Social Science & Medicine 97 (2013) 278–287

Contents lists available at SciVerse ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

# Periods of child growth up to age 8 years in Ethiopia, India, Peru and Vietnam: Key distal household and community factors☆

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ARTICLE INFO

*Article history:*
Available online 28 May 2013

*Keywords:*
Child growth
Child growth recovery
Child growth faltering
Household and community factors
Ethiopia
India
Peru
Vietnam

ABSTRACT

Recent research has demonstrated some growth recovery among children stunted in infancy. Less is known about key age ranges for such growth recovery, and what factors are correlates with this growth. This study characterized child growth up to age 1 year, and from ages 1 to 5 and 5 to 8 years controlling for initial height-for-age *z*-score (HAZ), and identified key distal household and community factors associated with these growth measures using longitudinal data on 7266 children in the Young Lives (YL) study in Ethiopia, India, Peru and Vietnam. HAZ at about age 1 year and age in months predicted much of the variation in HAZ at age 5 years, but 40–71% was not predicted. Similarly, HAZ at age 5 years and age in months did not predict 26–47% of variation in HAZ at 8 years. Multiple regression analysis suggests that parental schooling, consumption, and mothers' height are key correlates of HAZ at about age 1 and also are associated with unpredicted change in HAZ from ages 1 to 5 and 5 to 8 years, given initial HAZ. These results underline the importance of a child's starting point in infancy in determining his or her growth, point to key distal household and community factors that may determine early growth in early life and subsequent growth recovery and growth failure, and indicate that these factors vary some by country, urban/rural designation, and child sex.



## Introduction

Chronic undernutrition is a major global health challenge, particularly in low- and middle-income countries (LMICs). According to de Onis, Blössner, and Borghi (2011), about 171 million children under age 5 years (167 million in LMICs) are stunted (i.e., at least two standard deviations below the median in height-for-age *z*-score, HAZ). Undernutrition contributes to more than one-third of the 7.7 million deaths annually among children under age 5 years, mostly in the developing world (Black et al., 2008; Rajaratnam et al., 2010). Undernutrition, poverty and inadequate parental stimulation prevent more than 200 million children under age 5 years from reaching their developmental potential (Grantham-McGregor et al., 2007). Extensive research demonstrates the importance of nutrition in the first 2–3 years of life for child survival, health, motor development, cognitive and socioemotional performance, school participation, adult wage rates and next-generation child anthropometrics (Behrman et al., 2009; Black, Morris, & Bryce, 2003; Caulfield, Richard, Rivera, Musgrove, & Black, 2006; Crookston et al., 2011; Daniels & Adair, 2004; Hoddinott, Maluccio, Behrman, Flores, & Martorell, 2008; Maluccio et al., 2009; Victora et al., 2008).

Some have suggested that in developing country contexts, growth failure is essentially irreversible after about 2 years of age (Checkley, Epstein, Gilman, Cabrera, & Black, 2003; de Onis, 2003; Walker, Grantham-McGregor, Himes, Powell, & Chang, 1996). However, growth recovery from early childhood stunting may be


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http://dx.doi.org/10.1016/j.socscimed.2013.05.016

possible. Significant proportions of children in some low-income contexts experienced increases in HAZ between ages 1 and 5 years (Crookston et al., 2010, 2011; Lundeen et al., unpublished results). Less is known, however, as to what factors are associated with these reversals.

We developed evidence on the correlates of early child growth up to age 1, and deviations from expected growth from ages 1 to 5 and 5 to 8 years. We explored key distal factors at the household and community levels that were correlated with increases in HAZ from age 1 to 5 and from age 5 to 8 using Young Lives (YL) longitudinal data for Ethiopia, India, Peru and Vietnam, and also examined whether there are systematic differences in these relations by country, urban–rural location and child sex. While a few cohort studies have examined the association of distal factors with changes in child growth (Table 1), this is the first multi-country cohort study of which we are aware that has identified factors associated with change in height over time not predicted by initial height, thus identifying potential additional opportunities for improving child growth in resource-poor settings beyond those represented by correlates with HAZ at age 1 year.

## Data

We analyzed data on 7266 children in Ethiopia, India, Peru and Vietnam collected at ages about 1, 5, and 8 years in YL, a cross-national cohort study on poverty and child well-being in the developing world. We studied the younger cohort, enrolled in 2002 at ages 6–17.9 months (round 1). Sampling details are at http://www.younglives.org.uk; comparisons with representative data suggested that the samples represented a variety of contexts in each of the countries studied, though not of the highest part of the income distributions. Subsequent data collection occurred in 2006 when the younger cohort was about 5 years old (round 2) and in 2009 when these children were about 8 years old (round 3). We used all observations for which HAZ values were available for all three rounds (from 91.6% [Ethiopia] to 95.9% [Vietnam] of total observations), and excluded children who were not between the target ages of 6–17.9 months at the time of first HAZ measurement (from 0.0% [Ethiopia] to 3.5% [Vietnam] of total observations), or for whom absolute changes between two rounds were greater than four standard deviations (0.1% [Vietnam] to 3.9% [Ethiopia] of total observations). We retained 87.9% of the initial observations for Ethiopia, 90.8% for India, 90.0% for Peru and 94.4% for Vietnam. Excluded observations had higher values for caregivers' and fathers' schooling, lower values of mothers' height and consumption levels (except Ethiopia for consumption), were more likely to have moved, and had a longer time between measures (etable 1).

### *Growth variables*

HAZ at each round was based on the World Health Organization (WHO) 2006 standard for children under 5 years and the WHO 2007 standard for school-aged children (deOnis et al., 2007; WHO, 2006). We computed the change in HAZ from ages 1 to 5 and 5 to 8 years. As children in the YL data were first interviewed between 6 and 17.9 months, a period in which there is widespread growth faltering in many LMICs (Victora, de Onis, Hallal, Blössner, & Shrimpton, 2010), we controlled for the age at measurement in all analyses.

### *Household and community variables*

We studied key distal household and community variables that plausibly affect child growth (summarized in Fig. 1).

Household variables: (1) Poverty is associated with poorer growth outcomes (Black et al., 2008; Grantham-McGregor et al., 2007); we computed country-specific household consumption per capita quintiles, separately by country (thus we are capturing relative differences in consumption within countries rather than absolute differences across countries; etable 2 shows results using purchasing power parity (PPP)-adjusted consumption per capita to allow for comparisons across countries in absolute consumption levels.). We used consumption as it is a relatively stable measure of household resources. Household consumption per capita was calculated using adult respondents' estimation of food and non-food items with a recall period ranging from 15 days for food to

**Table 1**
Review of cohort studies examining distal factors associated with change in child height.

| Author(s) | Age range (years) | Country [*N*] | Estimation method & dependent variable | Independent variables [estimates] |
|---|---|---|---|---|
| Outes & Porter, 2013 | 1–5 | Ethiopia [1999] | Community fixed-effects linear estimates of HAZ at age 5 lagged on HAZ at age 1 | Wealth index quartile 4 × HAZ age 1 [−0.101 (−0.197, −0.004)] |
| Godoy et al., 2010 | 2–7 | Bolivia [673] | Random-effects panel linear regression model for growth rate in height | Number of younger siblings [−0.531 (−0.978, −0.084)[a]] Current income [−0.016 (−0.029, −0.003)[a]] |
| Crookston et al., 2010 | 1–5 | Peru [374] | Logistic regression model for catch-up growth among children stunted in infancy | Maternal height cm [OR: 1.66 (1.28, 2.17)] Maternal education [OR: 1.06 (1.00, 1.13)] |
| Lourenço, Villamor, Augusto, & Cardoso, 2012 | 0.5–10 | Brazil [256] | Cubic spline mixed-effects models were used to estimate average HAZ | Land ownership [0.34 (0.05, 0.63)] |
| Adair, 1999 | 2–8.5 | Philippines [2011] | Logistic regression model for higher than expected linear growth rates | Tall mother $>$ 154.75 cm [OR: 1.55 (1.14, 2.11)] Short mother $<$ 145 cm [OR: 0.39 (0.23, 0.66)] High assets, increase [OR: 3.07 (1.91, 4.97)] Number of younger siblings [OR: 0.89 (0.79, 0.99)] |
| Sedgh, Herrera, Nestel, el Amin, & Fawzi, 2000 | 0.5–7.5 | Sudan [8174] | Linear regression model predicting stunting reversal | Maternal literacy = no [RR: 0.73 (0.63, 0.84)] Water in house = no [RR: 0.80 (0.69, 0.92)] |
| Coly et al., 2006 | 1–23 | Senegal [2874] | Linear regression model for height increment | Four groupings of increasing duration of migration to urban settings [height increment in cm among girls: 67.2, 69.3, 67.4, 67.7; $p < 0.01$] |
| Eckhardt, Gordon-Larsen, & Adair, 2005 | 2–18.5 | Philippines [2029] | ANOVA (Group 1. decreased HAZ, Group 2. same HAZ, and Group 3. increased HAZ) | BOYS: Maternal education [Group 1,3: 7.7 (7.3, 8.1), 6.3 (5.9, 6.7)] GIRLS: Maternal education [Group 1,3: 7.5 (7.1, 7.9), 6.1 (5.8, 6.4)] Maternal height cm [Group 1,3: 149.4 (148.9, 150.0), 150.9 (150.3, 151.5)] |

[a] Confidence intervals estimated based on cut-off *p*-value reported.