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## Article

# Growth trajectories from conception through middle childhood and cognitive achievement at age 8 years: Evidence from four low- and middle-income countries



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## ABSTRACT

Child chronic malnutrition is endemic in low- and middle-income countries and deleterious for child development. Studies investigating the relationship between nutrition at different periods of childhood, as measured by growth in these periods (growth trajectories), and cognitive development have produced mixed evidence. Although an explanation of this has been that different studies use different approaches to model growth trajectories, the differences across approaches are not well understood. Furthermore, little is known about the pathways linking growth trajectories and cognitive achievement. In this paper, we develop and estimate a general path model of the relationship between growth trajectories and cognitive achievement using data on four cohorts from Ethiopia, India, Peru, and Vietnam. The model is used to: (a) compare two of the most common approaches to modelling growth trajectories in the literature, namely the lifecourse plot and the conditional body size model, and (b) investigate the potential channels via which the association between growth in each period and cognitive achievement manifests. We show that the two approaches are expected to produce systematically different results that have distinct interpretations. Results suggest that growth from conception through age 1 year, between age 1 and 5 years, and between 5 and 8 years, are each positively and significantly associated with cognitive achievement at age 8 years and that this may be partly explained by the fact that faster-growing children start school earlier. We also find that a significant share of the association between early growth and later cognitive achievement is mediated through growth in interim periods.

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## Introduction

Child undernutrition, as measured by stunting (low-height for age), is endemic in low- and middle-income contexts and poses a threat to child survival, health, and development. In 2011, there were 165 million stunted children worldwide, with undernutrition accounting for 45% of deaths among children under 5 years and resulting in a loss of individual developmental potential reflected

by poorer cognitive, psychosocial, and schooling outcomes (Black, Victora & Walker, 2013).

Although there is mixed evidence on the impact of stunting on cognitive development (Sudfeld, Charles McCoy & Danaei, 2015), a number of studies from low- and middle-income countries have identified the period from conception to the age of 2 years as critical, during which child growth and cognitive development are particularly susceptible to nutritional insults (Victora et al., 2008; Victora, de Onis, Hallal, Blössner, & Shrimpton, 2010). There is some evidence of improvements in nutrition beyond infancy (Adair, 1999; Mani, 2012; Schott, Crookston, Lundeen, Stein &

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**Table 1**  
Review of studies investigating the relationship between growth trajectories and human capital outcomes in low- and middle-income contexts.

Authors	Data Set	Periods of Growth Considered	Growth Measures	Human Capital Outcomes	Approach to Modelling Growth Trajectories	Periods when growth exhibits the strongest association with the outcomes (in descending order)
Glewwe and King (2001)	CLHNS, Cebu, Philippines	Gestation 0–1 y  1–2 y 2–8 y	Birth weight, height	IQ test score	Regression with change in body size	Gestation 1–2 y 0–1 y 2–8 y
Martorell et al. (2010)	Pelotas Birth cohort, Brazil  INCTS, Guatemala New Delhi Birth Cohort, India CLHNS, Cebu, Philippines Birth to Twenty cohort, South Africa	Gestation 0–2 y 2–4 y	Weight	Highest grade attained, ever failed a grade, age of starting school	Conditional body size model	0–2 y gestation 2–4 y
Cheung and Ashorn (2010)	CLHNS, Cebu, Philippines	Conception to 6 months 6–24 months 24 months–11 y	Height-for-age Z score (HAZ)	IQ test score, English reading comprehension test score, mathematics test score	Regression with change in body size	Conception to 6 months  6–24 months 24 months–11 y
Gandhi et al. (2011)	LCSS, cohort study, Malawi	Conception to 1 month 1–6 months 6–18 months 18 months–5 y	Height-for-age Z score (HAZ)	School attendance, highest grade completed, number of times repeating a grade, percentage of correct answers in a mathematics test	Conditional body size model	18 months–5 y, associations of growth in all other periods are statistically insignificant
Crookston et al. (2011)	Young Lives study, Peru	Conception to 1 y 1–5 y	Height-for-age Z score (HAZ)	Verbal test score, quantitative test score	Lifecourse plot	1–5 y Conception to 1 y
Crookston et al. (2013)	Young Lives study, Ethiopia, India, Peru, Vietnam	Conception to 1 y 1–8 y	Height-for-age Z score (HAZ)	Age-for-grade, reading comprehension test score, verbal test score, mathematics test score	Conditional body size model	Conception to 1 y 1–8 y
Adair et al. (2013)	Pelotas Birth cohort, Brazil INCTS, Guatemala New Delhi Birth Cohort, India CLHNS, Cebu, Philippines Birth to Twenty cohort, South Africa	Gestation  0–2 y 2–4 y	Birth weight, birth length, weight, height	Completion of secondary school	Conditional body size model	0–2 y gestation 2–4 y
Fink and Rockers (2014)	Young Lives study, Ethiopia, India, Peru, Vietnam	Conception to 8 y  8–12 y 12–15 y	Height-for-age Z score (HAZ)	Highest grade completed, verbal test score, mathematics test score	Lifecourse plot	8–12 y 12–15 y conception to 8 y

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