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Growth recovery and faltering through early adolescence in low- and middle-income countries: Determinants and implications for cognitive development

Andreas Georgiadis [a, b, *], Liza Benny [c], Le Thuc Duc [d], Sheikh Galab [e], Prudhvikar Reddy [e], Tassew Woldehanna [f]

[a] Brunel Business School, Brunel University London, Kingston Lane, Uxbridge, Middlesex, London, UB8 3PH, UK
[b] Department of International Development, University of Oxford, Oxford, UK
[c] Young Lives Study, University of Oxford, Oxford, UK
[d] Centre for Analysis and Forecasting, Vietnam Academy of Social Sciences, Hanoi, Viet Nam
[e] Centre for Economic and Social Studies (CESS), Hyderabad, India
[f] Department of Economics, Addis Ababa University, Ethiopia

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ABSTRACT

Child chronic undernutrition, as measured by stunting, is prevalent in low- and middle-income countries and is among the major threats to child development. While stunting and its implications for cognitive development have been considered irreversible beyond early childhood there is a lack of consensus in the literature on this, as there is some evidence of recovery from stunting and that this recovery may be associated with improvements in cognition. Less is known however, about the drivers of growth recovery and the aspects of recovery linked to cognitive development. In this paper we investigate the factors associated with growth recovery and faltering through age 12 years and the implications of the incidence, timing, and persistence of post-infancy recovery from stunting for cognitive development using longitudinal data from Ethiopia, India, Peru, and Vietnam. We find that the factors most systematically associated with accelerated growth both before and after early childhood and across countries include mother's height, household living standards and shocks, community wages, food prices, and garbage collection. Our results suggest that post-infancy recovery from stunting is more likely to be systematically associated with higher achievement scores across countries when it is persistent and that associations between growth trajectories and cognitive achievement in middle childhood do not persist through early adolescence across countries. Overall, our findings indicate that growth after early childhood is responsive to changes in the household and community environments and that growth promotion after early childhood may yield improvements in child cognitive development.

1. Introduction

Child undernutrition is one of the key risk factors to child survival, health, and development in low- and middle-income countries (LMICS) (Prendergast and Humphrey, 2014). The most common form of child undernutrition in LMICs is stunting, defined as height-for-age Z-score (HAZ) below −2, i.e. height that is more than two standard deviations below the median of the height distribution of a healthy-growing reference population of children of the same age and gender (WHO Multicentre Growth Reference Study Group, 2007). Although a number of studies have highlighted that stunting and its consequences for cognitive development are largely irreversible after early childhood (Victora et al., 2010), there is evidence both from the economics and the biomedical literature suggesting that growth recovery is possible beyond this period (Alderman et al., 2006; Prentice et al., 2013) and that it is positively associated with cognitive achievement (Crookston et al., 2013; Georgiadis et al., 2016).

Less is known however, about the factors associated with growth recovery and faltering at different periods following

* Corresponding author. Brunel Business School, Brunel University London, Kingston Lane, Uxbridge, Middlesex, London, UB8 3PH, UK.
E-mail address: andreas.georgiadis@brunel.ac.uk (A. Georgiadis).

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infancy. In particular, studies investigating predictors of growth recovery and faltering (Adair, 1999; Coly et al., 2006; Schott et al., 2013; see also Schott et al. (2013) for a survey of this literature) seem to explain a limited share of the variation in compensatory growth after early childhood, possibly because they consider a limited set of community predictors of catch-up growth. This seems to be an important gap in the literature, as aspects of the local environment such as standards of living and infrastructure have changed dramatically in recent years in low- and middle-income countries and are important policy levers linked to the reduction in stunting in several of these countries (Christiaensen and Alderman, 2004; Headey et al., 2016).

Moreover, studies considering the differences in cognitive achievement across children experiencing different post-infancy growth trajectories (Crookston et al., 2013; Fink and Rockers, 2014; Mendez and Adair, 1999; see also Georgiadis et al. (2016) for a survey of this literature) focus on the incidence of post-infancy growth recovery and ignore other aspects such as persistence and timing. Moreover, no study to our knowledge, to date, has investigated whether the associations between post-infancy growth recovery and cognitive achievement persist as children age.

In this paper, we address the aforementioned gaps in the literature using longitudinal data on children from Ethiopia, India, Peru, and Vietnam. In particular, we investigate a wide range of child, household, and community-level predictors of growth recovery and faltering at different periods from conception through early adolescence. A methodological innovation of our study is that we employ different estimators, including panel data estimators that deal with bias arising from fixed unobservables and a new measure of accelerated growth that addresses limitations of existing measures. We also examine whether the incidence, timing, and persistence of growth recovery, as measured by recovery from stunting, through middle childhood are significantly associated with cognitive achievement in this period and whether these associations persist through early adolescence.

2. Methods

2.1. Data

Our analysis uses data on around 8000 children born in 2001/2 in Ethiopia, India, Peru, and Vietnam (around 2000 in each country), collected as part of the Young Lives study (see Barnett et al. (2013) and Petrou and Kupek (2010) for details). The data include detailed information on a variety of indicators of children's health and development, such as height and cognitive achievement measures, and their household and community characteristics, when children were around 1, 5, 8, and 12 years old.

2.2. Measure of growth recovery and faltering

As a measure of growth recovery or faltering we use the change in child height relative to the change in height of the reference child measured in cm, as provided by the WHO standards (de Onis et al., 2007; WHO Multicentre Growth Reference Study Group, 2007), between two age points. This is a new measure that has many advantages over measures used by existing studies. For example, in contrast to the change in HAZ, it does not increase mechanically with age even if the height deficit relative to the reference, as measured in cm, remains the same or increases (Leroy et al., 2013; Lundeen et al., 2014) (see appendix for a detailed discussion).

2.3. Characterisation of growth trajectories

Child HAZ was calculated using child height and the 2006 WHO standard (WHO Multicentre Growth Reference Study Group, 2007) for children younger than 5 years and the 2007 WHO reference (de Onis et al., 2007) for children older than 5 years and an indicator for whether a child was stunted at each age was computed based on whether HAZ is less than −2 (WHO Multicentre Growth Reference Study Group, 2007). Child growth trajectories through age 8 years were characterised by stunting status at ages 1, 5, and 8 years that is an approach to modelling growth trajectories used in previous studies (Fink and Rockers, 2014). The different growth trajectories defined by this approach are presented in Fig. 1.

2.4. Measures of cognitive development

Cognitive development of children was assessed at ages 8 and 12 years using the Peabody Picture Vocabulary Test (PPVT), a widely-used test of receptive vocabulary, and a mathematics test at ages 8 and 12 years (Cueto and León, 2012). All tests were administered in different languages within each country to allow children to respond in the language they felt most comfortable. In our analysis, we used the number of correct answers in each test standardised by age in months as our measures of cognitive achievement.

2.5. Predictors of growth recovery and faltering

The identification of predictors of growth faltering and recovery at different ages was guided by the conceptual frameworks presented in Glewwe and Miguel (2007) and in Georgiadis (2017) who consider the determination of child health and cognitive development over different stages of the life course, and by previous empirical studies (Schott et al., 2013). Predictors included child characteristics, such as gender, birth order, age in months, and, only for growth between 8 and 12 years, whether the child has experienced puberty during this period; parental and household characteristics, such as caregiver's height, age at the index child's birth, years of schooling, and ethnicity (in the majority of cases the caregiver is the biological mother), father's years of schooling, household wealth index (see Woldehanna et al. (2011) for details of how the wealth index is constructed), and whether the household reported having been affected by shocks related to natural disasters, livelihood, and family events (see Table A.3 in the appendix for the type of shocks included in each category); and community characteristics, such as the number of credit-providing institutions in the community (i.e. banks, money lenders, etc.), that is used as a proxy of access to credit, price indices for food, medication, education, and other consumption items that are meant to capture aspects of the cost of living (see Table A.4 for details on the list of prices combined into each price index and how price indices were constructed), a wage index (see Table A.5 for details), a number of variables capturing different aspects of community's hygiene and health infrastructure (see Table A.5 for details), including whether water or air pollution is a problem in the community, whether there is access to improved water, improved sanitation, and to a hospital in the community, whether there is garbage disposal by truck, and finally the number of schools are used as a proxy of the learning environment in the community.

2.6. Predictors of cognitive development

Predictors of cognitive development other than growth trajectories were also identified using the conceptual frameworks of Glewwe and Miguel (2007) and Georgiadis (2017) as well as from previous empirical studies (Georgiadis et al., 2016). According to these frameworks, the predictors are a subset of those for growth faltering and recovery that excludes all factors that impact cognitive development through child growth trajectories such as