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Height and calories in early childhood

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ABSTRACT

This paper estimates a height production function using data from a randomized nutrition intervention conducted in rural Guatemala from 1969 to 1977. Using the experimental intervention as an instrument, the IV estimates of the effect of calories on height are an order of magnitude larger than the OLS estimates. Information from a unique measurement error process in the calorie data, counterfactuals results from the estimated model and external evidence from migration studies suggest that IV is not identifying a policy relevant average marginal impact of calories on height. The preferred, attenuation bias corrected OLS estimates from the height production function suggest that, averaging over ages, a 100 calorie increase in average daily calorie intake over the course of a year would increase height by 0.06 cm. Counterfactuals from the model imply that calories gaps in early childhood can explain at most 16% of the height gap between Guatemalan children and the US born children of Guatemalan immigrants.

1. Introduction

The formation of human height has been the subject of interest by economists in recent years because of its importance as a predictor of wages (Persico et al., 2004; Case and Paxson, 2008), health (Deaton, 2007), productivity (Schultz, 2003), cognitive skills (Case and Paxson, 2008), longevity (Fogel and Costa, 1997) and life satisfaction (Deaton and Arora, 2009). The causal mechanisms behind these associations are complex but the economics profession has adopted the "nutritionist view" on human height as an easily measured indicator of general health status (Steckel, 1995). Understanding the formation of height can be an important guide for programs that attempt to improve health, especially in developing countries. Although sibling and twin research suggests that environmental factors explain only 20% of the variation in human height (Silventoinen, 2003), the role of the potentially policy specific environmental factors is disputed.[1] Some research finds strong correlations between per capita GDP during childhood (as a proxy for nutrition) and subsequent average adult population heights (Steckel, 1995) while others argue that cross population differences in averages heights are driven more by selective survival of taller children (Bozzoli et al., 2009; Gørgens et al., 2012) than by nutritional differences in early childhood (Deaton, 2007). Silventoinen (2003) states that one difficultly with much auxology (human growth) research is that it tends to use aggregate or cross-sectional data, which makes causal conclusions difficult.[2]

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[1] Silventoinen (2003) also speculates that the effects of the environment explain more of the variation in height in developing countries.

[2] An exception is work in public health studying inputs into stunting and child mortality that uses meta analyses of cross country RCTs as inputs into a simulation model to predict child mortality in developing countries (Bhutta et al., 2008, 2013). Although less attention is paid to the behavioral interpretation of parameters and the focus of that work is more on child mortality, the conclusions from my preferred OLS model are, broadly speaking, of a similar magnitude to their findings and the IV models presented in my paper are inconsistent with their work.

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The formation of human height involves a complex interplay between polygenetic markers for height, the use of energy inputs by cells to divide, and how disease and deprivation causes feedback from the endocrine system to actually pause or suspend cellular division and growth (Tanner, 1990). Essentially theory points to genetics, nutrition and disease as all playing roles in the formation of height (Silventoinen, 2003) and a succinct characterization given by Deaton (2007), who states that "[h]eight is determined by genetic potential and by net nutrition," is a useful starting point for empirical work. A variety of observational, quasi-experimental and experimental evidence are all consistent with this biological theory of height formation and further suggest the importance of early environmental factors. Studies have examined the co-movement of secular trends in height and living standards (Fogel and Costa, 1997) and used heights to measure variation in standards of living by socioeconomic class (Komlos, 1994). Quasi-experimental evidence has found impacts on average population heights from famines (Meng and Qian, 2009), neonatal mortality (Bozzoli et al., 2009), and income shocks (Banerjee et al., 2010), and nutrition experiments, such as the Institute of Nutrition of Central America and Panama (INCAP) Longitudinal Study 1969–1977, which is the focus of the current paper, provide strong evidence that nutrient intake during early childhood has both short and long term impacts on many anthropometric measures and other kinds of human capital (Martorell, 1995b; Hoddinott et al., 2008; Behrman et al., 2009). Heckman (2007) argues that while health economics has focused on documenting sensitive periods of development, more work should take a life-cycle perspective in understanding the timing of investments and the possibility of remediation following the production function literature on cognitive and noncognitive skills.[3] For height, some studies strongly imply the possibility of such remediation; a study of the Dutch Hunger Winter 1944–45 (Stein et al., 1975) did not find impacts on adult height from famine exposure. A production function is the appropriate tool to answer many questions about such hypothetical inputs interventions (Rosenzweig and Schultz, 1983).[4] Furthermore, the parallels between the production process for skills and for height are actually quite strong and a common framework (Todd and Wolpin, 2003, 2007; Cunha and Heckman, 2007) can be brought to bear on both processes. A drawback relative to quasi-experimental methods for investigating height formation is the often strong modeling assumptions and the extensive panel data requirements on height, nutrition and disease.

The related literature on height is truly towering and spans the biomedical, public health and social sciences with sometimes seemingly little interaction between the fields. In economics, Behrman and Deolalikar (1988) and Strauss and Thomas (1998) both review a large literature on nutrition and health. Early height research in economics focused on whether there were causal links between maternal education and child height (Wolfe and Behrman, 1987; Behrman and Wolfe, 1987) and unpacking those mechanisms (Thomas et al., 1991). Martorell and Habicht (1986) provide a review of growth in childhood specifically in developing countries from an auxology perspective and Bhutta et al. (2008, 2013) provide an extensive meta-analyses from RCT public health interventions in developing countries. Even the literature on the INCAP experiment itself is quite extensive with much early work on the experimental impacts and subsequent analyses examining longer term impacts for each of the follow-up data collections during adolescence and adulthood (Martorell, 1995b).

This paper contributes to this literature by estimating a height production function using data from the INCAP Longitudinal Study, a randomized nutrition experiment conducted in rural Guatemala from 1969 to 1977, that collected extensive longitudinal data on calorie intake, disease measures and height for children until the age of 7.[5] The experiment consisted of a feeding center in each participating village that provided calorie supplements and in which the type of supplement was randomized across villages to create an experimental contrast in calorie intake. Using the INCAP experimental intervention and distance to the feeding center in the INCAP experiment as instrumental variables for calorie inputs, the IV estimates of the production function suggest that the effect of calories on height is an order of magnitude larger than the OLS estimates. To explore the divergence between the OLS and IV estimates, I investigate the role of measurement error in attenuating the OLS estimates and the plausibility of the model counterfactuals using both the OLS and IV estimates. Information from a unique measurement error process in the collected INCAP calorie data collection allows me to bound the effects of attenuation bias. The size of this attenuation bias cannot explain the divergence between the OLS and IV estimates. Furthermore, comparing calorie differences between the US and Guatemala during the same period as the INCAP experiment, I use the estimated production function to investigate the role of the US–Guatemala "calorie gap" in increasing the height of Guatemalan children. The difference between the OLS and IV estimates implies large differences in the counterfactual

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[3] Combining theory with experimental and non-experimental evidence has provided an extremely rich characterization of the efficient timing of investment for the production of skills (Doyle et al., 2009).

[4] A different strategy would be to estimate demand functions for child health, which can account for the effects of household resources and for household responses to the public provision of inputs. See Behrman and Skoufias (2004) for an overarching framework and a review of studies examining estimates of the demand for child health in Latin America. Related to this distinction, Todd and Wolpin (2003) have an extended discussion of the uses of production function versus policy parameters.

[5] In addition to height, the INCAP data have extensive measurement of other anthropometric outcomes. The basic pattern of regression results in the paper also hold for weight, head circumference, arm circumference, calf circumference, tricep skinfold, bicondylar breadth, arm length, subscapular skinfold and calf skinfold as outcome measures. The consistency across outcomes is perhaps not surprising given their correlation with height. Of the different anthropometric outcomes, I chose height as the outcome of interest given the focus on height in the economics literature as well as height information from Guatemalan migration studies.