Program) that are fraught with distributional leakages and inefficiencies at each tier and agency level (Lokshin et al. 2005; Khera 2011; Shukla 2014) and thus impede the poor from reaping the benefits of the programmes. Clearly, such areas offer scope for achieving greater efficiency in developmental spending by eliminating institutional bottlenecks and strengthening programme implementation (Dreze and Sen 2013).

High incidence of poverty and slow pace of poverty reduction are other areas of concern for India. It is noted that there has been no substantial reduction in poverty in India between 1993 and 2005. The all-India poverty HCR (as per official statistics) was 45.3% for 1993–1994 and 37.2% for 2004–2005, implying a 0.8 percentage point decline per year on average (Figure S3). However, the reduction in poverty was negligible in states such as Bihar or Uttar Pradesh, which have high prevalence of undernutrition. Even the reduction in incidence of poverty was lower in few high-growth states such as Gujarat (Table 1). Arguably, the official estimates are perhaps gross underestimates of reality, a fact borne out by the growing public outcry regarding official estimates of poverty in India (Subramanian 2011). For instance, in 2004–2005, the poverty HCR based on the Lakdawala methodology was 27.5%,
whereas it was 37.2% based on the Tendulkar methodology (Government of India 2014). Adding to these inconsistencies, the official poverty estimation in India continues to be based on methodologies rooted in caloric norms and focuses less on competing non-food items essential to ensure basic capabilities and functioning. In other words, the official poverty line itself is set too low, whereas a pragmatic assessment would yield poverty thresholds that would reject the official conclusions regarding poverty reductions in India (Subramanian 2011; Government of India 2009). Hence, states that already have a poor undernutrition base are doubly disadvantaged. Given such complexities, it is no surprise that official estimates of poverty reductions in India have not displayed any systematic association with stunting.

At the same time, an equally disturbing feature in the growth process is its limited engagement with rural economy, particularly agriculture – a sector that performed sub-optimally during the 1990s (Bhalla & Singh 2009). The issue is further aggravated with growing disparities in agricultural productivity across cultivating households and poor agriculture-nutrition linkage in India (Dev 2012). In fact, India experienced worrisome trends in per capita calorie consumption during 1990s and early 2000s (Deaton & Dreze, 2009; Patnaik 2004), and the share of household expenditure was more on non-food items (including fuel), which is misaligned with a growth process that could facilitate faster reduction in undernutrition (Basu & Basole 2012).

Furthermore, there is no evidence of macroeconomic growth being equalizing or pro-poor in India (Jayraj & Subramanian 2012; Suryanarayana 2008; Kohli 2006; Sen and Himanshu 2004). Sectoral imbalances in economic growth have also had adverse impact on marginalized social groups. For example, the tribal populations that reside in remote geographical regions do not benefit much from the growth process and continue to share a higher burden of nutritional deprivation (53.9% stunting, 27.6% wasting and 54.5% underweight in 2005–2006, IIPS Macro-International 2007). With several distributional issues and supply side bottlenecks around growth, it might be plausible to observe a lagged impact of growth on stunting, but it may require a longer period of high and sustained economic growth (Haddad et al. 2003).

In conclusion, a quantum leap in developmental spending and ‘inclusive’ macroeconomic growth is necessary to achieve a positive impact on stunting in India. Also, the PCDE has to be directed or invested in improving certain proximate determinants of stunting such as maternal and child care, food security, water and sanitation (Smith & Haddad 2015). Such focused investments further call for easing out the supply side bottlenecks of the existing institutional set-up with greater transparency and efficiency, which could promote child health and nutrition in India.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

SVS conceptualized the study. WJ and RR contributed to conceptualization and WJ led the data analysis, interpretation and writing of the manuscript. RR and SVS contributed to data interpretation and writing.

References


StataCorp (2013) Stata statistical software: Release 13. College Station, TX: StataCorp LP.


Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher’s web site:

Table S1. Descriptive statistics of socioeconomic variables used in the analysis, NFHS 1992-93 and 2005-06

Table S2. State-wise prevalence of underweight and wasting, Indian States 1992-93 and 2005-06

Table S3. State-wise ratio of percentage point reduction in undernutrition outcomes with percentage change in developmental indicators, 1993-94 and 2004-05

Table S4. Coefficient estimates for ecological models for the association of underweight and wasting prevalence with developmental variables, Indian States 1992-93 and 2005-06

Table S5. Odds ratio for multilevel models for the association of underweight and wasting prevalence with developmental variables, Indian States 1992-93 and 2005-06

Table S6. Fully adjusted multilevel logistic models for the association between early childhood stunting and developmental variables, Indian States 1992-93 and 2005-06

Table S7. Fully adjusted multilevel logistic models for the association between early childhood underweight and developmental variables, Indian States 1992-93 and 2005-06

Table S8. Fully adjusted multilevel logistic models for the association between early childhood wasting and developmental variables, Indian States 1992-93 and 2005-06

Table S9. Prevalence of undernutrition among children below age 5, NFHS 2005-06 and RSOC 2013-14

Table S10. Coefficient estimates for ecological association of developmental variables, Indian States 2004-05 and 2011-12

Table S11. Coefficient estimates for ecological models for the association of undernutrition prevalence with developmental variables, Indian States 2005-06 and 2013-14

Figure S1. Prevalence of stunting, underweight and wasting and association with per capita NSDP, Indian States 1992-93 and 2005-06

Figure S2. Correlation between levels and changes in early childhood underweight and key developmental indicators, Indian States 1992-93 and 2005-06

Figure S3. Correlation between levels and changes in early childhood wasting and key developmental indicators, Indian States 1992-93 and 2005-06

Figure S4. Per capita developmental expenditure as a percentage share of per capita NSDP, Indian States 1992-93 and 2005-06

Figure S5. Correlation between levels and changes in per capita NSDP, per capita developmental expenditure and poverty headcount ratio, Indian States 2004-05 and 2011-12

Figure S6. Correlation between levels and changes in child (aged below 5 years) stunting and key developmental indicators, Indian States 2005-06 and 2013-14

Figure S7. Correlation between levels and changes in child (aged below 5 years) underweight and key developmental indicators, Indian States 2005-06 and 2013-14

Figure S8. Correlation between levels and changes in child (aged below 5 years) wasting and key developmental indicators, Indian States 2005-06 and 2013-14
Drivers of nutritional change in four South Asian countries: a dynamic observational analysis

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Abstract

This paper quantifies the factors explaining long-term improvements in child height for age z-scores in Bangladesh (1996/1997–2011), India (1992/1993–2005/2006), Nepal (1997–2011) and Pakistan (1991–2013). We apply the same statistical techniques to data from a common data source from which we have extracted a set of common explanatory variables that capture ‘nutrition-sensitive’ factors. Three are particularly important in explaining height for age z-score changes over these timeframes: improvements in material well-being; increases in female education; and improvements in sanitation. These factors have comparable associations across all four countries.

Keywords: chronic malnutrition, economics constraints, infant and child nutrition, international child health nutrition, low income countries, socioeconomic factors.

Introduction

South Asia has long been synonymous with unusually high rates of child undernutrition (Ramalingaswami et al., 1997). Demographic Health Surveys from the 1990s suggested that more than half of South Asian pre-schoolers were stunted, a rate that far exceeds that of sub-Saharan Africa, a region substantially poorer than South Asia. These exceptionally high rates of undernutrition in South Asia have spawned substantial research into possible explanations, including intrahousehold biases (Pande, 2003, Jayachandran and Pande, 2013), low status of women (Shroff et al., 2009, Menon, 2012), early marriage and child birth (Raj et al., 2010), genetic predispositions (Nubé, 2009), low quality diets (Deaton and Dreze, 2008, Headey et al., 2012), poverty and household food insecurity (Menon, 2012), the inefficacy of nutritional programmes and strategies (Das Gupta et al., 2005, World-Bank, 2005) and exceptionally poor sanitation (Spears, 2013, Spears et al., 2013). These studies invariably focus on explaining South Asia’s lack of progress against undernutrition, even though recent decades have seen some significant increases in child growth outcomes across much of the sub-continent, with child height for age z-score (HAZ) improving by 15.6% to 25.6% in Bangladesh, Nepal, Pakistan and India. This progress suggests that reversing the focus of studies on South Asian nutrition – from a focus on why undernutrition is so high to a focus on why it has begun to drop – represents a potentially fruitful line of enquiry.

This encouraging trend in child nutrition provides the motivation for this paper, in which our focus is on explaining nutritional change over time. While there is a vast array of single country studies looking at associations between child, household and community characteristics and undernutrition – usually in a single cross-section – there are no comparative studies that systematically quantify and compare the factors that might explain long-term reductions in child undernutrition. Cross-country comparisons are problematic to interpret when there are differences in statistical methods, data collection techniques and explanatory variables across countries. To address this concern, building on (Headey et al., 2015) and (Headey and Hoddinott, 2014), we apply the same statistical
techniques to data from a common data source from which we have extracted a set of common explanatory variables that capture ‘nutrition-sensitive’ factors: improvements in material well-being (asset indices), expansions in female and male education, improvements in water and sanitation, demographic changes and improvements in access to health services. We use this common set of indicators to statistically explain improvements in child nutrition in four South Asian countries over extended periods of time: Bangladesh (1996/1997–2011), India (1992/1993–2005/2006), Nepal (1997–2011) and Pakistan (1991–2013). Given the theme of this supplement, we focus on HAZs. Linear growth is widely regarded as the single most relevant indicator of overall nutrition with poor HAZs causally linked to a whole host of poorer later life outcomes (Hoddinott et al., 2013).

The paper is structured as follows. Section 2 outlines the data and methods used in the paper. Section 3 presents our results, while Section 4 concludes.

Data and methods

Data sources

We use Demographic Health Surveys (DHS) from four South Asian countries – Bangladesh, India, Nepal and Pakistan – to analyze long-term nutritional change. We chose these specific South Asian countries as they have multiple DHS surveys containing data on anthropometric outcomes and a common set of explanatory variables. Details of these data sets and the surveys underlying them are found in (ICF-International, 2015). These multi-cluster surveys of ever-married women of reproductive age are well suited to our purposes. They are high quality, nationally representative surveys that cover a broad range of the hypothesized drivers of nutritional change. We use all available DHS data for these countries. Specifically, we use the 1996/1997, 1999/2000, 2004, 2007 and 2011 rounds of the Bangladesh DHS, the 1996, 2001, 2006 and 2011 rounds of the Nepal DHS, the 1992/1993 and 2005/2006 rounds of the India DHS, and the 1991 and 2013 rounds of the Pakistan DHS. Note that we cannot use the 1998 Indian DHS because in this survey round, it is not possible to uniquely identify households.

Our outcome variables are HAZs for pre-school children aged 0 to 59 months as measured against WHO growth standards that are described in de Onis et al. (2007). Table 1 presents weighted country HAZ means for the first and last round of data available to us. For all four countries, mean HAZ scores improved substantially from the 1990s to 2010s. The changes are larger in Bangladesh and Nepal (25.6% and 22.8%, respectively) than those in India and Pakistan (16.7% and 15.6%, respectively), especially in per annum terms. Indeed, (Headey et al., 2015) and (Headey and Hoddinott, 2014) find that Bangladesh and Nepal recorded two of the fastest reductions in undernutrition in the world in the 2000s.

The explanatory variables represent several broad sources of nutritional change: changes in asset ownership, maternal schooling, paternal schooling, take up of ante-natal care, sanitation and demographic factors. Some of the strengths and weaknesses of these indicators are discussed later.

As noted in Headey et al. (2015), one candidate for sustained nutritional change is general economic progress, which facilitates larger expenditures on food, health and other nutrition-relevant expenditures. While the DHS does not contain information on income or expenditures, it does collect information on assets and housing characteristics. These include ownership of household durables (TV, radio, motorcycle, tables and chairs and wardrobe), housing characteristics (floor, wall and roof materials and access to electricity), house ownership and farm land ownership. The precise list of assets varies across countries. In our analysis, we

Key messages

- In the last two decades, HAZ scores have improved by 15 – 25 percent in Bangladesh, India, Nepal and Pakistan.
- Three factors account for much of the observed change in HAZ in all countries: assets, women’s education and reductions in open defecation. Strikingly, there is little variation in the magnitudes of the estimated coefficients across countries.
- India’s relatively poor performance is driven by smaller changes in these variables.
use the set of assets that are recorded in all rounds for each country. Specifically, we use this information to construct an asset (or wealth) index. The weights of the different assets in this index were derived by running principal components analysis for all the pooled rounds of data available for a given country. Within each country, common weights are then used across rounds to ensure consistent measurement of asset scores over time. The index is then scaled so that it varies between 0 and 10, with 10 being the maximum score observed across all rounds in a country and zero being the minimum. The values of these indices rose by more than 100% from late 1990s to 2011 for Bangladesh and Nepal, and by around 50% for India and Pakistan (Table 1). World Bank poverty estimates also suggest that all four countries achieve substantial growth in household income and significant reductions in poverty (World-Bank, 2013).

The rapid expansion of education, especially among women as reflected in Table 1, is another significant change in South Asia, which may well have played a role in the reductions in child undernutrition, especially where improved female schooling is correlated with reductions in early marriage and improved women’s status.

Table 1 shows that all four South Asia countries made improvements in the utilization of health care. However, the DHS data do not allow us to assess whether this reflects changes in provision or changes

<table>
<thead>
<tr>
<th>Year</th>
<th>HAZ Asset index (1-10)</th>
<th>Maternal educ. (years)</th>
<th>Paternal educ. (years)</th>
<th>Four or more antenatal visits (%)</th>
<th>Born in a medical facility (%)</th>
<th>Open defecation (cluster %)</th>
<th>Piped water (%)</th>
<th>Tube well water (%)</th>
<th>Birth interval (years)</th>
<th>Number of children</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>–2.2</td>
<td>1.4</td>
<td>2.4</td>
<td>3.5</td>
<td>6.6</td>
<td>4.4</td>
<td>26.0</td>
<td>4.0</td>
<td>93.6</td>
<td>3.4</td>
</tr>
<tr>
<td>2011</td>
<td>–1.6</td>
<td>3.5</td>
<td>5.3</td>
<td>4.9</td>
<td>24.0</td>
<td>24.6</td>
<td>4.8</td>
<td>10.4</td>
<td>87.7</td>
<td>4.2</td>
</tr>
<tr>
<td>Change</td>
<td>0.6</td>
<td>2.1</td>
<td>2.9</td>
<td>1.4</td>
<td>17.4</td>
<td>20.2</td>
<td>21.2</td>
<td>6.3</td>
<td>–5.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Percent change (%)</td>
<td>–25.6</td>
<td>144.7</td>
<td>122.4</td>
<td>41.2</td>
<td>262.6</td>
<td>462.9</td>
<td>–81.6</td>
<td>157.7</td>
<td>–6.3</td>
<td>22.8</td>
</tr>
</tbody>
</table>

Bangladesh (N = 16,279)

<table>
<thead>
<tr>
<th>Year</th>
<th>HAZ Asset index (1-10)</th>
<th>Maternal educ. (years)</th>
<th>Paternal educ. (years)</th>
<th>Four or more antenatal visits (%)</th>
<th>Born in a medical facility (%)</th>
<th>Open defecation (cluster %)</th>
<th>Piped water (%)</th>
<th>Tube well water (%)</th>
<th>Birth interval (years)</th>
<th>Number of children</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>–2.1</td>
<td>1.0</td>
<td>1.1</td>
<td>4.0</td>
<td>9.4</td>
<td>7.9</td>
<td>86.8</td>
<td>28.9</td>
<td>42.3</td>
<td>3.0</td>
</tr>
<tr>
<td>2011</td>
<td>–1.6</td>
<td>4.0</td>
<td>3.5</td>
<td>5.6</td>
<td>48.9</td>
<td>35.0</td>
<td>48.5</td>
<td>39.4</td>
<td>43.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Change</td>
<td>0.5</td>
<td>3.0</td>
<td>2.4</td>
<td>1.6</td>
<td>39.4</td>
<td>27.2</td>
<td>–38.3</td>
<td>10.5</td>
<td>1.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Percent change (%)</td>
<td>–22.8</td>
<td>285.2</td>
<td>211.1</td>
<td>39.3</td>
<td>417.8</td>
<td>345.8</td>
<td>–44.1</td>
<td>36.2</td>
<td>3.6</td>
<td>13.9</td>
</tr>
</tbody>
</table>

Nepal (N = 9,852)

<table>
<thead>
<tr>
<th>Year</th>
<th>HAZ Asset index (1-10)</th>
<th>Maternal educ. (years)</th>
<th>Paternal educ. (years)</th>
<th>Four or more antenatal visits (%)</th>
<th>Born in a medical facility (%)</th>
<th>Open defecation (cluster %)</th>
<th>Piped water (%)</th>
<th>Tube well water (%)</th>
<th>Birth interval (years)</th>
<th>Number of children</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>–1.9</td>
<td>2.4</td>
<td>3.4</td>
<td>5.9</td>
<td>32.0</td>
<td>29.9</td>
<td>63.5</td>
<td>35.2</td>
<td>56.4</td>
<td>3.0</td>
</tr>
<tr>
<td>2006</td>
<td>–1.6</td>
<td>3.3</td>
<td>4.9</td>
<td>6.7</td>
<td>45.9</td>
<td>45.4</td>
<td>45.6</td>
<td>41.5</td>
<td>36.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Change</td>
<td>0.3</td>
<td>1.0</td>
<td>1.6</td>
<td>0.8</td>
<td>14.0</td>
<td>15.4</td>
<td>–17.9</td>
<td>6.3</td>
<td>19.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Percent change (%)</td>
<td>–16.7</td>
<td>41.9</td>
<td>46.2</td>
<td>13.0</td>
<td>43.7</td>
<td>51.5</td>
<td>–28.2</td>
<td>18.0</td>
<td>–35.1</td>
<td>1.2</td>
</tr>
</tbody>
</table>

India (N = 39,568)

<table>
<thead>
<tr>
<th>Year</th>
<th>HAZ Asset index (1-10)</th>
<th>Maternal educ. (years)</th>
<th>Paternal educ. (years)</th>
<th>Four or more antenatal visits (%)</th>
<th>Born in a medical facility (%)</th>
<th>Open defecation (cluster %)</th>
<th>Piped water (%)</th>
<th>Tube well water (%)</th>
<th>Birth interval (years)</th>
<th>Number of children</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>–2.0</td>
<td>3.5</td>
<td>1.8</td>
<td>4.5</td>
<td>16.4</td>
<td>15.2</td>
<td>50.2</td>
<td>38.7</td>
<td>51.9</td>
<td>2.8</td>
</tr>
<tr>
<td>2013</td>
<td>–1.7</td>
<td>5.3</td>
<td>3.5</td>
<td>5.9</td>
<td>38.4</td>
<td>49.8</td>
<td>22.1</td>
<td>32.6</td>
<td>54.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Change</td>
<td>0.3</td>
<td>1.8</td>
<td>1.7</td>
<td>1.4</td>
<td>22.0</td>
<td>34.6</td>
<td>–28.1</td>
<td>–6.1</td>
<td>2.2</td>
<td>–0.1</td>
</tr>
<tr>
<td>Percent change (%)</td>
<td>–15.6</td>
<td>52.9</td>
<td>98.7</td>
<td>31.3</td>
<td>134.6</td>
<td>227.4</td>
<td>–55.9</td>
<td>–15.7</td>
<td>4.3</td>
<td>–3.8</td>
</tr>
</tbody>
</table>

Pakistan (N = 4,865)

Source: Authors’ calculations from DHS surveys. HAZ, height for age z-score; DHS, Demographic Health Surveys.
in take up of existing services. As these healthcare variables are likely to be highly correlated with factors that cannot be completely controlled for, we also estimate models that drop these variables as a robustness test to gauge whether other coefficients in the model are sensitive to this exclusion.

We follow Spears (2013) in measuring sanitation as cluster-level open defecation. The assumption in this approach is that any fixed point defecation is likely to be better than open defecation and that negative community level sanitation externalities are more harmful that sanitation practices within the household. Both assumptions are contestable, and we do explore sensitivity to alternative definitions. The proportion of villages engaging in open defecation declined in all four countries, with the most marked decline in Bangladesh. This large change in sanitation contrasts with the small change in access to water (Table 1).

Lastly, the DHS has rich information on demographic factors that might affect undernutrition. We include two: the number of children born to mothers and the preceding birth interval. Rationales for this selection are discussed in Headey et al. (2015).

Statistical analysis

Following Headey et al (2015), using all available survey rounds, we estimate ordinary least squares regression models to assess the associations between HAZ for a child *i* at time *t* and the covariates described earlier (X). We include additional control variables (child and maternal age dummies, location fixed effects*κi*()) and trend effects represented by a vector of year dummy variables (T). The vector of coefficients (β) constitutes the set of parameters of principal interest. Adding in a white noise term (ε*it*), we represent this relationship by Equation (1):

\[ N_{it} = \beta X_{i,k} + \mu_i + T + \epsilon_{it} \]  

(1)

Stata version 13.0 was (Stata Corp, College Station, TX, USA) used to estimate regressions equations taking the form in (1). An important assumption within Equation (1) is that the model is appropriately specified in other dimensions, particularly in terms of capturing non-linearities in nutrition relationships. To that end, we took two steps. First, we adopted a very flexible specification of the time-invariant determinants including monthly dummy variables to capture the progressive growth faltering process that malnourished populations undergo until around 2 years of age (Shrimpton et al., 2001, Victora et al., 2009). Second, we undertook non-parametric graphical analyses of all time-varying continuous variables to examine whether there exists non-linearities in their relationships with HAZ scores (available on request). Most of the continuous explanatory variables have approximately linear relationships with HAZ scores with one important exception. Open defecation at the village level has a strikingly non-linear relationship. In the range of 0 to 30% open defecation (approximately), the gradient is steeply negative, but thereafter, it is mostly flat, before becoming negative again for the few very high levels of open defecation. As we did in Headey et al. (2014), to capture this non-linear relationship, we use a fractional polynomial transformation by raising this variable to the power of one-third.

We use the estimated parameters from Equation (1) to conduct a simple decomposition analysis described by Equation (2).

\[ \Delta N_{it} = \beta (\overline{X}_{i,k} - \overline{X}_{i,1}) \]  

(2)

For this analysis, we select the earliest DHS round (\( t = 1 \)) and the most recent round (\( t = k \), where \( k \) is the number of DHS surveys used for each country). This decomposition analysis entails multiplying observed changes in the means of each explanatory variable by its regression coefficient. Doing so gives the predicted change in HAZ from each change in a nutrition-sensitive factor and thus shows the estimated contributions of each variable to changes in HAZ. For example, suppose that women’s education rises by three grades between the first and last surveys for a given country, that is \( \overline{X}_{i,k} - \overline{X}_{i,1} = 3 \). Suppose also that the estimated coefficient on women’s schooling, \( \beta \), equals 0.025. Multiplying these together yields
0.075. This indicates that the observed changes in women’s schooling over time would predict a 0.075 increase in HAZ. We can do analogous calculations for other potential drivers of nutritional change to gauge the extent to which each factor explains changes in HAZ over time, as well as how all the explanatory variables as a whole (i.e. the model) performs in explaining HAZ changes. Note, however, that a key assumption in this very simple decomposition approach is that the regression coefficients are constant over time. This contestable assumption is discussed in the results section.

Results

Results of estimating Equation (1) for all four countries are shown in Table 2. There are several striking findings. First, a number of explanatory variables have statistically significant associations with HAZ in all four countries. These include the asset score, maternal schooling, paternal schooling, being born in a medical facility, open defecation, birth intervals and number of children.

Second, there is little variation in the magnitudes of the estimated coefficients across countries. For example, an additional year of maternal schooling improves HAZ by 0.022 standard deviations (SD) in India, 0.023 SD in Bangladesh, 0.028 SD in Nepal and 0.032 SD in Pakistan. We see that reductions in open defecation having equally strong associations across all countries. We also see equally sized impacts for our asset index (ranging from 0.047 to 0.071). Similar associations across countries are also found for paternal schooling (from 0.014 to 0.024), birth intervals (from 0.032 to 0.049) and number of children (from −0.022 to −0.035).

Table 2. Height for age z-score regressions pooled across years for full sample

<table>
<thead>
<tr>
<th>Model</th>
<th>(1) Bangladesh</th>
<th>(2) Nepal</th>
<th>(3) India</th>
<th>(4) Pakistan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset index, 1–10</td>
<td>0.069***</td>
<td>0.047***</td>
<td>0.071***</td>
<td>0.054***</td>
</tr>
<tr>
<td>(0.0067)</td>
<td>(0.0078)</td>
<td>(0.0059)</td>
<td>(0.0172)</td>
<td></td>
</tr>
<tr>
<td>Maternal education (years)</td>
<td>0.023***</td>
<td>0.028***</td>
<td>0.022***</td>
<td>0.032***</td>
</tr>
<tr>
<td>(0.0041)</td>
<td>(0.0052)</td>
<td>(0.0028)</td>
<td>(0.0084)</td>
<td></td>
</tr>
<tr>
<td>Paternal education (years)</td>
<td>0.024***</td>
<td>0.016***</td>
<td>0.014***</td>
<td>0.021***</td>
</tr>
<tr>
<td>(0.0034)</td>
<td>(0.0039)</td>
<td>(0.0024)</td>
<td>(0.0068)</td>
<td></td>
</tr>
<tr>
<td>Four or more antenatal visits</td>
<td>0.053</td>
<td>0.095***</td>
<td>0.069***</td>
<td>0.137***</td>
</tr>
<tr>
<td>(0.032)</td>
<td>(0.0380)</td>
<td>(0.0211)</td>
<td>(0.0664)</td>
<td></td>
</tr>
<tr>
<td>Born in a medical facility</td>
<td>0.114***</td>
<td>0.146***</td>
<td>0.071***</td>
<td>0.254***</td>
</tr>
<tr>
<td>(0.037)</td>
<td>(0.0475)</td>
<td>(0.0218)</td>
<td>(0.0714)</td>
<td></td>
</tr>
<tr>
<td>Open defecation†</td>
<td>−0.150***</td>
<td>−0.172***</td>
<td>−0.165***</td>
<td>−0.185***</td>
</tr>
<tr>
<td>(0.0417)</td>
<td>(0.0617)</td>
<td>(0.0386)</td>
<td>(0.101)</td>
<td></td>
</tr>
<tr>
<td>Piped water‡</td>
<td>0.0201</td>
<td>−0.149***</td>
<td>−0.0790</td>
<td>−0.138</td>
</tr>
<tr>
<td>(0.0667)</td>
<td>(0.0519)</td>
<td>(0.0464)</td>
<td>(0.109)</td>
<td></td>
</tr>
<tr>
<td>Tube well water‡</td>
<td>0.282***</td>
<td>0.198***</td>
<td>−0.0239</td>
<td>−0.0172</td>
</tr>
<tr>
<td>(0.0763)</td>
<td>(0.0515)</td>
<td>(0.0449)</td>
<td>(0.0922)</td>
<td></td>
</tr>
<tr>
<td>Birth interval</td>
<td>0.049***</td>
<td>0.032***</td>
<td>0.044***</td>
<td>0.043***</td>
</tr>
<tr>
<td>(0.0060)</td>
<td>(0.0086)</td>
<td>(0.0057)</td>
<td>(0.0168)</td>
<td></td>
</tr>
<tr>
<td>Number of children</td>
<td>−0.030***</td>
<td>−0.022***</td>
<td>−0.035***</td>
<td>−0.031***</td>
</tr>
<tr>
<td>(0.0098)</td>
<td>(0.0102)</td>
<td>(0.0068)</td>
<td>(0.0140)</td>
<td></td>
</tr>
<tr>
<td>Female child</td>
<td>0.005</td>
<td>0.017</td>
<td>0.041***</td>
<td>0.062</td>
</tr>
<tr>
<td>(0.0205)</td>
<td>(0.0249)</td>
<td>(0.0152)</td>
<td>(0.0470)</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.183</td>
<td>0.236</td>
<td>0.175</td>
<td>0.223</td>
</tr>
<tr>
<td>$N$</td>
<td>16279</td>
<td>9852</td>
<td>39568</td>
<td>4865</td>
</tr>
</tbody>
</table>

Notes: Village-level clustered standard errors in parentheses. *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively. The regressions earlier include a number of time-variant controls, including regional fixed effects, year fixed effects, month-specific child age dummy variables and dummy variables for various categories of maternal age. †’ Open defecation’ is measured as a cubic fraction for Bangladesh and Pakistan to capture the non-linear relationships observed in the non-parametric graphs (otherwise linear). ‡’ Piped water’ and ‘Tube well water’ is measured as a cubic fraction for all countries except for India to capture the non-linear relationships observed in the non-parametric graphs (otherwise linear).
Third, greater variation is seen in the associations between HAZ and access to health care. It is possible that this results from differences in quality of care, something we cannot observe in these data. Or it may be that demand for health care is often driven by other factors in the model, such as the asset index or parental education.

Lastly, the variable denoting the sex of the child is insignificant in three countries (Bangladesh, Nepal and Pakistan), and in the fourth (India), the estimated coefficient shows a positive association between being a girl and HAZ.

Results from the decomposition analysis are shown in Fig. 1. The vertical axis is HAZs, and so the height of the bars shows the estimated impact of changes in the explanatory variable on HAZ over time. So, for example, the value of 0.14 for assets in Bangladesh tells us that changes in asset holdings in Bangladesh between 1996/1997 and 2011 yield an estimated 0.14 SD improvement in HAZ. Looking across all countries, we see three factors account for much of the observed change in HAZ: assets, women’s education and reductions in open defecation. In Pakistan and to a lesser extent Nepal, improvements in access to health care (four or more antenatal visits plus being born in a health facility) are also estimated to lead to sizeable changes in HAZ. India’s relatively poor performance is driven heavily by smaller changes in assets, maternal education and open defecation relative to these other countries. Also of note – but not directly discernible from Fig. 1 – is that most of these models do a relatively good job of explaining total HAZ change over time. The share of total estimated HAZ change (from all X variables) to actual HAZ change varies from 52% in India, 65% in Bangladesh and 84% in Nepal. In Pakistan, the model explains 21% more HAZ change than is actually observed in practice, most likely because of the exceptionally large coefficients on health service indicators observed in the Pakistan regression model in Table 2. It may be that these coefficients are biased upwards because of some form of model misspecification.

These regression and decomposition results are based on pooling DHS data across years. We estimated these models separately by year and tested to see whether coefficients were stable over time. In the vast

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Fig. 1. Estimated contributions of selected factors to changes in height for age z-score (HAZ). Source: Authors’ estimates from Demographic Health Surveys data described in Section 2. Notes: These are estimates changes in HAZ scores due to changes in the explanatory variables listed in the legend over the country-specific time frames. These estimates (or retrospective predictions) are based on a linear decomposition at means, in which changes in the mean of each explanatory variable are multiplied by the corresponding coefficient from Table 2.

Source: Authors’ estimates from DHS data described in Section 2.

Notes: These are estimates changes in HAZ scores due to changes in the explanatory variables listed in the legend over the country-specific time frames. These estimates (or retrospective predictions) are based on a linear decomposition at means, in which changes in the mean of each explanatory variable are multiplied by the corresponding coefficient from Table 2.
majority of cases, we could not reject the null that there were no changes in parameter values (results available on request). As a robustness check, we re-calculated our decompositions using coefficients from the first and last DHS surveys in each country; doing so does not change the pattern of results found in Fig. 1.

We also conducted additional robustness checks. We re-estimated Equation (1) using stunting and severe stunting as the dependent variables. Doing so provides similar results to those reported in Table 2. Specifically, improvements in asset holdings, maternal schooling and reductions in open defecation all lead to statistically significant improvements in children’s nutritional status, and the magnitudes of these associations are similar across countries. We experimented with the functional form specification of our control variables, such as maternal and child age, but doing so does not affect our findings. Adding other control variables, including access to vaccinations and additional fertility-related controls, does not materially affect our findings.

Lastly, we estimated models that excluded indicators of healthcare and demographic variables, on grounds that these might be potentially endogenous; for example, they might primarily be a function of assets and education. We find that excluding health and fertility variables lead to increases in the coefficients on the asset index and maternal education variable but that the magnitudes remain comparable across countries. If we exclude the health and demographic variables, asset accumulation and maternal education account for more than three fourths of the predicted change.

Discussion

In this paper, we systematically quantify and compare the factors that might explain long-term reductions in child undernutrition in four south Asian countries: Bangladesh, India, Nepal and Pakistan. We find that the same explanatory variables have statistically significant associations with HAZ in all four countries: assets, maternal schooling, paternal schooling, being born in a medical facility, open defecation, birth intervals and number of children. Strikingly, there is little variation in the magnitudes of the estimated coefficients across countries. Moreover, assets, women’s education and reductions in open defecation account for much of the observed change in HAZ in all countries. The models also do well in accounting for aggregate change in HAZ scores across countries.

These findings confirm the multidimensional nature of nutritional change and the important role of nutrition-sensitive sectors, including broader economic development, education (particularly for girls), sanitation (and like also water and hygiene, although the former is not measured well and latter not measured at all), health and family planning. The statistical results imply that rapid nutritional change at a national level requires substantial progress in most if not all of these sectors, along with nutrition-specific interventions that are clearly important (Black et al., 2013), but not measured in our model. This finding also has important implications for nutritional monitoring. One implication is that monitoring ought to cover a broader range of socioeconomic variables (rather than a narrower focus on nutrition-specific factors). Another is that this kind of decomposition analysis could be used to diagnose potential determinants of undernutrition in any given setting, in order to prioritize policies and investments for reducing undernutrition. For example, high rates of open defecation relative to income and education levels – which is common enough in many parts of India – would be an obvious red flag.

The importance of asset accumulation in explaining HAZ outcomes is particularly interesting given the controversies surrounding the nutritional impacts of economic growth, particularly in India (Subramanyam et al., 2011). However, economic growth is typically measured as changes in GDP per capita, which is widely known to be an imperfect indicator of economic development both for conceptual and measurement reasons. Indeed, even poverty estimates based on household survey data have been hotly contested in the Indian context (Deaton and Dreze, 2002). In Table 1, we observed that India (42%) and Pakistan (53%) had much smaller growth rates in their respective asset indices than Bangladesh (145%) and Nepal (285%). In contrast, World Bank (2013) estimates suggest that Nepal (81%) and Pakistan (57%) had the fastest growth in household income over these same periods, distantly followed by India (33%) and Bangladesh (23%). Hence, the Indian paradox of rapid economic
growth with slower improvements in child nutrition could partly be due to national accounts and household surveys overstating the extent of progress in material well-being. Strikingly, India also made much less progress on other variables that had significant associations in these regressions, notably women’s education, sanitation and access to health services. This much weaker progress likely relates to India’s well-known problems of public service delivery in these sectors (Jha and Laxminarayan, 2009, Patil et al., 2014), but also to the much smaller role of non-governmental organizations in India (certainly when compared with Bangladesh and Nepal). Hence, the model quite accurately predicts less nutritional change in India relative to Bangladesh and Nepal, especially.

Our study has limitations. Our data are observational so are results should not be interpreted as causal; rather, our focus is on the ability of these factors to explain observed changes in stunting over time. Causal estimates can only be assured by experimental designs, although experiments on large scale income, education or sanitation programmes are very costly and often infeasible. Hence, our observational analysis complements the more experimental evaluations of nutritional programmes. Another limitation is that the need for comparability in model specification constrains us to include only those variables that appear in DHS surveys in all countries. So, for example, we cannot include maternal height because while it is available in all rounds for some countries (such as Bangladesh), it is not available in all rounds for other countries. Also, several of our covariates, such as assets, are ‘black box’ determinants of undernutrition, meaning that we can estimate associations between these variables and HAZ, but our data cannot tell us why such associations exist.

Set against these weaknesses are several study strengths, most notably the application of the same statistical techniques to national level data from a common data source from which we have extracted a set of consistently measured explanatory variables. Furthermore, our results are robust to a variety of checks, all of which consistently point to some common and very plausible drivers of nutritional change in South Asian countries.

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

Contributions
DH and JH designed the study. SP led the statistical analysis with support from DH and JH. All authors contributed to data interpretation and manuscript writing and have read and approved the final submission.

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References


Rethinking policy perspectives on childhood stunting: time to formulate a structural and multifactorial strategy

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Abstract

Stunting and chronic undernutrition among children in South Asia remain a major unresolved global health issue. There are compelling intrinsic and moral reasons to ensure that children attain their optimal growth potential facilitated via promotion of healthy living conditions. Investments in efforts to ensure that children’s growth is not faltered also have substantial instrumental benefits in terms of cognitive and economic development. Using the case of India, we critique three prevailing approaches to reducing undernutrition among children: an over-reliance on macroeconomic growth as a potent policy instrument, a disproportionate focus on interpreting undernutrition as a demand-side problem and an over-reliance on unintegrated single-factorial (one at a time) approaches to policy and research. Using existing evidence, we develop a case for support-led policy approach with a focus on integrated and structural factors to addressing the problem of undernutrition among children in India.

Keywords: stunting, undernutrition, childhood, cognition, economic growth, support-led strategy, social determinants, upstream interventions, multifactorial, India.

Introduction

If children under the age of 5 years from countries as diverse as Brazil, Ghana, India, Norway, Oman and the United States are exposed to optimal environmental conditions, a distributional plot of their normalized height, given their age, tends to follow a normal distribution (WHO MGRS 2006a). Our expectation would then be that under such optimal environmental conditions, only 2.5% of the children should fall below two standard deviations (SD) from median height, leading to a state commonly referred to as ‘stunting’, a well-established marker of chronic undernutrition (Corsi et al. 2011). However, in South Asia, the percentage of the children who are stunted is nearly 38% (UNICEF 2015). India, with a prevalence of 48% stunting, alone accounts for over 90% of the regional burden, and a third of the global burden (UNICEF 2015). Prioritizing and developing preventive as well as curative public health strategies to address this ‘high-risk’ (stunted) group cannot be more obvious.

It is, however, equally important to note that the extremely high prevalence of stunting suggests a broader underlying phenomenon of chronic undernutrition that affects all children in South Asia. The near perfect positive correlation between mean ‘height-for-age’, expressed as z-scores, and the proportion of children who are stunted (Fig. 1) suggests that a ‘population approach’ (Rose 1992) might be more appropriate to address the problem of chronic undernutrition among children in South Asia.

In this essay, we critique two perspectives that are commonplace in the policy, as well as scientific, discourses on addressing chronic undernutrition in childhood. The first relates to the disproportionately high reliance on macroeconomic growth as an instrument to reduce chronic undernutrition among children (Ravallion 1990; Pritchett & Summers 1997; Smith &
Haddad 2002). While it is certainly plausible that increases in macroeconomic growth can lead to reductions in chronic undernutrition, we scrutinize the degree of empirical support for the potency of macroeconomic growth to reduce chronic undernutrition.

The second prevailing idea relates to the disproportionate focus on ‘demand-side’ interventions with an aim to addressing ‘proximal’ risk factors (Bhutta et al. 2013), leaving the broader structural and supply-side determinants largely untouched (WHO 2008). Indeed, dramatic improvements in child health in the early parts of the 19th century in much of the industrialized nations were largely facilitated by changes in supply-side structural determinants (Cutler & Miller 2005; Semba 2008).

In this perspective, we focus on India as an example for developing our arguments given that Indian children experience the greatest share of the regional as well as the global burden on chronic undernutrition (UNICEF 2015). For brevity, we use the term undernutrition or stunting to reflect experiences of chronic undernutrition during childhood. We start with a brief overview on the underlying public health significance of stunting. This is followed by a critique of the ‘growth-mediated’ strategy to reducing child undernutrition. In the two subsequent sections, we describe and discuss concerns related to the prevailing framing of undernutrition largely as a demand-side issue problem along with a focus on one risk factor at a time failing to see the connections between different risk factors.

**Key messages**

- Eliminating child undernutrition is important from an intrinsic perspective and offers considerable instrumental benefits to individual and society.
- Evidence suggests that an exclusive reliance on a growth-mediated strategy to eliminate stunting needs to be reconsidered, suggesting the need for a substantial support-led strategy.
- Interpreting and addressing undernutrition as a demand-side problem with proximal single-factorial interventions is futile.
- There is an urgent need to develop interventions that address the broader structural and upstream causes of child undernutrition.
factors. In the concluding section, we argue for an urgent need to bolster a concerted support-led strategy focused on improving the structural and multifactorial determinants of child undernutrition in India.

Why should we care about stunting?

Expanding human freedom to live the kind of lives that people have a reason to value – as articulated by Nobel Laureate Professor Amartya Sen – provides a compelling framework to consider public health issues within the context of development (Sen 1999). Ensuring that a child reaches his or her underlying potential with regard to their physical and mental development can be seen as a freedom that should be valued for its own sake. An intrinsic perspective provides moral reasoning to considering undernutrition within a human rights framework. The 2013 National Food Security Act (Ministry of Law and Justice 2013), which aims to reduce child undernutrition through ensuring the elimination of one of the key causative factors (i.e. access to food), can be seen as an example of valuing the promotion of child development as an end in itself. As is often the case, promotion of such basic human capabilities and freedoms (e.g. ensuring conditions that facilitate optimal child development) invariably tends to bring about tremendous instrumental benefits leading to the formation of what is referred to as ‘human capital’ through their indirect role in influencing economic production and social change (Sen 1997). We briefly summarize the positive micro- and macro-socioeconomic gains that can be realized through substantial reductions in stunting.

Childhood stunting, cognitive development and schooling

Stunting has biological implications for brain development and neurological functioning that translate into cognitive impairment. Experiencing disadvantage early in life has significant implications for cognitive and social development by changing brain architecture and neurochemistry because neural plasticity is greatest during this time (Shonkoff & Phillips 2000; Knudsen et al. 2006). During this period of rapid change and development, brains adapt to the environmental conditions (Knudsen et al. 2006) with lasting changes in the prefrontal cortex affecting attention and memory as well as by reductions in dendritic density in the hippocampus that impair memory formation and consolidation (Hoddinott et al. 2013a). Other effects of undernutrition include diminished myelination of axon fibres, which reduces the speed at which neurological signals are transmitted (Hoddinott et al. 2013a). There is also significant evidence that many of these changes persist over the life course (Knudsen et al. 2006; Hoddinott et al. 2013a).

Several studies have found support for these biological and neurological implications of stunting, translating broadly into robust associations between stunting and cognitive impairment. In a recent systematic review and meta-analysis of 68 observational (cross-sectional and prospective) studies on linear growth and cognitive development in 29 low-income and middle-income countries, it was shown that children with lower height-for-age z-scores (HAZ) in the first 2 years had poorer cognitive outcomes (Sudfeld et al. 2015). In children ages 2 years or younger, one SD increase in HAZ was associated with a 0.24 SD [95% confidence interval (CI) 0.14–0.33] increase in cognitive ability (Sudfeld et al. 2015). Effects sizes among children over age 2 years were about a third the size (Sudfeld et al. 2015), suggesting that nutritional status early in life may be critical for cognitive development. Using longitudinal data from prospective birth cohorts in Brazil, Guatemala, India, Philippines and South Africa, Adair and colleagues (2013) found that faster linear growth was associated with higher schooling attainment with a one SD increase in conditional height at age 2 years associated with a half-year increase in schooling (Adair et al. 2013).

The associations observed in observational studies between stunting and adult educational outcomes have also been validated in studies using experimental designs. For instance, in Guatemala, nutritional supplementation in early childhood led to improvements in adult educational outcomes with a higher educational attainment of 1.2 grades for women and 0.25-SD increase in reading comprehension and non-verbal cognitive ability tests for both women and men (Maluccio et al. 2009).
In short, nutritional deprivation in early childhood, as reflected in growth faltering in height, negatively affects children’s cognitive development.

**Childhood stunting and economic production**

Early health investments allow individuals to gain even greater health stock later in life, and thereby influencing economic outcomes such as earnings potential and productivity in adulthood. There are two pathways through which a connection between childhood stunting and adult economic production could be conceptualized, measured largely through increased wages and productivity (Horton & Steckel 2011).

The first is a direct pathway whereby adults with better nutritional status, thus in better health (Perkins et al., forthcoming), are physically able to work and are likely to have higher output than those in poor nutritional status, while the second is an indirect pathway whereby stunted children, due to comorbidities and poor health status and lack of optimal cognitive development, are less likely to attain the same levels of schooling as healthy children and thereby have lower adult productivity and wages through lower levels of human capital (Horton & Steckel 2011).

While disentangling the two pathways is challenging, what appears to be clear is that stunting is correlated with lower adult wages or earning potential (Deolalikar 1988; Behrman & Deolalikar 1989; Strauss & Thomas 1996; Thomas & Strauss 1997; Schultz 2002, 2003; Hanushek & Wößmann 2008; Behrman et al. 2010; Dewey & Begum 2011; Hoddinott et al. 2013b).

**Limits to ‘trickle-down’ economics**

Despite the intrinsic importance of ensuring equitable access to opportunities and conditions that matter for child development, as well as the well-established instrumental benefits to individuals, society and economy, current policy perspectives have failed to recognize the seriousness of the problem of undernutrition. For instance, the current Vice Chairman of India’s National Institution for Transforming India Aayog, the country’s premier policy commission that works with states to promote economic development, Dr Arvind Panagariya, has gone to the extent of referring to the presence of child undernutrition in India as a ‘myth’ (Panagariya 2012). While it is relatively easy to counter and dismiss such a scientifically ignorant view (Table 1), it is the broader and long-standing prevailing belief that increased macroeconomic growth will automatically lead to alleviation of several of India’s social and health challenges, including undernutrition, which merits critical scrutiny.

It is not an exaggeration to state that in countries with low levels of per capita income, such as India, increasing the rate of economic growth is often justified as a key policy instrument to improving population health and nutrition (Pritchett & Summers, 1997; Smith & Haddad 2002). There are several reasons why increased economic growth could potentially lead to reductions in undernutrition. At the macro level, economic growth could lead to improvements in child nutrition through the following: (1) creating new industries and thereby expanding employment opportunities leading to increases in standard of living; (2) enabling greater allocation of resources towards social welfare programmes; and (3) increasing spending on health programmes (Subramanyam et al. 2011). These macro-level changes, in theory, could translate into raising household income and reducing income-poverty, educational attainment and food security, which then affect nutritional status for children (Subramanyam et al. 2011).

India did experience a period of sustained economic growth during the nineties as well as early part of the 2000s, with growth rates greater than 7% between 1994 and 1997 and about 8% or greater rate in 2004 and 2005 (Basu & Maertens 2007). Yet, over the two decades spanning the mid-1990s to the mid-2000s – the period when Indian economy was rapidly growing – the prevalence of stunting among children in India declined from 57% (1992–1993) to 39% (2013–2014), a reduction of 1.5% percentage points per year. Furthermore, there were considerable socioeconomic disparities in declines in stunting, with the richest quintile of Indian households experiencing a decline of 14 percentage points between 1992–1993 and 2013–2014, while the poorest quintile experienced a 13 percentage points decline over 21 years (Fig. 3). While such a casual perusal should hardly form the basis for evidence-based
public policy, rigorous analysis using well-established econometric techniques also questions the proposition that increased economic growth might be a potent policy instrument to reduce undernutrition among children in India.

In a comprehensive study that examined the role of state-level economic growth in explaining the decline in child undernutrition in India, the correlation between growth and undernutrition was close to zero; an Indian rupees (INR) 5000 increase in state per capita economic growth was associated with an odds ratio of 1.02 (95% CI: 0.99–1.05) for stunting (Subramanyam et al. 2011). Indeed, although an ecological association was found between levels of childhood stunting and levels of state per capita economic growth \( R^2(1992–1993, 2005–2006) = (0.06, 0.12) \), it was not statistically significant (Fig. 4a), and analyses of associations between change in per capita economic

Table 1. Summary of the arguments made by Professor Arvind Panagariya (2012) and counter arguments

<table>
<thead>
<tr>
<th>Panagariya’s arguments</th>
<th>Counter-argument</th>
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<tr>
<td>1. The WHO Multi Growth Reference Study (WHO MGRS) cannot be applied to India. He questioned whether the WHO-MGRS sample is an adequate reference for India – or other developing countries, in terms of geographical, cultural, socioeconomic and genetic backgrounds.</td>
<td>MGRS was designed to study growth among healthy children in five sites from Brazil, Ghana, India, Norway, Oman and the United States to develop growth standards rather than references such as in the National Center for Health Statistics/WHO 1977 growth curves (Wable 2013). One of the MGRS sites used was based in New Delhi (WHO MGRS Reference Study Group 2006). Of the total variation in child in length/height only, 3% of the variation was between-sites and is nearly twenty times lower than variability between individuals (WHO MGRS Reference Study Group 2006). It is also well established that children in India who have experienced healthy conditions have been able to grow according to international norms (Agarwal et al. 1991).</td>
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<td>2. Indians are genetically short.</td>
<td>If true, there should be little variation in height-for-age within India. Yet, large socioeconomic differences within India. For instance, stunting prevalence among the richest and poorest quartile is 27% and 40%, respectively (Fig. 3).</td>
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<tr>
<td>3. Mortality is coming down, so by extension, children must be growing optimally.</td>
<td>There is a misleading perception created under the label of “enigma” or “puzzle” with the suggestion that child/infant mortality indicators are somehow better even when prevalence of stunting is high, sparking unnecessary conjectures. The evidence stands directly in contrast to such perceptions. Within India, states that have lower levels of stunting also have lower levels of child/infant mortality (Fig. 2a); a strong and positive relationship between stunting and child/infant mortality is also observed among low and middle-income countries (Fig. 2b). Notwithstanding the strong correlation between child/infant mortality and stunting rates, it is obvious that factors influencing child survival on one hand, and an optimal child growth on other can be different (Gillespie 2013). Data on mortality are estimates; not observed, and based on the self-reports by respondents (usually mothers) on their entire life and death history of every child born. It remains unclear if the estimates of mortality are under or over-biased. On the other hand, anthropometry is objectively measured.</td>
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<td>4. Comprehensive medical exams should be used instead of anthropometry to measure nutritional status. Malnutrition needs to be distinctly characterized as either protein energy malnutrition or micronutrient deficiency.</td>
<td>While there are other measures of nutritional status, anthropometric measures are well established and are reliable (Corsi et al. 2011), and often the different measures have high correlation. Classification of malnutrition into two discrete categories of protein energy malnutrition and micronutrient deficiency is unfounded in scientific knowledge (Gillespie 2013; Gupta et al. 2013; Wable 2013). Focusing on protein, energy and micronutrient intake ignores the broader context of malnutrition in India that is rooted in social, economic, political and environmental conditions (Gillespie 2013; Gupta et al. 2013; Wable 2013; Coffey et al. 2014).</td>
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WHO, World Health Organization. Note: Also see Gupta et al. (2013) for a detailed critique of Panagariya (2012).
growth and change in childhood stunting revealed no significant results (Fig. 4b). Null associations were observed for both the lowest and highest quintile wealth groups (Fig. 4b). We conducted sensitivity analysis by approximating state-specific domestic product by wealth quintile and examining the association between change in stunting prevalence and change in economic growth in the richest quintile groups (fourth and fifth groups), confirming our initial findings of no association (see Table A1 and details of the estimation in the Supporting Information).

The evidence from India that macroeconomic growth did not contribute to the reduction in child undernutrition has also been corroborated at the global level. In an analysis of 121 Demographic and Health Surveys in 36 low-and middle-income countries, associations between country-level macroeconomic growth and reductions in childhood stunting ranged from zero to quantitatively very weak and were extremely robust to a wide range of econometric specifications (Vollmer et al. 2014; Vollmer et al. 2015).

**Fig. 2.** Association between stunting prevalence and child mortality rate (CMR)/infant mortality rate (IMR) among (a) Indian states and (b) 56 low- and middle-income countries.

Source: Authors’ calculations using data from NFHS-3 (IIPS 2007) for India; and mortality estimates from You et al. (2015) and stunting prevalence based on data from the latest Demographic and Health Survey (DHS) from 56 low- and middle-income countries. For state and country labels see Supporting Information.
Why macroeconomic growth did not matter

Even in the face of empirical evidence, it is challenging to alter long-held positions about the supposed potential of macroeconomic growth to improve health outcomes. For instance, in response to the aforementioned study, researchers continued to argue that the role of economic growth in reducing child undernutrition should not be dismissed (Alderman et al. 2014), even though little evidence was provided to support this statement (Vollmer et al. 2015).

At the same time, it is perfectly plausible why increases in economic growth did not translate to reductions in child stunting in India. First, average economic growth hides the huge imbalance in growth across different sectors; put simply, growth was not inclusive, and not all sectors of the population or regions of the country participated in the economic growth in the same manner (Kohli 2006a, 2006b). Indeed, the association between macroeconomic growth and changes in aggregate poverty at the state level was at best modest (Joe et al. 2016).

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Second, given the fact that not all populations (and especially those involved in low-performing economic sectors) participated in the growth, it then becomes necessary for the national and state governments to engage in redistributing income post-growth to those excluded population groups in order for the excluded groups to experience improvements in standard of living. There is again no evidence of any such income re-distribution (direct or indirect) to compensate for the non-inclusive growth; on the contrary, income inequality appears to have gone up during this period (Dev & Ravi 2007). There is also little evidence that macroeconomic growth led to re-distribution in an indirect manner such that public development expenditures that matter for social well-being and health increased (Joe et al. 2016).

Third, economic growth did not change any of the proximal risk factors of stunting, such as deficiencies in iron, iodine, vitamin A, zinc or suboptimal breastfeeding (Black et al. 2008). Building on Aguayo et al. (2014), we constructed a Child Nutrition Score (CNS) using National Family Health Survey (NFHS)-1 and NFHS-3 and found no statistical association between the change in the state-level CNS and the change in state-level economic growth between 1993 and 2005 (Fig. 5).

Finally, income generation (even when it happens) cannot immunize from the broader ‘supply side’
deficiencies. Even if it were the case that economic growth did lead to substantial improvements in individuals’ incomes, and especially those of the poor, this would still impact only few of the proximal risk factors that can causally reduce undernutrition, e.g. access to sufficient food. Even here, proper infrastructure (e.g. Public Distribution Systems or well-regulated markets) would have to be in place to efficiently deliver food at affordable prices. In India, where food inflation has been rampant, there is hardly any evidence that income improvements have vastly outstripped the food inflation, especially for the poor (Sen 2008). In fact, the evidence suggests a decline in calorie consumption in India (Deaton & Drèze 2009).

More importantly, reductions in child undernutrition are also dependent on other risk factors that are unlikely to automatically improve as direct consequences of higher household incomes. These include access to clean water and sanitation, as well as access to treatment to reduce recurring morbidities and prevention of infection through immunization. Improvements in these conditions are influenced by robust public investments, which often depend more on the policy and political environment than on the availability of resources. In countries such as India, there is no compelling evidence that economic growth has led to improved access to clean water and sanitation or treatment. For instance, as surprising as this might be for a casual observer, India has been formally declared to have achieved the Millennium Development Goal 7c related to water, which is to halve the proportion of the population without sustainable access to safe drinking water and basic sanitation by 2015 (WHO/UNICEF 2013). However, a recent study found alarmingly high contamination rates of water from the so-called ‘improved’ water sources in India (Johri et al. 2014). Although nearly 100% of the surveyed households in both urban and rural areas had access to ‘safe water’, as per the Millennium Development Goal definition, water tests revealed contamination in approximately 40% and 60% of urban and rural households, respectively (Johri et al. 2014).

In summary, before advocates of growth-mediated strategy exalt the role of macroeconomic growth as a policy instrument to reduce child undernutrition, it is critical to recognize the aetiology of undernutrition and mechanistic connections that are required to generate associations between growth and undernutrition. As the connections are far from being direct, it is critical to explore why undernutrition exists and is more prevalent among poorer individuals and how economic growth can improve nutritional status. Indeed, if economic growth is actually ‘pro-poor’, and the increased public revenue as a consequence of such growth is invested in improving the causative agents – structural as well as proximal – which matter for child.

Fig. 5. Association between change in state-level economic growth and change in state-level Child Nutrition Score (CNS). Source: Authors’ calculations using data from National Family Health Survey (NFHS)-1 and NFHS-3. (*) The dashed line was estimated after excluding GA. State abbreviations: AS, Assam; BR, Bihar; GA, Goa; GJ, Gujarat; HR, Haryana; JK, Jammu and Kashmir; KA, Karnataka; KL, Kerala; MH, Maharashtra; MN, Manipur; ML, Meghalaya; MZ, Mizoram; NL, Nagaland; OR, Odisha; PB, Punjab; RJ, Rajasthan; UP, Uttar Pradesh; DL, New Delhi; AR, Arunachal Pradesh. Child Nutrition Score (CNS) – We followed Aguayo et al. (2014) to estimate a CNS using five risk factors constructed using NFHS-1 and NFHS-3. The risk factors included were as follows: (1) early initiation of breastfeeding; (2) exclusive breastfeeding under 6 months; (3) timely introduction of complementary foods; (4) full vaccination; and (5) access to improved sanitary facilities. Although Aguayo et al. (2014) recommend the use of 10 proven essential interventions in the construction of CNS, we only used the first four indicators that we were able to estimate consistently from the available information in NFHS-1 and NFHS-3 and used access to improved sanitary facilities as a proxy for safe disposal of stools.
undernutrition, then growth, of course, can have an impact on undernutrition. Sadly, the evidence and reality appear to be the contrary.

**The folly of framing undernutrition as a ‘demand-side’ problem**

In addition to viewing economic growth as a panacea, the scientific and policy discourse tends to view undernutrition as a ‘demand-side’ problem. Under such a diagnosis, invariably, resources and efforts are disproportionately shifted to strategies for promoting behaviour change among individuals rather than investing in structural interventions. Such demand-side framing often triggers ‘downstream’ interventions that address the symptoms of the cause (‘proximal risk factors’) as opposed to the structural causes that are usually ‘supply-side’. To illustrate the folly of demand-side approach consider the current focus on, as well as efforts to address, the problem of open defecation in India, viewed as one of the major explanation for why Indian children are shorter (Harris 2014). Why do Indians defecate in the open?

One explanation, which is partially targeted at infrastructural aspects, might be because there is no provision for defecating in an enclosed and dedicated space (i.e. a latrine) in households. For instance, 69% of the rural households have no latrines in their homes, whatsoever; and only 19% of the households have ‘improved’ latrines (water closet) (Census of India 2011). Further, there are also large socioeconomic inequities in the quantity and quality of latrines (Table 2). It will not be an exaggeration to state that a water-based latrine (i.e. whereby excreta is transported with water or the ‘flush latrine’) is the ‘norm’ for the higher socioeconomic groups and perhaps the ‘aspiration’ for those who do not possess this luxury. A clear gradient is observed across socioeconomic groups for improved facilities; for example, nearly 90% of households in the highest wealth quartile have access to flush toilets connected to the piped sewer system, while it is 0% for those in the lowest wealth quartile (Table 2a). Conversely, lowest wealth quartile households either have no latrine (42%), compared with 2% for the highest wealth quartile households; and when they do, they are largely of the ‘not improved’ category of latrines (e.g. pit latrine without slab or open pit or a dry latrine) (Table 2a). Moreover, nearly 75% of households in the highest wealth quartile have access to an improved toilet facility, whereas nearly all households in the lowest wealth quartile have no latrine (95%) (Table 2b).

Another explanation, which appears to gain considerable currency in the policy and scientific discourse, is that open defecation is a demand-side problem, i.e. Indians prefer defecation in the open for various behavioural, cultural and religious reasons (Harris 2014; Coffey et al. 2015). Ignoring the stark realities and inequities outlined earlier with regard to dramatic shortfalls and inequities in quantity and quality, arguments have been made that even when latrines are available, they are not used (Barnard et al. 2013; Coffey et al. 2014). It is hard to resist wondering, if cultural reasons dominate over availability of an improved quality latrine, whether migrant Indians (poor or rich) practice open defecation in the richer countries to which they often emigrate? We are not aware of any documented evidence for such a practice.

Meanwhile, current efforts to end open defecation in India have focused on two things: (1) behaviour change (an intervention that presumes that open defecation is a demand-side problem) and (2) behaviour change by building a latrine in the home (a demand-side presumption along with a proximal intervention). Two recent randomized trials on toilet construction and awareness-raising projects studied whether such changes reduce the incidence of diarrhoeal disease or stunting (Clasen et al. 2014; Patil et al. 2014). The first trial, conducted in 80 rural villages in Madhya Pradesh, included promotion and subsidy of improved sanitation facilities as well as educational campaigns to change defecation behaviours and child health (Patil et al. 2014). Despite slight increases in the percentage of household with improved latrines and modest reductions in the open defecation practices, the intervention was ineffective in reducing the prevalence of gastrointestinal illness, intestinal parasite infections and increasing growth in children under 5 years of age (Patil et al. 2014). The second randomized experiment, conducted in 100 rural villages in Odisha, which involved installation of improved sanitation facilities, revealed no reduction in the exposure to faecal contamination or prevented
diarrhoea, soil-transmitted helminth infections or child malnutrition (Clasen et al. 2014).

We hope that such thoughtless experiments will not discourage from focusing on the aspects of water and sanitation, which is clearly in a state of crises, as a means for addressing the problem of undernutrition. They are thoughtless because we do know how to dramatically bring about improvements in child health through improvements in water and sanitation. It is well documented that substantial improvements in reducing child mortality and improvements in child health in the early 19th century in industrialized countries were linked to substantial investments in supply-side public health infrastructure related to public hygiene (Cutler & Miller 2005; Semba 2008). Yet demand-side interventions are ubiquitous when it comes to addressing the most basic and fundamental needs of living a dignified human life in low-income countries.

Open defecation in India is a symptomatic reflection of the abject failure at the structural level, which is both inadequate and highly inequitable (Narain 2002, 2012). The issue, as it relates particularly to undernutrition, is how should human excreta be disposed of and handled. Of the total excreta from the ‘closed defecations’ (i.e. the type of defecation practiced by upper-income groups), 80% is returned back to the grounds, rivers and seas completely untreated (Narain 2002). It is worth bringing a political economy perspective to treating human excreta in India; as Narain (2002)

Table 2. Weighted percentage of households with access to sanitary facility (a) by wealth quartile and (b) by type of facility in every wealth-quartile group in India, 2005–2006

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Wealth quartile (%)</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td></td>
</tr>
<tr>
<td>Flush to piped sewer system</td>
<td>0</td>
</tr>
<tr>
<td>Flush to septic tank</td>
<td>0.3</td>
</tr>
<tr>
<td>Flush to pit latrine</td>
<td>3.4</td>
</tr>
<tr>
<td>Ventilated improved pit latrine (vip)</td>
<td>1.4</td>
</tr>
<tr>
<td>Pit latrine with slab</td>
<td>12.1</td>
</tr>
<tr>
<td>Composting toilet</td>
<td>0.7</td>
</tr>
<tr>
<td>Not improved</td>
<td></td>
</tr>
<tr>
<td>Flush to somewhere else</td>
<td>0.6</td>
</tr>
<tr>
<td>Flush, don’t know where</td>
<td>2.4</td>
</tr>
<tr>
<td>Pit latrine without slab/open pit</td>
<td>22.1</td>
</tr>
<tr>
<td>No facility/bush/field</td>
<td>42.7</td>
</tr>
<tr>
<td>Dry toilet</td>
<td>20.6</td>
</tr>
<tr>
<td>Other or shared</td>
<td>4.6</td>
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<tr>
<td>(b)</td>
<td></td>
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<tr>
<td>Improved</td>
<td></td>
</tr>
<tr>
<td>Flush to piped sewer system</td>
<td>0</td>
</tr>
<tr>
<td>Flush to septic tank</td>
<td>0.2</td>
</tr>
<tr>
<td>Flush to pit latrine</td>
<td>0.6</td>
</tr>
<tr>
<td>Ventilated improved pit latrine (vip)</td>
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<tr>
<td>Pit latrine with slab</td>
<td>0.9</td>
</tr>
<tr>
<td>Composting toilet</td>
<td>0</td>
</tr>
<tr>
<td>Not improved</td>
<td></td>
</tr>
<tr>
<td>Flush to somewhere else</td>
<td>0</td>
</tr>
<tr>
<td>Flush, don’t know where</td>
<td>0</td>
</tr>
<tr>
<td>Pit latrine without slab/open pit</td>
<td>1</td>
</tr>
<tr>
<td>No facility/bush/field</td>
<td>94.5</td>
</tr>
<tr>
<td>Dry toilet</td>
<td>0.3</td>
</tr>
<tr>
<td>Other or shared</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Source: Author calculations using data from NFHS-3 (IIPS 2007).
shows sewer systems in India are subsidized for the use of the better-off groups in cities, while the poor (especially those in rural areas) left with no latrines or to experiment with alternate (‘ecosanitation’) types of latrines that are nowhere close to the ‘flushed latrines connected to a closed sewer’. Such ecosanitation technologies are likely to be interim alternatives when proposed for the unserved poor and most likely discarded for the ‘aspirational’ latrine when people’s incomes increase (Narain, 2002). Furthermore, as much as the excreta from open defecation can be an environmental risk factor for undernutrition, the excreta from closed defecation, while remains out of sight of the homes, equally poses the same magnitude of environmental risk, given the lack of integrated infrastructure to treat the excreta before it is back into our environments. It is also important to recognize that India on a classification of ‘water stress’ (ratio of withdrawals to supply) levels is considered ‘high stress’ (Reig et al. 2013), and a thoughtful debate and discussion on the appropriate and equitable technology suited for India that links water and sanitation is woefully missing. In absence of discussions and efforts focused on structural, supply-side conditions, the proposal to construct 110 million toilets (PIB/GOI 2015), while it will attenuate the socioeconomic inequalities with regard to access to latrines (even if of the unimproved type) may not have a considerable impact on reducing undernutrition.

While we use open defecation to exemplify the over-reliance on the demand-side approaches to intervene on child undernutrition, there are other examples as well. For instance, in India, the Expert Task Force on Infant and Young Child Nutrition of the Coalition for Sustainable Nutrition Security identified 10 strategies to address the high levels of undernutrition, all of which address only nutrition-specific, demand-side determinants such as breastfeeding, introduction of complementary foods and feeding practices (Box 1) (Swaminathan 2009). In addition, many programmes focus on promoting breastfeeding through both individual and group counselling (Haroon et al. 2013). Other programmes encourage parents to provide complementary foods (Lassi et al. 2013) or vitamin supplementation to their children (see studies in Bhutta et al. 2013). Priorities and programmes that only promote behaviour change ignore other drivers of undernutrition such as household poverty that may prevent families from affording high-quality foods or vitamin supplements or may affect women’s ability to breastfeed (Black et al. 2013; Ruel et al. 2013). Even though there is broad consensus that commensurate investments in supply-side, nutrition-sensitive programmes such as improvements in agricultural sectors and strengthening of social welfare programmes, as well as broader investments in early child development and schooling are required to substantially reduce undernutrition (Bhutta et al. 2008; Bhutta et al. 2013; Gillespie et al. 2013; Ruel et al. 2013, Pistrup-Anderson, 2013); in practice, there is little evidence of such complementary approaches.

In developed countries, supply-side structural interventions targeting social, economic, political and environmental determinants have had significant impact on improving child health and nutrition. Specific examples of such interventions include water filtration and chlorination, which provide clean, drinkable water and reduce exposure to water-borne illnesses. In response to the high incidence of cholera and other disease spread by drinking water from the Thames, the Metropolis Water Act of 1842 was enacted, decreeing that water be drawn from only particular regions of the river and be filtered before public distribution (Semba 2008). In the United States, nearly three quarters of reductions in infant mortality and half child

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**Box 1. Ten priority areas**

1. Timely initiation of breastfeeding within 1 h of birth
2. Exclusive breastfeeding within the first 6 months of life
3. Timely introduction of complementary foods at 6 months of age
4. Age-appropriate complementary foods, adequate in terms of quality, quantity and frequency for children 6–23 months
5. Safe handling of complementary foods and hygienic complementary feeding practices
6. Full immunization and biannual vitamin A supplementation with deworming
7. Frequent, appropriate and active feeding for children during and after illness, including oral rehydration with zinc supplementation during diarrhoea
8. Timely and quality therapeutic feeding and care for all children with severe acute malnutrition
9. Improved food and nutrient intake for adolescent girls particularly to prevent anaemia:
10. Improved food and nutrient intake for women, including during pregnancy and lactation

mortality were attributable to introduction of filtration and chlorination in the early 20th century (Cutler & Miller 2005). Other examples of structural interventions include new institutions and laws. The British Public Health Act of 1848 established a general board of health and enacted legislation to oversee food production and processing, water and sanitation with similar public health measures enacted in the United States (Semba 2008). In the early 1900s, much attention was also paid to the high infant mortality rates with promotion of breastfeeding, maternal education, better prenatal care and pasteurization of milk (Semba 2008). Other factors contributing to better nutritional outcomes include advanced agricultural technologies and relatedly increases in food production (Semba 2008). There were also improvements in food distribution systems, namely, the construction of railways (Semba 2008). Developing countries would do well to take lessons learned from these advances in developed countries and invest more in structural interventions.

Shifting from a single, siloed risk factor to an integrated multifactorial approach

Alongside a disproportionate focus on demand-side approaches to policy action, there is a tendency to consider one proximal risk factor at a time (often in an independent manner), as opposed to considering the simultaneous influence of different risk factors and appreciating the linkages between the different risk factors. The focus on single risk factors is partially justified by how effectiveness studies are designed. Most programme evaluations marshal evidence from randomized control trials or quasi-experimental designs (Bhutta et al. 2008; Bhutta et al. 2013), which only manipulate a single factor to assess its effect. However, there is a call to integrate evidence from these disparate studies into multisectoral interventions (Casanovas et al. 2013; de Onis et al. 2013; Ruel et al. 2013). Linked interventions are supported by studies from Brazil and sub-Saharan Africa that demonstrate that integrated interventions have led to substantial reductions in stunting (Casanovas et al. 2013). In parallel, there is a need to better evaluate multisectoral interventions to support further investment (Ruel et al. 2013).

The broader dilemma of a single factorial vs. multifactorial is perhaps tellingly captured in the parable by the medical sociologist, Irving Zola (Box 2). In the parable, an onlooker witnesses a man caught in a river current. The onlooker saves the man by pulling the man out of the river, resuscitating him and providing first aid, only to be drawn to the rescue of another drowning person, with the same cycle – pulling, resuscitating and treating – continuing. Caught up in the frenzy of efforts to rescue the drowning man, one forgets to ask: what is happening ‘upstream’ that is triggering the fall of so many people into the river? The ‘emergency’ nature of responding to child undernutrition with one risk factor at a time, as important and relevant as they are, only offer the ‘first aid’, and therefore, likely to be short term in nature (McKinlay 1979). In the absence of a simultaneous attention to the upstream conditions (i.e. the root causes and origin of the problems and often multifactorial in nature), single-factorial approaches might even be entirely futile (McKinlay 1979). This fundamental idea also forms the basis for the report of the World Health Organization (WHO) Commission on Social Determinants of Health (WHO 2008). Indeed, the theoretical and conceptual frameworks for addressing undernutrition are quite rich and capture the multilevel determinants of undernutrition (Black et al. 2008; Black et al. 2013; UNICEF 2013). Yet the practice (both in terms of scientific research as well as policy interventions) is often incredibly myopic to the underlying conceptual framework.

Box 2. The Parable by Irving Zola

‘You know’, he said, ‘sometimes it feels like this. There I am standing by the shore of a swiftly flowing river and I hear the cry of a drowning man. So I jump into the river, put my arms around him, pull him to shore and apply artificial respiration. Just when he begins to breathe, there is another cry for help. So I jump into the river again, reaching, pulling, applying, breathing and then another yell. Again and again, without end, goes the sequence: You know, I am so busy jumping in, pulling them to shore, applying artificial respiration, that I have no time to see who the hell is upstream pushing them all in’.

Reproduced from McKinlay (1979).
The need for integrated and multifactorial thinking, as opposed to addressing one risk factor at a time, cannot be emphasized enough. A recent study examining simultaneously the relative influence of vitamin A supplementation, vaccination, use of iodized salt, household air quality, improved sanitary facilities, safe disposal of stools, improved drinking water, prevalence of infectious disease, initiation of breastfeeding and dietary diversity (all identified as ‘risk factors’ for undernutrition) and broader social determinants such as age of marriage, maternal body mass index, height, education and household wealth found that these social determinants had a combined population attributable risk of 63.5% for stunting (Corsi et al. 2015).

To reduce the prevalence of undernutrition, it is imperative to jointly address the multiple determinants operating at various levels. Indeed, the recent failures of randomized trials of Vitamin A supplementation for child survival (Haider & Bhutta 2015) further underscore the limits of a single-factorial approach to improving child health.

Studies examining the effectiveness of these single risk factor approaches reveal the shortcomings of these programmes. Not surprisingly, effects from interventions are very small. For example, multiple micronutrient supplementation in children ages 6 months to 16 years led to a 0.13-cm increase in length, while zinc supplementation for 24 weeks led to a 0.37-cm increase in height among children younger than age 5 years (Bhutta et al. 2013 and Table 3). Furthermore, if these interventions were to be scaled up from experimental studies to the population level, 90% coverage would lead to only a 20% reduction in stunting (Bhutta et al. 2013). The greatest reductions in undernutrition would be brought about by approaches that target the multiple dimensions of undernutrition, linking behaviour change programmes with interventions to address the structural determinants (Corsi et al. 2015).

### Concluding remarks

In their book, *Hunger and Public Action*, Drèze and Sen (1991) make the distinction between pursuing a ‘growth-mediated’ and the ‘support-led’ strategy to address the problem of nutritional deprivation. The ‘growth-mediated’ strategy relies on promoting economic growth leading to greater employment opportunities and related increases in household income. The

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**Table 3. Demand-side interventions**

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breastfeeding promotion</strong></td>
<td>Effects of educational/counselling interventions on the following: Early breastfeeding; By 43% (95% CI: 9-87) on day 1, by 30% (95% CI: 19-42) at 1 month, and by 90% (95% CI: 54-134) from 1-6 months.</td>
</tr>
<tr>
<td><strong>Complementary feeding promotion</strong> (children ages 6–24 months)</td>
<td>Nutrition education in food secure populations: Height gain (standardized mean difference = 0.35; 95% CI 0.08-0.62), HAZ (standardized mean difference = 0.22; 95% CI 0.01-0.43). No significant effects on stunting. Nutrition education in food insecure populations: HAZ (standardized mean difference 0.25, 95% CI 0.09-0.42), stunting (relative risk: 0.68, 95% CI 0.60-0.76), Provision of complementary food with and without education in food insecure populations: HAZ (standardized mean difference = 0.39, 95% CI 0.05-0.73)</td>
</tr>
<tr>
<td><strong>Multiple micronutrient supplementation</strong></td>
<td>Children ages 6 months to 16 years receiving supplementation had 0.13 cm (95% CI 0.06-0.21) greater length</td>
</tr>
<tr>
<td><strong>Zinc supplementation</strong></td>
<td>Children under age 5 years receiving supplementation for 24 weeks experienced 0.37-cm (0.25-SD) increases in height, on average</td>
</tr>
<tr>
<td><strong>WASH interventions</strong></td>
<td>20 percentage point reduction in open defecation was associated with 0.1-SD increase in child height</td>
</tr>
</tbody>
</table>

CI, confidence interval; HAZ, height-for-age z-scores; SD, standard deviation. Source: Bhutta et al. 2013.
increasing affluence could also indirectly provide the basis for inducing demand for better public services (e.g. increased public expenditure to ensure adequate and quality of relevant services) that are critical for improving nutritional status. In contrast, the ‘support-led’ strategy involves direct interventions in creating equitable public policies and provisions that matter for nutrition (e.g. ensuring a strong food distribution system or investments in water and sanitation infrastructure).

Importantly, the two strategies are not mutually exclusive and are likely to be synergistic. There is also considerable evidence that investing in health and nutrition, especially during childhood, has substantial economic pay-offs. It turns out that in ‘cost-benefit’ analyses of investing in child nutritional programmes, the benefits (both short and long terms) substantially outweigh the costs of designing and implementing interventions. For instance, for every dollar spent on child nutrition programmes, the returns were valued at $34 for India (Deolalikar 1988). Indeed, with 30% of India’s population under the age of 15 years (United Nations 2013), it is imperative to invest in the overall child development if India is to reap its ‘demographic dividend’ (Bloom et al. 2003). It is the quality (healthy and educated) of the younger population, and not just the quantity, that will decide the extent to which any such dividends India might be able to accrue.

The evidence that a growth-mediated strategy can improve nutritional status among children is no longer compelling. Advocates for a growth-mediated strategy will continue to argue that economic growth has to be considerably higher and more rapid than what India has experienced, or that economic growth can be engineered to be substantially more broad-based, and that it is not advisable to dismiss the role of economic growth in improving nutritional status of children in India. Notwithstanding the merits of such an argument, there is no reason (moral or economic) to delay pursuing an equally aggressive support-led strategy focused on supply-side structural interventions with a multifactorial approach to substantially reducing the incidence of childhood stunting, as well as improving the lives of millions of children in South Asia.

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SVS conceptualized and wrote the article. IMG contributed to the data analysis and writing. AK contributed to the literature review and writing. Work done by AK was performed while a doctoral student at the Harvard T. H. Chan School of Public Health.

Conflicts of interest

The authors declare that they have no conflicts of interest.

References


Supporting information

Additional supporting information may be found in the online version of this article at the publisher’s web site:

Methods.
Stop stunting: situation and way forward to improve maternal, child and adolescent nutrition in Afghanistan

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While Afghanistan has made progress in improving the nutritional status of children and women, rates of under-nutrition, stunting and wasting remain among the highest in the world, requiring attention to address immediate and underlying causes (Varkey et al. 2015). Given potential human, societal and economic gains from investment in nutrition (Branca et al. 2015) reducing the dual burden of acute and chronic undernutrition must figure among social sector and development priorities for the country.

Comparisons of two national nutrition surveys in Afghanistan (2004 and 2013) show gradual improvements in the nutritional status of women and children, and yet, the rates of undernutrition continue to be too high. According to a National Nutrition Survey in Afghanistan in 2004, the prevalence of chronic malnutrition (stunted linear growth or low height-for-age) among children aged 6 to 59 months was 60.5%; in the same age group, the prevalence of acute malnutrition (wasting) was 8.7% (Afghanistan Ministry of Public Health, National Nutrition Survey 2004). The 2013 survey showed malnutrition rates among children 0 to 59 months of age with stunting at 40.9%, severe stunting at 20.9%, and moderate stunting at 20% (Afghanistan Ministry of Public Health, National Nutrition Survey 2013). Wasting or acute malnutrition, however, increased slightly from the previous survey to 9.5%, with moderate acute malnutrition at 5.5% and severe acute malnutrition at 4.0% (Afghanistan Ministry of Public Health, National Nutrition Survey 2013). These findings must be interpreted with caution given that the 2004 survey sample was much smaller than the 2013 survey. For the first time, child obesity was measured, and it was found that 5.4% of the children aged 0–59 months were overweight (Fig. 1).

The recent survey also reports moderate improvement in undernutrition in women of reproductive age in Afghanistan, although maternal wasting and micronutrient deficiencies remain widespread. Among women of reproductive age (15–49 years), 9.2% of women are thin or undernourished (BMI < 18.5 kg/m²). The proportion of women with mild thinness is 6.7% and severe thinness is 2.4%. The nutritional status of adolescent girls (aged 10–19 years) was assessed for the first time in Afghanistan in the 2013 survey, showing that 8% of adolescent girls are thin and 1.5% are severely thin. Anaemia (Hb levels < 11.99 gm/dl) is common in women of reproductive age (40.4%), among children 6–59 months of age (44.9%), and adolescent girls of 10–19 years (29.9%) (Afghanistan Ministry of Public Health, National Nutrition Survey 2013). Given that up to a fifth of all stunting in young infants may be associated with fetal growth retardation (Black et al. 2013) and the recognized association of stunting with maternal height in neighbouring Pakistan...
(Di Cesare et al. 2015), the relationship of adolescent and maternal nutrition with childhood stunting should be considered in the context of the mother–infant dyad and intergenerational effects of interventions.

Equity is a central issue, and major disparities in nutritional status in Afghanistan exist across geographic locations and socio-economic groups. The prevalence of acute undernutrition is higher in several provinces: Uruzgan (22%), Nangahar (21%), Nuristan (19%), Khost (18%), Kandahar (14%) and Helmand (14%). Higher prevalence of stunting was shown in Farah (70%), Nuristan (63%), Kunar (56%), Paktia (55%) and Nangahar (52%) (Afghanistan Ministry of Public Health, National Nutrition Survey 2013) (Fig. 2).

About 30.7% of Afghan children under 5 years in the poorest households are more likely to be underweight compared with 17.7% of children from the richest households. For acute malnutrition, about 9.8% of the children under 5 years of age in the poorest households are more likely to be wasted (low weight-for-height) compared with 6.8% in the richest households. About 49.4% of the children under 5 years of age in the poorest households are more likely to be stunted (low height-for-age) compared with 31.1% in the richest households (Afghanistan Ministry of Public Health, National Nutrition Survey 2013). There are other measures of inequity as well and significant differentials are also noted by geography, gender, parental education – especially maternal – and ethnicity.

Although the high poverty rate in Afghanistan influences these rates, many other determinants contribute to undernutrition of children and women, including those related to health status, dietary intake, food availability, care of mothers and children, health environment and services, and public policies and laws. Poor sanitation and hygiene lead to higher rates of childhood illnesses, including diarrhoea and pneumonia, and could well contribute to chronic enteropathy and associated linear growth retardation and stunting. Dietary intake is suboptimal, with only 14.2% of children aged 6–23 months from the poorest households likely to get a minimum acceptable diversified diet and about 31% in the richest households (Afghanistan Ministry of Public Health 2013). Poor hygiene, sanitation and limited safe water supply are other major causes of infectious illnesses, and just over half (56.7%) of the population has access to improved drinking water sources (Central Statistics Organisation (CSO) & UNICEF, 2012).

Maternal, newborn and child care practices are also suboptimal. Less than half of women give birth in a health facility with a skilled birth attendant (Central Statistics Organisation (CSO) & UNICEF, 2012; Black et al. 2013). While there has been steady improvement in the prevalence of children aged 0–6 months who are exclusively breastfed in Afghanistan, the rate of 58% means almost half of infants are not exclusively breastfeed (Afghanistan Ministry of Public Health, National Nutrition Survey 2013) (Fig. 3).

Showing high-level political commitment to improve maternal, child and adolescent health, the Afghan government has made new commitments in 2015 as part of *A Promised Renewed and Call to Action for Maternal and Child Survival*, through its Kabul Declaration, and the *Global Strategy for Women’s, Children’s and Adolescents’ Health* (2015–30), including to reduce the rate of stunting in children under 5 years of age to 30% by 2020 and 10% by 2030. With the government’s strong political will to immediately adhere to this new
Fig. 2 Distribution of stunting and wasting by province in Afghanistan (National Nutrition Survey, 2013).
global strategy with evidence-based targets, progress can be made through further inputs into supply, demand and quality dimensions.

To achieve these new targets, the Ministry of Public Health is revising the National Nutrition Strategy with a detailed costed plan that advocates for increasing investments for nutrition. There is a clear need to scale-up both nutrition-specific and -sensitive programmes in Afghanistan, given findings from the recent survey reveal a double burden of undernutrition – stunting and wasting – among children under 5 years of age.

The Ministry of Public Health, with support from its development partners, is prioritizing the following areas with a focus on the first 1000 days of life (Bhutta et al. 2013):

**Nutrition-specific interventions**

- Infant and young child feeding promotion programmes, including support for exclusive breastfeeding and complementary feeding both at the facility and community levels, and promotion of dietary diversity;
- Maternal nutrition interventions, including micronutrient supplementation, nutrition counselling and behaviour change communication, food fortification including iodised salt.
- Adolescent girls’ nutrition interventions, including weekly iron folic acid supplementation for both in-school and out-of-school adolescent girls;
- Micronutrient supplementation and fortification programme; and
- Treatment of acute malnutrition.

**Nutrition-sensitive interventions**

- Food and nutrition situational monitoring, assessments and surveillance;
- Creating linkages with livelihoods/income generating programmes to improve asset base of households;
- Improving water, sanitation and hygiene;
- Building the capacity of partners and government to deliver quality programmes; and
- Use of appropriate programme delivery platforms for nutrition specific interventions:
  - communities for nutrition education and promotion;
  - health facilities especially through integrated management of childhood illness (IMCI);
  - private sector - large-scale food fortification;
  - school-based delivery platforms for adolescent girls; and
  - social protection programmes including cash transfers.

Appreciating the multisectoral nature of undernutrition, there is also a need to create a forum at the highest level of government including the sectors of health, agriculture, education, finance, economy, rural development and public works to drive collective and integrated action for nutrition.
Over the past decade, Afghanistan has shown that progress in improving nutritional status of children and women is possible, even in challenging economic, security and political circumstances. New commitments for reductions in stunting and increased coverage of evidence-based interventions can be realized through multi-sectoral collaboration, led by the Ministry of Public Health and supported by its development partners. Nutrition must continue to be positioned as a central public health issue in Afghanistan with profound effects and potential for social and economic development.

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Contributions

AHS developed the drafts for the Commentary. PM and SV reviewed the drafts and provided technical inputs for the commentary. HL and NS provided inputs based on their involvement in the development, implementation, and analysis of the National Nutrition Survey (2013). ZAB was the principal investigator for the NNS 2013 and has provided technical assistance in data analysis and interpretation. All authors read and approved the final version.

References

Imperatives for reducing child stunting in Bangladesh

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Although there has been a decline in rates of child stunting in Bangladesh, more than one-third of under-five children still suffer from impaired linear growth. Results of the demographic health surveys since 2004 show that the rate of stunting decreased by only 1.5 percentage points per year (NIPORT, Mitra and Associates & ICF International, 2015). This is not anticipated, given the impressive results the country has demonstrated in reducing infant and maternal mortality over the past two decades (NIPORT, MEASURE Evaluation, and ICDDR,B 2012). Stunting seems to be pervasive throughout the country and is very high in children in slum settlements. Poverty and lack of education are associated with stunting in Bangladesh as elsewhere; however, 21% children from households belonging to the richest wealth quintiles are also stunted. About one-third of children of literate mothers also suffer from stunting. Therefore, the aetiology of stunting is still not clear, although data from Bangladesh suggest that factors associated with the condition include poor maternal nutrition, low birthweight (LBW), severe food insecurity, inappropriate complementary feeding, poverty, illiteracy, poor sanitation, and hygiene practices (Ahmed et al, 2012; Psaki et al, 2014). There is increasing evidence that environmental enteropathy, a condition where the small intestinal mucosa is colonized and damaged by pathogenic bacteria, is one cause of malabsorption of nutrients and stunting. This happens when hygiene and sanitation practices are poor and young children are chronically exposed to bacteria in the environment.

The pace at which stunting reduction is taking place in Bangladesh is not enough to achieve the World Health Assembly target of 40% reduction in stunting levels by 2025 (IFPRI, 2014). The current annual average rate of reduction is 2.7%, and this will need to be increased to 3.3% to achieve the target. This is not a phenomenal increase compared with the current rate of reduction, but it will require concerted planning and efforts. From an economic perspective, the cost to Bangladesh of not investing in accelerating this reduction will be huge in terms of lost gross domestic product and income. From a health perspective, it is essential to improve linear growth of children so that the negative effects of excess ponderal growth and resulting overweight and obesity are attenuated.

Priority action areas for improving linear growth and increasing the decline in rate of stunting in Bangladesh are summarized in the succeeding text.

Effective multisectoral coordination of nutrition interventions

This is essential for implementation of nutrition-specific and sensitive interventions at all levels. Given the extent and magnitude of the nutritional problems in the country, it is highly desirable that the national level multi-sectoral coordination be directed from the Prime Minister’s office. Experience in other countries suggests that improving public health nutrition has been successful where the highest level of government office was involved in giving high level directives for coordinating policy and national level implementation.
Formulating a national plan of action for nutrition

The government has recently approved the new national nutrition policy, which is based on new evidence. It is now important to have a realistic national plan of action and link financing for this plan, in line with the policy. It should include an assessment of health-related human resources, particularly at the grass-roots level, for effective behaviour change communication. It should also have a robust mechanism for monitoring and feedback for course correction of implementation, as well as accountability mechanisms at all levels.

Scaling up nutrition-specific and nutrition-sensitive interventions

Nutrition-specific interventions include balanced energy-protein supplementation and iron-folic acid, calcium supplementation during pregnancy; counselling to support breastfeeding and appropriate complementary feeding, micronutrient supplementation to young children, and treatment of moderate and severe acute malnutrition. These are essential nutrition interventions, but scaling them up can reduce mortality by 15% and stunting by only 20% (Bhutta et al., 2013). This implies that these have to be combined with nutrition-sensitive interventions, which can assure adequate water, sanitation and hygiene, food security, family planning, improving literacy, social safety net programmes and poverty alleviation. Economic and social policies that increase minimum wages and reduce socioeconomic inequalities should be formulated and implemented.

Reduction in low birthweight

Bangladesh has one of the highest rates of LBW in the world (36%) (UNICEF and Bangladesh Bureau of Statistics, 2005). One-fifth of stunting is attributed to LBW. Therefore, the importance of reducing LBW cannot be overemphasized. This can be attempted through a life cycle approach by improving health and nutrition of adolescent girls and encouraging optimum family food, rest, and proper antenatal care during pregnancy.

Iron-folic acid supplementation during pregnancy has a beneficial effect on birthweight and its coverage should be increased. Recent evidence suggests multiple micronutrient suppletions might have an even greater impact (West et al., 2014).

Nutrition education in secondary school (grade 6 to grade 10) curriculum

The current focus of nutrition education in school curricula is very limited. Educational curricula should emphasize the importance of appropriate nutrition for adolescent girls, pregnant and lactating mothers, and breastfeeding and complementary feeding of young infants as routes to better linear growth in Bangladesh.

Water, sanitation and hygiene

Although rates of open defecation have decreased to about 4% in Bangladesh, some critical hygiene and sanitation problems remain. These include proper disposal of excreta; clogged drainage systems and garbage in urban areas; handwashing at critical times; and safe preparation and storage of complementary food. Communications campaigns and further investment in waste management to reduce environmental enteropathy, a potential cause of stunting, can help greatly.

Population control

With a small land mass, Bangladesh has the highest population density in the world. The fertility rate has declined, but it could be brought below replacement levels by rejuvenating the family planning programme and scaling up both temporary and permanent methods of contraception in an inclusive manner.

Poverty alleviation

Although stunting is not restricted to the poor, poverty is a major constraint to ensuring nutritious diets and adequate health care. It also leads to migration rural-
urban migration or poor city areas where the situation is often worse. Currently, 21% of the population is extremely poor (Sen & Ali, 2015); rapid and effective implementation of the government's new social protection strategy and an emphasis on poverty alleviation in the upcoming seventh 5-year plan for the country are essential.

**Food security**

While food insecurity, as assessed for its access to food domain, has declined, it still affects 32% of the population (Helen Keller International and James P Grant School of Public Health, 2013). Opportunities to address food insecurity include improving livelihoods and income and increasing awareness regarding healthy diets and food supplementation where needed, that is, hard to reach or extremely food insecure conditions.

**Literacy**

Low maternal education and low literacy are key determinants of stunting. National efforts to bring and retain girls in schools and colleges need to be intensified.

Bangladesh is clearly a leader in reducing stunting across the South Asia region (Headey et al., 2014), but the levels of stunting still remain too high. For Bangladesh, and for the region, such high rates of stunting are unacceptable. We call for the government, development partners, researchers, and Bangladeshi society to act together to improve the various known drivers of stunting reduction in Bangladesh.

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The authors declare that they have no conflicts of interest.

**Contributions**

TA conceptualized and wrote the first draft of the paper. MH, MM, NC and SA substantially contributed by revising the paper.

**Prevalence of stunting among under-five children in Bangladesh: results of demographic health surveys, 2004–2014**

![Graph showing prevalence of stunting among under-five children in Bangladesh]

**References**


Reducing stunting in Bhutan: an achievable national goal

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The kingdom of Bhutan is a tiny country, landlocked between the two Asian giants of India and China, and has a population of about 762,864 (Bhutan at a glance 2014). Despite the very small size, the country has made remarkable progress towards modern development since initiating planned development in the 1960s. Bhutan has also experienced rapid progress in many of the key determinants of nutrition and health. The life expectancy of the Bhutanese has been increasing steadily over the years, currently standing at 68 years (Statistical Yearbook of Bhutan 2014). The country’s infant mortality rate has declined to 30 per 1000 live births down from 90 per 1000 in 1990 (National Health Survey (NHS) 2012). The 2010 Multiple Indicator Survey showed the prevalence of stunting in children under 5 years to be 33.5%, indicating a 24% decline from 1986 levels (Bhutan MultipleIndicatorSurvey).

Stunting in Bhutan

Stunting or poor linear growth, in young children, is caused by multiple determinants, including antenatal, intra-uterine and postnatal malnutrition (Waterlow 1994). According to the 2010 Multiple Indicator Survey, the prevalence of stunting is higher in the poorer districts, particularly, in the east of the country. In that region, 43% of the children under five are stunted compared with 31% in the West region and 28% in the Central region. In the poorest wealth quintile, the prevalence of stunting is 41% compared with 21% in the richest quintile (Bhutan Multiple Indicator Survey (BMIS) (2011)).

A situation analysis of nutrition in Bhutan points to the following as major determinants of stunting: diarrheal diseases, high parasite loads in parts of the country and high prevalence of Helicobacter pylori infections. Diseases related to environmental and personal hygiene and the poor nutrition and care of women before and during pregnancy were also identified as risk factors for stunting (Atwood et al. 2014).

Improving linear growth in Bhutan

The nutrition agenda, including stunting reduction, has become a national priority in Bhutan. In the current 5-year plan (which ends at 2018), stunting reduction is one of the key performance indicators at the national level, which needs to be achieved by the end of the planned period (Eleventh Five Year Plan (2013–2018) 2013). Specific interventions undertaken by Bhutan in the past decade to reduce undernutrition include a focus on optimizing infant and young child feeding practices, supplementation for children, adolescents and pregnant and lactating women with essential micronutrients and the establishment of treatment and rehabilitation centres in health facilities for severely malnourished children.

Although the interventions undertaken by Bhutan are time-tested and known to have worked in other countries, there is still room for improvement.
Strengthening the existing programmes, and continuing to advocate to high level decision makers, to ensure that nutrition remains the top agenda, is important. Co-ordinating with multiple sectors for targeted funding to improve the coverage and quality of maternal and child nutrition services will also help the nation’s effort to improve linear growth in children. These programmes should be undertaken in the backdrop of broader socio-economic improvements if stunting is to be reduced in the country.

Role of maternal nutrition, child feeding, and household sanitation

Stunting really begins at conception, and maternal nutrition plays an important role in the development and growth of the fetus. Poor maternal nutrition has been related to intrauterine growth retardation and adverse birth outcomes (Villar et al. 2003). In Bhutan, many interventions to promote maternal health and fetal growth are delivered through the health system. It is recommended for pregnant women to come for a minimum of eight antenatal care visits (ANC). An in-depth analysis of determinants of child stunting in Bhutan found that, after controlling for many other variables, children whose mothers received three or fewer ANC visits during the last pregnancy had 31% higher odds of being stunted, while children whose mother did not receive any ANC visits had 51% higher odds of being stunted (Aguayo et al. 2015). ANC promotes optimal nutrition and delivers specific interventions, such as anaemia prophylaxis and treatment, de-worming prophylaxis, monitoring of fetal growth and assessment of the mothers health. However, during the last nationally represented survey, only 26% of pregnant women in Bhutan were found to have had eight ANC visits.

Adequate nutrition during infancy and early childhood is essential to ensure the growth, health and development of children to their full potential. In terms of infant and young child feeding practices, Bhutan has not been faring well. Only 49% of children under 6 months are exclusively breastfed, while 63% of the infants between the ages of 6 and 23 months receive the minimum frequency of complementary feeds. The role of infant and young child feeding is particularly important for Bhutan as children who were not fed complementary foods at 6–8 months had about threefold higher odds of being severely stunted than children who were fed complementary foods (Aguayo et al. 2015).

In Bhutan, 96% of the population use improved sources of drinking water, while 3% of the population practice open defecation. However, only 58% of the population has access to improved sanitation. The lack of safe drinking water and basic sanitation are known to undermine efforts to combat poverty and diseases. The 2010 Multiple Indicator Survey found the highest stunting rates in the eastern region and among people from the poorest wealth quintile, which was also where the sanitation coverage was the lowest.

Future of stunting in Bhutan

Gaps are still present in child feeding, maternal nutrition and household sanitation in Bhutan, but many encouraging changes are also taking place to cover these shortcomings. Every mother in Bhutan is now tracked to ensure that she benefits from the required number of ANC visits; discussions to extend maternity benefits have started among the highest levels of decision makers and advocacy campaigns to improve breastfeeding, and complementary feeding are ongoing. Efforts are also underway to improve water and household sanitation in the country.

In addition to ongoing child feeding, maternal nutrition and household sanitation interventions, Bhutan has also been making significant strides in socio-economic development. Between 2007 and 2012, the percentage of poor halved to 12%, and Bhutan has nearly ended extreme poverty (a low of 2% in 2012) (Bhutan Poverty Assessment 2014). The average economic growth between 2009 and 2013 was 6.7% (National Accounts Statistics 2014), which is a very respectable number for a small donor dependent country (12).

Bhutan’s interventions are similar to the interventions undertaken by Brazil, which were very successful in reducing stunting levels through vast targeted funding to improve access to maternal and child health and nutrition services coupled with broad social, economic and political changes (Requejo 2015).
set of interventions that are already in place and those that are being scaled up, there is no reason why Bhutan cannot replicate or even exceed the Brazilian success.

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**Conflicts of interest**

The authors declare that they have no conflicts of interest.

**Authorship responsibilities**

LD did the research, planning, and manuscript writing. KD did the review and manuscript writing. All authors have read and approved the final manuscript. The opinions expressed in this paper are those of the authors and do not necessarily represent an official position of the organizations they are affiliated with.

**References**


India has among the highest rates of child malnutrition rates in the world, but these rates have been declining rapidly during the past decade. Between 2006 and 2014, stunting rates for children under five in India have declined from 48 to 38% (Global Nutrition Report, 2014). Despite this progress, child undernutrition rates in India are among the highest in the world, with nearly one-half of all children under 3 years of age being either underweight or stunted. India is still home to over 40 million stunted children and 17 million wasted children (Global Nutrition Report, 2014). In addition, the rates of decline have been highly variable across India’s states. Some states, including Arunachal Pradesh, Mizoram and Delhi, had large rates of reduction in stunting, but overall levels of undernutrition remained high because of high baseline rates. Meanwhile, in Uttar Pradesh, Jammu and Kashmir, Manipur and Jharkhand the situation has not changed significantly (Raykar et al., 2015). Similar variability is observed in the prevalence of anaemia rates as well, which range from 38% in Goa to 78% in Bihar (IIPS & Macro International, International Institute for Population Sciences (IIPS) and Macro International, 2007).

Global evidence shows that child malnutrition is only weakly correlated with income. In fact, a quarter of Indian children from the top income quintile were stunted in 2006. Stunting is a marker for poor environmental, maternal and child factors, including poor sanitation, intrauterine growth restriction, micronutrient deficiencies, and sub-optimal infant and young child feeding practices. Current global recommendations for achieving 20% reduction in stunting and 61% reduction in severe wasting include delivery of a set of nutrition-specific interventions at 90% coverage level (Bhutta et al., 2013). These interventions span the continuum of care and include food and micronutrient supplements before and during pregnancy, counselling for initiation of breastfeeding and food and micronutrient supplementation for mothers in the newborn period and breastfeeding counselling, food and micronutrient supplementation along with routine immunization for the under five children (Fig. 1). Available data indicate that less than 50% of mothers and children in India are exposed to a majority of these interventions. The shortfall is greater for iron folic acid supplementation, food supplementation and minimum diet diversity, whereas exclusive breastfeeding and immunization have improved in recent years (Fig. 2).

Policy and programmatic context, implementation guidance and financing

In India, the policy and programme environment to facilitate at-scale delivery of nutrition-specific interventions is broadly in place but varies by intervention. Supportive policies exist (except for community-based management of acute malnutrition, for which guidelines are under development) (Vir et al., 2013). However, operational guidelines and/or monitoring indicators are only available for a few of the interventions (e.g. monitoring indicators do not exist for

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1 This perspective paper was commissioned by the guest editors of this special supplement of Maternal and Child Nutrition to bring country-specific perspectives to the issue of stunting in South Asia. It has not been peer reviewed. The views in this paper are the authors’ views and do not necessarily reflect the views or policies of their organizations.
counselling for infant and young child feeding practices; guidelines are under development for paediatric iron folic acid supplementation). Two national programmes, implemented by separate ministries, Ministry of Women and Child Development and Ministry of Health and Family Welfare, operate across the country and are designed to together deliver all of the nutrition-specific interventions through their frontline workers (Avula et al., 2013). There are, however, gaps in the implementation of these interventions, arising from challenges such as operationalizing interministerial convergence, limited understanding of the frontline worker roles and responsibilities, inadequate training, limited mechanisms for supportive supervision, and the burden of multiple responsibilities for frontline workers and other health staff. In addition to these challenges, operational evidence for at scale implementation of all nutrition-specific interventions, especially across the continuum of care, is limited. There are few published studies and a limited grey literature on how to deliver nutrition-specific interventions in ways that achieve impact, specifically for interventions on complementary feeding counselling, prevention of paediatric anaemia, and treatment of severe and acute malnutrition (Avula et al., 2013).

From a financing perspective, India requires at least $6bn annually to deliver the nutrition-specific interventions at full coverage. A bulk of this amount is required
for food supplementation (39%), while counselling, health interventions and micronutrient supplementation and deworming together require much less – 12% of the total cost (Menon et al., 2015). The cost of implementing the interventions varies tremendously by the state and is driven by the target population base of the state. Thus, populous states like Uttar Pradesh require more funds (close to $1bn) for delivering the interventions compared with states like Kerala or Chhattisgarh. A challenge for India, looking ahead, is managing fiscal devolution appropriately for health and nutrition to ensure that at the state-level, adequate financing will continue to be available, along with capacity to manage the delivery of nutrition interventions across the continuum of care.

**Underlying determinants of nutrition and nutrition-sensitive interventions**

Several factors influence stunting other than those addressed through nutrition-specific interventions. Antenatal care, decreased open defecation, low fertility, agriculture, safe water and sanitation, women’s education and empowerment, and the quantity and quality of food available have been the key drivers of stunting reductions, while income growth and governance played a facilitating role (Headey et al., 2014; Smith & Haddad, 2014). Nearly 55% of the population in India defecates in the open, which puts them at greater risk of enteric diseases (Ministry of Women and Child Development, 2014), and only 12% of women have secondary school education (Ministry of Home Affairs. Census, 2011). To achieve accelerated reductions in stunting, increased investments in programmes that address these underlying determinants are imperative (Ruel et al., 2013). Poverty, food insecurity, early marriages, high fertility rates and birth spacing have to be addressed to achieve greater reductions in stunting.

India has several social safety net programmes that aim to enhance food security and bridge gaps in seasonal availability of work. The national food security act aims to extend coverage of consumer food subsidy, provide subsidized grains and other essential commodities through the Public Distribution System. The supplementary nutrition programme of the Integrated Child Development Services aims to bridge the calorie and nutrient gap among pregnant and lactating women and children under 6 years, while the Mid-Day Meal scheme attempts to do the same for school children. The National Rural Employment Guarantee Scheme aims to provide work to ensure resources at home in rural areas during non-agriculture seasons. Additionally, there is a national campaign, the Swachh Bharat Abhiyan, to improve sanitation facilities and their usage through providing support for building toilets. Across the states, however, these programmes are fraught with different implementation challenges such as poor targeting, leakages, inadequate infrastructure, corruption and delayed payments, and this is reflected in the state of these underlying determinants (Raykar et al., 2015). It is timely, therefore, to revisit programme designs and to identify and test new approaches to plug implementation gaps if these large-scale social safety net programmes are expected to influence the underlying determinants of stunting.

**The way forward**

India has several existing policies and programmes, both nutrition-specific and nutrition-sensitive to address several known drivers of stunting, other dimensions of nutrition and child development. However, the utility and impact of these programmes will vary across India due to gaps in the implementation of the policies and programmes. Gaps in implementation are often a result of complicated design of the programmes, lack of operational guidelines, limited financial and human resources for adequate and high quality implementation, poor monitoring and lack of political commitment at the state level. There is a need for focused efforts on closing implementation gaps and building evidence, revisiting programme designs, and establishing feedback mechanisms to inform policy and programmatic decisions.

In conclusion, an all-out effort is now needed to improve the functioning of nutrition-specific interventions as well as a focus on addressing underlying social factors by reducing income inequality, improving the health and social status of women, scaling-up water and sanitation services, and addressing food insecurity.
The most critical aspect is to ensure that all of these multiple investments converge at the same time, at the same place, for the same mother–child dyad. India’s birth cohort of 27 million babies each year deserve better life conditions than those that await them at present (Raykar et al., 2015).

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Contributions

RA and PM drafted the commentary. NR and RL revised the draft. All the authors read the final commentary and approved it.

Conflicts of interest

The authors declare that they have no conflicts of interest.

References


Globally, nearly half of all under-five deaths annually (3 million deaths) are attributable to undernutrition, as malnutrition is associated with increased risk of morbidity and infections, which leads to mortality (Liu et al. 2015). In 2011, at least 165 million children worldwide were stunted, and 52 million were wasted, with higher prevalence in south Asia and sub-Saharan Africa. Malnutrition is not confined to children but is also rampant among women of reproductive age. This maternal malnutrition contributes to fetal growth restriction, which leads to low birthweight and increased risk of childhood infections and mortality. Children exposed to these risks early in life have a higher risk of growth faltering and stunting, which can cause long-term irreversible and detrimental cognitive, motor and health impairments (Black et al. 2013). Most of the irreversible damage due to malnutrition occurs during gestation and in the first 24 months of life, hence underscores the importance of intervening in this period.

Malnutrition is widespread in Pakistan among all ages, and the progress has not been encouraging over the last decade. One-third of children in Pakistan are underweight, 44% are stunted, 15% are wasted, half of them are anemic, and almost one-third of the children have iron deficiency anemia (Table 1) (Government of Pakistan 2011). There is prominent inequity between the nutritional indicators of urban and rural populations, and children from the poorest wealth quintile are faring the worst. Among women, 14% of women of reproductive age are thin or undernourished (BMI less than 18.5 kg/m²), and this prevalence is highest among the poorest, uneducated and rural-dwelling women. Micronutrient deficiencies are also prevalent among women with half of the women anaemic and high rates of vitamin A, zinc and iron deficiencies (Government of Pakistan 2011). Figure 1 shows that stunting prevalence varies greatly within Pakistan’s districts, ranging between 22% and 76%. The lowest figures for wasting and underweight were both less than 2.5% and the highest were 42% for wasting and 54% for underweight (Di Cesare et al. 2015).

Current recommendations for improved infant and young child nutrition (IYCN) include initiation of breastfeeding within 1 h of birth, exclusive breastfeeding of infants until 6 months of age, introduction of safe and nutritionally rich foods in addition to breastfeeding at about 6 months of age and continued breastfeeding with complementary feeding until 2 years of age or older. All IYCN indicators in Pakistan are ‘undesirably low’ even when compared with other countries in the South Asian region. Pakistan is conspicuous for having the lowest rates for early initiation of breastfeeding, exclusive breastfeeding rates and timely initiation of complementary feeding (Table 2); and the highest rate in the region for bottle feeding. Latest data suggest that immediate breastfeeding is initiated in 18% of all births, whereas exclusive
breastfeeding is carried out in only 38% of infants younger than 6 months in 2011. In Pakistan, 20% of children aged 2 months and 46% aged 9 to 11 months were reported using bottles with nipples and 19% of children aged 4–5 months were being fed solid to semi-solid food. In addition, complementary feeding practices are far from optimal as 15% of the children meet the minimum acceptable diet and 22% observe minimum dietary diversity (Government of Pakistan 2011; Pakistan Demographic and Health Survey 2013).

**Underlying determinants and interventions**

Several factors account for these failures in improving child-feeding practices and hence nutrition. There is a general lack of awareness among the population regarding optimal feeding practices and other social taboos and misconceptions (such as the concept of ‘hot and cold foods’ or inappropriateness of foods for children) that further affect practices. The promotion and marketing of infant formulas is a recognized barrier for exclusive and predominant breastfeeding practices. To improve child nutrition and reduce stunting, it is imperative to focus on other parallel factors including improving maternal nutrition and antenatal care and especially nutrition of adolescent girls and young mothers. Low literacy rates among women, their lack of empowerment and involvement in decision-making, early marriages, high fertility rates with lack of birth spacing, and poor access to health care facilities are all important determinants of child and maternal malnutrition. To this must be added measures to prevent common childhood illnesses such as diarrhea and acute respiratory infections and improve access to timely and quality care. Other factors affecting nutrition include poverty, food insecurity, unsafe water, poor sanitation and environmental hygiene. Recent data in Pakistan suggest that about 58 million people (36%) either defecate in the open or have access to shared toilets, in rural areas, 45% of the population still practice open defecation. Around 50% of the population has access to piped water, while other measures indicate that the majority of households (90%) do not treat their drinking water, and only 8% of households use an appropriate water treatment method (Government of Pakistan 2011).

In addition to the lack of progress, there are also widespread disparities in health care accessibility and quality that need to be bridged. Bringing the health services closer to women and children would make the difference. Pakistan has an extensive existing lady health workers programme, which with improvements can pave the way to reduce these inequalities. Social safety nets are another recognized medium, which can be implemented. There is a need to ensure regular data on nutrition indicators with more discrete regional-level or district-level data. There is need for integrating various different sectors and programmes to achieve the desired results effectively and efficiently as many of the determinants and influencing factors are outside the health sector. A behavioral change communication activity should be designed and implemented at national level to impart the IYCN messages, and these messages (behavioral change communication) should be tailored to the local needs and should be very specific and clear, and it should be given at the same level so that mother should associate with it. Promotion of practices that promote healthy lifestyle, food availability, diversity, access, proper storage, preparation and utilization among economically disadvantaged segment of population should be ensured. Religious leaders in Pakistan can play a vital role in this advocacy as the Holy Quran has advised breastfeeding for 2 years, this must be used as a motivating agent in all advocacy campaigns, and religious leaders must be given detailed

### Table 1. Malnutrition status of children in Pakistan

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Stunted (%)</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-23 months</td>
<td>18.3</td>
<td>18.3</td>
</tr>
<tr>
<td>24-59 months</td>
<td>24.9</td>
<td>24.1</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Wasted (%)</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-23 months</td>
<td>8.8</td>
<td>11.7</td>
</tr>
<tr>
<td>24-59 months</td>
<td>5.2</td>
<td>8.2</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Underweight (%)</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>Moderate</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-23 months</td>
<td>13.1</td>
<td>18.6</td>
</tr>
<tr>
<td>24-59 months</td>
<td>11.4</td>
<td>19.4</td>
</tr>
</tbody>
</table>
trainings on the code. The skills of health care providers should be enhanced to ensure optimum nutrition during pregnancy and early infancy and this should include lactation support.

The way forward

Improving maternal and child nutrition and reducing stunting require concerted efforts across a broad range of measures, legislation and policies, which can be universally implemented. There has been a singular lack of emphasis on nutrition promotion in the public sector primary health care initiatives. A set of measures that can impact stunting in Pakistan must include multisectoral initiatives. All the provinces in Pakistan have recognized that improving nutritional status of the population would require a multipronged approach with both nutrition-sensitive and nutrition-specific approaches. Although these ‘multisectoral nutrition strategies’ have been approved, implementation remains variable. There is clear need for implementation plans and commensurate political will and leadership to bring about change at the grassroots. This would need a nutrition lens for defining, implementing and measuring nutrition-sensitive interventions, especially in sectors including agriculture, water and sanitation, education, poverty alleviation and social protection. Some of these measures include

- Attention to developing and deploying human resources for nutrition at district level. A critical mass of people is required at all levels from policymakers, implementers, supervisors, health care professionals and community workers. These workers should have expertise and training in nutrition and work full time on nutrition activities in both nutrition sensitive and specific sectors.

- Improving nutrition will require food safety and social protection. Pakistan has cash transfer

**Table 2.** Breastfeeding and complementary feeding rates in Pakistan

<table>
<thead>
<tr>
<th></th>
<th>NNS 2011</th>
<th></th>
<th>DHS 2013</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Exclusive under 6 months</td>
<td>2174</td>
<td>13</td>
<td>1164</td>
<td>37.7</td>
</tr>
<tr>
<td>Continued breastfeeding</td>
<td>1616</td>
<td>77.3</td>
<td>864</td>
<td>80.6</td>
</tr>
<tr>
<td>12-15 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continued breastfeeding at 2 years</td>
<td>753</td>
<td>54.3</td>
<td>837</td>
<td>56</td>
</tr>
<tr>
<td>Age-appropriate breastfeeding children (0-23 months)</td>
<td>9083</td>
<td>63.6</td>
<td>4262</td>
<td>56</td>
</tr>
<tr>
<td>Introduction of semi-solid (6-8 months)</td>
<td>1591</td>
<td>51.3</td>
<td>466</td>
<td>66</td>
</tr>
<tr>
<td>Minimum dietary diversity (6-23 months)</td>
<td>6909</td>
<td>3</td>
<td>2855</td>
<td>22.2</td>
</tr>
<tr>
<td>Minimum meal frequency (6-23 months)</td>
<td>6909</td>
<td>56.4</td>
<td>2855</td>
<td>62.7</td>
</tr>
<tr>
<td>Minimum acceptable diet (6-23 months)</td>
<td>6909</td>
<td>7.3</td>
<td>2855</td>
<td>14.8</td>
</tr>
</tbody>
</table>


**Fig. 1.** District comparisons of undernutrition in Pakistan.
programmes and Bait-ul-Maal funds, and these transfers can be conditionally linked to health and nutrition services, with upward revision in cash transfer amounts to adjust for food inflation and linkage of beneficiaries with livestock and agriculture schemes.

- There are significant nutritional needs for women of reproductive age in Pakistan, and some of the associations with maternal height reflect intergenerational problems, and others reflect more acute exposures during pregnancy. Addressing fetal growth retardation and small for gestational age births, estimated to account for over a quarter of all births, may also reduce the burden of stunting in young infants and improve developmental outcomes. Targeting women nutrition way before pregnancy and during adolescence and preconception care provides a window of opportunity, which can bear enduring results for generations to come.

- Pakistan must do better to improve rates of exclusive breastfeeding. This requires mass education and stringent implementation of the ‘International Code of Marketing of Breast-milk Substitutes’. Additionally, support structures for working mothers to continue breastfeeding must be provided including paid maternity leave beyond the current limitations, availability of child care centers and designated area for breastfeeding at work place as well as support for women working in the non-formal sectors.

- Beyond breastfeeding, Pakistan has never had a concerted programme to improve complementary feeding, which is a major determinant of linear growth deviation after 6 months of age. The current focus and guidelines on complementary feeding are particularly poor. Interventions are needed to optimize the timing of introduction of complementary foods, with appropriate low-cost fortified foods or in food secure households, appropriate home available diets. In high-risk food insecure households, consideration should be given to the provision of low-cost commodities for complementary feeding.

- Amidst the water scarcity crisis in Pakistan, public-sector investments are essential in providing secure and safe water to the population. Similarly, a massive national campaign must be launched to improve environmental and living conditions, promote the use of toilets and reduce the risks of fecal contamination.

The situation in Pakistan is ripe for change with a greater current emphasis on nutrition and formulation of various national and provincial nutrition focused strategies; policy makers and planners need to recognize the importance of improved child health and nutrition for national development and look at nutrition strategies as a net investment in the nation’s future.

Conflict of interest

The authors declare that they have no conflicts of interest.

Contributions

All authors contributed to the writing.

References


Nepal has made impressive gains in health and nutrition despite being in a state of political, economic and demographic transition. According to the Nepal Demographic Health Surveys, stunting in Nepal has fallen from 57% in 2001 to 41% in 2011, an annual decline of 1.7 percentage points. A 3.9% annual reduction is, however, required to achieve the global target of 40% fewer stunted children by 2025. The Multiple Indicator Cluster Survey conducted in 2014 by the Central Bureau of Statistics and UNICEF indicated a further reduction in the proportion of stunted children to 37.4%. The recently drafted Sustainable Development Goal for Nepal, 2016–2030 has outlined a daunting challenge of reducing stunting in children under 5 years of age to 1% by 2030 for the long-term health, wellbeing, human capital development and national economic growth.

Stunting, which is caused by long-term nutrition deprivation early in a child’s life, often begins before birth and is associated with increased risk of mortality from infectious diseases such as diarrhoea, pneumonia and measles in childhood (Pelletier et al. 2012; UNICEF 2013). It also leads to irreversible physical and cognitive damage, and poorer educational outcomes later in childhood and adolescence, with economic consequences for the individual, household and community levels (Walker et al. 2007). Stunted children who experience rapid weight gain after 2 years of age have increased risk of becoming overweight or obese later in life, with associated higher risk of non-communicable diseases like coronary heart disease, stroke, hypertension and type II diabetes (Black et al. 2013).

The determinants of linear growth failure in Nepal consist of factors operating at different levels of causation and include poverty, low maternal education and food insecurity. Underlying causes include poor caring behaviours, including infant and young child feeding, inadequate access of households to a diverse and quality diet, low access to health care and repeated infections due to unhealthy environment. Less than half (46%) of newborns are breastfed within 1 h after birth, while 70% of infants younger than 6 months are exclusively breastfed. Only 66% are introduced to complementary foods at 6–8 months, and more importantly, complementary feeding is infrequent and inadequate in terms of quality, quantity and safety. Only a quarter of children (24%) are fed with the recommended infant and young child feeding practices (breastfeeding or receiving milk products, four or more food groups, and a minimum meal frequency according to their age and breastfeeding status) (MoHP, NEW ERA, et al. 2012).

Almost all stunting takes place in the first 1000 days after conception (Dewey & Vitta 2013). Evidence reinforces the importance of the nutritional status of women at the time of conception and during pregnancy for healthy fetal growth and development (Gluckman & Pinal 2003; Black et al. 2013). Intrauterine growth retardation due to maternal undernutrition is known to account for 20% of childhood stunting. Other maternal contributors to child stunting include short stature, short birth spacing and adolescent pregnancy (Prakash et al. 2011). Nearly a quarter (23%) of mothers in Nepal...
give birth before 18 years of age, while about half have given birth by the age of 20. Currently, 18.2% of Nepali women and 25.8% adolescents have a low body mass index. The prevalence of anaemia in pregnant women – despite the intensification effort – stands at 48% and is increasing, which is clearly above the World Health Organisation threshold of ≥40%, indicating that maternal anaemia is a severe public health problem. Thus, the health, nutritional and social status of women is an important area for investment to reduce stunting even further in Nepal.

There exists substantial inequity in stunting rates between population subgroups because of the complex interplay of geographic, social, economic and political realities. Children from the poorest households are more than twice as likely to be stunted (56%) compared with children in the wealthiest households (26%). Similarly, children in rural areas are more likely to be stunted (42%) than those in urban areas (27%), and ecologically, the mountain zone has the highest proportion of stunted children (53%). Past trends show that declines in stunting were greater among wealthier (fourth and fifth) quintiles than the poorest quintile, indicating that an equity lens is important (Bredenkamp et al. 2014).

Efforts have recently steered towards scaling up evidence-based cost effective, nutrition-specific and sensitive interventions with a focus on reducing undernutrition among adolescent girls, pregnant and lactating women, and all children under 24 months of age. Nepal is an early riser in the global Scaling Up Nutrition movement, and this has substantially elevated and energised the national discourse on maternal and child nutrition. An ambitious Multi-sector Nutrition Plan, endorsed by the Government of Nepal and supported by Nepal’s development partners, is being rolled out. It links undernutrition with water, sanitation and hygiene, agriculture, education and local governance, are expected to be utilised to design and implement the programmes. The plan is being rolled out gradually in different parts of the country.

The strong momentum and commitment in the present context must be harnessed with political commitment, policy and programmatic coherence, capacity enhancement and accountability at the national and subnational levels, and community involvement through effective communication and advocacy. Strong monitoring and accountability systems must be put in place to know if current efforts are yielding the benefits that are anticipated.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

MDD developed the draft of the country paper, RKA and SRU reviewed the drafts and provided technical inputs. All authors read and approved the final version of the paper.

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Introduction

3 Stop stunting: improving child feeding, women’s nutrition and household sanitation in South Asia
Víctor M. Aguayo and Purnima Menon

Review Articles

12 Childhood stunting: a global perspective
Mercedes de Onis and Francesco Branca

27 Reducing stunting by improving maternal, infant and young child nutrition in regions such as South Asia: evidence, challenges and opportunities
Kathryn G. Dewey

39 Feeding practices for infants and young children during and after common illness: evidence from South Asia
Kajali Paintal and Víctor M. Aguayo

51 Can breastfeeding, nutrition and hygiene help eliminate stunting? Current evidence and policy implications
Dilsin C. Vir

83 Preventing severe childhood anaemia through improved water, sanitation and hygiene: an opportunity for stunting reduction in developing countries
Miqdad Ali, K. M. Maleka and Jeannet A. Humphrey

Original Articles

121 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
Víctor M. Aguayo, Rajanath Naik, Nikita Badgaiyan and Sunam Chakrabarti

141 Achieving behaviour change at scale: Alive & Thrive’s infant and young child feeding programme in Bangladesh
Tina Sanghvi, Airak Naqvi, Sumitro Roy, Kaveri Athana, Reena Sidel, Sanjukta Islam, Ann Johnson and Ann Baker

155 Evidence-based evolution of an integrated nutrition-focused agriculture approach to address the underlying determinants of stunting
Nancy J. Haselow, Ame Stormer and Alissa Pries

186 The costs of stunting in South Asia and the benefits of public investments in nutrition
Meera Shekar, Julia Dayton Eberwein and Jakub Kakietek

205 Understanding the null-to-small association between increased macroeconomic growth and reducing child undernutrition in India: role of development expenditures and poverty alleviation
William Joe, Rajanath Naik and S. V. Subramanian

210 Drivers of nutritional change in four South Asian countries: a dynamic observational analysis
Derek Headey, John Hoddinott and Seollee Park

219 Rethinking policy perspectives on childhood stunting: time to formulate a structural and multifactorial strategy
S V Subramanian, Juan Mejía-Guevara and Aditi Krishna

Commentaries

237 Stop stunting: situation and way forward to improve maternal, child and adolescent nutrition in Afghanistan
Andi Cahya Ho, Stijn Vanhee, Shabana Khan, Hamayoun Lodin, Najafollah Safi and Zulfiquar A. Bhutta

240 Improving breastfeeding children in Bangladesh
Tanweer Ahmed, Moulupati Hossain, Muthu Marfah, Naqash Choudhury and Shaheen Ahmed

246 Reducing stunting in Bhutan: an achievable national goal
Jagdip Devi and Khine Wanyo

249 Reducing stunting in India: what investments are needed?
Kavita Arora, Neha Raykar, Purnima Menon and Ramanan Laxminarayan

256 Stop stunting: Pakistan perspective on how this could be realised
Abid A.C. Alias, Abdul Aziz Khan Artakhan and Zulfiquar A. Bhutta

257 Stunting in Nepal: looking back, looking ahead
Muddu Dutt Devkota, Ramesh Kanti Adhikari and Senendra Raj Uperti