CHILD STUNTING, HIDDEN HUNGER
AND HUMAN CAPITAL IN SOUTH ASIA

Implications for sustainable development post 2015
Contributors:


Corsi, Daniel: Harvard Center for Population and Development Studies, Cambridge, MA, USA.*

Harding, Kassandra L.: Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA.

Kim, Rockli: Harvard Center for Population and Development Studies, Cambridge, MA, USA.

Krishna, Aditi: Harvard Center for Population and Development Studies, Cambridge, MA, USA.*

McGovern, Mark E.: Harvard Center for Population and Development Studies, Cambridge, MA, USA.*

Mejía-Guevara, Iván: Harvard Center for Population and Development Studies, Cambridge, MA, USA.*

Perkins, Jessica M.: Harvard Center for Population and Development Studies, Cambridge, MA, USA.*

Rasheed, Rishfa: South Asian Association for Regional Cooperation (SAARC) Secretariat, Kathmandu, Nepal.

Subramanian, S.V.: Harvard Center for Population and Development Studies, Cambridge, MA, USA.

Torlesse, Harriet: UNICEF Regional Office for South Asia (ROSA), Kathmandu, Nepal.

Webb, Patrick: Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA.

*Contributor's affiliation at the start of the research and/or when the bulk of the research was conducted

The findings, interpretations and conclusions expressed in this report are those of the authors and do not necessarily reflect the policies and views of UNICEF.

Permission to copy, disseminate or otherwise use the information in this report is granted as long as appropriate acknowledgement is given.


Design by: EKbana Solutions

Photograph credits:
Cover page: © UNICEF/2010/Pirozzi
Pages vi: © UNICEF/2014/Qadri
Page x, 21, 22: © UNICEF/2016/Giacomo
Page 36: © UNICEF/2017/Brown
CHILD STUNTING, HIDDEN HUNGER
AND HUMAN CAPITAL IN SOUTH ASIA

Implications for sustainable development post 2015
# ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AARR</td>
<td>Average annual rate of reduction</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence interval</td>
</tr>
<tr>
<td>DHS</td>
<td>Demographic and Health Survey</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>HAZ</td>
<td>Height for age z-score</td>
</tr>
<tr>
<td>IFPRI</td>
<td>International Food Policy Research Institute</td>
</tr>
<tr>
<td>IQ</td>
<td>Intelligence quotient</td>
</tr>
<tr>
<td>LMIC</td>
<td>Low and middle income countries</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>SDG</td>
<td>Sustainable Development Goal</td>
</tr>
<tr>
<td>SUN</td>
<td>Scaling Up Nutrition</td>
</tr>
<tr>
<td>UIE</td>
<td>Urinary iodine excretion</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
</tr>
<tr>
<td>VAD</td>
<td>Vitamin A deficiency</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>YLD</td>
<td>Years lived with disability</td>
</tr>
</tbody>
</table>
South Asia’s policy decision makers today have vital choices for the economic growth and prosperity of the region. With inequality rising, the demographic dividend diminishing and middle income traps threatening, the social and economic options have never been more daunting, or more promising. Today, the most prominent source of economic growth lies in cognitive and human capital.

Cognitive and human capital cannot be mined or traded, but rather must be carefully cultivated by forward-looking policies. Investments in children, particularly in the earliest years, yield dividends that help pave the way to an economic prosperity characterized by the achievement of cognitive and human capital.

Events in early life influence cognitive and human capital. During the first one thousand days between conception and a child’s second birthday, the brain is developing at an enormous rate. Vitamins, minerals and other nutrients are essential for healthy brain development. If they are in short supply to the mother during pregnancy or the child following birth, there can be considerable consequences for growth, brain development, learning and productivity.

This regional report raises a serious concern that poor nutrition in early life is very common in South Asia and is holding back children, their families and nations from prosperity. The region has a higher percentage (35%) and number (59.4 million) of stunted children than any other region in the world. Stunted children are short for their age, and stunting signals that they have been deprived of nutrients for linear growth and for the growth of essential organs, including the brain. There has also been insufficient progress in reducing vitamin and mineral deficiencies (known as ‘hidden hunger’) in women and children in the region.

Poor nutrition in early life is not only very common, it is also extremely costly. The annual economic losses from low weight, poor growth, and vitamin and mineral deficiencies average 11% of GDP in Asia and Africa. Yet, the returns on investments to prevent stunting and hidden hunger are considerable. Every one centimetre increase in height is associated with a 4% increase in wages for men and 6% increase in wages for women, and every US$ 1 invested in interventions to reduce stunting will have an average return of US$ 18.

These findings highlight that investments in cognitive and human capital must begin in early life if children are to achieve their learning potential and benefit from education and training opportunities in later life. These investments should address the main drivers of stunted growth and hidden hunger, including the poor nutritional status of adolescent girls and women, both before and during pregnancy, poor diets of children in the first two years of life, and poor sanitation and hygiene. Cost-effective interventions are available but they need to reach all children, particularly those who are most marginalized and disadvantaged, as articulated in SAARC’s South Asia Action Framework for Nutrition.
Introduction

The early years of a child’s life provide the best opportunity to nourish physical and brain development. There is mounting evidence that poor nutrition in early life can have long lasting consequences for learning and future productivity (Victora et al., 2008). When a girl or boy becomes stunted, it signals that they have been deprived of nutrients for linear growth and for the growth of essential organs, including the brain. These links explain why nutrition has the potential to transform the lives of the world’s most vulnerable citizens and why it is so central to the achievement of the Sustainable Development Goals (Development Initiatives, 2017).

Policy makers require evidence on the impact of poor nutrition on human capital and the long-term benefits associated in investments to improve nutrition so that they can take informed decisions on the allocation of resources. Nowhere is this more crucial than South Asia, which bears the highest prevalence (35.0%) and burden (59.4 million) of stunted children of all regions in the world (UNICEF et al., 2018) and where micronutrient deficiencies, known colloquially as hidden hunger, continue to be a public health concern.

The aim of this report is to review the evidence on the human and economic impacts of stunting and hidden hunger and the implications for South Asia. Chapter 1 reviews the current evidence linking stunting with child development, economic outcomes in adulthood and economic growth in low- and middle-income countries. It then examines where to focus policy and programme attention in South Asia by exploring recent temporal trends, socioeconomic inequities and predictors of stunting in children aged 6-23 months in the five South Asian countries that account for over 95% of the region’s stunting burden: Afghanistan, Bangladesh, India, Nepal and Pakistan. Chapter 2 presents an overview of the evidence on the human and economic impacts of micronutrient deficiencies, and recent patterns and trends in micronutrient deficiencies across
South Asia. It draws on the most recent surveys and datasets to highlight where gains have been made and where a lack of progress continues to be of concern.

Key findings

There is considerable evidence from many low- and middle-income countries that support a plausible link between stunting and poor child development. The effect sizes vary by development domain, with greater effects indicated for cognitive and schooling outcomes. There is also evidence of positive synergistic interactions between nutrition and early stimulation on child development. These effects on child development in early life appear to have long-lasting economic impacts. For example, two long-run evaluations found that child nutrition interventions increased adult wages by 25% (Hoddinott et al., 2008) and 46% (Gertler et al., 2014), while a one centimetre increase in stature is associated with a 4% increase in wages for men and 6% increase in wages for women (McGovern et al., 2017).

The most common micronutrient deficiencies in South Asia – iron, vitamin A, iodine and zinc – cause so much impairment to intellectual development, physical growth, health and productivity that their hidden impacts on the economy can also be considerable. Iron-deficiency anaemia costs low-income countries an estimated 4% of national income (Horton & Ross, 2003), while low vitamin A status is associated with an annual loss of 1% of gross national product (Meenakshi et al., 2010). More often than not, multiple micronutrient deficiencies combine together in the same individual, and with other nutrition deficits. Anemia and iodine deficiency was associated with a 1% annual fall in national economic growth rates (Madsen, 2016), and annual economic losses from low weight, poor growth, and micronutrient deficiencies average 11% of GDP in Asia and Africa (IFPRI, 2016).

The returns on investments to prevent stunting and micronutrient deficiencies are considerable. An analysis of country-specific cost-benefit ratios for interventions that reduce stunting had a mean value of 1:18 (Hoddinott et al., 2013a), while a separate study found that a combination of investments to prevent micronutrient deficiencies could generate annual benefits of US$ 15.3 billion at a cost:benefit ratio of 1:13 (FAO, 2013).

This body of evidence has immense implications for South Asia. Although stunting has declined in the region, the current prevalence remains unacceptably high. Socio-economic disparities have not declined over time and in some cases increased for the most deprived children. In the pooled analysis for the five countries, short maternal stature and the delayed introduction of complementary foods are associated with a significantly higher odds of stunting in infants aged 6-8 months. In children aged 6-23 months, short maternal stature, low household wealth, maternal underweight, failure to meet children’s minimum dietary diversity, lack of maternal education and mother’s low age at marriage were the strongest correlates of child stunting. In addition, children who are not fully vaccinated or are not fed with a minimum frequency are at a higher risk of being severely stunted.

In addition, there has been little progress across South Asia in resolving hidden malnutrition. Several countries have seriously high levels of micronutrient deficiencies and others have pockets of unusual severity. The region has the highest burden of vitamin A deficiency in children and anaemia in children and women in the world (Stevens et al., 2013, Stevens et al., 2015), and the per capita supply of zinc is highly inadequate (Marc et al., 2016). The underlying and proximate drivers of deficiencies are numerous, and their respective roles vary by country context. However, lower household wealth, lower maternal education, pregnancy status and increasing parity, and poor quality diets are common drivers of anaemia in women.

Implications for South Asia

South Asia’s insufficient progress in resolving stunting and hidden hunger affects the survival, growth, development and future livelihoods of children, and continues to hamper the region’s attempts to accelerate human capital formation. Improvements in child linear growth and micronutrient nutrition will allow young children to reach their full growth and development potential and expand their economic opportunities as adults, generating substantial economic returns at the individual and society level, as well as significant increases in economic growth.

Preventing child stunting and micronutrient deficiencies should be moved to the forefront of advocacy, policy, programme, and research agendas in the region. This renewed attention should focus on the following priorities:

- South Asian countries need to universalize evidence-based policies and programmes designed to improve the nutrition situation of young children and their mothers as a national development priority. Nutrition investments that
focus on adolescence and the 1000 days from conception to age two years are cost-beneficial. Research evidence indicates that packages that combine context-specific nutrition, care, and stimulation interventions may bring about the greatest impact on stunting.

- Greater attention needs to be paid to ensure that economic growth reduces persistent inequities and addresses the drivers of child stunting and hidden hunger among the most vulnerable population groups. There is increasing consensus that economic growth will only be effective in addressing child stunting if increases in national income are directed at improving the diets of children, strengthening the status of women, addressing inequities, and reducing poverty.

- Nutrition-specific and nutrition-sensitive programmes should be implemented jointly to address the main drivers of stunted growth and hidden hunger in South Asian children. Nutrition-specific interventions, such as the protection, promotion and support of breastfeeding, appropriate complementary foods and feeding, care and hygiene practices, adolescent girls’ and maternal nutrition, micronutrient supplementation, food fortification, and the prevention and treatment of severe acute malnutrition and infectious diseases, should be combined with nutrition-sensitive programmes that address the more distal determinants of undernutrition through agriculture, water, sanitation and hygiene, education and social protection.

- There is a need for research and programmatic evidence to better understand how to drive faster and larger declines in stunting and hidden hunger in South Asian countries, particularly among the most vulnerable children: the youngest, poorest, and the socially excluded. Understanding how best to scale up programmes to improve children’s growth and development is key area of further inquiry.
CHILD STUNTING AND HUMAN CAPITAL IN SOUTH ASIA

Rockli Kim, Aditi Krishna, Mark E. McGovern, Iván Mejía-Guevara, Jessica M. Perkins, Daniel Corsi, S.V. Subramanian, and Victor M. Aguayo

Introduction

In 2017, there were 151 million stunted children worldwide. Importantly, about 24% of children younger than five years in low and middle income countries (LMICs) had stunted growth (UNICEF et al., 2018). Stunting is a linear growth failure that has severe short-term and long-term consequences (Aguayo & Menon, 2016; Onis & Branca, 2016). For instance, stunting is associated with increased morbidity and mortality from infections, in particular pneumonia and diarrhea (Black et al., 2008; Kossmann et al., 2000; Olofin et al., 2013), and is the cause of about one million child deaths annually (Aguayo & Menon, 2016). Furthermore, growth failure in infancy and early childhood is associated with reduced stature in adulthood (Coly et al., 2006; Stein et al., 2010), increased risk of maternal, perinatal and neonatal mortality (Lawn et al., 2005; Özaltin et al., 2010), and increased risk of chronic diseases, including elevated blood pressure, renal dysfunction and altered glucose metabolism (Huxley et al., 2000; Victora et al., 2008; Whincup et al., 2008), especially when accompanied by rapid weight gain in later childhood (Gluckman et al., 2007). In addition, evidence shows that stunting has functional consequences that hamper the development of entire societies. Stunting in early childhood is associated with poor cognition (Prendergast & Humphrey, 2014) and worse educational performance in school-age children (Adair et al., 2013; Martorell et al., 2010a), as well as lower productivity and reduced earnings in adult men and women (Hoddinott et al., 2013a).

To understand the full impact of stunting in early childhood, we review current evidence linking stunting to child development and individual and national
economic outcomes. In Section 1, we summarize the evidence on stunting and child development in low- and middle-income countries and discuss the issues for further research. We focus on studies measuring low height-for-age caused by experiences of chronic nutritional deprivation among children less than 5 years old as the exposure and gross/fine motor skills, psychosocial competencies, cognitive abilities, or schooling and learning milestones as outcomes. This review highlights three key findings. First, the variability in child development tools and metrics used among studies and the differences in the timing and frequency of the assessments complicate comparisons across study findings. Second, despite methodological differences and differential associations, considerable evidence from across many countries supports an association between stunting and poor child development. Effect sizes differ by development domain with greater effects shown for cognitive/schooling outcomes. How stunting influences child development, which domains of child development are more affected, and how the various domains of child development influence one another require further research. Finally, there is some evidence of positive synergistic interaction between nutrition and stimulation on child development. However, understanding how best to improve child developmental outcomes – either through nutrition programs or integrated nutrition and psychosocial stimulation – is a key area of further inquiry.

Focusing on the costs of stunting to children and societies supports the case for investing in childhood nutrition. In Section 2, we review the literature on the association between stunting in early childhood and economic outcomes in adulthood. At the national level, we also evaluate the evidence linking stunting to economic growth. Two long-run evaluations of randomized childhood nutrition interventions indicate substantial returns to the programs (a 25% and 46% increase in wages for those affected as children). Cost-benefit analyses of nutrition interventions using calibrated return estimates have been found to range from 3.5:1 to 42.7:1 per child, with a median of 17.9:1. Assessing the wage premium associated with adult height, we find that the median return to a 1 centimetre increase in stature is associated with a 4% increase in wages for men and a 6% increase in wages for women in the set of studies that have attempted to address unobserved confounding and measurement error. In contrast, the evidence on the impact of economic growth on stunting is mixed. South Asia bears 40 percent of the global burden of child stunting. Hence, the third and fourth sections specifically focus on trends in stunting rates and risk factors of stunting in South Asia. In Section three, we provide a comprehensive analysis of social and economic inequalities in stunting prevalence, within and among South Asian countries and stunting rates over time. We also investigate inequalities in stunting due to multiple dimensions of deprivation (poor child diets, low maternal education, and household poverty). Based on a time-series analysis using multiple, cross-sectional Demographic and Health Surveys (DHS) on children aged 6 to 23 months in Bangladesh, India, Nepal, and Pakistan from 1991-2014, we find that all countries had markedly high stunting prevalences and that, although stunting rates declined in all countries, Bangladesh and Nepal recorded the largest reductions. Moreover, we find that there were heterogeneous changes over time between countries and among groups defined by multiple dimensions of deprivation within countries. For instance, there was greater stunting among children who had poorer diets, had mothers with low educational attainment, and/or lived in poor households within all South Asian countries. Although there were marked declines in stunting in the most deprived groups in some countries, socio-economic differences in the prevalence of stunting were largely preserved over time, and in some cases worsened, namely among wealth quintiles.

In Section four, we assess the relative importance of 13 correlates of child stunting and severe stunting selected based on a collective review of existing multi-factorial frameworks: breastfeeding, complementary feeding (timely introduction, feeding frequency and dietary diversity), maternal height, body mass index (BMI), education, and age at marriage, child vaccination, access to improved drinking source and sanitation facilities, household indoor air quality, and household wealth. We use the most recent DHS from Bangladesh (2014), India (2006), Nepal (2011), and Pakistan (2013), and the National Nutrition Survey from Afghanistan (2013), and find that in South Asia (combined sample), short maternal stature and delayed introduction of complementary foods are associated with a significantly higher risk of stunting in infants aged 6-8 months. In children aged 6-23 months, failure to meet children’s minimum dietary diversity, mothers’ short stature, underweight, lack formal education, or underage at marriage, and poor household wealth are statistically significant risk factors for child stunting. In addition, children who are not fully vaccinated or are not fed with a minimum frequency are at a higher risk of being severely stunted. Some differences were found in the relative ordering and statistical significance of the correlates in country-specific analyses.

Our findings make important contributions to the existing evidence demonstrating that eliminating child stunting
Child stunting and human capital in South Asia: a review of the evidence

Introduction

Establishing a causal relationship between stunting and child cognitive development is complicated. Stunted children are more likely to grow up in conditions of overall deprivation (Grantham-McGregor et al., 2007) that affect physical growth and child development, potentially confounding the relationship between stunting and child cognition. Yet, if stunting causes developmental deficits, the consequences at the population-level are immense considering the 151 million children who are stunted (UNICEF et al., 2018). Moreover, global development priorities (e.g., the 2015 Sustainable Development Goals) and experts in child development have set the stage for further prioritizing research and interventions to address the global challenge of poor child development (Black et al., 2016; Britto et al., 2016; Dua et al., 2016; Richter et al., 2016). Therefore, if there is a strong evidence base linking stunting and child development, this strengthens the case for investing in programmes targeted at reducing the prevalence of stunting.

We provide a substantive review of the association between stunting and child development across the world, citing both correlational evidence as well as studies that aim to address causality, including interventions. Our intention is to create a useful repository of information for policymakers, practitioners, and program managers, or researchers new to these fields, who seek to address stunting and child development challenges and consequences, particularly in low- and middle-income countries. Thus, this review summarizes the literature on stunting and child development with the objective of understanding the conceptual relationships between stunting as a measure of nutritional deprivation and child development, which can generally be defined as the attainment of gross motor and fine motor skills, psychosocial competencies, and cognitive abilities.

Identifying peer-review evidence on stunting and child development

We conducted a comprehensive review of key databases in public health, economics, social science, and psychology (PubMed, Web of Science, PsycInfo and Embase) to identify studies on stunting and child development to include in this review. We searched for studies or reviews of studies assessing height (or length) among 0-5 year old children as an exposure for child development. Height could be measured as (a) height-for-age, which is a linear growth measure standardized into z-scores using international growth standards or (b) stunting, which is a widely used binary indicator of chronic undernutrition in infancy and early childhood (WHO, 2006). We further required studies and reviews to have focused on at least one measure of child development as the outcome. Most child development assessment tools focus on major educational milestones, measure a specific individual developmental domain (e.g., gross motor skills, fine motor skills, or psychosocial development), or represent a battery of skills tests. The following search terms were used: cognition, cognitive, awareness, consciousness, cognitive disorder, intelligence, intelligence tests, mental tests, achievement, achievement tests, school readiness, psychosocial, behavior, attitude, height, stunting, stunt, height-for-age, anthropometry, anthropometric, growth, growth disorders, infant, infancy, child, childhood, adolescent, adolescence, teenage, youth. Only studies published in English were included.

Challenges with child development assessments

Most child development assessments were designed for use with English-speaking populations in high-income countries. Thus, there are challenges with using them with children in low- and middle-income countries (Grantham-McGregor, 1984, 1993). Although many of the metrics have been adapted for local contexts, they may not be appropriate for children living in poverty and lead to biased testing results (Isaacs & Oates, 2008; Prado & Dewey, 2014). In addition, studies on child development often evaluate learning and schooling outcomes such as grade completion or years of schooling in lieu of cognitive tests as the more specific tests are difficult to adapt and administer in diverse contexts and even more challenging to compare across these different settings. Yet, the quality of education, the selection of material that is taught, and the amount of learning that occurs during years of education, vary both within and between countries (Behrman & Birdsall, 1983).
Moreover, the use of different child development tools and metrics across studies and differences in the timing and frequency of the assessments complicate comparisons of findings in the literature (Grantham-McGregor & Baker-Henningham, 2005; Sudfeld et al., 2015). In addition, implementation of assessments varies in practice. For cognitive assessments, children most often engage in the testing. In contrast, to assess motor and psychosocial development, parents, teachers, or an observer often assess a child’s skills. Therefore, children’s performance on these assessments is not only a measure of their abilities, but also reflects their interactions with the test administrator and the testing situation (Isaacs & Oates, 2008). Lastly, there are also differences in how test results are analyzed. Some studies use number of successes as measures of cognitive ability (e.g., number of objects correctly identified by children taking the Peabody Picture Vocabulary Test) while others transform the raw numbers of successes into age-standardized z-scores or percentiles (Cheung et al., 2008). Given this background, these differences in testing approaches and methodology need to be considered when interpreting findings in the literature (Cheung et al., 2008).

Evidence of a link between stunting and child development

Cross-sectional observational studies

A recent review found that across studies, height-for-age z-scores (HAZ) among children three years old or younger were positively associated with gross motor scores (Sudfeld et al., 2015). Similarly, HAZ scores were positively associated with cognitive scores among children 0-23 months old, and, to a lesser extent, also with cognitive scores among children aged two and older (Sudfeld et al., 2015). Due to differences in how psychosocial development was measured and the small number of studies included, generalized findings about the association between HAZ and psychosocial development could not be established. Overall, these studies show a positive relationship between height and child development. (Abubakar et al., 2008; Avan et al., 2010; Bogale et al., 2013; Crookston et al., 2011; Fernald et al., 2006; Handal et al., 2007; Kariger et al., 2005; Ketema et al., 2003; Kordas et al., 2004; Kuklina et al., 2006; Mohd Nasir et al., 2012; Olney et al., 2009; Olney et al., 2007; Siegel et al., 2005; Taneja et al., 2005)

Longitudinal observational studies

The same recent review study described above also reported positive prospective associations between HAZ at 3 years old or younger and gross motor scores at age 5-8 years and also between HAZ at two years old or younger and cognition at age 5-11 years (Sudfeld et al., 2015). In addition, evidence across several studies suggested that stunting was associated with poor psychosocial development among children who were stunted at age 9-24 months. Most studies indicated an association between stunting or child height and child development across each of the developmental domains. (Adair et al., 2013; Alberto Camargo-Figuera et al., 2014; Aubuchon-Endsley et al., 2011; Aurino & Burchi, 2014; Berkman et al., 2002; Casale et al., 2014; Chang et al., 2002; Chang et al., 2010; Cheung & Ashorn, 2010; Cheung et al., 2008; Cheung et al., 2001; Crookston et al., 2013; Hamadani et al., 2012; Hamadani et al., 2014; Kuklina et al., 2004, 2006; Lima et al., 2004; Meeks Gardner et al., 1999; Mendez & Adair, 1999; Niehaus et al., 2002; Pollitt et al., 1993; Sanchez, 2013; Walker et al., 2007a; Walker et al., 2000; Whaley et al., 1998; Yang et al., 2011).

Quasi-experimental studies

Quasi-experimental studies have provided some evidence that stunting causes cognitive impairments. These studies used instrumental variables, such as rainfall or food price shocks, or natural experiments in the form of social welfare programs (i.e., the Protective Safety Nets Program, the National Rural Employment Guarantee Scheme, or similar initiatives), which are not randomly implemented but are plausibly exogenous to stunting and cognitive status. Other quasi-experimental studies use data from siblings to account for unmeasured confounding at the household level. Most of these studies have found negative effects of stunting on cognitive development with varying effect sizes (Dercon & Porter, 2014; Glewwe et al., 2001; Glewwe & King, 2001; Leight et al., 2015; Outes-Leon et al., 2011; Umana-Aponte, 2011).

Experimental studies on social welfare

Some experimental studies assess how program-facilitated changes in nutritional status influence child development by studying the effects of social welfare programs, which enroll participants randomly. Two out of five studies included in this review found that improvements in cognitive development due to cash transfer programs were mediated by increases in height (Fernald et al., 2008; Fernald et al., 2009). In contrast, the other three studies indicated that cash transfers had no effect on height, but independently improved cognition (Fernald & Hidrobo, 2011; Macours et al., 2012; Paxson & Schady, 2010). However, follow-up periods in these studies may not have been long enough to observe changes in height or stunting status.
Experimental studies on nutrition supplementation

Only two out of seven studies included in this review found improved motor development among children who received nutrition supplementation and no study found psychosocial development benefits. In contrast, several studies included in this review found that early nutrition supplementation appeared to influence cognitive development (Chang et al., 2010; Grantham-McGregor et al., 1991; Grantham-McGregor et al., 1997; Grantham-McGregor et al., 1996; Meeks Gardner et al., 1999; Nahar et al., 2012; Polliitt et al., 1993; Pollitt et al., 1995; Polliitt et al., 1997; Vazir et al., 2012; Waber et al., 1981; Walker, 2006). A recent review of more than 20 postnatal nutrition intervention studies among children under two years of age in low- and middle-income countries found small effects on mental development (Larson & Yousafzai, 2017). Although some evidence suggests that nutrition supplementation improves developmental outcomes, there is significant heterogeneity in the design of the studies. Moreover, the effects of supplementation may not be uniform and may instead depend on many factors which non-experimental studies have been found to be relevant for child development, such as the timing and duration of the intervention (Martorell, 1995; Polliitt et al., 1995), child sex (Martorell, 1995; Waber et al., 1981) and socioeconomic status (Polliitt, 2009; Polliitt et al., 1993; Polliitt et al., 1995).

Interventions integrating nutrition supplementation and stimulation

Comprehensive summaries of existing studies that examined integrated programs are provided in recent reviews (Black et al., 2015; Grantham-McGregor et al., 2014). In addition, one paper reviewed the implementation of integrated nutrition and psychosocial stimulation (Yousafzai & Aboud, 2014) and a more recent study reviewed the benefits and challenges of implementing integrated interventions to address early childhood nutrition and development (Hurley et al., 2016). Of the six studies included in the present review, two found that the combined treatment effects (i.e., nutrition supplementation plus psychosocial stimulation) were significantly more effective than either alone for motor skills and cognitive development among children in Bangladesh (Nahar et al., 2012) and Jamaica (Grantham-McGregor et al., 1991). However, the additive effect of combined treatments was no longer significant four years after the end of the study in Jamaica (Grantham-McGregor et al., 1997). Other studies found no interaction between the two interventions on stunting and child development (Chang et al., 2010; Meeks Gardner et al., 1999; Walker et al., 2007a).

Potential pathways

The associations between stunting and child development present in some of the papers we reviewed may be due to a variety of different processes linking the exposure and outcome. Although it is a nascent area of work, several studies suggest various mechanistic pathways, including neurological pathways (Black, 1998; John et al., 2017; Lozoff, 2007; Vohr et al., 2017), hormonal (Berger, 2001; Le Roith, 1997; van Pareren et al., 2004), functional isolation pathways (Grantham-McGregor et al., 2007), stress (Fernald & Grantham-McGregor, 1998; Soeters & Schols, 2009; Wachs et al., 2013), stigma (Currie & Vogl, 2013), and pathways related to infectious diseases (Black et al., 2013; UNICEF, 2013; Walker et al., 2007b). The research to date, however, is often unclear on whether such factors act as mediators or as precursors to stunting.

In addition, there may be dynamic interplays between these processes. For example, impaired motor development may mediate the relationships between stunting and cognitive development (Larson & Yousafzai, 2017). Stunted children with lower motor activity are more likely to be carried by caregivers, further handicapping motor development and inhibiting cognitive and psychosocial development attained through independent exploration of environments (Adolph et al., 2003; Kariger et al., 2005; Meeks Gardner et al., 1995; Olney et al., 2007; Siegel et al., 2005). Greater apathy as well as distress in stunted children (Grantham-McGregor, 1995; Pollitt, 2000) increase the likelihood that caregivers treat stunted children as if they were younger, resulting in a lack of age-appropriate stimulation (Kuklina et al., 2004). This evidence supports the idea that children’s motor, psychosocial, and cognitive development occur in an interactive and dynamic manner with significant influence from their social environments (Wachs et al., 2013). However, the lack of study designs permitting rigorous mechanistic study prohibits a definitive layout of a complete framework for pathways and mediators. Research on these pathways (as well as other potential mechanisms) is still in its early stages, and future work may be able to shed light on this important issue, which will be of particular interest to policy makers trying to identify potential interventions designed to improve child development.
Further questions about stunting and child development

Timing of nutrition interventions

Nutrition intervention effects on cognition may be greatest in the first two years of life (Pollitt et al., 1993). This claim is supported by findings from several observational studies (Pongcharoen et al., 2012; Sudfeld et al., 2015). However, it is difficult to draw strong conclusions on this issue, at least in respect to the pre and postnatal periods, as some studies have found either no difference in associations between prenatal and postnatal linear growth and cognition (Yang et al., 2011) while others have found that postnatal growth is more salient (Adair et al., 2013; Kuklina et al., 2004). Children who experience developmental impairments due to nutritional deprivation in the first 1,000 days may be able to recover later on (Levitsky & Strupp, 1995; Strupp & Levitsky, 1995). Moreover, brain development continues into adulthood (Thompson & Nelson, 2001) with important periods of growth in adolescence and early adulthood (Isaacs & Oates, 2008; Wachs et al., 2013). Furthermore, growth faltering can also happen after the first two years (Lundeen et al., 2013; Prentice et al., 2013), suggesting that children may also be vulnerable to impaired development later in later life (Crookston et al., 2011).

Long-run associations and the role of catch-up growth

The degree to which associations between early stunting and later cognition are mediated by later growth remains unclear. While some studies find that children who catch-up in growth are also able to recover in development (Cheung & Ashorn, 2010; Crookston et al., 2010a; Crookston et al., 2010b; Crookston et al., 2013; Gandhi et al., 2011; Mendez & Adair, 1999), other work finds that catch-up growth does not help children recover cognitive deficits (Sokolovic et al., 2014). Moreover, there is no conclusive evidence about the best timing for catch-up growth (Cheung & Ashorn, 2010; Gandhi et al., 2011). Further research is required to resolve the ambiguity about critical windows for physical and cognitive development as well as the role of catch-up growth.

Differential effects on development domains

Many of the nutrition studies report improvements in cognitive development but no impact on gross or fine motor development or psychosocial development. While it is possible that there are heterogeneous effects which differ by domain, perhaps current assessments for gross and fine motor development and psychosocial development do not adequately reflect the positive impact of nutrition interventions. Alternatively, there may be dynamic interactions not captured by analyses. Advanced statistical techniques such as structural equation models, which allow for an investigation into interactions between multiple determinants, may help illuminate the pathways by which different developmental domains influence one another and how nutritional status may directly or indirectly influence developmental outcomes.

Integrating interventions

Child development occurs in a dynamic fashion in which children’s characteristics interact with the social environment to influence their development. Therefore, impact of integrated interventions may be stronger than any nutrition supplementation alone (Black et al., 2015). Although evidence on synergy between nutrition and stimulation interventions is inconsistent and inconclusive, some evidence supports the addition of stimulation to nutrition programs to improve child growth as well as developmental outcomes in the long-run (Alderman et al., 2014; Black et al., 2015; Christian et al., 2015; DiGirolamo et al., 2014; Fernandez-Rao et al., 2013; Grantham-McGregor et al., 2014). Moreover, while studies have largely focused on integrated interventions that combine macro- or micronutrient supplementation with psychosocial stimulation to improve child development outcomes, there is little evidence on the interaction between child development and other exposure variables such as sanitation, hygiene, access to health care, and early responsive learning interventions. Thus, there is a need for comprehensive evaluations of a variety of integrated programs, including those addressing macronutrient deficiencies combined with child stimulation and hygiene and sanitation intervention (Larson & Yousafzai, 2017), and especially concerning the long-term sustainability of benefits. Despite inconsistent evidence on synergistic interaction between nutrition and stimulation on child development, simultaneous implementation of cross-functional policies and programs at the population level aimed at improving food security, reducing poverty and social inequalities, and improving maternal education has exhibited success in reducing undernutrition in some countries in South East Asia and Latin America (DiGirolamo et al., 2014). Finally, a recent review concluded that multi-sectoral approaches combining nutrition, health, education, child protection, and social protection are critical for building successful and sustainable interventions, and that families and caregivers should be supported in providing nurturing care (Britto et al., 2016).
Conclusion

Our comprehensive review of stunting and child development has three salient findings. First, there is considerable heterogeneity in the methodology used to examine the relationship between child stunting and child development. Such heterogeneity makes comparisons of study findings difficult. Creating a harmonized way to measure and evaluate the relationship between stunting and child development is one solution. Second, there is evidence that stunting is plausibly linked to poor developmental outcomes among children despite variability across studies. How stunting influences child development, which domains of child development are more affected, and how the various domains of child development influence one another all require further research. Finally, understanding how best to improve developmental outcomes – either through nutrition programs or integrated nutrition and psychosocial stimulation – is a key area of further inquiry. This process requires a better understanding of the complex relationship between stunting and the different domains of child development and scaling up proven interventions to target these multiple, interacting factors. Improving multiple aspects of the early life environment that are critical for child development may have synergistic effects. However, more research is needed to rigorously evaluate the effects of these types of integrated programs, particularly in the long-run.

Given that nearly 40% of children under age five suffer from loss of developmental potential - for which stunting is likely one of the key risk factors - reductions in stunting could have tremendous implications for child development and human capital formation, particularly in low- and middle-income countries. If interventions are able to address the etiology of stunting, or preferably the etiologies of stunting and other determinants of poor child development such as poor child stimulation or poverty simultaneously, all of which are concentrated in resource-poor settings, they are likely to be more effective in targeting the root causes of developmental deficits in young children than interventions which focus solely on educational outcomes.

Child stunting and national development: a review of the evidence

Introduction

Assessments of the effects of child stunting on economic outcomes provide an evidence base for interventions targeted at preventing stunting and assist in identifying priorities for national and international efforts (Halim et al., 2015). Despite the potential substantial returns of programs aimed at reducing stunting (Gertler et al., 2014; Hoddinott et al., 2008), progress in reducing stunting has been sub-optimal in many countries (Stevens et al., 2012). The aim of Section 2 is to provide a comprehensive review of the evidence of the long run economic impact of child undernutrition, as measured by stunting. Assessing the potential economic benefits of investments in child nutrition will inform whether these programs are an efficient use of public funds. We also consider the evidence linking child undernutrition and economic growth at the national level, and conclude with a discussion of the implication of these findings for countries with high stunting prevalence in the context of Sustainable Development Goals (SDGs) post-2015.

Methods

We conducted a literature search for published studies up to July 2015 which examined whether childhood stunting was associated with economic outcomes in later life. We used the Pubmed and Econlit databases to search for keywords in abstracts and titles related to the following economic outcomes; wages, income, salary, pay, earnings, productivity, capital, resources, work, employment, industry, hours worked, occupation, labour, sector, job, socioeconomic, savings, economic, returns, make ends meet, welfare, poverty; and the following measures of childhood undernutrition; stunting, child development, growth retardation, linear growth, linear growth retardation, growth failure, early life growth failure, child undernutrition, child malnutrition, child nutrition.

Findings for stunting in early childhood and economic outcomes in adulthood

There are two long term follow ups to nutrition intervention studies. The first, the Institute of Nutrition of Central America and Panama (INCAP) study (Engle & Fernandez, 2010; Stein et al., 2008), allocated nutritional supplements to pregnant women and infants in two Guatemalan villages in the late 1960s and 1970s. While not a pure randomized design, two nearby comparison villages did not receive the supplements. Studies which follow the INCAP children into adulthood find positive effects of nutritional supplementation in early childhood on economic outcomes in adulthood, including increased productive capacity, wages, and expenditure, and lower probability of living in poverty.
Prospective analyses evaluate the association between measured height in childhood and economic measured outcomes in adulthood. Many of these analyses are based on cohort studies in the UK, Brazil, and the Philippines (Adair et al., 2011; Elliott & Shepherd, 2006; Power & Elliott, 2006; Victora & Barros, 2006). Only one study in Barbados (1967-1972) includes a matched control group and has followed a cohort of children who were hospitalized because of undernutrition during the first year of life and a matched cohort of children who did not experience undernutrition (Galler et al., 2012). Children who experienced undernutrition as children were found to be lower on social position and standard of living indices in adulthood. An early study in India found that HAZ at age 5 years was associated with lower work capacity at age 14-17 years (Satyanarayana et al., 1978; Satyanarayana et al., 1979). In the Philippines, better HAZ at age 2 years was found to be associated with an increase in the probability of being engaged in formal work at age 20-22 years, both in men and women (Carba et al., 2009). Research from US and UK cohort studies has found that height at various stages in childhood and adolescence is positively related to work status, wages, and measures of socioeconomic status in later life (Case et al., 2005; Case & Paxson, 2008; Montgomery et al., 1996; Persico et al., 2004; Sargent & Blanchflower, 1994). In a cohort of men born in Helsinki, Finland, between 1934 and 1944, length in the first year of life was associated with subsequent earnings (Barker et al., 2005). A review of three cohort studies in LMICs found that HAZ at age 2 years was associated with an 8% increase in income in Brazil and Guatemala, and a 21% increase in household assets in India (Victora et al., 2008).

Cost benefit analysis of childhood nutrition interventions

A number of publications focus on the cost-benefit analysis of interventions aiming to reduce child stunting and estimate the economic impact of stunting reduction. A micronutrient supplementation and early childhood stimulation program in Nicaragua was found to have a cost-benefit ratio of 1.5 (Boo et al., 2014). An intervention in Indonesia was found to have a cost-benefit ratio of 2.08 based on productivity enhancements from reduced undernutrition, earnings from deaths averted, and household savings from health care costs avoided (Qureshy et al., 2013). In a review of cost-benefit ratios of nutrition interventions, estimates ranged from 3.5:1 to 42.7:1 per child, with a median of 17.9:1 (Hoddinott et al., 2013a).

A similar methodology has been used to estimate the aggregate burden of stunting at a national level and worldwide. Productivity gains due to reductions in child stunting in China over the period 1991 to 2001 were estimated at US$ 12 billion in 2001 (Ross et al., 2003) while the productivity-related costs of stunting in Peru were estimated at 2.2% of gross domestic product (GDP) (Alcázar et al., 2013). The cost of undernutrition in Cambodia has been estimated at more than US$ 400 million annually, or approximately 2.5% of yearly GDP, of which 57% is a result of undernutrition in early childhood (Bagriansky et al., 2014). Based on a model originally developed for Latin America (Fernández & Martinez, 2007), the Cost of Hunger in Africa (COHA) study aims to provide economic estimates of the costs of malnutrition in 13 countries. A recent report on Malawi indicated that the costs associated with stunting were of the order of 10% of GDP per year (African Union Commission/World Food, 2015). The annual GDP loss due to undernutrition has been estimated to be up to 12% in LMICs (Horton & Steckel, 2011).

Stunting and economic growth

Individual level estimates of the costs of stunting do not take into account the potential spillover effects on aggregate capital formation, labour markets, savings and investment behavior, and other factors that make up the determinants of economic growth. Relevant pathways, summarized in Figure 1, include increases in morbidity, mortality and health expenditure, and reductions in human capital investment (for example, education), physical capital investment, and labour supply. Productivity may suffer because of ill health or...
reduced work capacity in adulthood, and reductions in human capital and technological progress (due to lower cognitive development or levels of educational attainment and infrastructure). Other channels include the impact of undernutrition on chronic disease, which would involve the diversion of productive savings, which boost investment, towards unproductive treatment costs (Bloom et al., 2014). While the available evidence indicates a strong association between economic growth and proxies for nutritional status in childhood (Arora, 2001; Chakraborty et al., 2010; Dalgaard & Strulik, 2015; María-Dolores & Martínez-Carrión, 2011; Piper, 2014; Weil, 2007), it is hard to quantify the causal magnitude of these effects. One recent paper finds that each centimetre increase in height at the population level is expected to raise income per capita by 6% (Akachi & Canning, 2015).

There are numerous pathways through which poverty, and therefore income per capita, are expected to impact the nutritional status of children. For example, capacity to purchase food, raising both the quantity and the quality of food and nutrient intake by women and young children. In addition, net nutritional intake is also likely to increase because of reductions in the risk of infection and poor health (Shekar et al., 2006). At the national level, education, infrastructure and health services are all positively associated with GDP. However, economic growth may not necessarily translate into improvements in household income due to unequal sharing of growth gains and lack of access to public and private services (Haddad, 2015; Lawrence et al., 2015). The impact of a 10% increase in GDP per capita in the short-run is generally estimated to be in the range of 0.2 percentage point absolute decrease in stunting prevalence (Bershteyn et al., 2015; Harttgen et al., 2013; Headey, 2013; Helteberg, 2009; Ruel et al., 2013; Smith & Haddad, 2002; Vollmer et al., 2014; Webb & Block, 2012), although some estimates, particularly those which focus on long run changes in national income, are found to be larger (Haddad et al., 2003; Ruel et al., 2013; Smith & Haddad, 2002). In contrast, a recent analysis of Indian states found that economic growth was not associated with reductions in stunting or other measures of undernutrition (Subramanyam et al., 2011). One paper examined whether the timing of economic growth is important for attained height and found that economic growth in the first year of life and puberty were most associated with the adult height of women in sub-Saharan Africa (Moradi, 2010).

**Conclusion**

Welcome progress has seen stunting fall from 50% in 1970 to 30% in 2010 in LMICs. However, the prevalence of stunting remains high in some regions, and is currently at 38% in South Asia and 37% in sub-Saharan Africa. Assessing the wage premium associated with adult height, we find that the median return to a 1 centimetre increase in stature is associated with a 4% increase in wages for men and a 6% increase in wages for women in our preferred set of studies which have attempted to address unobserved confounding and measurement error. In contrast, the evidence on the impact of economic growth on stunting is mixed. Further evidence needs to inform how best to prioritize effective and cost effective interventions to reduce stunting in the most adversely affected areas.

**Trends and inequalities in child stunting in South Asia**

**Introduction**

Recognizing the importance of early child nutrition, much global attention has focused on averting child undernutrition through the Millennium Development Goals, the Scaling Up Nutrition (SUN) movement, and the SDGs, which endorse the World Health Assembly’s target of reducing the number of stunted children aged 0-59 months by 40% by 2025 (UN, 2015b). A key recommendation from these initiatives is the need for better quality data, information and analyses to understand who is most vulnerable to stunting (Black et al., 2013). Following on this recommendation, Section 3 seeks to provide a comprehensive assessment of the patterns in child stunting in South Asia with particular attention to temporal trends and variations in the prevalence of stunting among different socioeconomic groups.

There is substantial evidence that child stunting follows a socioeconomic gradient (Akhtar, 2015; Di Cesare et al., 2015; Gaiha & Kulkarni, 2005; Kanjilal et al., 2010; Kumar & Kumari, 2014; Kumar et al., 2014; Menon, 2012). In this section, we look at the patterning of child stunting along three domains of deprivation: 1) children’s access to food, represented by dietary diversity; 2) social, represented by maternal educational attainment; and 3) economic, represented by household wealth. Together, these three domains represent three levels of the determinants of child nutrition – child-level, mother-level, and household-level – in UNICEF’s conceptual model of nutrition (UNICEF, 2013). While much work considers the second two aspects of deprivation (Gaiha & Kulkarni, 2005; Kumar & Kumari, 2014; Kumar et al., 2014), to our knowledge, only a few studies consider all three domains of deprivation in South Asia (Di Cesare et al., 2015;
Kanjilal et al., 2010). We focus on children ages 6-23 months as the first two years of life are critical for linear growth and growth faltering (Victora et al., 2010), and the existing population surveys assess dietary diversity in children aged 6-23 months, after the initial six-month exclusive breastfeeding period. We identify patterns in the prevalence of stunting by children’s dietary diversity, mother’s education, and household wealth and examine temporal changes in the prevalence of stunting in groups defined by these social and economic dimensions of deprivation. Furthermore, we consider both absolute and relative changes in the prevalence of stunting by categories of deprivation to understand inequalities in the prevalence of child stunting more comprehensively.

**Methods**

We used cross-sectional data from 15 DHS, collected in Bangladesh, India, Nepal, and Pakistan between 1991 and 2014. The final analytic sample comprised 55,459 children aged 6 to 23 months. In the dietary diversity analyses for India and Pakistan, only 13,570 children from the latest survey were included due to lower data availability and/or quality in the previous surveys. Linear growth was measured as length in younger children (6-23 months) using Shorr measuring boards, which are adjustable to the nearest millimetre (WHO, 2006). Measurements were standardized into HAZ using WHO age- and sex-specific child growth standards. Children who were two SD or more below median HAZ score were classified as stunted.

We considered three domains of deprivation as key explanatory variables: child dietary diversity, mother’s education, and household wealth. Dietary diversity was measured using a score (Corsi et al., 2016; WHO, 2008; WHO, 2010) ranging from 0 to 7, based on the number of food groups a child was fed during the 24 hours preceding the survey. The seven food groups are: 1) grains, roots and tubers; 2) legumes and nuts; 3) dairy products (milk, yogurt, cheese); 4) flesh foods (meat, fish, poultry and liver/organ meats); 5) eggs; 6) vitamin-A rich fruits and vegetables; 7) other foods and vegetables. Dietary diversity scores were categorized in three groups – low, medium, and high - depending of the level of dietary diversity and using the following cut-offs from the dietary diversity score: 0-1, 2-3, and 4-7, respectively. Children 6-23 months old with a dietary-diversity score between 4 and 7 were classified as meeting the minimum dietary diversity (WHO, 2010). Mother’s education was stratified in 3 levels: no education, primary, and secondary and higher. Wealth quintiles were provided by the DHS (Rutstein & Johnson, 2004).

We estimated the weighted prevalence of stunting over time and by children’s dietary diversity group, mother’s
education level, and household wealth quintile. We estimated the percentage change in the prevalence of stunting between the earliest and latest estimates from each country within each group. We also estimated Average Annual Rate of Reduction (AARR), which is annualized change in stunting prevalence for each subgroup, to account for differences in time intervals between the earliest and latest surveys within countries. Absolute and relative differences were calculated between the two categories in dichotomous social groups, and between the lowest and highest categories in categorical groups, for both the earliest and latest survey years in every country. Standard design-based confidence limits were approximated using the logit transformation procedure, which guarantees that the endpoints of the estimated proportion lie between 0 and 1. Adjusted models were also estimated using logistic regression to assess associations between stunting and different degrees of deprivation, controlling for age, sex, birth order, and place of residency. We accounted for the cluster design of the survey in our analyses.

Results

Country-specific analyses

Approximately half of children were stunted at baseline in all countries. From the 1990s, when the earliest DHS surveys were administered, to the most recent survey, which took place between 2006-2014, all countries experienced reductions in stunting prevalence with the largest declines recorded by Bangladesh and Nepal, where stunting prevalence declined annually by 2.9 AARR and 4.1 AARR respectively compared to 1.3 AARR in India and 0.6 AARR in Pakistan. At 43.5% (95% CI 42.3-44.8) and 39.7% (95% CI 35.4-44.2), India and Pakistan had the highest prevalence of stunting in the most recent DHS survey (2006 and 2013 respectively).

Trends in stunting by dietary diversity

In general, the prevalence of stunting was lower among more educated mothers (Figure 3). Stunting prevalences among children whose mothers’ had secondary education or higher were 27.2% (95% CI 24.4-30.1), 32.3% (95% CI 30.7-34.0), 16.4% (95% CI 11.4-22.9), and 25.4% (95% CI 18.9-33.2) in the most recent surveys in Bangladesh, India, Nepal, and Pakistan respectively. In comparison, about 40-50% of children whose mothers were uneducated were stunted in the most recent surveys. All sub-groups experienced declines in stunting prevalence in all countries; however, there was some country variability. In Bangladesh, children of mothers with no education and primary education experienced similar declines – around a 1.9-2.1 AARR in stunting while children of mothers with secondary and more education experienced no significant decline in stunting. Meanwhile, in India and Nepal, the greatest reductions in stunting occurred among children with mothers who had secondary or more education although significant reductions were also recorded among children whose mothers had no education. In Pakistan, no significant annual reductions were observed in any education group. The education gradient in stunting was preserved in all four countries despite changes over time among education groups.

Patterning in stunting by household wealth

In both the earliest and latest surveys, the prevalence of stunting was significantly higher among children from poorer households, with half to nearly two thirds of children in the lowest two quintiles being stunted (Figure 4). Stunting rates declined in all quintiles in all countries; however, reductions were not uniformly distributed. In all four countries the largest reductions in the prevalence of stunting occurred in the richest quintiles while the poorest quintiles recorded the smallest declines. In the richest quintile, the prevalence of stunting prevalence declined by 2.6, 2.7, 7.0, and 0.8 AARRs in Bangladesh, India, Nepal and Pakistan, respectively. In comparison, in the poorest quintile, the prevalence of stunting declined by 2.4, 0.5, 2.1, and -0.5 AARRs for the same order of countries. Absolute and relative differences between the poorest and richest quintiles increased in all four countries with the largest increases in Nepal and Pakistan.

Association of stunting with different domains of deprivation

After controlling for child age, sex, birth order, and place of residence, results from fully-adjusted models, using pooled data from the latest survey years, revealed

Gradients in stunting by mother’s education

The prevalence of child stunting was lower among more educated mothers (Figure 3). Stunting prevalences among children whose mothers’ had secondary education or higher were 27.2% (95% CI 24.4-30.1), 32.3% (95% CI 30.7-34.0), 16.4% (95% CI 11.4-22.9), and 25.4% (95% CI 18.9-33.2) in the most recent surveys in Bangladesh, India, Nepal, and Pakistan respectively. In comparison, about 40-50% of children whose mothers were uneducated were stunted in the most recent surveys. All sub-groups experienced declines in stunting prevalence in all countries; however, there was some country variability. In Bangladesh, children of mothers with no education and primary education experienced similar declines – around a 1.9-2.1 AARR in stunting while children of mothers with secondary and more education experienced no significant decline in stunting. Meanwhile, in India and Nepal, the greatest reductions in stunting occurred among children with mothers who had secondary or more education although significant reductions were also recorded among children whose mothers had no education. In Pakistan, no significant annual reductions were observed in any education group. The education gradient in stunting was preserved in all four countries despite changes over time among education groups.
Figure 2. Prevalence of stunting (95% confidence intervals) by dietary diversity score groups (limited data for India and Pakistan*)

Figure 3. Prevalence of stunting (95% confidence intervals) by mother’s education*


significant associations between stunting and children’s dietary diversity, mother’s education, and household wealth quintile. The odds of stunting was significantly higher for children in the most deprived groups; for instance, a higher odds of stunting was observed for children in the group with the lowest dietary diversity compared to children in the group with the highest dietary diversity (odds ratio (OR)=1.47, 95% confidence interval (CI) 1.28-1.69); for children of uneducated mothers compared to children of the most educated mothers (OR=1.51, 95% CI 1.34-1.69); and for children in the poorest wealth quintile compared to children in the richest wealth quintile (OR=3.01, 95% CI 2.48-3.64). In an extended model using the pooled sample, we included interactions between dietary diversity and levels of mother’s education, and found significant interactions (p-value <0.05) between these two domains of deprivation. We conducted the same interaction tests in subsamples of the poorest and richest children in separate models; however, we found no evidence of multiplicative effects of maternal education and dietary diversity among either the poorest or richest children. In country-specific models, we observed mixed results. In India, the odds of stunting was significantly higher among children from the most deprived groups in terms of child’s dietary diversity, maternal education, and household wealth. In Bangladesh, the odds of stunting was significantly higher across wealth quintiles groups, but not by children’s level of dietary diversity and maternal education. No significant differences were observed in any domain in Nepal. Lastly, in Pakistan the odds of stunting was significantly higher for wealthier and more educated groups, but not by dietary diversity group. Differences in the findings from pooled models and the country-specific models can be attributed to the influence of the data from India, which is the most populous country in the pooled analyses. Indeed, the findings from the India-specific model are similar to the pooled analyses.

**Conclusion**

Our analysis of the prevalence and trends in child stunting in South Asia had three key findings. First, all countries had high stunting prevalence with nearly...
half of the children suffering from stunted growth at baseline. Stunting declined in all four countries with greater reductions in Bangladesh and Nepal. Second, in all four countries, the prevalence of stunting was greater among children who had poor diets, who had mothers with low educational attainment, or who lived in poor households. Pooled, adjusted models showed higher rates of stunting in children who experienced all three dimensions of deprivation. However, country-specific models showed varying relationships between domains of deprivation and stunting. Third, the largest declines in stunting were recorded in higher wealth quintiles while the lower wealth quintiles recorded the smallest declines in stunting. Disparities in stunting rates were largely preserved over time, and in some cases worsened between children from poorer vs. richer households and between children whose mothers had low vs. high educational attainment. Future efforts to avert child stunting should target groups that are most vulnerable.

Drivers of child stunting in South Asia

Introduction

The conceptual models for child undernutrition describe immediate, underlying and basic determinants of undernutrition at the individual, household, environmental, socioeconomic, structural and cultural domains, and support the need for multifactorial interventions (Bhutta et al., 2008; Black et al., 2013; UNICEF, 2013). Nutrition-specific interventions that address the immediate and underlying determinants of fetal and child nutrition are less likely to be effective in sustainably reducing undernutrition unless the household, social and structural determinants of maternal and child nutrition, including household poverty, access to health services, health environment, women’s education and social exclusion, are also addressed (Black et al., 2013; Bryce et al., 2008; Ruel et al., 2013).

Empirical research on a selective set of risk factors on child growth and development are valuable for assessing the role of specific determinants, but do not allow an examination of the relative importance of multiple factors on children’s health and nutrition outcomes (Bhutta et al., 2008). Existing studies focused on LMICs have identified child feeding practices, maternal nutrition, and household wealth as key determinants of the nutritional status for preschool age children (Espo et al., 2002; Jones et al., 2008; Kanjilal et al., 2010; Smith & Haddad, 2015). These findings have important policy and programme implications at the national level, but the relative significance of the same set of risk factors may substantially vary when the focus is on the outcome of stunting, a measure of chronic undernutrition, as opposed to general nutritional status; the first two years of life, when most child stunting happens in LMICs, as opposed to children under age of five; and by different countries. In Section 4, we use the most recent nationally representative data from Afghanistan, Bangladesh, India, Nepal, and Pakistan (home to over 95% of stunted children in South Asia) to investigate the relative and joint importance of a set of 13 correlates of stunting and severe stunting in infants and young children aged 6-23 months old.

Methods

Data for Afghanistan (2013) come from the National Nutrition Survey (Afghanistan, 2013) while data for Bangladesh (2014), India (2006), Nepal (2011), and Pakistan (2013) come from the latest DHS (Measure DHS, 2016). Both National Nutrition Survey and DHS are nationally representative household surveys that collect detailed information of health and nutrition indicators from children and their mothers, including anthropometric measurements and demographic characteristics. We stratified the sample and performed separate analyses for two different model specifications, depending on the age of children and the risk factors that are relevant for each age group. In the first model (Model 1 hereafter) we analyzed data for 3,159 children aged 6-8 months. In the second model (Model 2), we included data from 18,586 children aged 6-23 months.

Children were considered stunted if their HAZ was below -2 SD of the median for their sex according to the WHO Child Growth Standards. Additionally, severe stunting was considered as a secondary outcome for analysis of Model 2. Children were classified as severely stunted if their HAZ was <-3 SD of the median of the WHO Child Growth Standards (de Onis, 2006).

We considered a comprehensive set of 13 correlates that has shown varying degree of association with stunting in different settings (Bhutta et al., 2008; Bhutta et al., 2013; UNICEF, 2013). Child’s timing of the introduction of complementary foods and minimum dietary diversity were defined closely adhering to the UNICEF and WHO infant and young child feeding indicators (WHO, 2008, 2010). Timely introduction of complementary foods was defined for infants 6-8 months old as having received solid, semi-
Continued breastfeeding was defined for all children aged 6-23 months. The definition of minimum feeding frequency varied by age and breastfeeding status: for breastfed children, it was defined as two times if 6-8 months, and three times for 9-23 months; for non-breastfed, it was defined as four times for all children 6-23 months old. Based on the dietary diversity score used in the previously published literature (Ruel & Menon, 2002), minimum dietary diversity was defined for children aged 6-23 months as having received foods from four or more of the following food groups: 1) grains, roots and tubers; 2) legumes and nuts; 3) dairy products (milk, yogurt, cheese); 4) flesh foods (meat, fish, poultry and liver/organ meats); 5) eggs; 6) vitamin-A rich fruits and vegetables; and 7) other fruits and vegetables.

Several maternal variables were also considered. Mother’s education was categorized in three levels: no schooling, primary, and secondary or higher. Mother’s height was measured by trained field investigators and was categorized in four groups: <145, 145-149.9, 150-154.9, and 155+ cm. Of note, height measures below 100 cm or above 200 cm were excluded (Özaltin et al., 2010). Mother’s BMI was calculated from the objectively measured height and weight, and was grouped in <18.5, 18.5-25, and 25+ kg/m2. Mothers’ age at marriage was defined dichotomously for married or cohabitating mothers, using the age of 18 years as cutoff.

Finally, the following proxy variables for household socioeconomic conditions were included. Child’s full vaccination was defined as having received 8 vaccines (measles, BCG, DPT 3, and Polio 3). Household indoor pollution was defined as high air quality if non-solid fuels were used for cooking and poor air quality if solid fuels were used (Corsi et al., 2015). The source of drinking water was defined as safe if water sources were available in the household (piped into dwelling or yard/plot, public tap/standpipe, tube well or borehole, protected well or spring, rain water, and bottled water), and unsafe otherwise. Household sanitation facility was defined as improved if households had access to flush to piped sewer system, septic tank, or pit latrine, ventilated improved pit latrine, pit latrine with slab, and composting toilet, and unimproved otherwise. We included the household wealth index, as reported by the NNS and DHS, which was constructed as a weighted sum of household assets by using the first factor resulted from a principal component analysis on those assets as weights. The resulting wealth index was used to construct cut offs to rank households into wealth quintiles, based on the weighted frequency distribution of households (Rutstein et al., 2004).

The following logistic regression models were conducted to evaluate the association between selected variables and stunting by pooling the data from five countries and then for each country separately. A different set of correlates was considered for 6-8 months old infants (Model 1) and 6-23 months old children (Model 2) due to clinical relevance and technical reasons. For instance, the timely introduction of complementary foods was included only in Model 1 since data on this indicator are only obtained for infants aged 6-8 months. On the other hand, the child’s vaccination status was included only in Model 2 since full vaccination data are applicable for children aged 12-23 months. For technical reasons, minimum feeding frequency was excluded from Model 1 due to high correlation with timely introduction of complementary foods; and continued breastfeeding and minimum dietary diversity were excluded from Model 1 because of the small sample sizes and stunting cases for this age group in country-specific models that resulted in lack of statistical power and unstable estimation. For Afghanistan-specific analysis, mother’s age at marriage and child’s full vaccination were not available. For this reason, the pooled analyses are presented for results including and excluding Afghanistan. For Model 2, we also estimated the fully-adjusted models for the secondary outcome of severe stunting. Based on these models, the relative significance of each of the correlates was compared and ordered by magnitude. As a sensitivity analysis, we re-estimated the fully-adjusted models after removing type of drinking water, sanitation facility, and indoor air quality since these assets were considered in the estimation of DHS wealth quintiles and may have issues of multicollinearity. All analyses were accounted for the cluster survey design, and were further adjusted for age and sex of the child, birth order, and place of residency (urban/rural). The country fixed effects was included in the pooled analysis. All statistical tests were two-sided and p<0.05 was considered to determine statistical significance. We used Stata (version 13.1) for all analyses procedures.

Results

South Asia

Among 3,159 children aged 6-8 months in South Asia, 25.9% (n=896) were stunted. About two in five (37.5%) of these 3,159 children were not fed complementary foods indicating late initiation of complementary feeding. Among 18,586 children aged 6-23 months, 38.8% (n=7,140) were stunted and 18.3% (n=3,362) were severely stunted. 70.1% of the children aged 6-23 months did not meet the minimum dietary diversity requirements. Mother’s nutrition and status varied
substantially across the countries. Overall, 2.8% of the mothers of children aged 6-23 months had short stature (height <145 cm), 12.4% were underweight (BMI <18.5 kg/m²), and 82% had no formal education. In terms of household level characteristics, 25.8% of the children aged 6-23 months did not have access to improved water source, 61.8% did not have access to improved sanitation facility, and 16.1% were from the lowest wealth quintile.

In the fully adjusted Model 1 (excluding Afghanistan), maternal stature and timely introduction of complementary foods were statistically significant risk factors of stunting in children aged 6-8 months. Children with short mothers (<145cm) had 2.93 times higher odds of being stunted (95% CI: 1.93-4.46) than those with taller mothers (155+ cm). Children who had delayed introduction of complementary foods had 1.47 times higher odds of stunting (95% CI: 1.12-1.93) compared to their counterparts (Figure 5). When Afghanistan was included in the pooled analysis, no factor remained statistically significant.

For children aged 6-23 months (fully adjusted Model 2, excluding Afghanistan), the statistically significant risk factors of stunting, ranked from the strongest effect sizes, were: maternal short stature (OR: 3.37, 95% CI: 2.82-4.03), poorest household wealth quintile (OR: 2.25, 95% CI: 1.72-2.94), maternal underweight (OR: 1.59, 95% CI: 1.27-2.00), failure to meet the minimum dietary diversity (OR: 1.48, 95% CI: 1.27-1.72), no maternal education (OR: 1.36, 95% CI: 1.18-1.56), and mother’s young age at marriage (<18 years) (OR: 1.17, 95% CI: 1.05-1.30) (Figure 6). When Afghanistan was included in the pooled analysis, lack of continued breastfeeding (OR: 2.02, 95% CI: 1.37-2.97) was also found to be statistically significant, while maternal underweight and young age at marriage were no longer significant. Finally, in the pooled analysis for severe stunting among children aged 6-23 months (both including and excluding Afghanistan), the statistically significant predictors were: maternal short stature (OR: 3.15, 95% CI: 2.55-3.90), poorest wealth quintile (OR: 3.07, 95% CI: 2.20-4.28), no maternal education (OR: 1.48, 95% CI: 1.25-1.76), maternal underweight (OR: 1.41, 95% CI: 1.05-1.90), no minimum dietary diversity (OR: 1.37, 95% CI: 1.11-1.70), not fully vaccinated (OR: 1.22, 95% CI: 1.06-1.41), mother’s young age at marriage (OR: 1.16, 95% CI: 1.01-1.33) and no minimum feeding frequency (OR: 1.14, 95% CI: 1.01-1.29).
Figure 6. Fully adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for risk factors staged 6-23 months in South Asia* (pooled sample)

**Afghanistan**

In Afghanistan, there were 341 children aged 6-8 months and 26% of them were stunted. None of the risk factors were found to be statistically significantly associated with risk of stunting for children aged 6-8 months in Afghanistan. Of 3,644 children aged 6-23 months, 38.7% were stunted and 18.3% were severely stunted. In this age group, lack of formal education for mothers (OR: 3.01, 95% CI: 1.53-5.93), short maternal stature (OR: 2.61, 95% CI: 1.41-4.84), poorest wealth quintile (OR: 2.28, 95% CI: 1.48-3.63), lack of continued breastfeeding (OR: 2.08, 95% CI: 1.35-3.21), and failure to meet the minimum dietary diversity (OR: 1.34, 95% CI: 1.04-1.72) were statistically significant risk factors for stunting. Consistent results were found for severe stunting in this age group, but dietary diversity and maternal education were not statistically significant.

**Bangladesh**

The prevalence of stunting in Bangladesh was 16.9% among children aged 6-8 months. For this age group, all the risk factors for stunting (Model 1) were found to be statistically not significant, probably due to the small sample size. Among children aged 6-23 months, 31.9% were stunted and 10.8% were severely stunted. The following five risk factors were found to be statistically significant for stunting among children aged 6-23 months (Model 2): short maternal stature (OR: 3.42, 95% CI: 2.03-5.76), maternal underweight (OR: 2.05, 95% CI: 1.27-3.30), lowest wealth quintile (OR: 1.98, 95% CI: 1.08-3.63), no education for mothers (OR: 1.78, 95% CI: 1.17-2.70), and no minimum dietary diversity (OR: 1.58, 95% CI: 1.11-2.24). For severe stunting, only maternal stature and wealth quintile remained to be statistically significant predictors.

**India**

Among the five South Asian countries considered in this study, India had the highest prevalence of stunting for children aged 6-8 months (25.1%) and for those aged 6-23 months (43.5%). In the fully adjusted model for children aged 6-8 months (Model 1), short maternal stature (OR: 3.39, 95% CI: 2.10-5.45) and failure to introduce complementary foods in a timely manner (OR: 1.50, 95% CI: 1.11-2.04) were the
only statistically significant risk factors for stunting. Maternal underweight, household wealth, maternal education, and other factors were not statistically significant. These findings were consistent with those from the pooled analysis. For children aged 6-23 months (Model 2), there were five statistically significant risk factors for stunting: short maternal stature (OR: 3.43, 95% CI: 2.82-4.18), lowest wealth quintile (OR: 2.26, 95% CI: 1.67-3.05), maternal underweight (OR: 1.56, 95% CI: 1.20-2.03), poor dietary diversity (OR: 1.52, 95% CI: 1.26-1.82), and mothers with no education (OR: 1.36, 95% CI: 1.17-1.57). In addition to these risk factors, not being fully vaccinated (OR: 1.29, 95% CI: 1.11-1.51) and failure to meet the minimum feeding frequency (OR: 1.15, 95% CI: 1.01-1.31) were also found to statistically significantly increase the odds of severe stunting for children aged 6-23 months.

Nepal

In Nepal, 18.8% of the children aged 6-8 months and 29.2% of those aged 6-23 months were stunted. The sample size and number of stunted children were very small in Nepal, and therefore both Models 1 and 2 could not be reliably estimated due to low statistical power. Among 122 children aged 6-8 months, only 23 cases (18.9%) of stunting were detected, and all the estimates associated with stunting, except for short maternal height, were found to be statistically not significant. Among children aged 6-23 months, short maternal stature (OR: 5.58, 95% CI: 2.52-12.4) and lowest wealth quintile (OR: 5.26, 95% CI: 1.35-20.5) were found to be statistically significant predictors of stunting, but the associated confidence intervals were very wide, which indicated unstable estimation. The same was true for severe stunting among children aged 6-23 months.

Pakistan

The prevalence of stunting was 25% and 39.6% for children aged 6-8 months and 6-23 months, respectively, in Pakistan. Due to small number of stunted children (n=62) aged 6-8 months, all the risk factors for stunting were found to be statistically not significant, expect for no maternal education (OR: 7.39, 95% CI: 1.71-31.9), but the wide confidence interval indicated unstable estimation. For children aged 6-23 months (Model 2), short maternal stature (OR: 3.56, 95% CI: 1.24-10.2), child marriage (OR: 1.71, 95% CI: 1.10-2.67), unimproved drinking water source (OR: 1.63, 95% CI: 1.00-2.68) and no minimum feeding frequency (OR: 1.59, 95% CI: 1.05-2.42) were statistically significant risk factors for stunting. For severe stunting, only short maternal stature was statistically significant (OR: 4.68, 95% CI: 1.57-13.9).

Conclusion

Our findings provide evidence on the relative importance of multiple correlates of child stunting, and enriches the existing assessments of determinants of nutritional status among pre-school age children in LMICs (Espo et al., 2002; Jones et al., 2008; Kanjilal et al., 2010; Smith & Haddad, 2015). For instance, child feeding has been increasingly recognized as a key determinant of child nutrition, with greater than two-thirds of malnutrition-related deaths in children estimated to be associated with inappropriate feeding practices (Black et al., 2008). Young children should be introduced to complementary foods at six months of age (WHO, 2002), and failure to do so has been shown to leave children vulnerable to irreversible outcomes of stunting (Gross et al., 2000; Saha et al., 2008). Almost 40% of infants aged 6-8 months in our pooled sample were not given complementary foods, and failure to do so was significantly associated with increased odds of stunting. Moreover, not meeting the minimum dietary diversity was also found to be important for stunting among children aged 6-23 months, which is consistent with a prior review reporting that dietary diversity was associated with height-for-age in many LMICs (Arimond & Ruel, 2004). In addition, maternal height, a marker of mother’s early life nutritional and environmental conditions that has intergenerational consequences on nutrition and health (Özaltin et al., 2010; Subramanian et al., 2009), was also found to be one of the strongest predictors of child stunting and severe stunting in South Asia. Moreover, the consistent findings on the importance of maternal undernutrition, maternal education and household wealth index further support that the overall environmental and socioeconomic conditions influence child nutrition through pathways involving food insecurity and inadequate access to care and dietary resources for children (Ruel et al., 2013). Overall, our analysis found that the top five risk factors identified for stunting and underweight for children aged 6-59 months in a recent study in India (short maternal stature, mothers having no education, households in lowest wealth quintile, poor dietary diversity in young children, and maternal underweight) (Corsi et al., 2015) are also applicable for infants and children aged 6-23 months across five South Asian countries, albeit the notable variations in the ranking and significance of correlates by country. An important policy implication of our research is to further emphasize that interventions focused on specific risk factors alone may be...
inadequate, and that a multi-factorial framework approach should be employed to address child stunting in South Asia. For instance, comprehensive strategies focused on a broader progress on maternal and household socioeconomic factors as well as investments in nutrition specific programs to promote dietary diversity and appropriate complementary feeding are needed to improve stunting rates at the population level (Bhutta et al., 2008; Bhutta et al., 2013; Black et al., 2008; Ruel et al., 2013).

**Implications for action**

Stunting in childhood has immense implications as stunted children experience worse survival, growth, development, and livelihoods than non-stunted children (Black et al., 2013; Grantham-McGregor et al., 2007), leading to significant losses of human capital and productivity (Behrman et al., 2015; Black et al., 2013; Grantham-McGregor et al., 2007; Horton & Steckel, 2011). In this chapter, we provide evidence to further support that eliminating child stunting should be moved to the forefront of national and international policy, programme, advocacy, and research agendas. More specifically, we argue that renewed attention to four main priorities is needed:

- **South Asian countries, which have the largest proportion and burden of stunted children globally, need to universalize evidence-based policies and programmes designed to improve the nutrition situation of young children and their mothers as a national development priority.** We provide evidence that proven nutrition investments that focus on the 1,000 days from conception to age two years and the 10-18 years adolescence period (i.e. the two windows of opportunity to address stunting) are cost-beneficial. Research evidence indicates that packages that combine context-specific nutrition, care, and stimulation interventions may bring about the greatest impact (Alderman et al., 2014; Gertler et al., 2014; Yousafzai et al., 2014). Improvements in child linear growth and reductions in child stunting allow young children to reach their full growth and development potential and expand their economic opportunities as adults, generating substantial economic returns at the individual level (Barker et al., 2005; Hodapp et al., 2013b; Martorell et al., 2010b; Victora et al., 2008). Furthermore, because of the spillover effects of reductions in the prevalence of stunting on labour markets and productivity, investments targeted at reducing child stunting bring about substantial returns to society, including significant increases in economic growth (Akachi & Canning, 2015; Bloom et al., 2014).

- **In South Asia, economic growth ‘per se’ will not address child stunting. Greater attention needs to be paid to ensure that economic growth reduces inequities and addresses the drivers of child stunting among the most vulnerable population groups.** Economic growth as a policy instrument to reduce stunting is not enough. Greater attention needs to be paid to addressing the social, economic, and political drivers of child stunting, with targeted efforts towards the populations at higher risk of growth faltering and stunting in children. There is increasing consensus that economic growth will only be effective in addressing child stunting if increases in national income are directed at improving the diets of children, strengthening the status of women, addressing inequities, and reducing poverty. Therefore, the literature has begun to emphasize the importance of the “quality of economic growth”, or how income gains translate in reductions in child undernutrition (Haddad et al., 2015). The impact of intermediary factors, such as growth in food production, sanitation, access to health services, education, fertility, governance, and the roll-out of program interventions have all been highlighted (Alderman et al., 2006; Fink et al., 2011; Headey, 2013; Smith & Haddad, 2015; Webb & Block, 2012). Therefore, focusing on promoting an economic growth model that does not address these intermediary factors among the most vulnerable populations is not likely to be effective in addressing child stunting (Haddad, 2015). The disproportionate burden of stunting experienced by the most deprived population groups in South Asia and the persistent and worsening inequalities among socio-economic groups is of great concern. To unleash the potential of nutrition policies and programmes, progress is needed in addressing persistent socio-economic inequities (Oruamabo, 2015).

- **Nutrition-specific and nutrition-sensitive programmes should be implemented jointly to address the main drivers of stunted growth and development in South Asian children.** Programming efforts to prevent and reduce stunting, especially those focused on the critical 1,000 day window of opportunity, should be guided by the multi-factorial conceptual framework...
of maternal and child undernutrition (UNICEF, 2013). This framework recognizes the interaction between the underlying and basic causes of undernutrition in determining optimal nutrition, growth, and development in infancy and early childhood (Bhutta et al., 2008; Maternal & Child Group, 2013). In our analyses, when we considered three levels of determinants of child nutrition (child-level, mother-level, and household-level), delayed introduction of complementary foods, failure to meet children’s minimum dietary diversity, mother’s short stature, underweight, lack of education, and early marriage, and poor household wealth were found to be the most significant drivers of child stunting in South Asia. Nutrition-specific interventions, such as the protection, promotion, and support of breastfeeding, appropriate complementary foods and feeding, care, and hygiene practices, adolescent girls’ and women’s nutrition, macro and micronutrient supplementation for vulnerable population groups, food fortification programmes, and the prevention and treatment of infectious diseases and severe acute malnutrition, should be combined with nutrition-sensitive programmes that address the more distal socio-economic determinants of maternal and child undernutrition to prevent stunting in the first two years of life (Bhutta et al., 2008; Bhutta et al., 2013; Black et al., 2008; Pinstrup-Andersen, 2013; Ruel et al., 2013). We argue that neither approach in isolation is adequate to address the challenge of widespread stunted growth and development among South Asia’s children.

In parallel to national and regional efforts to reduce child stunting, there is a need for research and programmatic evidence to better understand how to drive faster and larger declines in South Asian countries, particularly among the most vulnerable children: the youngest, poorest, and the socially excluded. Understanding what drives child stunting at the national and subnational levels (i.e. the importance of context), how stunting influences child growth and development, and which domains of growth and development are more affected require further research. Relatedly, understanding how best to implement and scale up programmes aiming at improving children’s growth and development and reducing stunting – either through information, counselling and support on optimal child feeding and care, through dietary diversification, nutrition supplementation and/or fortification programs, or through integrated child nutrition and psychosocial stimulation programmes are key areas of further inquiry. Recent reviews indicate that integrated interventions have great promise (Black et al., 2015; Christian et al., 2015; Grantham-McGregor et al., 2014; Yousafzai & Aboud, 2014; Yousafzai et al., 2014). However, more research is needed to evaluate rigorously the effects of these programs, particularly in the long-run. If these interventions are able to address the joint etiologies of stunting and poor child development, they may be more effective in promoting child health and well-being.

High child stunting rates in South Asia challenge progress towards the SDGs, notably ending poverty in all its forms (SDG 1); promoting sustained, inclusive, and sustainable economic growth, full productive employment and decent work for all (SDG 8); and reducing inequality within and among countries (SDG 10) (UN, 2015b). Indeed the SDGs explicitly note the importance of nutrition with SDG 2 aiming to end hunger, achieve food security and improved nutrition and endorsing the WHA target to reduce the number of stunted children by 40% by 2025 (UN, 2015b). The achievement of this global target requires that South Asian countries accelerate efforts to reduce the prevalence of stunting in the region and contribute to achieve the SDGs related to child survival, growth, development, education, participation, and equity.
Introduction

Much of the world’s burden of malnutrition is visible. Children and adults who are wasted or obese can often be identified without special training or equipment. However, there are other equally important forms of malnutrition that are less obvious to the naked eye; namely, deficiencies of essential vitamins and minerals. According to the World Health Organization an estimated two billion or more people suffer what is called micronutrient malnutrition or more colloquially ‘hidden hunger’ (WHO, 2016). This form of malnutrition tends to be hidden both to the person suffering the deficiency and to the outside world until it becomes so severe that clinical signs emerge.

The most serious deficiencies of some micronutrients, such as vitamin A and zinc, cause death: roughly 270,000 annual deaths in children less than 5 years old are attributed to these two micronutrient deficiencies alone (Black et al., 2013). Yet even mild or moderate forms of hidden malnutrition have wide-ranging implications for human growth and development. Deficiencies in iodine and iron, for example, contribute to physical growth impairment in utero and early childhood, as well as to cognitive deficits. In 2013, out of 289 diseases and injuries contributing to the global burden of disease, the combination of just three - iron, iodine and vitamin A deficiencies - contributed 5% of the world’s burden of ‘years lived with disability’ (YLD), which is a metric of lost wellbeing associated with a poor state of health (Global Burden of Disease Study 2013 Collaborators, 2015).

Such nutrition losses are associated with impaired human capital. The term human capital is used to reflect the combination of skills, knowledge, and experience accumulated by individuals throughout the life-course based on their physical attributes and brain development. Growing well as an infant, learning in
school, working productively as an adult, and providing for the next generation all contribute to the social and economic wealth of nations. By contrast, threats to human capital represent a drag on sustainable development. South Asia is one of the regions of the world carrying the highest burden of hidden malnutrition and associated health burdens (Vos et al., 2012).

This paper presents an overview of what is empirically known about the human and economic impacts of various micronutrient deficiencies, and about recent patterns and trends in micronutrient deficiencies across South Asia. It draws on the most recent surveys and datasets to highlight where gains have been made and where a lack of progress continues to be of concern. A final section lays out policy and programme implications, calling for an urgent prioritization by South Asia’s governments and development partners of this largely unseen threat to future development.

**Hidden malnutrition and the development of nations: a review of evidence**

There are many forms of micronutrient malnutrition, but a few essential vitamins and minerals stand out in terms of the scale of global deficiencies and for the significance of their public health impact. Arguably the most pernicious and widespread condition is anaemia. Defined as a low blood haemoglobin concentration, anaemia affects an estimated 2 billion people (WHO, 2015). An estimated 50% of cases of anaemia are due to iron deficiency; other causes include deficiencies in other micronutrients such as folate, riboflavin, vitamins A or B12 and infections such as malaria, tuberculosis or HIV/AIDS.

Iron deficiency anaemia adversely affects birth weight, children’s cognitive and motor development, and adult labour productivity (Stevens et al., 2013). Almost one in five children under the age of five years have some form of iron deficiency anaemia, while severe anaemia is associated with around 90,000 deaths annually (Stevens et al., 2013;WHO, 2014).

While delivery of supplements to pregnant women and fortification of staple foods have been widely pursued for decades, anaemia remains a major challenge marked out for the “lack of progress” made in reducing prevalence rates since the early 1990s (IFPRI, 2015).

A second major global hidden deficiency is zinc. Assessments of national diets suggest that more than 17% of the world’s population is at risk (Black et al., 2013). Deficiency in zinc (a serum concentration of <60 µg/dl) is linked to poor child growth outcomes, impaired immune function, the incidence and severity of diarrhoeal disease, and numerous other nervous and reproductive system problems (Wessels et al., 2012). Indeed, an estimated 116,000 child deaths are ascribed to zinc deficiency or to elevated risk of deficient dietary intake of zinc each year (Black et al., 2013). Conversely, zinc supplementation to pregnant women has been shown to significantly reduce pre-term births in low income countries (Mori et al., 2012).

The third micronutrient deficiency of significance is vitamin A. Globally, one third of all children under five years suffer vitamin A deficiency (VAD) which causes blindness or death when associated with severe bouts of diarrhoea or measles. An estimated 157,000 children under five die annually due to VAD (Black et al., 2013). Around 15% of pregnant women also experience VAD, susceptibility being at its highest during the third trimester due to accelerated foetal development. Overall (across all ages), VAD is associated with over 800,000 YLD (Vos et al., 2012).

Around 30% of people suffer from iodine deficiency disorders, which represent the fourth nutrient deficiency of critical importance globally (Andersson et al., 2012). Iodine deficiency in pregnant women is responsible for birth defects, including in utero foetal brain development and impaired cognitive potential, while in children it impairs cognitive ability; in the most severe cases, iodine deficiency results in the growth of goitre, in cretinism or even in death (Vos et al., 2012).

These ‘big four’ micronutrients cause so much damage to health, education, physical and mental growth, labour productivity, and longevity that their hidden impacts on the economy can be enormous. Good nutrition supports high mental acuity and individual earnings, which in turn support macroeconomic and societal growth. Conversely, malnutrition impairs individual output, which acts cumulatively as a drag on national growth.

For example, Meenakshi et al. (2010) calculated that low vitamin A status among mothers and children can be associated with an annual loss of 1% of gross national product. Similarly, Horton & Ross (2003) showed that the cumulative economic impact of

* The term “children under 5 years old” refers to children 6 to 59 months old unless otherwise specified.
cognitive impairment and lower labour productivity due to iron-deficiency anaemia is on average 4% of national income in low income countries. Indeed, children who were iron deficient in Costa Rica during infancy had 10% lower cognitive test scores than those who were not deficiency, but also 26% lower test scores at the age of 19 years; in other words, the impairment persisted throughout their childhood (Lozoff et al., 2006). Similarly, roughly 10% of children born to iodine-deficient mothers are likely to suffer severe mental retardation (Hunt, 2005). This has extraordinary implications for countries of South Asia, where almost a third of households do not consume adequately iodized salt on a regular basis (UNICEF, 2014).

What is more, where there is one nutrient deficiency there are often others. It has been estimated that annual economic losses from low weight, poor growth, and clusters of micronutrient deficiencies average 11% of gross domestic product (GDP) in Asia and Africa (IFPRI, 2016). Indeed, Madsen (2016) showed that from 1960 through 2006, the combination of anaemia and iodine deficiency was linked to lower intelligence quotients (IQ), and that a 10% fall in IQ among individuals was associated with a 1% fall in national economic growth rates each year.

In terms of hidden malnutrition, the main drivers of such negative economic impacts are lower learning and productivity capabilities due to iron deficiency anaemia, diarrheal episodes associated with zinc deficiency, low immunity to diseases linked to a lack of vitamin A, and compromised intellectual potential due to iodine deficiency. Many individuals suffer more than one of these deficiencies simultaneously, and many deficiencies persist through a person’s lifespan. Micronutrient deficiencies are also associated with the growing global problem of overweight and obesity, which carry high risks of non-communicable diseases (Via, 2012). The association of obesogenic conditions and vitamin and mineral deficiencies is underpinned by low quality diets (Aitsi-Selmi, 2014). Monotonous, nutrient-poor diets affect maternal health and nutrition, but they can also lead to in utero malnutrition that has effects on the newborn that last into adulthood and can impact the next generation. One study in Thailand that followed children from birth to age 9 years found that “growth between birth and four months, whether in length or weight, was the variable most consistently and strongly related to IQ.” (Pongcharoen et al., 2012).

Since much of a child’s risk of malnutrition is determined by the mother’s nutrition and health status at conception, conditions during her pregnancy, birth outcomes, and subsequent childcare, what women know about nutrition, how well educated and literate they are, and how they are able to act on knowledge is a major determinant of hidden malnutrition and the ability of societies and nations to interrupt the cycle of hidden hunger.

Women’s education and hidden malnutrition: a review of evidence

Formal educational attainment and informally-obtained knowledge held by mothers have both been shown to be significantly linked to improved nutrition among their children (Smith and Haddad, 1999). Cross-country time series as well as studies using natural experiments have confirmed that maternal education is a key determinant of birthweight, neonatal survival, and children’s attained height. For example, using Demographic and Health Survey (DHS) data from 19 countries, Ruel and Alderman (2013) showed that the risk of child stunting was significantly lower among mothers with primary or secondary education even after controlling for wealth, residence, and child’s age and sex. The same study found a significant yet smaller effect of paternal education. Single country studies, such as one in Bangladesh, note that as the proportion of women with some secondary education rises (in Bangladesh it doubled between 1994 and 2005), the prevalence of child stunting tends to fall -- as it did in Bangladesh from 70% to 48% over the same period (Heady, 2013). Similarly, Cunningham et al. (2016) argue that maternal education in Nepal was a key factor in underpinning what they describe as "remarkable improvements" in child undernutrition from 1996 to 2011.

While correlations between education levels and undernutrition are robust across regions and over time, the links between education and micronutrient deficiencies have received less attention. Although, maternal education is a commonly identified predictor for risks of anaemia, serum retinol, serum zinc, and other measures of micronutrient status among children, few studies have explicitly considered how maternal education interacts with micronutrient deficiencies in the household, and vice versa. Such links are bi-directional in that knowledge may allow families to prevent or deal with micronutrient deficiencies, while such deficiencies impact individuals’ ability to obtain and act on knowledge. As Block (2007) points out, the ability to understand and identify micronutrient content and quality in foods may require more knowledgeable and/or educated consumers, thus maternal education could be an important determinant of a child’s micronutrient status.
Figure 7. Prevalence of micronutrient deficiencies by average years of women’s schooling at the country level (Harding et al., 2018)


A recent analysis using cross-country data (roughly 200 countries depending on the outcome of focus) for the period 1990 to 2013 confirmed such relationships (Harding et al. 2018). The number of years of women’s schooling was significantly associated with all micronutrient deficiencies, with the exception of iodine (Figures 7a-c).

Importantly, when controlling for national income per capita, women’s years of schooling was no longer associated with child anaemia in the upper middle income countries, but it remained a significant predictor of child anaemia in the lower income categories, especially in the lowest income group, while the lack of formal education among women was not predictive of zinc deficiency in the lower income countries, but remained a significant predictor of zinc deficiency in the upper income countries. Thus, in the case of child anaemia, education appears to matter relatively more in the context of greater poverty, whereas in the case of zinc deficiency, measured as inadequate zinc intake, there may be a base level of resources needed before education can impact zinc status (i.e. in poor context, regardless of education or knowledge, it may not be feasible to purchase foods rich in zinc).

These findings, complemented by others, strongly support the conclusions that i) girls’ education plays an important role in improving nutrition across generations; it represents a nutrition sensitive action that all governments should act upon; ii) while women’s anaemia and children’s vitamin A improve along with women’s education, improvements in zinc and child anaemia are mediated by the effects of poverty; which means that complementary actions (beyond) education are needed to address multiple forms of hidden malnutrition; and iii) where poverty, overt (not hidden) malnutrition and education of girls all lag (as in parts of South Asia), there is an urgent need for governments to prioritize actions to address such problems simultaneously.

Additionally, it is important to invest in appropriate informal knowledge acquisition (beyond schooling) by girls and mothers relating to quality diets and nutrition. For example, Webb and Block (2004) assessed the impact of a mass media campaign in Central Java that promoted population-wide understanding of good dietary sources of vitamin A. Using seven survey rounds involving almost 32,000 rural households, the authors correlated with child nutrition outcomes mothers’ responses to questions about the messages that had formed the basis of the campaign. The messages included information about the value of dietary vitamin A to child health and growth, and the importance of feeding vitamin A-rich foods to young children. They showed that while maternal schooling was, as expected, an important determinant of child growth, even ‘uneducated mothers’ (i.e. mothers lacking formal education) benefitted from well-crafted

nutrition information that they could act on. That is, knowledge gained informally (rather than just the years spent in school) offers a strong basis for mothers to improve the diversity and quality of the food that they provide to their children (Webb and Block, 2004). As such, it becomes all the more important for governments to seek to equip girls and women with the resources (informational as well as educational) they need to be able to do all they can to tackle hidden hunger through their own dietary choices.

### Trends in hidden malnutrition in South Asia

While hidden malnutrition is still global in its reach, its prevalence and impacts area disproportionately concentrated in poorer regions of the world such as South Asia. The scale of the problem facing South Asia’s national governments and development partners is huge. South Asia alone accounts for almost 40% of the entire world’s YLDs attributed to anaemia (Kassebaum et al., 2014). In 2013, roughly 2% of all preventable child deaths in low and middle income countries (LMICs) were attributable to vitamin A deficiency, and South Asia has some of the highest prevalence of vitamin A deficiency in the world: exceeding 30% in countries like Nepal and Sri Lanka and exceeding 60% in India (Stevens et al., 2015). At the same time, South Asia has the highest rates of inadequate zinc intake, at 30% compared with the global average of 17% (Wessels et al., 2012)

This matters for South Asia’s future. Despite some important progress made across the region in recent years, at least in terms of economic growth, agricultural output and exports, poverty reduction and even in improved health, South Asia’s burden of micronutrient deficiencies is still very large: Pakistan has long been classified as a nation with ‘severe iodine

---

**Figure 8.** Prevalence of micronutrient deficiencies globally and in South Asia and Sub-Saharan Africa*

<table>
<thead>
<tr>
<th>Micronutrient Deficiency</th>
<th>World</th>
<th>South Asia</th>
<th>Sub-Saharan Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A deficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iodine deficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc deficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaemia among children &lt;5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaemia among pregnant women</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

*Vitamin A deficiency: Serum retinol <0.70 µmol/L; data from 2013 (Stevens et al., 2015); Iodine deficiency: Urine iodine excretion <100 µg/L among school aged children; South Asia includes Southeast Asia and Sub-Saharan Africa includes all of Africa; data from 2011 (Andersson et al., 2012); Zinc deficiency: Weighted average of country mean of estimated inadequate zinc intake at population level; data from 2005 (Wessels et al., 2012); Anaemia: Defined as haemoglobin <11 g/dL; data from 2011; Sub-Saharan Africa includes West and Central Africa (Stevens et al., 2013).
deficiency’; almost two-thirds of children under 5 in Afghanistan suffer vitamin A deficiency and India continues to report that around 53% of women of reproductive age are anaemic (India, 2016), compared, for example, with only 19% in China (IFPRI, 2016).

At the same time, improvements remain patchy and slow. The prevalence of inadequate zinc intake in South Asia has changed little between 1990 and 2005: Afghanistan, Nepal, and Sri Lanka, for example, recorded less than a one percentage point change over 15 years (Wessels et al., 2012). Between 1995 and 2011, the prevalence of anaemia among non-pregnant women in South Asia fell only slightly from 53% to 47%, but with little change among pregnant women (Stevens et al., 2013). Similarly, the estimated prevalence of vitamin A deficiency among children under 5 years of age across South Asia declined very slowly and only slightly from 47% in 1991 to 44% in 2013 (Stevens et al., 2013). The lack of progress in reducing these deficiencies puts most of the countries in the region off-course in their attempt to reach global nutrition targets set for the coming couple of decades.

The details of country-level patterns and trends matter a lot to the design of appropriate policy and programme responses by location. That is, since micronutrient problems are not equally felt by all populations in the same ways everywhere in the region, detailed knowledge of drivers and differential outcomes is a key to effectively-tailored action. For example, South Asia had the highest prevalence of anaemia in 1990, and still had the world’s 4th highest prevalence among males in 2010, and 3rd highest among females (Kassebaum et al., 2014). However, important differences exist across the region. In Afghanistan, Nepal, and Sri Lanka, anaemia is considered to be a ‘moderate’ public health problem for non-pregnant women, whereas it is a ‘severe’ problem in Bangladesh, Bhutan, India, and Pakistan (Kassebaum et al., 2014; Harding et al., 2017a).

With around 50 percent of women of reproductive age suffering some form of anaemia in the mid-2000s, India has one of the highest prevalences of anaemia in South Asia; further, this prevalence was largely remained unchanged at a national level between the late 1990s and 2006 (India 2006; Bharati et al., 2015) (Figure 9). In recent years (2016), there has been a substantial decreased in anaemia among women of reproductive age in some states in India and not others, though the prevalence remains high. For example, the prevalence in Tripura dropped from 65% in 2006 to 55% in 2016 and the prevalence in Sikkim dropped remarkably from 60% to 35%. On the other hand, the prevalence increased or did not change in states such as Haryana, Tamil Nadu and West Bengal (India, 2016). Anaemia rose in Afghanistan,

Figure 9. Prevalence of anaemia among women of reproductive age across time (1990 to 2012), by country [data from Stevens et al., 2013 and Harding et al., 2017a]
from 40% of children under 5 in 2004 to 45% in 2011 (Afghanistan, 2013), and in Pakistan, from 51% in 2001 to 62% in 2011 (WHO, 2007; Pakistan, 2011). Yet, countries like Nepal and Sri Lanka have seen declines in anaemia among pregnant women since the 1990s. Current rates are still too high (they remain public health problems), but the downward trend over 20 years from 1990 to around 2010 is a bright spot to be noted so that lessons might be learned on how this positive trend has been achieved (Stevens et al., 2013).

Of course, even within countries there are important differences. In India, Bangladesh and Nepal, anaemia is more prevalent in rural than in urban populations, whereas in Pakistan there is little difference by location. In neighbouring Nepal, the prevalence of anaemia among children is highest in the low-lying plains (50%), but only slightly lower in the hills (41%) (Bhandari and Banjara, 2015). Some Indian states such as Puducherry, Goa, Meghalaya and Tripura have a relatively low prevalence of anaemia in children aged 6 to 59 months below 50%, while other states such as Haryana have an anaemia prevalence rate exceeding 70% (India, 2016). Trend lines also differ: Bharati et al., (2015) reported that in India’s southern states, mean haemoglobin levels in women of reproductive age fell from roughly 11.9 g/dL in 1998/99 to slightly above 11.6 g/dL in 2005/2006 but rose over the same period in the north-east (from 11.6 g/dL to 11.8 g/dL) (Bharati et al., 2015).

Similar differences in rates across locations and populations apply to other micronutrients as well. In the case of zinc, about 39% of children under five in Pakistan are deficient (Pakistan 2011), while in Bangladesh the rate is 45% (ICDDRB et al., 2013). Wessels et al. (2012) proposed that Sri Lanka had one of the highest population-wide rates of inadequate dietary intakes of zinc in the world at 48% in the mid-2000s (2003-2007). But a more recent assessment of dietary zinc deficiency using 2009 data suggests that India tops the South Asia ranking with a risk of inadequacy of 46% (Mark et al., 2016).

Again, there is large intra-nation variability; in a sample of states, serum zinc deficiency (cut-off level ≤65 μg/dL) was highest in Orissa (>51%) and Uttar Pradesh (48.1%), but below 40% in Madhya Pradesh (39%), and Karnataka (36%) (Akhtar, 2013). After India, the next highest risk of inadequate dietary intake of zinc was reported for Pakistan at over 39%, while the lowest in the region was Nepal (less than 16%) (Mark et al., 2016). In Bangladesh, zinc deficiency is higher in slums (52%) and rural areas (49%) than in urban areas (30%) (ICDDRB et al., 2013). Yet, rates do not differ between urban and rural Pakistan (Pakistan 2011).

Where vitamin A deficiency (VAD) is concerned, South Asia is still the region with the greatest number of affected children; while all LMICs together have

**Figure 10.** Prevalence of vitamin A deficiency (VAD) among children 6-59 months old across time (1991 to 2013), by country [data from Stevens et al., 2015 and Harding et al., 2017b]
seen VAD decline from almost 40% to less than 30% between 1991 and 2013, South Asia’s average remains in the order of 44% (Stevens et al., 2015). Sri Lanka and the Maldives are two positive outliers, as it appears that these countries have made huge improvements in the vitamin A status of its children since the early 1990s (Thompson and Amoroso, 2014) (Figure 10).

Where adult women are concerned, a relatively low 11% of women of reproductive age were vitamin A deficient in Afghanistan in 2011/12 (Afghanistan 2013). This may in part be due to the effective roll out of vitamin A supplementation and associated prenatal care since the early 2000s. For example, two-dose coverage rose in that country from only 58% in 2000 to 95% in 2014 (UNICEF, 2015). By contrast, the prevalence of vitamin A deficiency in women was recently over 40% in Bangladesh and Pakistan (Pakistan 2011; ICDDR, B, et al., 2013). Pregnant women in Pakistan recorded rates around 46% (Pakistan 2011). The average for Pakistan in 2011 masked a wide range, running from around 16% of pregnant women in Sindh with severe VAD (serum level <0.35 μmol/L), to almost 48% in Khyber Pakhtunkhwa, and almost all regions of the country reporting 20% to 30% mild VAD (0.35-0.70 μmol/L) (Akhtar et al., 2013).

Finally, iodine deficiency is also unevenly distributed across and within the region. At national level, iodine deficiency (median UIE <100 μg/L) is not a public health problem for any country in South Asia (Andersson et al., 2012) (Figure 11) However, some countries like Afghanistan (where only 20% of households consumed adequately iodized salt) still show rates almost double those of other parts of the same region, such as Nepal (UNICEF 2014).

Drivers of hidden malnutrition in South Asia: a focus on anaemia

There has been little progress across South Asia in resolving hidden malnutrition. Furthermore, some countries have seriously high levels of micronutrient deficiencies and others have pockets of unusual severity. Therefore, much more needs to be understood about the context-specific drivers of various micronutrient deficiencies and how to formulate interventions appropriately to accelerate positive change. The underlying and proximate drivers of deficiencies are numerous, and their respective roles may vary by country context.

Take anaemia as an example. An analysis of recent datasets suggests that the factors that are most significantly associated with anaemia in women of reproductive age vary by country. In Nepal and Pakistan, there is wide variation across agro-ecological...
CHILD STUNTING, HIDDEN HUNGER AND HUMAN CAPITAL IN SOUTH ASIA

zones: around 40% of Nepalese women in the plains are anaemic compared with 25% in the hills and mountains; in Pakistan, anaemia rates range from 67% in sub-tropical Sindh to 30% in mountainous Gilgit (Nepal 2011; Pakistan 2011).

In India and Bangladesh, household wealth is strongly associated with the presence or absence of anaemia in women. Balarajan et al. (2013) note that anaemia in India is "socially patterned", meaning that it is higher among women from poorer households, who also tend to have less schooling and to belong to scheduled castes and scheduled tribes. Level of household wealth - be it income or assets-based - is also correlated with anaemia among children in Pakistan, yet in Nepal, wealth is not statistically correlated with anaemia for either women or children. By contrast, in Nepal access to improved sanitation facilities and to improved drinking water sources are associated with lower anaemia rates. What is more, in Nepal children in from homes with a de facto female head of household were at a lower risk of anaemia. In Pakistan, low egg consumption by women and current breastfeeding were both linked to higher risk of anaemia (Harding et al., 2017a).

Other factors must also be taken into account. According to Bhutan’s National Nutrition Survey 2015, the prevalence of anaemia was lower among pregnant women (27.3%) than among non-pregnant women (34.9%), probably due to the iron and folate supplementation programme during pregnancy (Bhutan, 2015). In Sri Lanka, the prevalence of anaemia among pregnant and non-pregnant women was similar (both groups at roughly 25%) while in Afghanistan it was higher among pregnant women than among non-pregnant women (44% v. 31% respectively) (WHO, 2015). The fact that parity was associated with anaemia in Bangladesh (OR=1.94-66.1) and India (54% anaemia prevalence among women who have yet to give birth compared with over 50% among mothers with five or more children) suggests that more attention needs to be paid to reaching women during pregnancy, but also to improving their diets and health over the long-run (Merrill et al., 2012; Balarajan et al., 2013).

Finally, the nutritional status of pre-pregnant adolescent girls cannot be overlooked. Akhtar et al. (2013) reported that 90% of adolescent girls in 16 districts of India were iron deficient (Akhtar et al. 2013), which sets in motion the problem of poor maternal nutrition when adolescents become pregnant leading to compromised birth outcomes and nutrient deficiencies in infants. A recent comprehensive review highlights these and other challenges pertaining to the nutrition situation of adolescent girls in South Asia (Aguayo & Paintal, 2017).

Of course, diets vary widely across the region based on wealth, location, culture and religion. Self-professed religion is a household-level factor that was statistically correlated with anaemia among women in Bangladesh, Nepal and India. In Bangladesh, a predominately Muslim country, being non-Muslim was associated with a higher prevalence of anaemia compared with being Muslim (>49% vs. 40%) (Kamruzzaman et al., 2015), while in India, which is predominately Hindu, being Muslim (56%) or Christian (51%) was associated with a slightly lower risk of anaemia than being Hindu (57%) (Balarajan et al., 2013). In Nepal, which is largely Hindu, but also Buddhist, being of the Kirat religion (the Rai people of eastern Nepal) was associated with a lower prevalence of anaemia (prevalence ratio =0.61; CI 95% 0.39-0.97) compared with being Hindu, after controlling for other potential factors (Harding et al., 2017). Perhaps surprisingly, Balarajan et al. (2013) reported that having any or severe anaemia among Indian women of reproductive age was lower among vegetarians than non-vegetarians. If confirmed, the latter would indicate that diet alone is not the sole driver of anaemia in South Asia.

Education and literacy are additional important predictors of anaemia among adult women, as noted in the section above. In Bangladesh, women with higher education had lower rates of anaemia (33%) than those with secondary (38%) or no education (46%) (Kamruzzaman et al., 2015). In India, women with ≥ 13 years of education had a lower prevalence of anaemia than those who had none (43% vs. 60%) (Balarajan et al., 2013), and in Pakistan, women’s literacy was associated with a lower prevalence of anaemia (Pakistan 2011).

Iron depletion was a co-morbid condition with anaemia in Pakistan. Indeed, roughly 27% of non-pregnant women and 44% of children from the 2011 National Nutrition Survey had low ferritin levels, with a higher prevalence of low ferritin concentrations among children in urban than in rural areas, and variation across provinces (Pakistan 2011). In a recent survey in rural Bangladesh, a high prevalence of anaemia was reported (57%) where iron deficiency was absent (Merrill et al., 2012). It was found that women exhibited high levels of thalassaemia, and that they had high iron intake from groundwater. Similarly, a recent survey in Nepal of pregnant women in the western district of Banka found that women of Tharu ethnicity (who are also known to exhibit thalassaemias) had a higher odds ratio for anaemia than Brahmin women (OR=2.28; CI 95% 1.06-4.90) (Balarajan et al., 2011; Ghosh et al., 2012).
2016). Such findings underline the importance of understanding the local causes of anaemia to know how to prevent and treat it.

Implications for action

South Asia’s lack of progress in resolving hidden malnutrition over recent decades continues to hamper the region’s attempts to accelerate development. The median cost of iron deficiency for 10 low income countries was found to be approximately US$ 2.32 per capita (0.57% of GDP) based on annual physical productivity losses alone; when both physical and cognitive losses are accounted for this increased to US$ 16.78 lost per capita (4% of GDP) (Horton and Ross, 2003). When one considers countries with larger economies, such as India, the economic impact of hidden malnutrition escalates rapidly. For example, Stein & Qaim (2007) calculated the costs just for India, where an estimated 9.3 million DALYs were lost to iron deficiency anaemia, and zinc, vitamin A and iodine deficiency in the mid-2000s, equivalent to losing no less than 0.8% of annual GDP. Based on India’s 2007 GDP of US$ 1.2 trillion, this translates in 2014 dollars to more than US$ 16 billion (based on 2014 GDP of US$ 2 trillion). Such a huge figure from a single country contributes about one-third of the estimated global cost of malnutrition of US$ 3.5 trillion (FAO, 2013).

A significant proportion of such economic cost is due to the effects of poor child nutrition on educational performance and subsequent lifetime earnings. That is, impaired child growth and intellectual development across South Asia hinders school enrolment at an appropriate age, causes absenteeism or early drop-out due to ill-health and/or poor learning, and prevents optimal learning and skills development. Thus, there remains a lot to be done to stem the losses at individual and national levels, and to bolster good nutrition as an input to faster human and economic development in the future. As the International Food Policy Research Institute (2016) puts it, countries of the region “…so long synonymous with the problem of malnutrition, can become a major part of the solution.”

The solutions will have to come from a stronger more consistent national level political and policy commitment to urgently addressing micronutrient malnutrition from multiple directions at once. A nutrient-by-nutrient approach will not suffice and neither will a focus on some but not all micronutrient problems. Similarly, reliance on the distribution of supplements and other targeted nutrition-specific actions by themselves will achieve some but not all the gains required.

This does not mean that governments should remove supplementation from the tool-kit available to policymakers and other development practitioners where it is cost-effective. Quite the contrary. Supplementation with vitamin A, iron and folic acid, and sometimes multiple micronutrients has proven to be very cost effective in appropriate contexts. Currently, LMICs are “doing well” on providing vitamin A supplements to pre-school age children, with a median population coverage of 79 percent, and in providing iron and folic acid supplementation to pregnant women, with a median coverage of 78 percent (IFPRI, 2016). Hoddinott et al. (2012) estimate that the benefit:cost ratio of vitamin A supplementation for children under five in low income countries was 12.5, while the figure for iron and folic acid supplementation for children aged 6 to 23 months and mothers was double that at 24 months. In the case of salt iodization the benefit:cost ratio was 81.

Vitamin A supplementation efforts have been ongoing across the region for decades. High dose biannual supplementation of children under five in Pakistan from the 1990s has been linked to a roughly 24% reduction in VAD as a result of effective program administration and targeting (Siddiqi and Iqbal 2008; Haider and Bhutta, 2011). In Sri Lanka, a vitamin A supplementation programme has been associated with fewer school days missed due to illness compared to the placebo group (Mahawithanage et al., 2007).

However, with an average coverage of vitamin A supplementation of only 62% in 2014 (largely driven by India’s lower performance), South Asia still has one of the lowest coverage rates globally – the world average being 69% (UNICEF, 2016a). Even current rates of coverage are at risk of declining in some countries as a result of the phasing out of National Immunization Days. Horton et al. (2008) point out that Bangladesh relied on accessing hard-to-reach populations with vitamin A supplements by combining routine health services with Child Health Days that linked vitamin A distribution with immunization. But Child Health Days are increasingly questioned by governments seeking places to save on health budget outlays. The implication is that rates of supplementation coverage cannot be guaranteed into the future where nation mechanisms for delivery are not secure.

Iron (plus folic acid) supplementation relies on clinic distribution or community health workers to reach remote populations. For example, Nepal has demonstrated the feasibility of achieving wide coverage by empowering community health workers and by focusing resources on antenatal and postnatal care.
In response to a 75% prevalence of anaemia among pregnant women in 1998, the government began the Intensification of Maternal and Neonatal Micronutrient Program in 2004 with financial support from UNICEF and the Micronutrient Initiative. The program targeted antenatal care visits, iron and folic acid supplementation and deworming medication during pregnancy using female community health volunteers. Monitoring indicators suggested successful implementation, and the prevalence of anaemia among pregnant women fell to 42% by 2006 (Pokharel et al., 2011). The rate of anaemia among pregnant women continued to fall, reaching 34% by 2010/11 (Nepal 2011).

However, supplementation is not enough to achieve sustained full micronutrient nutrition to entire populations. In addition to high supplementation coverage where appropriate, additional actions are needed. This requires other interventions focused on i) additional non-supplement micronutrient delivery mechanisms, including food fortification, biofortification and diet diversification, ii) actions to promote the nutrition security of infants and young children, and iii) complementary nutrition-sensitive interventions that will support gains in human capital development.

The non-supplement approaches to delivering micronutrients have also been widely implemented in the region. For example, vegetable oil and ghee are fortified with vitamin A and D in Afghanistan since 2014, and there have been several attempts to implement iron fortification of wheat flour. India and Pakistan have pursued the fortification of wheat flour with iron, folic acid and vitamin B12, while Nepal has also implemented mandatory wheat flour fortification with iron and folic acid. Several countries in the region, such as Nepal are testing the potential of point-of-use or ‘home’ fortification; that is, the distribution of small packets of multiple micronutrient powders mixed into the complementary food offered to infants after 6 months of age (Ip et al., 2009; Sazawal et al., 2014). An additional means of delivering micronutrients into the local food matrix at the point of consumption is through small dose lipid nutrient supplements which are highly nutrient-dense oil-based spreads that can be blended into an infant’s meal (Lopriore et al., 2004).

Salt iodization is another widely adopted approach to tackling iodine deficiency. As mentioned above, the benefit:cost ratio of salt iodization is very high at 81 (Hoddinott et al., 2012). However, policy and regulatory/monitoring mechanisms are required to ensure that adequate iodization is actually occurring and that families have access to such salt. While the global average for adequately iodized salt consumption stood at 75% in 2014, South Asia was still lagging at 69% (UNICEF, 2014). That said, a renewed push is underway among governments of the region towards the universal goal of 90% coverage. In India, for example, this included the formation of state level coalitions, the provision of technical support to enhance the capacity of salt producers, and the sensitization of wholesalers and retailers to procure only adequately iodized salt. Recent data show that conditions are improving, with household use of adequately iodized salt increasing from 71% in 2009 to 78% in 2014 (Rah et al., 2015).

Actions to improve the dietary intake of essential nutrients in early life include approaches to protect, promote and support breastfeeding and higher quality complementary foods and feeding practices. Exclusive breastfeeding immediately after delivery until six months of age provides infants with nutrients and protects them from diseases that may lead to nutrient loss. Only 64% of infants in South Asia benefit from exclusive breastfeeding, and 55% are not breastfed from within the first hour of life (UNICEF, 2016b). The introduction of solid, semi-solid or soft foods should occur at the age of 6 months, yet half of infants (46%) receive foods too late for optimal growth and development. Only 47% of children aged 6-23 months are fed the minimum number of meals a day and only 23% are eating the minimum number of food groups, leaving the vast majority vulnerable to micronutrient deficiencies.

All countries in South Asia recognize infant and young child feeding as a strategic development priority and have a range of policy and legislation support for breastfeeding (Thow et al., 2017). However, gaps in the design and implementation of these policies and legislation remain, and there is need to strengthen health system support for counselling and education on breastfeeding, as well as workplace, community and family support to breastfeeding mothers. There is relatively little policy emphasis on complementary feeding in the region (Thow et al., 2017), and greater government leadership, prioritization and financing is needed to address the nutrient gap in children’s diets (UNICEF, 2016b). Progress on complementary feeding requires actions by multiple sectors and stakeholder groups that can collectively ensure a household has access to affordable and nutritious food, and whether caregivers have the skills, knowledge and other resources to prepare frequent nutritious and safe foods.

The promotion of dietary diversification is a food-based approach to increasing intake of micronutrients. Diet diversification represents a large-scale but as yet unfulfilled opportunity. While the consumption of foods high in beta carotene by vitamin A deficient
consumers has been shown to have a significant positive association with serum retinol concentrations (Fujita et al., 2012; Webb and Kennedy, 2014), there is limited empirical evidence of cost-effective policy or programme interventions that succeed in sustaining diet diversity across a range of nutrients (Thompson and Amoroso, 2014). What is more, Mark et al. (2016) calculated that the current food supply in most of South Asia is not adequately composed to deliver seven of the most important nutrients required for sound nutrition and health. For example, India has the lowest supply (in foods) of vitamin B-12 and zinc, Pakistan has the lowest supply of thiamine, and Bangladesh the lowest supply of vitamin A, riboflavin and calcium. This does not mean that promotion of agricultural diversity and market access for all consumers cannot achieve such a goal, but more needs to be done to demonstrate effective approaches that can be adopted by governments across the region (Sibhatu et al., 2015).

The most recent food-based approach to delivering micronutrients is biofortification. An expert consultation suggested in 2003 that “probably as many as 30 biologically distinct types of foods, with the emphasis on plant foods, are required for healthy diets” (WHO and FAO, 2003). Achieving access to a diverse diet is not easy for poor people, and it represents a major policy challenge for developing country governments. Many consumers are constrained by income level or distance to markets to eating a monotonous nutritionally-inadequate diet. Biofortification represents a way to ‘deliver more’ in the context of dietary constraints. It is pursued through conventional crop breeding techniques that are used to identify varieties with high concentration of desired micronutrients. Those varieties are then cross-bred with high-yielding varieties to develop biofortified varieties that have high levels of, for example, zinc or betacarotene, in addition to other productivity traits desired by farmers (Global Panel, 2015).

Rice biofortified with zinc was released to farmers in Bangladesh in 2013 (Chowdhury, 2014). These biofortified varieties have a zinc content that is 30% higher than local varieties, and it matures faster than some traditional strains (HarvestPlus, 2014). The capacity to scale up adoption of high-zinc rice has still to be demonstrated, but since poor consumers in Bangladesh rely heavily on large amounts of rice daily, such an approach could significantly improve dietary intake of zinc. The same applies to biofortified pearl millet, with higher iron and zinc content, which is already being grown in Maharashtra state of India (HarvestPlus, 2014).

It is the complementary among a set of actions that offers the best promise for accelerated change. Such complementarity has been underlined by FAO, which calculated that an annual investment of US$ 1.2 billion in the combination of a) micronutrient supplementation, b) staple food fortification and c) biofortification of staple crops, would result in “better health, fewer deaths and increased future earnings” valued at over US$ 15 billion per year: a 13-to-1 benefit to cost ratio (FAO, 2013).

The second set of actions needed to complete the work of resolving micronutrient deficiencies in South Asia involve nutrition sensitive approaches that support human capital formation. As noted by Ruel et al. (2013) “nutrition-sensitive programmes can help scale up nutrition-specific interventions and create a stimulating environment in which young children can grow and develop to their full potential.” This means appropriately supporting agriculture, social safety nets, early child development activities, water, hygiene and sanitation (WASH) activities, health promotion and universal education. It is critically important that all children in South Asia gain access to the right kinds of care, health services and diets; that agricultural programmes and social safety nets be designed to reach the most vulnerable and protect them effectively from negative effects of food price and other shocks. It is equally important that national and local policies support women’s empowerment, literacy and formal education.

It is also essential that policymakers should promote poverty- and inequity-reducing economic growth. Gross national income growth is critical to enabling governments to make the investments in the nutrition specific and nutrition sensitive programmes outlined above. Yet, while economic growth does tend to reduce most forms of malnutrition over time, the decrease is generally far slower and less equitably distributed than the corresponding poverty reduction might have predicted (Ruel et al., 2013). In other words, malnutrition in general, and hidden malnutrition in particular, “does not take care of itself” (Webb and Block, 2004).

South Asia’s future depends on ensuring that policies across the many sectors with responsibility for promoting good nutrition are mutually-supportive, that public programming is evidence-based and measurably cost-effective, and that the benefits of accelerated improvements in nutrition are equitably shared. Human capital has to be preserved, protected and nurtured as a South Asia-wide goal. For this to happen, hidden malnutrition has also to be embraced as a South Asia-wide problem to be resolved as a matter of urgency.


Martorell, R., Horta, B.L., Adair, L.S., Stein, A.D., Richter, L., Fall, C.H., et al. (2010a). Weight gain in the first two years of life is an important predictor of schooling outcomes in pooled analyses from five birth cohorts from low-and middle-income countries. Journal of Nutrition, 140, 348-354.


CHILD STUNTING, HIDDEN HUNGER AND HUMAN CAPITAL IN SOUTH ASIA


American Psychologist, 56, 5-15.


