Age-Profile Estimates of the Relationship Between Economic Growth and Child Health

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Abstract

In the last several years, there has been a debate in the Public Health literature regarding the association between economic growth and child health in under-developed countries, with some arguing the association is weak or non-existent and others arguing it is strong and robust. Recognizing that child growth faltering is a process that unfolds over the first several years of life, and using insights from dynamic human capital accumulation theory, we provide new evidence tracing out the relationship between macroeconomic trends and the trajectory of child growth through age 5. Using two novel regression models that each harness different kinds of within- and between-country variation in GDP, and data on over 600,000 children from 38 countries over more than 20 years, our estimates of the association are small but precise, and are consistent across both estimators. We estimate that a 10% increase in GDP in the years prior to a child's birth is associated with a decrease in the rate of loss of HAZ of about 0.002 SD per month over the first two years of life, or a cumulative effect of around 0.05 SD by age 3. This effect then persists through age 5. Our estimates are small compared to most previously published statistically significant estimates, but larger and more precisely estimated than previous insignificant estimates.

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1 Introduction

With over 159 million children experiencing stunted growth, growth faltering due to chronic malnutrition and infection is still endemic in developing countries[1]. Can economic growth lead to improved health outcomes for children? In some sense the answer is obvious. Countries that have experienced long term economic growth have seen improvements in almost all measures of child health (Demeny, 1965; Preston, 1975; Deaton, 2013).

In this paper we ask, can 'short or medium term economic growth improve children's health, even in developing economies with low baseline GDP?' The mechanisms exist. Changes in economic or health environment in very early life can have lasting effects on children's development. This has been shown true for cash and in–kind transfer programs (Amarante et al., 2012; Hoynes et al., 2015, 2011; Dupas and Miguel, 2016), improved access and quality of health facilities (Das and Hammer, 2014; Banerjee et al., 2004; Headey, 2013), improved disease and health environment (Almond and Mazumder, 2005; Almond and Currie, 2011; Bleakley, 2010), improvement in water and sanitation (Cutler and Miller, 2005; Miguel and Kremer, 2004) and increased household earnings (Pongou et al., 2006; Jensen, 2000; Hoddinott and Kinsey, 2001). Changes in economic growth affect both the quality of the labor market (and thus household earnings) and government services (and thus consumption of public goods) (Topel, 1999; Kea et al., 2011; Case et al., 2002). It is thus little surprise that we find a measurable association between per capita gross domestic product (GDP) and child height–for–age z–score (HAZ), a cumulative measure of early life health and nutrition.

The empirical contribution of our work is to quantify this relationship more precisely, using comparisons across and within countries, and to tie our analysis specifically to the theory of dynamic health capital accumulation (Grossman, 1972; Becker, 1960). We estimate the effect of economic growth in the 4–6 years preceding a child's birth on average child growth trajectory over the first few years of life. In general, we find that exposure to a 10% increase

[1] UNICEF data, Date Accessed: 07/12/2016: http://data.unicef.org/nutrition/malnutrition.html

in GDP during early childhood increases HAZ by approximately 0.04-0.05 SD by age 3. We also find that an increase in GDP is associated with a small increase in the vaccination rates of children between the ages of 0 to 1, while incidence of fever increases across all ages. In terms of measurement, our estimates use more observations from more countries than any previous study based on Demographic and Health Survey data (DHS), combine both within and between country variation in growth and child health measures, and are sufficiently precise to rule out both 0 and very large effects.

We make two conceptual improvements over previous attempts to estimate the relationship between child health and economic growth. First, we carefully disentangle the timing of exposure (in calendar time and child age) from the age at measurement (in survey time and child age) in a framework that specifically models health capital accumulation as an age–dependent outcome. Figure 1 shows survey round observations for 5 child ages in 126 Demographic and Health Surveys (DHS) across 38 countries, comparing HAZ and GDP in year of birth. The upper panel of Figure 1 shows how mean HAZ for a country correlates with the level of GDP in year of birth. The bottom panel shows changes in HAZ and changes in GDP from one survey round to the next. Fitted lines show the relationship for each age in years and notes on the tables provide the value of beta from a regression of GDP on HAZ. From the figure we see that GDP at birth is correlated with HAZ at every age. Within–country changes in GDP are less strongly associated with HAZ across age, but the effect is still visible. This graph is similar to those shown in Rieger and Trommlerová (2016), with the difference being that children of different ages in the same country and same survey round faced different GDP growth "exposures" because they were born in different years. Since HAZ is a cumulative measure of health, any correlation between contemporaneous GDP and HAZ is essentially, by definition, spurious: economic growth today cannot immediately make a child taller. However, increased inputs over the life–course (via improved household economic prospects and better public goods provision, both strongly associated with economic growth) can alter a child's growth trajectory (Martorell, 1985;

Currie, 2000; Smith and Haddad, 2002; Cutler and Miller, 2005). By tying GDP exposure to the year of birth, we fix the 'age at exposure' and only allow the 'age at measure' to vary. In this model, we let the subsequent effects of this exposure (on the child health input stream) play out over the course of a child's first 5 years of life.

Our second conceptual contribution is to shift focus from estimating effects of growth on mean HAZ to estimating the effects of economic growth on the HAZ–age profile. A consistent result in the demography of child health is that children in developing countries grow too slowly and lose ground relative to healthy children over the first two years of life. Estimates looking at the impact of economic growth on mean health outcomes thus miss an important heterogeneity (the effect across age) and systematically misrepresent the effects of growth by ignoring the fact that cumulative effects are more important than effects at earlier ages.

Figure 2 shows the HAZ–age profile for countries above and below the median GDP in our sample (top panel), and for each country separately (bottom panel). In the top panel, we see that all children in developing countries are born just slightly shorter than the WHO reference children and then children rapidly lose HAZ over the first few years of life. That is, children in every country grow too slowly compared to children in the well nourished, healthy WHO reference group. This is the process that health researchers refer to as "growth faltering" (Rieger and Trommlerová, 2016). The graph also shows us that children in the poorer countries lose HAZ relative to the reference population at a much faster rate, that is, they grow more slowly than children in less poor countries[2]. However, the differential trajectories in terms of growth (relative to the distribution of WHO reference children) flatten out by age 2. Mean child HAZ in a country is then essentially constant from age 2 through age 5, though there is some visual evidence that the gap in HAZ between richer and poorer countries may close slightly by age 5 (so called "catch–up" growth). The bottom panel confirms that this is not an aggregation issue but instead an empirical regularity in each individual country. In

[2]This would also mean that in the first two years of life, poorer and sicker children steadily lose ground in terms of height compared to richer and more healthy children.

this paper, we account for the growth faltering phenomena as seen in the HAZ age profiles while estimating the impact of economic growth on child health.

In order to more carefully quantify the relationship between economic and child growth, we also make several methodological contributions. First, we define a new outcome measure, the effect of GDP on the rate of loss of HAZ over the first two years of life. We estimate the impact of changes in GDP on the intercept (length at birth z score) and the slope (rate of loss) of the HAZ–age profile. Despite their simplicity, these two parameters well characterize the HAZ age profile at a specific time and place and provide two easy to interpret and simple to estimate summary statistics for overall child health. Their use could be applied in a variety of other settings where conditions have changed in a country and researchers want to examine the impacts of that change on child growth.

Our second methodological contribution is to generate a new set of fixed effects models to estimate the effects of pre–birth conditions on child development. Cummins et al. (2013) shows that, when a time series of exposures is linked to birth cohorts and the outcome is strongly age determined, within country estimates using standard models can generate strongly biased estimates if there is any spurious correlation between age–at–measure and the covariate of interest. We develop the concept of a "lifespan" temporal fixed effect that removes the bias described in (Cummins et al., 2013) that exploits both within and between country variation. We believe these models will prove useful to researchers interested in estimating effects of health and other human capital inputs on development in other contexts.

2 Background

2.1 Health Measurement

In 1995, a WHO expert working committee identified that height–for–age (HAZ), weight–for–age (WAZ), weight–for–height (WHZ) z scores[3] best reflected the interaction between social determinants of health and the physical development of children (World Health Organization, 1995). They determined that indicators that used weight, such as the WAZ and WHZ, could accurately predict mal–nourishment within a population at a given time. However, since weight is highly responsive to food and nutrition availability, WAZ or WHZ could not be used predict the effect of past shocks on the current or future health and productivity of an individual. On the other hand, between these 3 measures, the WHO committee identified that HAZ scores did the best job capturing the cumulative effects of malnutrition for an individual at a particular age [4], could better predict lower productivity in adults (Glewwe and Miguel, 2007; Hoddinott et al., 2008) and could predict two year future mortality risk in young children.

In order to interpret a HAZ score, each z score needs to be compared to a reference group of similar aged children. The nutrition levels and standards derived from the reference group reflect the highest potential for physical growth and human development. Prior to 2005, the WHO had used a reference standard that was calculated from well fed children who lived in Iowa. However, based on concerns that these standards did not appropriately account for heterogeneity in population heights across different countries, a new standard was introduced in 2005 (World Health Organization, 2006). The new standards were gleaned from growth curves that were estimated from children between the ages of 0 to 5 in six countries –United States, Oman, Norway, Brazil, Ghana and India. In order to capture the anthropometry

[3] $Zscore = \frac{observedvalue - referencemean}{standarddeviationofreference}$

[4] For example, stunting in a 1 year old would indicate current poor nutrition but stunting in a 5 year old would represent both concurrent nutrition problems as well as past problems such as the disease environment in which a child grew up in.

measures of well fed children, the WHO collected data on children from higher socio economic groups who were breast fed up to at least 12 months after they were born by non smoking mothers who lived within a sub set of locations in these countries. To account for genetic and developmental differences, the WHO created the new standards both by age and by sex[5]. In this paper, we incorporate new 2005 reference standards for all children in all survey years.

In order to capture the how economic growth, as an input, impacts health capital accumulation in children, and to align ourselves with the literature on health measurement, our paper uses HAZ scores as the outcome of interest. As a note, authors of the WHO report also described the existence of the relationship that we see in Figure 2 and cautioned that any study that used HAZ as an outcome would be confounded by it's relationship with age if this relationship was not accounted for properly. We are the first in the literature to directly and explicitly model this problem in the context of cross-country, repeated cross-sectional analysis.

2.2 Previous Estimates of the Effect of Economic Growth on Child Anthropometric Status

Many within country and cross country studies have estimated various associations between economic growth and child health. Within country studies for example, have examined how changes in economic status of a household (asset wealth, household income, or various economic "shocks") affects child growth. Jensen (2000) and Hoddinott and Kinsey (2001) show that droughts in Ivory Coast & Zimbabwe (respectively) increases malnutrition of children, showing that the income effect of shocks outweigh substitution effects within a household. Similarly, Maluccio et al. (2005) shows that a sharp reduction in coffee prices in Nicaragua increases malnutrition status of children from households that were dependent on coffee plantations for their livelihoods. Pongou et al. (2006) using DHS data, show

[5] The mean of the new standards ranged from around 50 cm at Age 0 to 110 cm at Age 5, for both boys and girls.

that after controlling for health seeking behavior by mothers, a reduction in socio economic status of households in Cameroon increase malnutrition. A lot of these within country studies also use shocks created during periods of economic turmoil and compare health outcomes of children born and measured before and/or after the event. In Pongou et al. (2006), the study shows that lower socioeconomic status children were harmed more by the economic crisis in Cameroon than children in relatively more privileged households. Agüero and Valdivia (2010) examines the Peruvian recession of the 1990's and find weak evidence for the effects of economic loss on HAZ. Closer to our work, in that it exploits both spatial and temporal variation in economic conditions, and looking at a period of strong economic growth, Subramanyam et al. (2011) finds that province level per capita GDP does not have any impact on the nutrition status of children in India.

Cross country studies on the other hand have relied primarily on differences in GDP and HAZ across countries at one point in time. Those that use the DHS for example, often choose the most recent DHS available or similar survey round for each country for the analysis. The majority of the cross country studies can only estimate the impact of contemporaneous GDP on child wasting or undernutrition, since wasting (WHZ <= -2.0) & undernutrition (WAZ <= -2.0) are more responsive to changes in current nutrition availability (World Health Organization, 1995). Very few of these cross country studies utilize both spatial and temporal forms of variation, and when they do, it is most often done as an "ecological" analysis done at the aggregate country-year level. These studies typically use aggregate country - year proportion on wasting as the dependent variable. Smith and Haddad (2002) and Headey (2013) find that a 10% increase in GDP decreases undernutrition rates by 6.3% and 1.8pp respectively. Haddad et al. (2003) estimates a much bigger cumulative effect, finding that a 10% increase in GDP decreases undernutrition by 32pp over two decades. Some previous studies have used micro-level data with either continuous or dichotomous outcome variables. Vollmer et al. (2014) uses cross country height and weight scores from 126 DHS surveys and find a very small association of GDP and wasting rates in developing countries, with a 10% increase in GDP decreases the log odds ratio by 1.4%. Harttgen et al. (2013) find that GDP has a very small impact on the reduction of the logs odds ratio of being stunted and under-nourished. Using data from the DHS for the year 2000, Headey (2013) finds that 5.5% increase in GDP per capita, reduces malnutrition by 5.5pp.

No previous study has estimated directly the effect of medium-term economic growth on child HAZ, and none have used micro-data tied specifically to a single age-at-exposure. This is likely the result of theoretical and methodological limitations that researchers have faced. First, there has been a lack of theoretical discussion grounding precisely how GDP can affect child anthropometric development. Instead, the most parsimonious means of analyzing economic growth's effects on child development has been to focus on the association between contemporary GDP and wasting, despite the fact that wasting is less strongly associated with future earnings than stunting (World Health Organization, 1995). Second and more pragmatically, there has been a lack of methodological tools available to more carefully fix both the timing of inputs and the timing of measurement. Only economic growth in the past is likely to become apparent in child height. Previous reliance on aggregate country-year measures (mean HAZ/WAZ or mean stunting/wasting rates) was likely a computational necessity until very recently, but this too encourages work that fails to account for the timing of exposure because children of different ages and different cohorts (and thus different exposures) are aggregated together into a single measure. Our work contributes most broadly to this literature by providing both theoretical and econometric models for linking age-at-exposure and age-at-measurement for individual level data on children collected in repeated cross-sectional datasets (the most common form of data on children's health in developing countries).

3 Human Capital Accumulation Theory

3.1 Structure

We begin with a 3 equation, inter-temporal household utility optimization problem, drawing from health capital models such as Grossman (1972) and Ghez et al. (1975) and household decision models like those in Singh et al. (1986). Household decision makers have preferences for their own consumption (C) and for their children's health (H).

$$\sum_{T} U_t(H_t^a, C_t) \tag{1}$$

Child health is super-scripted 'a' to re-enforce the link between calendar time 't' and child age once a child is born. This becomes important because while setting t=0 normalizes the relationship between "time" and "age" for that child, exposures in the world must be indexed in "calendar time" not "age time".

The evolution of child health over time, in our case the height of a child at some age, is modeled by an age-specific human capital production function that also takes inputs from calendar-time features of the world:

$$H_t^a = f^a(H_{t-1}^{a-1}, I_{t-1}, G_{t-1}; \delta^a) \tag{2}$$

Household's can purchase inputs I that increase child health (food, medicine), and children are affected by the general public health environment (G) and availability of public health goods and services (such as water and sanitation, health knowledge campaigns, clinic and market access). Both public and private inputs have differing effects on children at different ages. The exact same exposure happening to a one year old may affect a four year old much differently. Furthermore, changes in G or I (and thus changes in H) in the past will persist, since health is a cumulative measure of the entire stream of past health investments and outcomes.

Given their preferences and the nature of $f_a()$, household's optimally purchase consumption and child health investments (I) to maximize Equation 1 over the course of their expected lifetimes (set of years T).

$$W_t = P_t.C_t + I_t^a \tag{3}$$

Every period household's earn income W_t and they spend all of it on either personal consumption or health investment in the child. Households gain current period utility from private consumption and a stream of future utility if they invest in their child's health. Given standard parameter restrictions including decreasing marginal utility of consumption and concavity of the human capital production function, household's will optimally proportion their period specific income with positive purchases of both C and I, and will trade off on the margin if relative prices or the efficiency of human capital production change. The addition of common modeling complications such as inter-temporal borrowing, endogenous earnings or later life wealth transfers from children to parents do not change these basic conclusions. However, non-concavities in the human capital production function could easily change these predictions, and we address that to some degree below.

3.2 Comparative Age Dynamics

Fix the initial conditions: a child is born. This child is born into a household in year t with health status H_t^0 and family wealth W_t. This implies, for the first period, an optimal $I_t^*(f^1(H_t^0, G_t; \delta^1), W_t; P_t)$[6], and thus implies an optimal $H_{t+1}^{*1}(H_t^0, G_t, W_t; P_t, \delta^1)$

Differences across countries in GDP, and changes within a country, are likely to affect two

[6] C_t drops out because choosing $I*_t$ implies a choice of $C*_t$

elements in the determinants of optimal child health investment and thus in future child health. First, increases in GDP lead to improvements in the labor market. During times of GDP growth, households are more likely to find employment, and conditional on finding employment, likely to receive more income (Topel, 1999). We model this as an increase in W_t and thus a direct wealth effect for the household. This increases the quantity demanded of health inputs, so long as additional health inputs continue to increase child health capital. Second, increases in GDP are likely to increase the provision of public goods (G_t). In this simplified model, this would lead to a crowding out of private investment in child health, though the net effect on child health is still positive. Public goods here work as a sort of in-kind transfer from the government that pays in child health.

Now consider the child at age 3, after a series of realized exposures to the time-series of public goods availability that begins in their birth year and the decision making adjustments that follow. Optimal health for a child at age three is:

$$H_{t+3}^{*3}(H_t^0, G_t, G_{t+1}, G_{t+2}, W_t, W_{t+1}, W_{t+2}; P_t, P_{t+1}, P_{t+2}, \delta^3, \delta^2, \delta^1).$$

If we want to know how a change in W or G at birth affects health status at age 3, we have to trace its effect through optimal investment decisions in periods 1 and 2 and the development of G and W over time[7]. If standard economic assumptions are made and there is decreasing marginal productivity of health capital, then the effect of health at birth on investment patterns will be persistent but likely to diminish over age - household's will slowly compensate because the marginal productivity of health capital investment will be lower than it would have been, shifting a larger wealth share onto consumption.

If GDP growth prior to birth influences the trajectory of the time-series of public goods provision and the quality of the labor market, then the effect of that growth will continue to exert itself throughout the child's development via the stream of calendar time inputs, likely re-enforcing the initial effect in the first year of life. Prior studies have failed to address this

[7] Assuming that public goods do not depreciate 100% over night.

in either their theoretical framework or through their empirical contributions.

By fixing the age-at-exposure we are able to compare effect-sizes across age that are interpretable in the framework of health capital accumulation. We can then interpret the effect of this initial condition on the trajectory of human development, allowing us to determine whether the combination of the persistence of exposure on later inputs (W, G) to the health capital production function and the character of the function itself over child age leads to lasting, permanent effects on child health or simply to short-term, transient effects that leave no lasting impact. Said plainly, we can watch the net effect of the change in GDP play out over a child's early life.

4 Methodology

We develop two methods for estimating the relationship between medium-term GDP growth prior to birth and child growth rates. The first method uses each individual DHS survey as a single observation of an HAZ-age profile. This provides two-parameters that summarize the relationship between GDP growth and and how quickly children in developing countries lose height relative to the WHO reference population of healthy, well-nourished children. The second method uses fixed-effects estimators developed to specifically control for both the average HAZ-age profile for the child's country and the experience of growing from age 0 to age a during the years t to t+a. As in our discussion in the preceding section, these models fix the timing of exposure and then allow the resulting effects of that exposure to play out over the first five years of a child's life.

4.1 Rate of Loss of HAZ

Recall the common defining feature of the HAZ-age profiles presented in Figure 2. The loss of HAZ experience by children in developing countries is rapid and nearly linear over the first two years of life, and then becomes essentially flat (or slightly positively inclined) from ages 2 through 5. We define two parameters to characterize this empirical regularity: a) we define α as the *intercept of the HAZ-age profile on the Y-axis*, that is, the implied length-for-age Z-score (LAZ) at birth; b) we define β as the *rate of loss of HAZ from birth to age 2*, that is, how much more slowly are children growing than the WHO reference median child (in units of standard deviations of the reference population). We estimate these parameters separately for each survey round in each country as an OLS regression of HAZ for child i measured at age a for the entire set of surveys S:

$$HAZ_{ia}^{s} = \alpha^{s} + \beta_{age}^{s} * Age_{ia}^{s} + u_{ia}^{s} \forall s \in S \tag{4}$$

This allows use to estimate $\hat{\alpha}^s$, a country by time period specific estimate of the LAZ at birth and $\hat{\beta}^s$, an estimate of the rate of loss from that initial birth LAZ over the first two years of life. As simple as they are, these summary measures provide a relatively complete characterization of the HAZ-age profile in country j in calendar year y.

We then take the estimates $\hat{\alpha}^s$ and $\hat{\beta}^s$ and turn them into $\hat{\alpha}_{jy}$ and $\hat{\beta}_{jy}$, observations from country j in survey year y for a second stage regression on the determinants of the shape of the HAZ-age profile over the first two years of life. The second stage regressions treat $\hat{\alpha}_{jy}$ and $\hat{\beta}_{jy}$ as the outcomes of interest. We merge this data with a panel of (log) per capita GDP measures from the World Bank, generating an unbalanced panel of observations at the country-year level that include the parameters of the first-stage regressions and the GDP data from the World Bank panel [8]. Our identifying variation within a country comes

[8]In this specification, we merge GDP from the survey year with the outcome data. This means that children who are infants in our regressions are being given a measure of GDP associated with their year of birth, but children who are two years old are being given GDPs that they experience at age 2. In the next section we more strictly link GDP measure to year of birth for all children, but in this section we simply note that, given both the relatively small changes in GDP across one or two years, and the high serial-correlation in GDP over time within a country, this should make little difference to our estimates. Furthermore, this set of estimates abstracts away from the fact that children of different ages are living through periods of growth at different points in their development, but since we are taking each survey as a single observation at one point in time, this seems natural to the empirical environment, and is consistent with the previous literature.

not from one calendar year to the next, but from one survey year to the next, an average time difference of about 6 years. The between country identifying variation comes from binning them within a survey year period of 3 years[9]. This set of estimates thus captures medium-term economic growth that took place before birth and during very early life.

The second stage regression takes a form involving some or all of the elements of the fully saturated regression model below, for country j in year y:

$$\hat{P}_{jy} = \delta.GDP_{jy} + \gamma_j + \lambda_y + \eta_{jy} \tag{5}$$

Variants of this equation, keeping or dropping different elements, allow us to estimate the effect of GDP growth on the parameters of the HAZ-age profile using fundamentally different types of identifying variation. Without γ and λ, the equation reduces to the OLS estimate of the association between economic growth and HAZ. $\hat{\delta}$ is the estimate of the effect of GDP on the outcome $\hat{P}_{jy}$ (either $\hat{\alpha}$ or $\hat{\beta}$). After adjusting for units[10] $\hat{\delta}$ can be interpreted as the effect of a 10% change in GDP on HAZ. This regression treats every observation as independent from the others, as though an observation from Armenia in 2000 can be naively compared to an observation from Zimbabwe in 2010. In that sense, the equation fully exploits both within- and across-country variation.

In order to address more carefully the question of whether medium-term economic growth is correlated with improvements in child health, we then specify a mean-differences regression with country level fixed effects. Including γ_j in the regression (that is, including country fixed-effects but removing survey-time fixed effects), forces the regression to identify $\hat{\delta}$ using temporal, within-country variation along calendar time (that is, the typically 4-6 years be-

[9] Technically, it is possible to include individual survey year dummies into the regression. However, since surveys for different countries occur at different times, this forces the year dummies to identify off a small and changing set of countries in each potential survey year. We thus bin time into 3 calendar-year bins, chosen so that no country appears in the same temporal bin twice. Results are generally robust to the use of individual year dummies .

[10] HAZ is measured as the WHO score*100, which is how it is provided in the DHS. The calculation above is based on a change of 0.1 in the log of GDP .

tween survey rounds). By de-meaning the outcome variable and the GDP time-series within a country, $\hat{\delta}$ estimates how changes in GDP within a country over time affect LAZ at birth and the rate of loss of GDP over the first two years. Symmetrically, we might want to focus only on the across-country differences, even if only to understand any potential differences between the OLS results and the within-country estimates. We show this by including λ_y while dropping γ_j. This between country model estimates effects comparing changes only across countries at each point in time.

The single fixed-effects estimates in the preceding paragraph are regression analogues of single-difference estimators. If GDP was imagined as a binary outcome (high/low), then we would be estimating either across-subject effects (survey time fixed-effects) or within-subject effects (country fixed-effects). Returning to the situation above, in the within-country regressions, researchers should be concerned that secular, world-wide trends in human health (developments of medicines and treatments, better access to health services, food and financial markets, and more defuse health care knowledge) are driving the results, since, on average, most countries have grown in terms of real per capita GDP in the last several decades. Thus, the result could be simply the effect of a secular trend in child health being correlated with a long-term growth in the world economy or other un-observed differences between government institutions, baseline public goods levels, sanitation, knowledge of health practices and so on.

Exploiting both across- and within-country variation allows us to partially address this problem. The inclusion of both λ_y and γ_j generates a "difference-in-difference" type of variation. The model is now implicitly comparing changes in HAZ in a country with low growth over the period, to changes in HAZ in a country with high growth. The secular trend in improvement is thus differenced out, and the model estimates based on how much more improvement there was in the high growth countries.

We offer two strategies for estimation of standard errors for $\hat{\delta}$. First, we provide analytic standard errors clustered by country. These standard errors may be biased towards 0 relative to the true sampling distribution of $\hat{\delta}$, since they do not account for the uncertainty in the left-hand side variables. To account for this, we provide a second set of standard errors estimated from a 2-stage bootstrap procedure. In that procedure, we first choose (with replacement) 38 countries, and give each observation a new ID number. We then bootstrap sample by the interaction of primary sampling unit (PSU) and survey round within each ID number, and jointly estimate $\hat{\alpha}$ and $\hat{\beta}$ for each survey replacing country based fixed effects with ID based fixed effects. We repeat the double bootstrap sampling 500 times and report the standard deviation of the estimates of $\hat{\delta}_{bootstrap}$ as the bootstrap standard error estimate of $\hat{\delta}$.

4.2 Age-Profile Fixed-Effect Models

Our second method implements a new fixed effects methodology that isolates the effect of economic growth before birth on the entire HAZ-age profile. The intuition for the fixed-effects models we estimate below can be motivated by a simple thought experiment. Suppose a researcher has a set of cross-sectional surveys with child HAZ from different countries covering a number of years each. Collapsing this data down into country-year observations generates a country-year panel dataset, allowing for estimates similar to those in the second stage regression above (Equation 5). The insight we exploit is simply that this same procedure can apply even if we keep only the observations from any particular round that are children of age A. The following equation, similar to Equation 5 represents the regression analogue of this thought-experiment, containing observations for only children aged A:

$$HAZ^A_{icj} = X'_{ijc}\beta^A + \delta^A * GDP_{cj} + \mu^A_j + \lambda^A_c + \zeta^A_{icj} \tag{6}$$

This equation reduces to the standard "quasi-difference-in-difference" method employed using panel or repeated cross-sectional methods on mean impacts, but estimates the effect only on children of age A. There is no reason this cannot then be repeated for children aged A+1, A-1, A+2... etc. Furthermore, the particular GDP changes that a child is exposed to are tied to the calendar-time change from when they were born to when other children in the same country in other survey rounds were born. Thus, when we estimate on the sample of children aged A and then on children aged A+1, we are identifying off of GDP measurements that are a year further in the past. The key point is that cohort and country determine the particular GDP levels to which you are exposed, and those vary within a survey round across child age. A two year old child in country A born in 2000 might be compared to a two year old born in 1995. Then, 3 year olds from those countries would be compared using changes between 1999 and 1994.

We generalize the above thought experiment and regression equation into a multi-age framework where we can estimate δ^A simultaneously for children of all ages. We generalize the above function by allowing μ_j^A and λ_c^A to become μ_{ja} and λ_{ca}, that is, we interact country and cohort with age, generating fixed-effects for the country-specific HAZ-age profiles (λ_{ac}) and child's lifespan (μ_{ja}).

$$HAZ_{ijca} = X'_{ijca}\beta + \sum_a \delta^A * GDP_{jc} + \mu_{ja} + \lambda_{ca} + \epsilon_{ijca} \tag{7}$$

This regression again has both within- and between-country comparison analogs, but these comparisons are now made only within a particular country's children of the same age, or across children who have lived the same "lifespan". That is, our "within" variation comes from comparing children of age A in country J and born in cohort C, with children of the same age A and same country J but born in cohort C'. Identifying variation comes from changes in the shape of the HAZ-age profile from survey round to survey round and the model picks up on correlations between those changes and changes in the amount of economic growth that occurred between the survey rounds. HAZ is not an instantaneous outcome - it is a cumulative measure of lifetime health status and nutritional inputs. Thus, the calendar time in which one is measured can only affect HAZ by determining the life-span through time in which an individual child grows - that is, by being a proxy for the time and place into which you were born. The country-specific HAZ-age profile (μ_{ja}) controls described in this paragraph non-parametrically control for the age-dynamic effects of the place you were born.

Our "between" variation (λ_{ca}) then comes from comparing children who are born at the same time and measured at the same age, but in different countries. These children experienced being born in the same time and growing up to the same age over the same calendar years, that is, they lived the same life span. This link from age-time to calendar-time is important because GDP operates in calendar time, and so do both household income and the stream of public goods investments generated by increased GDP that would generate improvements in HAZ. Controlling non-parametrically for child lifespan allows the secular time to be age specific[11].

5 Data

For the outcome variables and other covariates, we use information from 126 demographic health surveys (DHS) from 38 countries surveyed between the years 1986 and 2013(I C F, 2011). The DHS are nationally representative multi stage cluster surveys that provide health and welfare information of women (15-49 years) and children (0-5 years). These surveys are conducted every 3 to 5 years in different countries, and can be weighted to be nationally

[11]We do not weight these regressions for probability of selection, and refer to (Solon et al., 2015) for justification. DHS weights are designed to generate nationally-representative estimates of population means and proportions. Any reweighing of repeated cross-sections of the DHS from different countries requires deeply subjective choices about the target population of interest: after relative probability weights are applied, the sum of those weights within a survey round could be weighted equally across all surveys, by sample size, by country population (repeated or broken up over survey rounds), or by some optimal variance minimizing quantity. We choose instead to simply let each observation represent one observation, and concede that we have already assumed away heterogeneity in impact by estimating a single parameter for each age (one that does not vary by individual type or sub-group). Our analysis code, which is freely available, includes options to add or change the weighting scheme and judge robustness of the results to choice of weights.

representative. A two stage sampling format is used where countries are divided into regions based on political and geographical criteria and each region is classified into urban and rural areas. Within these, enumeration areas called the primary sampling unit (PSU) are chosen such that the probability of being chosen is equal to the proportion of the population in the PSU to the total population from the census data. In the second stage, 25 households from each PSU are randomly selected for the survey. The surveys include information on anthropometry, household wealth, and other health care seeking behaviors of households. Eligible respondents are women between the ages of 15 to 49, and information is collected on the household and on children under the age of 5[12]. We use the (2005) WHO referenced HAZ scores that are the secondary HAZ measures in the DHS. For DHS surveys completed before the 2005 WHO references were adopted, we merge back in the DHS-computed WHO z-scores from the auxiliary files online.

Our estimation sample includes children between the ages of 0 to 60 months with valid HAZ scores which were referenced to the WHO 2005 values. Only countries with at least 2 surveys in which all the ages were available were used for the analysis[13]. Anthropometry scores between -6 and 6 were considered valid and included in the analysis per the WHO recommendations (World Health Organization, 2006)[14]. Our regressions include only those individuals with complete information on sex, their mother's education level & age and type of residence (urban or rural). After following this inclusion criteria, our estimation sample consists of a total of 685,075 children in 38 countries. The consort diagram (Figure 3) shows the sample selection criteria and loss of sample size at each stage.

GDP per capita (adjusted for 2005 USD) time-series for individual countries were downloaded

[12]Sometimes the sampling frame includes any children under 5 and sometimes only children of the respondent, but this varies from country to country and over time

[13]For example, India was dropped from the analysis since 2 out of the 3 surveys did not have children between the ages of 3 to 4.

[14]The DHS multiplies standard WHO scores by 100, and we maintain this convention to make coefficients more easily interpretable, so in practice our analysis includes those that range from -600 to 600 in the DHS surveys

from the World Bank Databank[15]. The data for GDP is merged to individual observations by cohort and country. However, given that survey timing within the calendar year is not constant across survey rounds and almost never covers the entire calendar year, we have to make a slight adjustment. For each age of child (0, 1,..4), we calculate the modal birth year for children measured in that survey round and of that age, and we assign this as the"merge" year. This has a clear motivation in theory - it removes the possibility of identifying effects of GDP on HAZ off of "December-January" babies. That is, if we allowed children from one cohort (defined as combination of country, survey round, and age group) to have multiple values of GDP, our model derives identifying variation off comparing children born in December with those born in January. If a survey takes place in other months, the children from December will be measured at an older age than the children in January, and since GDP tends to increase over time, younger children (with higher HAZ) will be associated with (on average) higher GDP from the next calendar year. By defining cohort in the manner that we do (constant within round-country-age bin) our fixed-effects models do not identify off within-cohort variation in a way that can cause the bias described in Cummins et al. (2013) or that relies on accidental variation in a single month of birth timing.

Summary information on the countries used, the survey years, characteristics of the households and children and the outcome and GDP measure can be found in table 1. The mean age of the children is around 29 months and is evenly split by gender. 36% of the children live in urban areas. Mothers are on average 29 years old, 36% of them have no education and 35% of them have at least primary education. The average GDP per capita of all countries in the sample is around 721 USD per capita between the survey years of 1986 to 2013. The average HAZ score for all children in the sample is -144., or, the average child in our sample is 1.4 SD below the WHO reference for the median healthy and well-nourished child of that age and gender.

This table describes the (small) set of covariates used in our analysis. By controlling for

[15] Economic Indicators from http://databank.worldbank.org/; Accessed Dec 2014

the sex of the child, the maternal age and education and the type of residence, we are able to control for some of the main determinants of the differences in HAZ scores that come from heterogeneity within the population. We limited the number of covariates in order to maximize the final sample size and limit the potential for bias induced by differential omission from the analysis set[16]. Our analysis files make it possible to easily add or remove covariates in order to test the robustness of the estimates, but in general we find that covariates do not strongly influence estimated effect size conditional on the fixed-effects specification.

6 Results

6.1 Rate of Loss of HAZ

Table 2 presents results for Equation 5. The column alpha shows the effect of GDP on the the length of age z scores (LAZ) and the column beta represents the effect of GDP on the rate of loss of HAZ. The first specification provides the OLS estimate of GDP on the parameters $\hat{\alpha}$ and $\hat{\beta}$ (obtained from Equation 4). The "between" specification shows how the medium term GDP growth impacts $\hat{\alpha}$ and $\hat{\beta}$ across countries in a specific time period. The "within" specification represents the impact of GDP on LAZ and rate of loss of HAZ within countries that occur over time. The specification "DnD" represents the net change of medium term economic growth when both country and survey fixed effects are included. This specification tells us how the additional growth of a high growth country as compared to a low growth country can impact the LAZ and rate of loss of HAZ of a child.

In Table 2 we see that the a 10% increase in the medium term GDP of a country, increases beta by 0.002 SD. This can be interpreted as a 25% increase over a negative mean of 0.08 SD. In other words, the 10% increase in GDP, will reduce the rate of loss of HAZ by 0.02

[16]This parsimonious set of controls that was chosen such that the information was available in all survey rounds in the DHS and the coding of the variables was consistent across DHS questionnaires.

SD by his first birthday and 0.05 SD by her second birthday. In Figure 2 we see that across developing countries, children under 24 months in age see a rapid decline in the HAZ after their birth. This loss becomes permanent sometime after their second birthday. Our model suggests that economic growth can slow down the rapid decline of HAZ within the first two years, altering the growth trajectory of the child permanently. From the table, we also see that magnitude of beta is stable across specifications. This is to be expected since this decline is a common feature across all countries and in all surveys in the DHS (Figure 2).

Column alpha in Table 2 shows that between countries, the 10% increase in GDP increases LAZ by 0.1 SD and within a country, economic growth over time increase LAZ by 0.4 SD. However, the “DnD” specification shows that LAZ is not impacted by economic growth. The results seem intuitive when one refers to Figure 2. In the graphs we see that even though children in low GDP and high GDP countries initially start off at birth very similar to each other, by their fifth birthday, they find themselves at different levels on the growth chart as compared to their contemporaries living in other parts of the world. The within and between specifications capture this experience but differencing out both the effects in the “DnD” specification, shows that economic growth does not impact LAZ across countries and over time.

In conclusion for this section, we see that medium term economic growth does not impact the length at birth, but can permanently alter the child’s growth trajectory within the first twenty four months of a child’s life.

6.2 Age specific results

Figure 4 shows the coefficients and standard errors from the specification that includes country-age (μ_{ja}) and life span (λ_{ca}) fixed effects in Equation 7. The coefficients represent the change in HAZ scores for a child at age ‘a’ due to additional economic growth in a high growth country in comparison to another child, aged ‘a’, whose country did not experience the same economic growth.

From the figure, we see that at age 0, economic growth does not impact HAZ. This can be expected since alpha (LAZ) in the previous section is not impacted by economic growth. Said plainly, economic growth in the birth year of a child cannot change her length at birth. Since HAZ represents a cumulative effect of nutrition availability, during the birth year, a child has not been able to fully experience the impact of economic growth. Other factors such as mother's health and nutritional status, genetics or the health environment into which a child is born may instead determine initial HAZ. Between the ages of one to three, the 10% increase in economic growth in the birth year increases HAZ scores of children by 0.03 - 0.04 SD. The results suggest economic growth in the medium term prior to the birth year of a child leads to cumulative positive effects on HAZ scores in the first three years of life. This effect maybe be driven by better nutrition, improved economic conditions for households and improved quality of public goods that affect health input quality and hence health outcomes for children. By age four, the 10% increase in GDP increases HAZ by 0.02 SD. Here, it can be the case that more recent GDP growth (not birth year GDP) or exposure to the disease environment before his fourth birthday plays a bigger role in determining HAZ than past inputs in health. This could mean that for older children, the impact of birth year GDP diminishes in strength even though it still has some role to play.

Table 3 provides some robustness checks for Equation 7. The specification in column 1 has only country and survey fixed effects. Column 2 includes country-age with survey fixed effects and column 3 includes country fixed effects with lifespan fixed effects. The specification in column 4 includes both the country-age and life span fixed effects. We see that our estimates are stable across specifications. Unlike other specifications, the specification in column 4 accounts for the shape of the HAZ-age profile, changes in health that impact HAZ-age profile across cohorts within countries and the changes in GDP that vary across countries and over time and is thus our preferred specification.

6.3 Public Health Mechanisms

As discussed in the conceptual model, economic growth can impact health of a child either through private investments made by households or through public health channels. In the case of the latter, improved health care services and disease environment can translate into better short term health of the child which can manifest as improvements in HAZ over time. In this section we explore a few of these public health mechanisms through which GDP can impact households.

For the public health channel (Table 4), we find some evidence that increases in GDP improve the overall health services. In Table 4, we can see that a 10% increase in GDP increases vaccination rates (Cols 1 & 2) by around 0.013%, an increase of 18% over the mean vaccination rates. Traditional births, i.e births taking place outside formal health institutions, seem to be reducing during times of economic growth (Cols 3 & 4). However, the coefficients are not statistically significant. The coefficient on the percentage of households reporting that their child has a health card decreases, but this is not statistically different from 0.

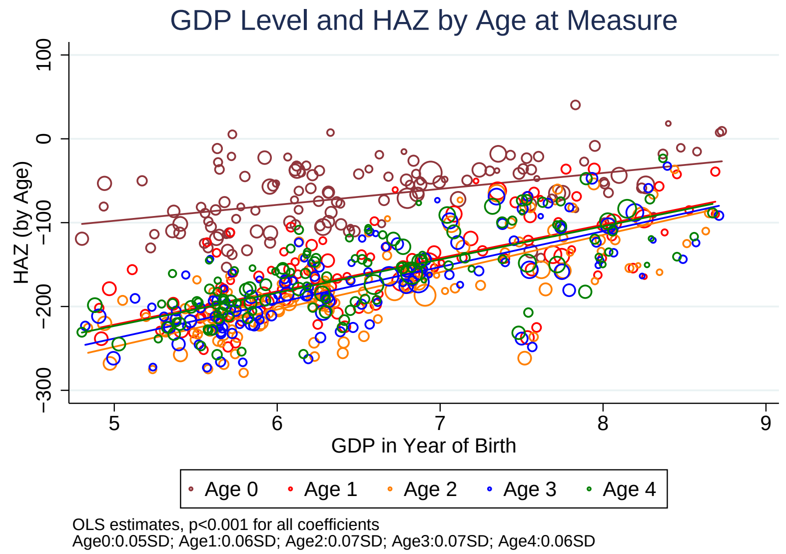
Another potential mechanism that can explain improvements in HAZ is an improvement in the health environment (through investments in water and sanitation etc). In Table 5, we see evidence that a 10% increase in GDP increases the incidence of fever by 0.3%, a 30% increase over the mean, for children between the ages of 0 to 1. Some of this effect could be working through the vaccination channel, where it could be possible that children who are getting more vaccinations, report greater incidence of side effects such as fever. Another possible explanation is that public health improvements from GDP growth maybe crowding out private investments in health. This would imply that the actual impact of GDP growth on HAZ may have been larger had these substitution effects not been in play.

7 Discussion & Conclusions

Human capital theory has recognized that inputs in the health production function have cumulative effects on the health of an individual. Economic growth can stimulate household wealth and investments in the public health system, thus changing the input quality. This in turn will impact the development pathways for health in the long term.

The health of young children is known to be more responsive in the short to medium term to changes in health inputs. In our paper, we show that medium term economic growth in the birth year of a child has lasting impacts on a child's health, as measured by HAZ scores. Prior studies in the literature that have estimated the relationship between economic growth and child health, have often assumed away the role of the input timing and the confounds that arise from the relationship between health (HAZ) and child age. This could be partly because of their inability to deal with the problem empirically and because conceptually, they assume (maybe too lightly) that weight related anthropometric indicators reflects both past and future risk to health of the individual. In this paper we set out to develop new conceptual and methodological tools to capture the dynamic effects of inputs on the health production function of a child. In the first part, we model the impact of GDP growth on the length at birth (LAZ) and the rate of loss of HAZ over the first 2 years of the child's life. We find that an increase of GDP by 10% reduces the rate of loss of HAZ by around 0.05 SD in the first twenty four months after birth but does affect LAZ. This would mean that economic growth in the first two years can cushion the child against the rapid loss in HAZ, thus permanently altering (for the better) their growth trajectory. We also carefully adjust for differences that arise between the 'age at measure', i.e, the age at which a child is measured in the survey, and 'age at exposure', i.e, the age at which a child is exposed to GDP growth. We introduce new lifespan fixed effects and country age fixed effects that use variation within and across countries and cohorts to capture the impact of medium term economic growth on the child health development pathway. We find here that a 10% increase in medium term GDP (pre birth conditions), does not change HAZ of a new born, but increases HAZ by 0.03 to 0.04 SD for a child from age 1 to age 3 and increases HAZ by 0.02 SD for a child at age 4. The age 0 estimates can be explained by the fact that HAZ represents cumulative changes in inputs and hence the impact of economic growth cannot be captured in the first year of a child. The HAZ at age 0 maybe instead determined by mother's health, genetics or the current disease environment into which a child is born. However, exposure to GDP growth in the birth year can impact the growth trajectory of the child at all other ages. After age 3 however, inputs in the birth year may matter less than the current inputs or more recent economic growth. We also explore some public health mechanisms that are impacted by GDP and find some evidence that medium term economic growth increases vaccination rates but incidence of fever also increases.

8 Figures & Tables



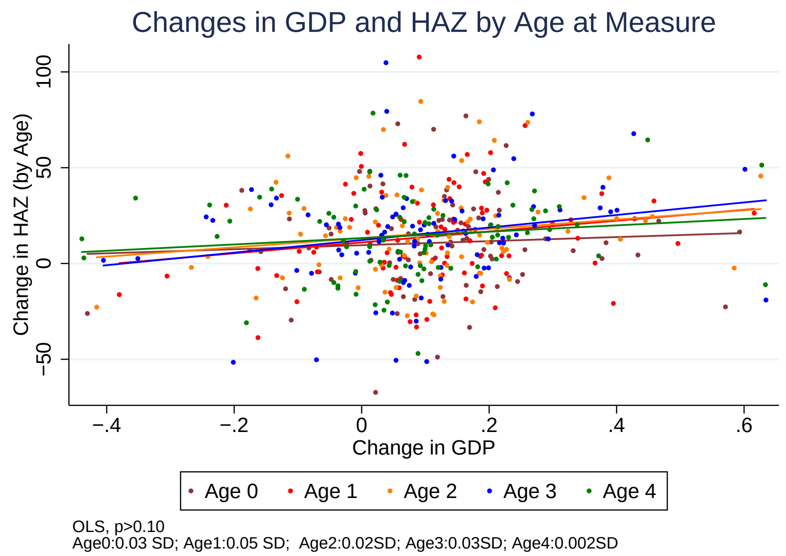


Figure 1: Birth Year GDP and Child HAZ

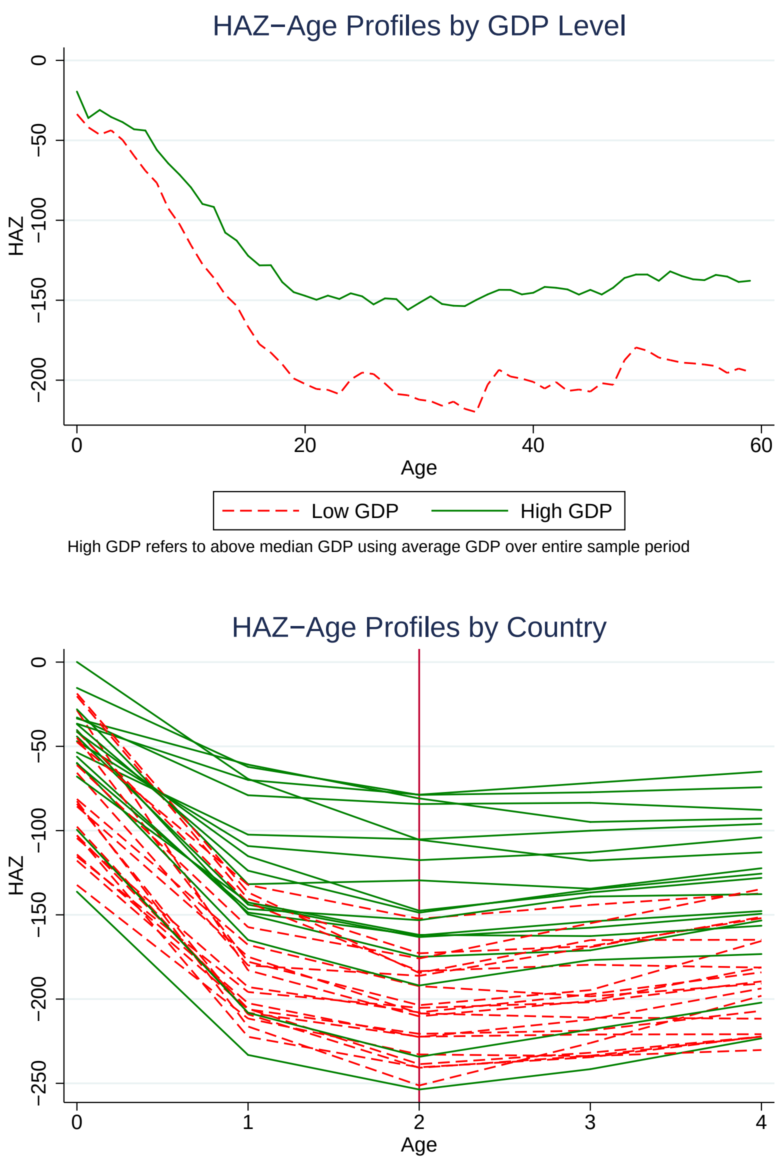


Figure 2: HAZ Age Profiles

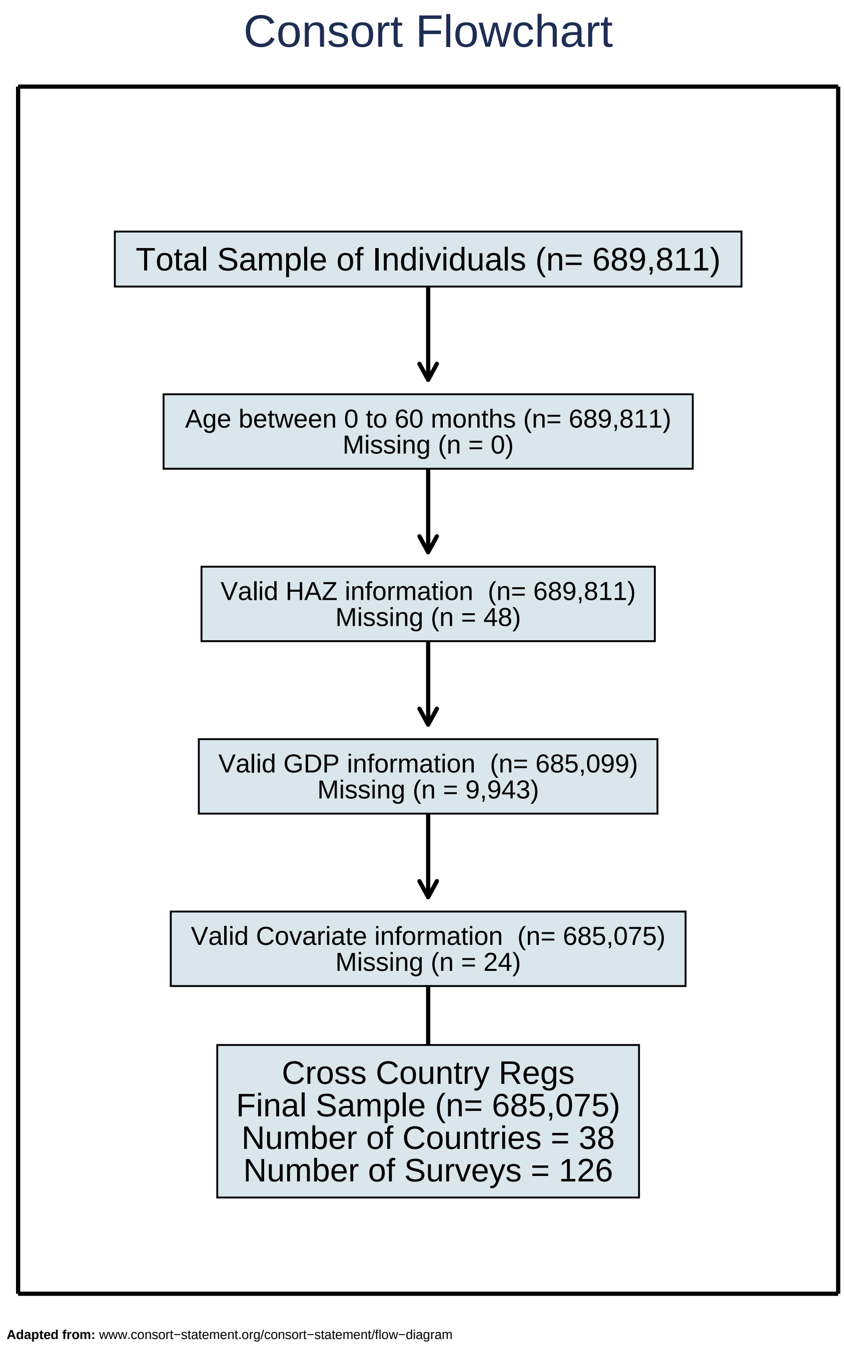


Figure 3: CONSORT Diagram

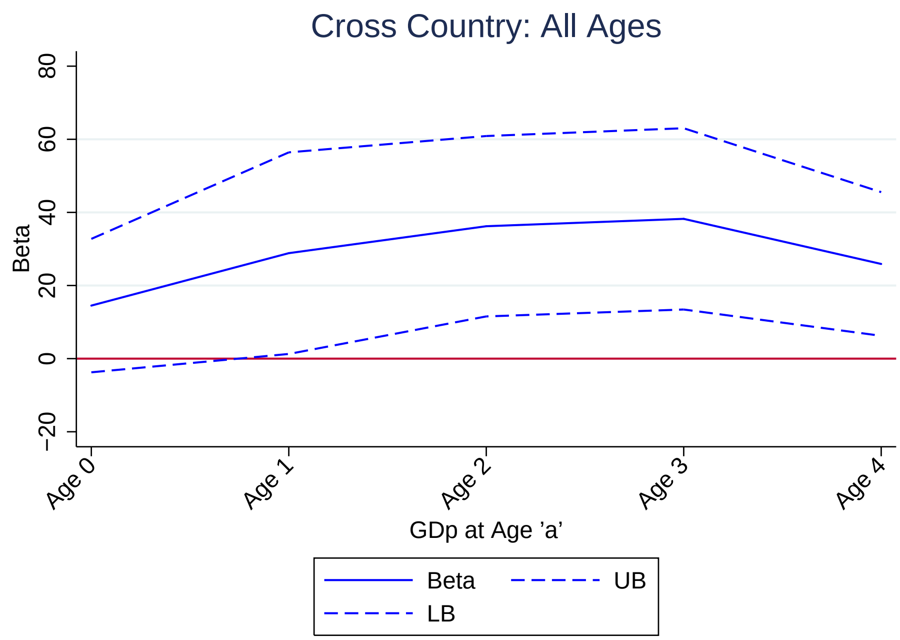


Figure 4: Results: Age-Specific Effects of GDP on HAZ

Table 1: Summary Statistics: Covariates

Variable	Mean	SD
HAZwho	-143.89	168.16
Child age (months)	28.40	17.17
GDP per capita (log)	6.58	0.92
Survey Year Gap (years)	5.98	2.28
Covariates		
female (%)	0.50	0.50
Maternal Age (years)	28.80	6.83
Maternal Education		
No Education (%)	0.36	0.48
Primary Education (%)	0.35	0.48
Secondary Education (%)	0.24	0.42
urban (%)	0.36	0.48
N	685075	

Table 2: Results: Rate of HAZ Loss and LAZ

	OLS		Between		Within		DnD	
	Alpha b/se/bse	Beta b/se/bse	Alpha b/se/bse	Beta b/se/bse	Alpha b/se/bse	Beta b/se/bse	Alpha b/se/bse	Beta b/se/bse
GDP	9.00	1.68***	10.0+	1.65***	36.4*	2.21*	2.08	2.34*
	(5.54)	(0.33)	(5.33)	(0.33)	(17.8)	(0.93)	(15.7)	(0.90)
	[5.60]	[0.35]	[5.40]	[0.36]	[18.4]	[0.99]	[20.6]	[1.15]
Mean	-19.7	-7.6						
Survey FE			✓	✓			✓	✓
Country FE					✓	✓	✓	✓
r2	0.04	0.36	0.15	0.37	0.08	0.08	0.23	0.10
N	126	126	126	126	126	126	126	126

+ 0.10, * 0.05, ** 0.01, *** 0.001; Robust standard errors clustered at the country level for 41 countries; For each specification columns represent results for children under 2, the first column presents values of the average LAZ scores (α) and the second column presents values for the rates of loss of HAZ (β) from Equation 5; Analytic cluster standard errors in ( ), 2-stage Bootstrap SE in [ ].

Table 3: Results: Age Specific HAZ Outcomes

	(1) HAZ b/se	(2) HAZ b/se	(3) HAZ b/se	(4) HAZ b/se
Age 0	8.8	3.2	12.8	14.5
	(10.5)	(10.4)	(9.6)	(9.3)
Age 1	28.8***	30.3**	32.5***	28.9**
	(10.5)	(13.4)	(10.0)	(14.1)
Age 2	33.6***	38.8***	36.7***	36.2***
	(10.7)	(13.1)	(10.0)	(12.6)
Age 3	31.3***	38.6***	34.2***	38.2***
	(10.6)	(11.0)	(9.9)	(12.6)
Age 4	28.8***	24.8**	31.9***	25.9**
	(10.5)	(9.5)	(9.6)	(10.0)
Urban	31.9***	32.0***	31.9***	32.0***
	(2.0)	(2.1)	(2.0)	(2.1)
Mat. Age	0.8***	0.8***	0.8***	0.8***
	(0.1)	(0.1)	(0.1)	(0.1)
Female	14.3***	14.3***	14.3***	14.3***
	(1.2)	(1.2)	(1.2)	(1.2)
Sample Mean	-143.91			
Survey FE	✓	✓		
Country FE	✓		✓	
Country-Age		✓		✓
Lifespan			✓	✓
r2	0.119	0.049	0.120	0.049
Obs	685075	685075	685075	685075

Ordinary Least Squares, All Controls Included, Regressions clustered by country, controls also include dummies for maternal education

Table 4: Results: Access to Health Care Services

	(1) Vax b/se	(2) Vax b/se	(3) Trad b/se	(4) Trad b/se	(5) Card b/se	(6) Card b/se
GDP at Birth	0.13*	0.13	-0.13	-0.12	0.0024	-0.017
	(0.07)	(0.08)	(0.08)	(0.08)	(0.07)	(0.07)
Urban	0.066***	0.066***	-0.15***	-0.15***	0.075***	0.075***
	(0.009)	(0.009)	(0.02)	(0.02)	(0.01)	(0.01)
Mat. Age	0.0013***	0.0013***	0.00076	0.00076	0.00065	0.00066
	(0.0004)	(0.0004)	(0.0005)	(0.0005)	(0.0007)	(0.0007)
Female	-0.0014	-0.0015	0.0048***	0.0048***	-0.0017	-0.0018
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Sample Mean	.69		.29		.82	
Country FE	✓		✓		✓	
Country-Age		✓		✓		✓
Lifespan	✓	✓	✓	✓	✓	✓
r2	0.158	0.042	0.076	0.076	0.055	0.050
Obs	681610	681610	671787	671787	685075	685075

Ordinary Least Squares, All Controls Included, Regressions clustered by country, controls also include dummies for maternal education

Table 5: Results: Age Specific Morbidity

	(1) Cough b/se	(2) Cough b/se	(3) Fever b/se	(4) Fever b/se	(5) Diarrhea b/se	(6) Diarrhea b/se
Age 0	0.04	0.05	0.09*	0.1**	-0.02	-0.003
	(0.05)	(0.06)	(0.05)	(0.05)	(0.02)	(0.03)
Age 1	0.06	0.07	0.09*	0.1*	-0.02	-0.004
	(0.05)	(0.06)	(0.05)	(0.07)	(0.02)	(0.04)
Age 2	0.06	0.07	0.09*	0.09	-0.02	-0.005
	(0.05)	(0.06)	(0.05)	(0.06)	(0.02)	(0.02)
Age 3	0.06	0.04	0.10*	0.07	-0.01	-0.03
	(0.05)	(0.06)	(0.05)	(0.06)	(0.02)	(0.02)
Age 4	0.06	0.07	0.1**	0.08	-0.01	0.010
	(0.05)	(0.05)	(0.05)	(0.05)	(0.02)	(0.02)
Urban	0.008	0.008	-0.02***	-0.02***	-0.006**	-0.006**
	(0.005)	(0.005)	(0.006)	(0.006)	(0.003)	(0.003)
Mat. Age	-0.0007***	-0.0007***	0.0005***	0.0005***	-0.001***	-0.001***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Female	-0.007***	-0.007***	-0.009***	-0.009***	-0.01***	-0.01***
	(0.002)	(0.002)	(0.0010)	(0.0010)	(0.001)	(0.001)
Sample Mean	.28		.28		.15	
Country FE	✓		✓		✓	
Country-Age		✓		✓		✓
Lifespan	✓	✓	✓	✓	✓	✓
r2	0.026	0.020	0.024	0.011	0.032	0.006
Obs	673599	673599	658003	658003	680641	680641

Ordinary Least Squares, All Controls Included, Regressions clustered by country, controls also include dummies for maternal education

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A Summary Statistics by Country

Table A1: Summary Statistics: Asia

Country Name	Survey Years	BirthYears	N	HAZ	Birth Year GDP pc (USD 2005)
1. Armenia	3	1996-2010	4,074	-73.08	1356.94
2. Bangladesh	5	1992-2011	22,391	-190.37	391.141
3. Cambodia	3	1995-2010	10,803	-181.53	420.29
4. Jordan	5	1986-2012	27,806	-67.39	2183.46
5. Pakistan	2	1986-2012	7,114	-202.13	611.84
6. Turkey	3	1989-2003	9,943	-81.47	5605.791

Table A2: Summary Statistics: South America

Country Name	Survey Years	BirthYears	N	HAZ	Birth Year GDP pc (USD 2005)
7. Bolivia	3	1993-2007	23,032	-135.51	971.06
8. Brazil	2	1982-1995	5234	-80.06	4035.81
9. Colombia	5	1984-2009	38,430	-91.91	3321.21
10. DominicanRepublic	3	1987-2013	10,109	-75.47	3081.81
11. Guatemala	2	1991-1998	12,420	-232.49	3081.80
12. Haiti	3	1997-2011	9,217	-111.84	472.59
13. Peru	4	1987-2000	34,168	-148.99	2183.584

Table A3: Summary Statistics: Africa

Country Name	**Survey Years**	**BirthYears**	**N**	**HAZ**	**Birth Year GDP pc (USD 2005)**
14. Benin	3	1997-2011	23,748	-167.17	535.46
15. BurkinaFaso	4	1988-2010	22,319	-149.18	358.81
16. Cameroon	3	1986-2010	10,548	-127.84	963.09
17. Congo	2	2001-2011	8,368	-109.47	1746.24
18. CoteDIvoire	2	1994-2011	4,689	-123.17	1013.27
19. Egypt	5	1988-2013	53,200	-96.21	1195.76
20. Ethiopia	3	1988-2002	22,035	-181.96	138.30
21. Ghana	3	1994-2008	8,099	-130.72	463.35
22. Guinea	3	1995-2012	8,645	-121.63	292.66
23. Kenya	3	1988-2008	14,647	-141.86	529.37
24. Liberia	2	1981-2013	7,495	-140.04	207.41
25. Madagascar	3	1988-2008	13,277	-196.03	289.29
26. Malawi	4	1988-2009	25,037	-194.54	215.22
27. Mali	3	1996-2012	24,450	-150.38	420.92
28. Morocco	3	1982-2003	14,203	-111.99	1458.99
29. Mozambique	2	1999-2011	17,372	-170.48	317.04
30. Namibia	4	1988-2012	10,675	-122.68	3317.52
31. Niger	3	1987-2011	12,579	-173.03	280.13
32. Nigeria	4	1986-2012	53,293	-148.08	855.14
33. Rwanda	4	1988-2010	18,045	-184.38	254.15
34. Senegal	3	1988-2010	10,271	-114.48	731.27
35. Tanzania	5	1987-2009	27,852	-181.88	329.15
36. Uganda	5	1984-2011	17,784	-167.55	251.265
37. Zambia	4	1987-2006	20,978	-189.17	647.78
38. Zimbabwe	4	1984-2010	13,302	-134.20	539.93

B Aggregate Regressions

This table provides the results from the aggregate regressions for 2 outcomes HAZ and stunted growth[17]. Column 3 and 6 are the preferred specifications and include both country-age and cohort-age fixed effects. Here we see that a 10% increase in GDP increases aggregate HAZ by 0.025 SD and decreases stunting by 0.005% (not statistically significant). The estimates on the aggregate HAZ outcome lies within the range of the individual age wise regressions in table 3. This reiterates our argument that other studies that estimate changes at the aggregate level will tend to underestimate the effect of GDP on HAZ.

Table A4: Results: Aggregate Impacts of GDP on HAZ

	(1) HAZ b/se	(2) HAZ b/se	(3) HAZ b/se	(4) Stunted b/se	(5) Stunted b/se	(6) Stunted b/se
GDP at Birth	22.6	26.6*	25.4*	-0.04	-0.06	-0.05
	(11.7)	(10.9)	(11.1)	(0.03)	(0.03)	(0.03)
Urban	32.6***	32.6***	32.6***	-0.09***	-0.09***	-0.09***
	(2.3)	(2.3)	(2.3)	(0.008)	(0.008)	(0.008)
Mat. Age	0.8***	0.8***	0.8***	-0.002***	-0.002***	-0.002***
	(0.1)	(0.1)	(0.1)	(0.0003)	(0.0003)	(0.0003)
Female	14.3***	14.3***	14.3***	-0.04***	-0.04***	-0.04***
	(1.2)	(1.2)	(1.2)	(0.003)	(0.003)	(0.003)
Mean	-144			.36		
Age	X			X		
Survey	X			X		
Country	X	X		X	X	
Country_Age			X			X
Lifespan		X	X		X	X
r2	0.16	0.16	0.05	0.13	0.13	0.04
N	685075	685075	685075	685075	685075	685075

[17]Stunting is defined as a condition in which a child's HAZ score is 2 SD below the reference group's mean.