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Review article

# Understanding the association between stunting and child development in low- and middle-income countries: Next steps for research and intervention

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ABSTRACT

Stunting, caused by experiences of chronic nutritional deprivation, affects approximately 25% of children under age five globally (i.e., 156 million children). In this review, evidence of a relationship between stunting and child development in low- and middle-income countries is summarized, and issues for further research are discussed. We focus on studies that measured low height-for-age 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 the 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, considerable evidence from across many countries supports an association between stunting and poor child development despite methodological differences and heterogeneity in the magnitude of associations. Further, effect sizes differ by developmental domain with greater associations 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 experimental research to test causal pathways. Finally, there is mixed evidence of the additive effect of nutrition + stimulation interventions on child development. However, understanding best methods for improving child developmental outcomes – either through nutrition programs or through integrated nutrition + psychosocial stimulation programs (or nutrition + other program interventions) – is a key area of further inquiry. 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.

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## 1. Introduction

The 2015 Sustainable Development Goals (UN, 2015) and several expert reviews on child development call for new research and interventions to prioritize solutions to the global challenge of poor child development in low- and middle-income countries (LMICs)

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(Black et al., 2016; Britto et al., 2016; Dua et al., 2016; Richter et al., 2016). Child development can generally be defined as the attainment of gross motor and fine motor skills, psychosocial competencies, and cognitive abilities. Although many factors may impact child development, numerous cross-sectional studies and two meta-analyses provide important initial evidence of a link between impaired linear growth and poor child development (Miller et al., 2015; Sudfeld et al., 2015; Walker et al., 2007b, 2011). The behavior of stunted children is often associated with apathy, detachment from social environments, cognitive deficits, poorer learning outcomes and lower educational attainment, as well as reduced economic prospects in the future, thus perpetuating intergenerational transfers of undernutrition and poverty (Alderman et al., 2014; Currie and Vogl, 2013; Grantham-McGregor et al., 2007; Perkins et al., 2016). If stunting causes developmental deficits, then the consequences at the population-level are immense, as there are 156 million children across the world who are stunted (UNICEF et al., 2016).

A meta-analysis of cross-sectional studies found that linear growth among children less than two years old was associated with cognitive and motor development across diverse studies from 29 LMICs (Sudfeld et al., 2015). Similarly, evidence from 15 countries participating in the Multiple Indicator Cluster Surveys showed associations between stunting and some child development domains, though the associations varied by country and other factors (Miller et al., 2015). Drawing a definitive conclusion about these relationships from meta-analyses is difficult, however, given substantial heterogeneity in how studies are conducted, the populations that are targeted, whether it is linear growth or stunting that is measured, and the tools used to measure various child development domains. Challenges with accurately measuring linear growth and stunting may also affect conclusions (Corsi et al., 2017).

In addition, a causal relationship between stunting and child development should not be assumed based on evidence from observational studies due to the potential for many factors, such as socioeconomic status and place, to confound the relationship. For example, stunted children are more likely to grow up in conditions of overall deprivation, which affect both physical growth and child development (Grantham-McGregor et al., 2007). Thus, studies need to adequately account for a variety of confounding factors at various levels of influence.

Taken together, these challenges make it difficult to determine how to use observational evidence about the stunting-child development relationship for intervention purposes, particularly for researchers and policy-makers who may be unfamiliar with this area of work. Moreover, caution is needed when using evidence from meta-analyses for decision-making about further research and intervention development (Ioannidis, 2016).

To address these challenges, several studies have used designs that permit causal assessments of the extent to which linear growth and stunting impact child development. Including these studies' conclusions alongside findings from observational studies that have been reviewed in the past would provide a stronger case for deciding how to invest in programs that target stunting reduction while supporting paths to meet global goals for improving child development. Thus, the purpose of this paper is to provide a substantive review of the association between stunting and child development in LMICs based on evidence from correlational designs, quasi-experimental studies, randomized nutrition interventions and nutrition + psychostimulation interventions. This review moves beyond presenting a quantitative summary assessment of the observational relationship between stunting and child development by discussing the current extent of 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. In addition, we describe challenges associated with measures and study designs as well as with interpretation of results within and across studies.

Finally, we discuss how this area of research may evolve and inform the development of evidence-based intervention programs. Although other determinants of child development are important for policy and intervention (e.g., addressing socioeconomic conditions), we focus here on the direct relationship between stunting and child development. We are motived to offer this review given the considerable interdisciplinary attention on addressing child development and on how nutritional deprivation may play a role in impacting population human capital and wellbeing. This repository of information will be useful for policymakers, practitioners, program managers, or researchers new to this field, who seek to reduce stunting and address child development challenges, particularly in LMICs.

## 2. Identifying peer-reviewed 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). Stunting occurs when a child's height is more than two standard deviations below the median height-for-age among children of a given sex according to WHO Child Growth Standards. We included papers using either or both height measures as they capture different, but related exposures.

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 use a battery of skills tests. Web Tables 1–3 provide a list of common assessments and the typical targeted population. For a more in-depth discussion on individual child development assessment tools, there are several recent reviews (Fernald et al., 2009b; Frongillo et al., 2014; Sabanathan et al., 2015).

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, and childhood. Only studies published in English were included.

As part of this review, we first discuss the many challenges that exist when comparing studies on child development, which make comparisons between results and generalizations difficult. After acknowledging such challenges and caveats, we review evidence of the association between stunting and child development provided by cross-sectional and longitudinal observational studies, as well as from quasi-experimental studies and randomized experiments. After establishing a plausible link between stunting and child development, we then briefly review potential mechanisms through which stunting may lead to developmental impairments. Finally, we highlight gaps in knowledge and further directions for this area of research. We conclude by discussing why the potential

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