The Intergenerational Correlation of Health: Evidence from Africa

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Abstract

This paper investigates the intergenerational transmission of health in Africa. Our measure of maternal health is height and we explore two alternative measures of child health, namely infant mortality risk and child height. We use individual survey data on 1.26 million children born to 250000 mothers in 28 African countries during 1970-2000 which we match to aggregate macroeconomic data by region and birth cohort. Our main findings are as follows. Maternal and child health exhibit a positive correlation in every country in the sample. On average, children born to mothers who are at least one standard deviation below the mean height in their region are 1.1 percentage points [9.9% of the sample infant mortality rate] more likely to suffer infant death than children born to mothers of mean height. The gain associated with having a tall mother is only half as large as the penalty attached to having a short mother. If the correlation were purely genetic then this sort of asymmetry would be unlikely. Since height is positively correlated with socioeconomic status, it seems likely that poor women are constrained in the investments they can make in child health. We therefore investigate whether economic development weakens the average intergenerational coefficient. The idea is that, with development, fewer women are liquidity constrained and public services improve so that child health is less tied to family wealth. We find that it does- the intergenerational correlation of health is weaker in richer countries and especially so amongst shorter women. This result is more pronounced when estimated on between-country variation than when estimated on within-country cohort/year variation, which suggests that it is longer term development that matters. Given evidence that the variation in heights in early childhood is largely determined by environmental factors, with the role of genes kicking in later in life, we investigated how the relationship between child and mother height changes with child age in the range 0-5. We find some tendency for the relationship to strengthen with age. We argue that although this is an interesting result in itself, there are alternative interpretations of it.

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Section I: Introduction

This paper investigates the intergenerational correlation of health in Africa. As a measure of maternal health we use height and we explore two alternative measures of child heath, namely infant mortality risk and (standardised) height. These measures of health are widely used and will be discussed further below. We may expect to see a positive intergenerational correlation of health for the following reasons. First, a stature gene is passed on from mother to child.[1] Second, physiological characteristics such as pelvic size may constrain a small woman to produce a small child. Third, if adult height indicates "permanent health"[2] then some part of the frailty acquired over their lifetime by short women may be passed on to their offspring by biological mechanisms that may not involve genes.[3] Fourth, to the extent that height indicates socioeconomic status[4], shorter women may produce smaller children because they are liquidity constrained in the investments they make in pregnancy, birth and early childhood.[5]

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[1] Under assortative mating, missing information on the father will not add too much noise.

[2] Some studies show that adverse conditions in childhood have persistent effects on adult height (e.g. Bozzoli et al. 2007, Bhalotra 2007). Other studies suggest that this "scarring" is associated with a greater proclivity to certain diseases and lower life expectancy (e.g. Waaler 1984). One explanation of this is that, while adaptation to small size is thrify for the foetus or the newborn child that is faced with the challenge of surviving against resource scarcity, this adaptation may exert a penalty later in life when resource constraints are relaxed (Barker 1992).

[3] For example, if small adult stature reflects metabolic or endocrine adjustments in childhood, then shorter women may be less good hosts for the foetus. Alternatively, if small women are undernourished, children may be born undernourished; for an account of reproductive malnutrition see Osmani and Sen (2003).

[4] Evidence that adult height is positively correlated with socioeconomic status is in Maccini and Yang (2007) for Indonesia and in Bhalotra (2008) for India.

[5] In their survey of the literature on intergenerational correlations, Grawe and Mulligan (2002) argue that, if the level of parental investment in child health is limited by liquidity constraints, then the intergenerational transmission of health may occur via (low) income.

In this paper, we first investigate whether a woman's height (relative to the population of her country) has any implications for the survival chances of her children. We find that it does, with births to shorter women systematically experiencing higher infant mortality across 28 different countries in the African subcontinent. This result is interesting as it stands. We have already cited evidence that (adult) stature predicts (own) life expectancy, and the finding that it also predicts survival or life expectancy for offspring is an important extension of the evidence. We also find an asymmetry in that the decrease in infant survival chances associated with the mother being short is almost twice as large as the increase in survival chances associated with the mother being tall.

A priori, it is unclear whether the underlying mechanism is entirely biological, as suggested by the second and third reasons above, or whether some part of it is economic, as suggested by the fourth. Identifying the force of the economic mechanism as distinct from biological mechanisms is difficult when individual incomes are used because individual income is correlated with individual frailty. In any case, there are no time-varying data on individual incomes for the African sample that we analyse. We therefore exploit cross-country and country-cohort variation in GDP per capita, which is plausibly exogenous to individual mortality risk. Our hypothesis is that, to the extent that the tendency for shorter women to produce smaller children reflects economic constraints, we may expect economic development to relax these constraints and, so, to weaken the impact of maternal stature on child survival or health. Using annual within-country variation in GDP across birth cohorts, we find some evidence that the relationship is weaker in upturns, but this is statistically insignificant. However, there is a more significant relationship in the cross-section: the relationship of maternal and child health is weaker in countries with higher average GDP over the period and the difference between richer and poorer countries is more pronounced amongst shorter women. We interpret this to mean that long run economic development weakens the tie between maternal and child health, even if the effect of short run changes is small. Overall, these results suggest that the there is a socioeconomic element to the relationship between maternal stature and child survival. This may work through maternal nutrition and antenatal care, delivery conditions, or postnatal investments in the child.

On average in the sample 11% of children die by the age of one (in infancy). We take the investigation further by analysing the impact of maternal height on the height (health) of surviving children. To the extent that smaller children are more likely to die, survivors will be taller on average. We argue that selection on survival will tend to weaken the intergenerational correlation of height. So, even though we do not directly control for sample selection, our estimates are conservative (biased downwards). We find, in every country, a positive impact of maternal on child height. There is now no significant asymmetry. If the intergenerational correlation of height were merely an expression of a genetic trait then it would have no particular implication for social inequalities. However, on the grounds that maternal height is correlated with her health and socioeconomic status, and in the knowledge that a child's health is indicated by their age-standardised height, the correlation of mother and child heights is of interest. We find that shocks to GDP within-country weaken this correlation amongst shorter women. Amongst taller women, the correlation is smaller but the change is not significant.

A tranche of research on richer countries has studied birth weight, motivated by the finding that low birth weight predicts worse health and lower education and earnings in adulthood (e.g. Behrman and Rosenzweig 2004). Most studies by economists have focused attention on the impact on birth weight of substance use by the mother during pregnancy (e.g. Almond and Chay 2004, Tominey 2007). Our ultimate motivation is similar: we are interested in the determinants of initial health or frailty at birth and we measure this as neonatal or infant mortality. This is the more commonly used index in developing countries, where birth weight data are often missing or unreliable. Rather than consider the effects of maternal behaviour, we are interested in the effects of maternal stature. In this way, our study is more closely linked to a literature that emphasises the impact of adverse conditions in (a woman's) childhood on her height at maturity (e.g. Bozzoli et al. 2007, Bhalotra 2007), which can have persistent harmful effects (e.g. Waaler 1984, Barker 1992). The evidence in this paper is consistent with the view that these effects have far-reaching consequences that extend to the survival or growth of the next generation (also see Osmani and Sen 2003). The natural relatives of this study are other studies of the intergenerational correlation of health, education and earnings. These are described in the following section.

To summarise, to the extent that adult height indicates health and health is correlated with income, the intergenerational transmission of health predicts persistent polarisation of society in the same way that the transmission of education across generations does (e.g. Ahlburg 1998). We analyse household survey data from 28 African countries that provide unprecedented scope to study the intergenerational correlation of health and its variation with economic development. The existing evidence base on this topic is small and scattered, and especially small for developing countries, where the issues are of greater pertinence. We find some evidence that interventions that relax liquidity constraints amongst the poor will lead to improvements in the stature and survival prospects of their children, putting them on higher lifetime trajectories of income and wellbeing.

Section II: Related Literature

Child health is important not only for intrinsic reasons but also because there is a growing body of evidence that suggests a link between health in early childhood and health, education and earnings later in life (Currie and Madrian 1999, Royer, 2006, Case, Fertig and Paxson 2003, Oreopoulous et al. 2006).

The seminal model of the intergenerational transmission of wealth was put forward by Becker and Tomes (1979, 1986). They show that when parents are utility maximising and care about their own and their children's consumption, then the earnings of children depend on parental investment in children's human capital, luck, and "inherited" earnings capacity. They stress the importance of optimising responses of parents to their own and children's circumstances, and their model implies that intergenerational mobility of earnings is affected primarily by parental propensity to invest and the inheritability coefficient. The empirical literature has focused upon earnings (see Grawe and Mulligan (2002), some looking directly at intergenerational correlations in education and heritability of innate ability (see for example, Black et al (2003); Chevalier, 2004). In this paper, we are concerned with parental investment in health and with the heritability of health, which we shall refer to as (genetic) frailty. The only previous studies that examine the intergenerational correlation of health are Currie and Moretti (2007), Conley and Bennet (2000, 2001), Kebede (2005), and Thomas et al (1990).

Whilst the natural sciences literature contains many empirical papers on the heritability of height or birth-weight (for a review see Silventoinen, 2003), the economics literature is much smaller. Few papers use maternal stature as a measure of health. Instead, some studies have sought to establish a correlation between the birth weight of the mother and child (see for example Emmunuel et al 1992, Currie and Moretti, 2007).

The only previous studies we know that has, like us, investigated how the intergenerational correlation of health varies with income or socioeconomic status is Currie and Moretti (2007). They use data from Californian birth records to measure the intergenerational transmission of birthweight. They are able to identify siblings of mothers, which permits estimation of a grandmother fixed effects model. Defining SES as either poverty or income in the zip-code of residence or hospital at birth, they investigate an interaction term between SES and mother birth weight. They check whether it matters if this measure is for the mother at the time of her own or at the time of her child's birth. They find that, even after controlling for grandmother fixed effects, having a mother who is low birth weight significantly raises the probability of the child being of low birth weight. And this correlation is higher at lower income levels. The probability of being of low birth weight is raised by 88% if the mother lives in a high poverty area. The paper therefore argues that children from low poverty families are more at risk of the negative effects of having a mother with low birth weight. This result is as we might expect if we believe that households with higher income can invest more in the health capital of their children, giving them more opportunity to override a low genetic endowment of health compared to poorer households.

Conley and Bennett (2000) instead investigate whether an effect of income on birth weight persists after taking into consideration the effects of mother's own birth weight and other family factors. Using data from the Panel Study of Income Dynamics, from 198 – 1992, they estimate fixed effects models to eliminate unobserved heterogeneity amongst families. They find that income during pregnancy does not affect whether a child is low birth weight, once mother birth weight has been accounted for. In a further paper, Conley and Bennet (2001) show that income matters for children born to parents, at least one of whom was of low-birth weight.

Using data on Ethiopian households in 1994-1997, Kebede (2005) finds a result similar to that of Conley and Bennet (2000). Controlling for individual fixed effects, income per capita has no significant effect on child height but parental height is highly significant. To investigate further whether the observed correlation of parental and child height reflects genetic endowments, he regresses the heights of children on the height of the household head, interacting the latter with the child's relationship to the head. He finds some interesting and some odd results. Across his two specifications, the coefficient for children of the household head is significantly larger or at least as large as coefficients for grandchildren. He interprets this as evidence that the intergenerational height correlation is mostly genetic. However, to undermine this, he finds no significant difference in the correlation obtained for nieces and nephews compared to children of the head.

Silventoinen, Kaprio, Lahelma, and Koskenvuo (2000) look at changes in height across four cohorts over the period 1928-57 using data from the Finnish Twin Cohort Study. They argue that the contribution of genetic factors rises between the first and last cohort, although this change was significant only for women. Since there was an increase in GDP over the period, they argue for lower heritability of body height in poorer environments due to environmental effects outweighing genetic contributions to height; for example changes in the disease environment in which a child is born (Silventoinen, 2003). However, they do not formally test whether GDP did in fact cause this rise in heritability. In addition, they use self-reported height, measures of which have been shown to bias downwards estimates of the heritability of height (Macgregor et al, 2006). Dubois et al (2007) study the relative contributions of environment and genetics on height and weight of children, using a sample of 177 twins from the Quebec Newborn Twin Study, in which heights and weights of children were measured at birth, and then after 5 and 60 months. They find weight is determined to a large degree by genetics, and argue that their results imply a lack of environmental effects on body weight that are independent from genetic history. In contrast, they find the effect of environmental factors on early childhood height is much more substantial, although the importance of genetic factors appear to increase with child age.

In developing countries, birth weight data are often missing for large fractions of the surveyed population. It is more common in this domain to use child height for age or infant mortality as a measure of child health. Using household survey data from Brazil, Thomas et al (1990) investigate the relationship between household characteristics including parental heights and child health. They find a positive effect of parental height on child height and survival, after controlling for per capita household expenditure and education. Their estimates of the effect of standardized mother height on child height for age are in the range 0.32 to 0.37 depending on specification, region, and whether urban or rural. The inclusion of parental height leads to a decline in the estimated effect of maternal education by between 20 and 40%. They suggest that the effect of maternal height on child survival may reflect, “its effect on birth weight and its role as a proxy for family background” (Thomas et al, p. 198). Martorell et al (1981) use data on 381 Guatemalan women studied from 1977-1979 and find that shorter mothers have more children but fewer of these survive than taller women, but they do not control for education or income.

Overall, the empirical literature on the intergenerational transmission of health is small and, for developing countries, even smaller. Several studies find a positive association. There is no conclusive evidence on the share of the correlation that is genetic, although studies of twins provide some insight. Some studies include both parental height and household income and report that one or the other of these variables dominates. This does not tell us much more than that parental height is correlated with parental income. One previous study shows, using Californian data, that the intergenerational correlation of health is stronger in poorer areas. This paper contributes to the literature in the following ways. First, it uses unusually large and rich microdata that capture substantial variation in the level of health and income. Second, it provides comparable evidence for 28 African countries. Third, it uses a number of alternative strategies to get at the key question of the extent to which there is a non-genetic component to the intergenerational correlation coefficient. First, it allows asymmetry in the effect which only makes sense if there is a non-genetic component to the effect. Second, it investigates how the intergenerational correlation of health varies across region and cohort. Under the assumption that the genetic part of the correlation is more or less constant across space and time, space/time variation in the correlation signifies socio-economic variation. Using GDP per capita as a specific (if restricted) measure of economic development that varies across countries and time, it investigates how the correlation varies across countries and cohorts with different levels and growth rates of GDP).[6]

Section III: Data

The data used in this analysis are compiled from 57 Demographic and Health Surveys (DHS) for 28 African countries. These contain information on a wide range of demographic and health variables for households, women and children (see www.measuredhs.com). A great advantage of these is their breadth- we have

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[6] Only one previous study investigates a similar question (Currie and Morretti).

information on about 1.26 million children born to 250000 mothers in 28 African countries during 1970-2000.

Women record their complete fertility history so that we have information on the birth of every child of the sampled women, and any deaths. Children in the data are born during 1954–2006. We restricted the sample to children born after 1970 since the data on mortality available for years prior to 1970 is both scarce and unrepresentative (see Bhalotra, 2007). Infant mortality is defined as death in the first year of life. To allow for age-heaping at six monthly intervals, we define this to include the twelfth month. To ensure that every child in the sample had full exposure to infant mortality risk, children born less than 12 months before the interview data were excluded. The time range of these data varies by country but is about 1970-2006.

Information on anthropometrics (height, weight) was gathered by direct measurement of living children for a sub-sample of children born in the 3-5 years preceding the date of the survey. For countries for which there is more than one round of the survey, pooling rounds gives us heights information for at best 6-10 birth cohorts. So the time variation in these data is much smaller than in the data on infant mortality. The age range of children for whom information on heights is recorded is 0-5 years. Since children of this age are, of course, growing, their heights are standardised (converted into z-scores), using an age and gender specific distribution of heights of healthy children, using calculated means and standard deviations from our sample. A problem with the heights data is that they are selective. At every age, we have information on height only for children who survived to that age. If mortality-selection disproportionately eliminates the potentially short children then surviving children are tall on average. Although we use infant mortality as a measure of health that is interesting in its own right, our estimates will indicate the extent to which children of shorter mothers (who, other things equal, are potentially short) are more likely to die. In studying the relationship between maternal and child height, we do not directly address this selection problem, although we take it into account in interpreting our results. There appears to be only one previous study that attempts to model the effects of mortality selection on the health of survivors in a high mortality environment (Lee et al. 1997).[7] They find that selection effects are negligible. There

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[7] As discussed below, Deaton (2007) suggests that the predominance of selection over scarring effects might explain the paradox of African women (and children) being relatively

are scores of studies of child health (including child height) that simply ignore the selection problem.

Our measure of maternal health is height. Data on men's heights are not collected in most surveys. Also, women record retrospective fertility histories and it is easier to link children to mothers than to fathers. Mother's height, like that of children is measured by surveyors and has the virtue of objectivity. However many of the surveys interview ever-married women and age at marriage tends to be positively correlated with height in these data. In these cases, the sample selectively includes shorter women amongst younger cohorts. To circumvent this problem, women younger than their country's 95th percentile of age at first marriage are excluded from the analysis. This also allows for the fact that women continue to grow beyond the age of 15, which is the lower age limit used in the survey of women.

Where we find missing values for mother's height, these are imputed rather than removed (Cameron and Trivedi, 2005 p.923). Child height is available only for children aged 0 – 5, and for most countries, missing values for child height are recorded for less than 2% of observations, and we drop these. Pooling across countries means we lose 29% of observations this way. We assume missing mother heights are "missing at random", and then regress height on all of our right hand side variables, using prediction-matching to generate imputed values[8]. Some implausible values for height appear in the data. We exclude from the analysis women with height that is more than three standard deviations away from the country mean.

As ethnicities are country-specific, the regression includes country-specific dummies for ethnicity. There are a large number of cases (42%) in which ethnicity is missing. Since we are not particularly interested in the coefficients on ethnicity, but would like to include women whose ethnicity was not recorded, a dummy variable for missing ethnicity was included in the regression.

Inclusion of women in the survey is conditional on them being alive at the time of interview, resulting in a selectively healthy sample of women, implying in turn that we probably have a selectively healthy sample of children.

Data on GDP per capita in constant 2000 prices (chain series) for 1970-2004 is obtained from the Penn World Tables (Summers, Heston and Aten, 2006). These are

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tall inspite of poor living conditions. The modelling exercise in Lee et al. (1997) uses data from Bangladesh and the Phillipines in the 1980s.

[8] We use the –uvis-command in Stata to perform this imputation.

merged with the individual data by country and birth year. Although there is some information on assets at the time of survey, which we exploit, there is no time-varying information on household income. There is information on education but this is fixed for the mother and does not vary across her births (/time).

Section V: Methodology

The baseline model is:

$$Y_{imjt} = b_0 + b_1 H_m + b_2 X_{im} + g_t + g_j + e_{ihjt}$$

The dependent variable (Y) is, first, a binary variable indicating whether the child died before the age of 12 months, and then the z-score of child height. H_m is mother's height, X are controls that we describe below, and the other terms are year and country fixed effects. The subscripts refer to child i born to mother m in country j in time t. Consider first the model for infant mortality risk. This can be estimated using maximum likelihood estimation, with either a logit or a probit. Since in practice the predicted probabilities from the two models are often very similar, and differences between the two models are small when we are looking at average marginal effects, the probit model, which is motivated by a latent normal random variable will be used (Cameron and Trivedi, 2005 p.472). Estimated marginal effects will be normalised upon the country-specific mean of the dependent variable for comparison across countries. Our height regressions use z-scores of child height, which have been standardised so that the reference group is gender, age (in months) and country specific. The height models are estimated by OLS. Standard errors are robust to arbitrary forms of heteroskedasticity and clustered by country to allow for autocorrelation within country.

It has been suggested that there are biological limitations to improvements in the stature of children (Morgan, 2000) and we can imagine that this may also be true of infant mortality risk. Cole (2003) argues that whilst the trend in heights has not always been linear, particularly in the 18th century, adult height has followed almost a linear trend since the 19th century. He suggests that this latter trend in height reflects an intergenerational phenomenon, with children of each generation becoming taller than the previous generation, but with a natural limit to the increases in height between generations. It is then reasonable to assume that the returns to mother height in terms of improving child mortality are diminishing. For these reasons, indicators of mother height are given by four dummy variables, each indicating whether a mother is one or two standard deviations above or below the mean height, calculated to be country- specific. This allow for asymmetric effects of mother height, that is, for the effect of being short to be different from the effect of being tall.

This formulation takes care of another potential problem, which is that there are long-standing ethnic differences in height such that a tall person in Madagascar would be regarded as short in Chad. For this reason, it is important to have a measure of height – as we do- that is relative to the country mean.

X_{imjt} includes child gender and month of birth, mother education level, mother age at birth, whether mother lives in an urban or rural area, father education level and religion and dummy variables for ethnicity. X_{jt} includes real per capita GDP. The year dummies, $?_t$, and the country-specific trends, $?_j*t$, allow for trends in health such as driven by technological progress. Country dummies, $?_j$, control for time invariant unobserved differences between countries.

The model is first estimated on the microdata pooled across countries and birth years. It is then estimated separately for each country in the data, to examine regional variation in the intergenerational correlation of health. Since the relationship may not be constant over time, we also run the infant mortality regressions for four cohorts of children; 1970-79, 1980-89, 1990-99 and 2000-05. Our child height data does not span a long enough time period to enable cohort analysis. However, we do investigate whether the relationship differs between children in different age groups.

To investigate whether the relationship changes with family socioeconomic status or country income, socioeconomic status indicators are interacted with the height variables. We run two separate specifications to investigate the role of GDP. First, on the full sample, we interact GDP with each of the height variables, also allowing for an additive effect. Secondly, we run the baseline model on two sub-samples constructed as countries with below and above median GDP[9]. GDP is expected to capture economic development that not only raises average household income but also improves public services. It is therefore expected to weaken the intergenerational correlation of health. As there is likely to be an upper bound to health and hence diminishing returns to scale in the health production function,

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[9] We calculate the median based on the average GDP for countries during the period 1970-1997. As a robustness check, we also use countries classed as above or below the median in 1970.

increases in health inputs such as nutrition or health services may have larger beneficial effects on children of shorter women.

In order to capture within-country heterogeneity in the effects of economic change, we interact GDP with the mother's level of education and we also investigate the effects of income inequality. Our nonlinear specification of maternal height as four dummies indicating height as one or two standard deviations above or below the country mean allows for this.

Section VI: Descriptive Statistics

For all descriptive statistics reported in the paper, sample weights provided in the surveys are applied to make the data representative of the population. Although the data span 1970-2004, few countries have observations on height after 2000, so these years have omitted. Across the 28 countries and the 35 years in the sample, the mean infant mortality rate (IMR) is 11.1% and the mean height of mothers is 158.3 cm (standard deviation 6.42 cm). Figure 5.1 plots the country-averaged trends in IMR and maternal height. IMR falls steadily between 1970 and 2000, from 15.7% to 8.0%, whilst height rises very slightly from 157.2 to 158.3 cm. Figure 5.2 shows that country-averaged GDP trends upwards until 1975, after which there is no secular trend and many instances of negative growth during the 1980s. There is considerable between-country variation in the variables of interest. Infant mortality and mother's height differ widely between countries, ranging from 6% in Zimbabwe to 16% in Mali and 153.8cm in Madagascar to 162.7cm in Chad, respectively. Growth rates of GDP vary between -54.8% and 47.9%. Country-specific trends in IMR, maternal height and GDP are in Figures 5.3–5.5. Level differences across countries are huge and dominate any trends. IMR exhibits a secular decline in each country and there is some convergence by the end of the period. The average height of mothers does not show much change and any trends are concealed by the scale of inter-country variation. Trends in GDP vary substantially across countries- rising, falling, or staying constant.

We now use the microdata to study the unconditional relationship between maternal and child health. Since infant mortality is recorded as a discrete variable (0/1), we obtain a continuous prediction at the individual level that lies in the range 0-1 by running a non-parametric (lowess) regression. Since lowess on the full sample is computationally very intensive, we did this on a random sample of 30% of observations. Average predicted infant mortality risk of every child is then plotted against the height of their mothers in Figure 5.6. Infant mortality risk is declining in maternal height, consistent with a positive intergenerational correlation of health. Figure 5.7 plots the predicted standardised height of children against their mother's height using lowess to avoid imposing any functional form on the relationship. Again, we see a clearly positive association of mother and child health. Country-specific lowess plots of the relationship between maternal height and the two indicators of child health are in Figures 5.8[10] and 5.9. These show that the intergenerational correlation of health is positive in every country in the sample. The graphs suggest greater cross-country variation in health amongst children born to shorter women.

To examine whether the intergenerational correlation of health is stronger in poorer countries, in Figure 5.10, we draw a scatter plot showing time-averaged IMR and maternal height across countries, distinguishing them by whether the country's GDP is above or below the sample median. The scatter suggests that richer countries have taller women and lower rates of infant mortality. Below we investigate whether the tie between adult height and child health is also weaker in richer countries.

Section VII: Empirical Results

In this section, we examine whether the unconditional correlation of health across generations that is apparent in the data persists after conditioning upon other variables and, in particular, year and country fixed effects. Using micro-data nested in a country-year panel, we now use what is effectively a difference in difference strategy. We examine whether within-country changes in the heights of women are associated with within-country changes in the infant mortality risk or height of children.

Table 6.1 shows estimates of equation (1), with controls being added successively and cumulatively in moving from left to right in the Table. We find a positive intergenerational correlation of health even after controlling for country-year dummies, GDP, ethnicity, parental education, rural residence, religion, maternal age at birth, child birth month and child gender. A woman's height has a significantly positive effect on the chances that her children will survive infancy and (amongst survivors at each age, averaged over age 0-5) and on their height. Being one standard

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[10] This graph excludes some heights for Nigeria, where we observe much shorter women, and where there are negative outliers in terms of mother height.

deviation above the median height provides some advantage, and being two standard deviations above the median provides a further advantage. And similarly for heights that are below the median level. At both one and two standard deviations, the penalty associated with being born to a short woman is larger than the gain associated with being born to a tall woman.

To put the estimated effect sizes in perspective, the predicted probability of infant death was calculated setting one of the height indicators at a time to unity, and the others to zero, with all other variables set to their mean value.[11] The effect of moving from within one standard deviation of mean height to more than one standard deviation above mean height is to lower predicted infant mortality by 0.60 percentage points, which is 5.4% of the sample mean IMR. For two standard deviations above mean height, the corresponding fall in predicted infant mortality is 1.03 percentage points, 9.36% of the sample IMR. A move to greater than one standard deviation *below* mean height causes a rise in predicted infant mortality of 1.09 percentage points, which is 9.9% of the sample mean. A move from the mean of height to greater than two standard deviations below mean height causes a rise in infant mortality of 2.80 percentage points, which is 25.5% of the sample mean. These effects are large and the effect of being short is approximately twice that of being tall.

When we control for GDP, the coefficients on height show no significant change. To allow for the possibility that the effects of changes in GDP on child survival or height are different for parents with different skills or different liquidity constraints, we interacted GDP with years of education of the mother and father.[12] Again the coefficients on the height variables were unchanged. This suggests that the estimated coefficients on mothers height are not simply picking up income effects on child health.

We investigated whether the intergenerational correlation of health has weakened over time by estimating the model for four birth cohorts of children, 1970-79, 1980-89, 1990-99, but found no evidence of cohort effects. Results when we looked at country cohort regressions were unclear and again we failed to find any conclusive evidence of cohort effects (results available on request).

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[11] Predicted changes in probabilities calculated using the –prvalue- command in Stata (Long and Freese, 2005)

[12] Results omitted from the paper, but available on request.

Child Height

The data on child height span the period 1987- 2000, with some variation across countries. Estimates of equation (1) are in Table 6.2. Even after conditioning upon child and household level covariates and year and country effects, maternal height has a positive influence on the height of her children. A 1 s.d. increase from the mean maternal height raises child height by 0.192 standard deviations, whilst a 2 s.d. increase raises it by a further 0.112 standard deviations. A 1 s.d. decrease in maternal height lowers the child height by 0.201 standard deviations, and a move to 2 s.d. below mean height lowers it by a further 0.153 standard deviations.

We do not find here the asymmetry between the effects of being tall *vs* short that we found when looking at the effects of maternal height on infant mortality. Indeed the asymmetry we saw there might explain the absence of asymmetry here. In other words, the fact that children of short women are more likely to die and therefore to be absent from the heights data, will weaken the intergenerational correlation of health. Deaton (2007) argues that, when mortality risk is high, then selection effects on average height may dominate scarring effects. He speculates that this may explain the seeming paradox that African women are consistently taller than many women who live in less poor conditions in, for example, Asia and Latin America. The same applies to children and Klasen (2003), for example, has noted that African children have better nutritional indicators than Asian children, even though infant mortality rates are higher in Africa than in Asia. Here, when comparing short and tall mothers within Africa, rather than think in terms of spatial variation in mortality rates, we may think of mortality rates varying by maternal height; as we demonstrated they do in the previous section. Then the average height of surviving children of shorter women will increase more (on account of greater mortality selection) than will the average height of children of taller women. This will tend to weaken the intergenerational correlation of heights for shorter women and to strengthen it for taller women.

Since mortality risk declines exponentially with child age, with most children dying in the first month of life and with risk levelling out considerably by age 5, we investigated how the intergenerational correlation of health varies with child age (see Table 6.3). Mostly, it does not vary significantly.

Does the relationship differ with household socioeconomic status?

As explained in the Introduction, it is only when family-level persistence in height signifies social disadvantage that it is of wider interest. So we investigated whether how the intergenerational correlation of health varies with the socioeconomic status (SES) of the mother. We used two alternative definitions of socioeconomic status, namely, the level of education of the child's mother and father, and an indicator for whether the mother lives in an urban area and is educated to at least the secondary level. The measures of socioeconomic status are interacted with maternal height (see Table 6.4). There is one significant interaction term and this suggests that women who are a standard deviation above mean height and urban and relatively highly educated do not have the advantage that other women exhibit in terms of infant survival. All of the other interactions are insignificant. Overall, we can find no evidence to support our hypothesis that the health of children of more educated parents (who will tend to have higher permanent income) is less tied to the health of their parents. While this empirical result is interesting, it is probably not surprising that it does not work to support our initial hypothesis. This is because the education of the mother (and, on account of assortative mating, of the father) is highly positively correlated with her height. What we need instead as a measure of socioeconomic status is the income of the household that the child is born into around the time of birth- as a measure of resources available to invest in the child's survival and growth. The DHS surveys do not contain information on household income or consumption. They do contain data on ownership of assets, but this is available at the time of the survey and so cannot be matched, across some 30-35 years, to birth year. For this reason, we use shocks to GDP in the child's birth year. To generate household level variation in the effects of aggregate income shocks, we interact GDP with the educational level of both parents.

Does the relationship differ between countries according to levels of or shocks to GDP?

We first investigate whether the average relationship between maternal and child health over the sample period varies across countries with the average level of GDP. We then consider the effects of contemporaneous GDP shocks by pooling the data across countries (as in equation 1) and including as an additional regressor, an interaction term between GDP and maternal height. Given that this equation includes country and year dummies and country-specific trends, the coefficient on GDP will reflect the effects of annual changes in GDP within-country.

Country-specific equations showing the marginal effect of GDP on child health are in Tables 6.5 and 6.6 in the Appendix. There are 28 countries in the sample. For infant mortality, tall 1 is significantly negative in six and tall2 in three. Short1 is significantly positive for 13 countries and short2 for 7. We group countries into the set for which tall1 is significant and the set in which it is not. In Figure 6.1 we show density plots of average GDP (over the period 1970-2004) for these two groups. We construct a similar separation of countries that do and do not exhibit a significant coefficient on short1 and show the distribution of GDP in each of the two sub-samples in Figure 6.2. The graphs suggest that countries in which the intergenerational correlation of health is significant are poorer. Differences between the samples are more pronounced for short1 than for tall1, suggesting that GDP may matter most for the relationship when we look at the weaker end of the heights distribution.

The results for child height follow a similar pattern, with most countries now showing a significant coefficient for tall1 and short1. These coefficients vary substantially across countries, which suggests that there is more to them than genetic frailty passed from mother to child. To investigate whether the size of the coefficients depends upon the level of economic development, Figures 6.3 and 6.4 show a scatter of the significant coefficients against average GDP (over the sample period). Although the correlation of mother and child health is larger in richer countries amongst taller women (using tall1), it is larger in poorer countries amongst shorter women (using short1).[13]

So far we have described the between-country variation in the relationship between health transmission and GDP. We now investigate the effects of GDP shocks on this relationship by including GDP in the baseline regression. We use two alternative specifications for this. First, we estimated the model on two sub-samples of the data, constructed as countries with below and above median GDP, where the median was over the entire period. Second, we pool all countries and include interaction terms between GDP and each of the height indicators (see Table 6.7).

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[13] With the exception of two outlier countries, Gabon and Namibia, that have much larger GDP.

For both infant mortality and child height, marginal effects obtained on the sample of poorer countries tend to be larger. For infant mortality, a formal test of whether the coefficients differ significantly between the two samples fails to reject the null that the coefficients are equal. For child height, short1 differs significantly between the two samples, suggesting that, amongst shorter women, the relationship is stronger in poorer than in richer countries.[14] Table 6.8 shows the results from these tests.

Section VIII: Conclusion

The aim of this paper has been to investigate the intergenerational transmission of health in Africa. Using microdata from 28 countries for as long a period as 1970-2004, we find a significantly positive intergenerational correlation of maternal height with infant mortality risk and child height in every country. The estimated impact of the mother being more than one standard deviation below mean height is to raise infant mortality by 1.10 percentage points, or 9.9% of the sample mean, and to lower child height by 0.201 standard deviations. Our results provide evidence that a woman's stature is not merely a genetic disposition, but that it is correlated with her health and socioeconomic status and, for both reasons, puts her children at a disadvantage in terms of survival and growth.

Analysing the infant mortality data by four birth cohorts spanning about a decade each, we find no evidence to support our conjecture that the intergenerational transmission of height weakens with time, but this may be because of the atypical situation in Africa, with many countries in our sample failing to experience steady growth over the period. We therefore analyse GDP directly.

The between country variation suggests that the intergenerational correlation of health is weaker in richer countries, and this gradient is steeper amongst shorter women. Annual within-country variation in GDP is associated with a weakening of the correlation although this effect is only significant amongst shorter women and when the measure of child health is height rather than survival probability. Overall, these results suggest that longer run economic development does weaken the

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[14] For the infant mortality regressions, a formal test of equality of coefficients was carried out using the –suest- command in Stata. Equality of coefficients was tested in the child height regressions by including interaction terms of an indicator for above median with the height variables and testing whether significantly different from zero.

intergenerational transmission of health, although annual changes in GDP are less effective. Also, not only is the impact of maternal on child health stronger amongst shorter women (who, on average, are les healthy) but economic development is more effective in weakening intergenerational health transmission amongst children of shorter women.

Tables

Table 6.1: Infant mortality

	No Controls	+ Country Dummies	+ Time Dummies	+ Country-specific trends	+ Child Controls	+ Mother and Father Controls	+ Log GDP
tall1	-0.011**	-0.012**	-0.009**	-0.009**	-0.009**	-0.006**	-0.006**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
tall2	-0.004	-0.002	-0.003	-0.002	-0.002	-0.005*	-0.005*
	[0.003]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
short1	0.014**	0.014**	0.016**	0.015**	0.016**	0.011**	0.011**
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
short2	0.018**	0.018**	0.019**	0.019**	0.019**	0.016**	0.016**
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Log gdp							-0.066**
							[0.013]
Observations	1257315	1257315	1257315	1257306	1257306	1207486	1091103
Mean dep var	0.110	0.110	0.110	0.110	0.110	0.110	0.113
mean tall1	0.157	0.157	0.157	0.157	0.157	0.145	0.143
mean tall2	0.040	0.040	0.040	0.040	0.040	0.027	0.027
mean short1	0.145	0.145	0.145	0.145	0.145	0.146	0.146
mean short2	0.022	0.022	0.022	0.022	0.022	0.022	0.022

The dependent variable is 1 if the index child died before his or her first birthday. Sample is restricted to children born at least 12 months before the date of the survey. The estimator is probit and these are marginal effects. Robust standard errors are in brackets. Tall1 is an indicator for whether the mother is at least one standard deviation taller than the country-specific mean. Tall2 is similarly defined for two standard deviations and, conditional upon tall2, tall1 will capture the effects of the mother being between one and two standard deviations above mean height. Short1 and short2 are similarly defined, but for negative deviations from the mean.

* significant at 5%; ** significant at 1%

Incremental changes are noted in the column head and are cumulative in moving from left to right except that, when we include GDP then we replace the country-time dummies with time dummies and country-specific trends. The child-level controls are birth month, gender and mother's age at birth. The household-level controls are mother's education, father's education, ethnicity, religion and whether living in a rural or urban area.

	No Controls	+ Country Dummies	+ Time Dummies	+ Country-specific trends	+ Child Controls	+ Mother and Father Controls	+ Log GDP
tall1	0.218**	0.218**	0.217**	0.213**	0.210**	0.192**	0.210**
	[0.014]	[0.014]	[0.013]	[0.013]	[0.013]	[0.013]	[0.016]
tall2	0.118**	0.118**	0.119**	0.117**	0.118**	0.112**	0.125**
	[0.021]	[0.021]	[0.020]	[0.018]	[0.018]	[0.018]	[0.019]
short1	-0.233**	-0.233**	-0.232**	-0.227**	-0.225**	-0.201**	-0.233**
	[0.010]	[0.010]	[0.010]	[0.010]	[0.011]	[0.010]	[0.012]
short2	-0.168**	-0.168**	-0.167**	-0.162**	-0.163**	-0.153**	-0.164**
	[0.024]	[0.024]	[0.023]	[0.023]	[0.021]	[0.020]	[0.018]
log gdp							0.091
							[0.074]
Observations	202856	202856	202856	202856	202856	195106	190776
Sample z-score	0.000	0.000	0.000	0.000	0.000	-0.002	-0.003
Sample mean tall1	0.176	0.176	0.176	0.176	0.176	0.174	0.174
Sample mean tall2	0.037	0.037	0.037	0.037	0.037	0.036	0.036
Sample mean short1	0.170	0.170	0.170	0.170	0.170	0.170	0.170
Sample mean short2	0.029	0.029	0.029	0.029	0.029	0.029	0.029

See Notes to Table 6.1.

Table 6.2: Child height z-score

Table 6.3: Child height equations for 6-month age intervals

	0 - 6 months	7 - 12 months	13 - 18 months	19 - 24 months	25 - 30 months
tall1	0.148**	0.195**	0.216**	0.217**	0.216**
	[0.025]	[0.024]	[0.024]	[0.017]	[0.030]
tall2	0.101	0.121*	0.145**	0.091	0.201**
	[0.050]	[0.045]	[0.037]	[0.053]	[0.027]
short1	-0.197**	-0.216**	-0.210**	-0.187**	-0.236**
	[0.025]	[0.027]	[0.022]	[0.033]	[0.013]
short2	-0.142**	-0.197**	-0.216**	-0.204**	-0.162**
	[0.048]	[0.048]	[0.033]	[0.047]	[0.041]
Observations	23477	21607	22128	19952	21627
Mean z-score	0.003	-0.003	-0.002	0.001	-0.004
Mean tall1	0.166	0.170	0.174	0.180	0.179
Mean tall2	0.034	0.036	0.036	0.039	0.038
Mean short1	0.181	0.172	0.175	0.169	0.170
Mean short2	0.031	0.029	0.030	0.029	0.030

	31 - 36 months	37 - 42 months	43 - 48 months	49 - 54 months	55 - 60 months
tall1	0.193**	0.244**	0.229**	0.249**	0.235**
	[0.023]	[0.025]	[0.027]	[0.022]	[0.023]
tall2	0.088*	0.141**	0.078	0.155**	0.167**
	[0.040]	[0.046]	[0.057]	[0.051]	[0.058]
short1	-0.223**	-0.272**	-0.234**	-0.270**	-0.280**
	[0.019]	[0.025]	[0.029]	[0.028]	[0.034]
short2	-0.146**	-0.175**	-0.141*	-0.126*	-0.094*
	[0.051]	[0.050]	[0.052]	[0.048]	[0.039]
Observations	19719	18229	17158	17807	13401

Mean z-score	-0.003	-0.005	-0.004	0.000	-0.003
Mean tall1	0.181	0.174	0.174	0.172	0.174
Mean tall2	0.035	0.036	0.034	0.037	0.036
Mean short1	0.168	0.162	0.168	0.168	0.167
Mean short2	0.028	0.027	0.026	0.028	0.027

Robust standard errors in brackets

* significant at 5%; ** significant at 1%

Table 6.4: Infant mortality and child height models including interactions with socioeconomic status of mother

	Infant Mortality		Child Height	
	Level of Mother and Father Education	Educated and Urban Women	Level of Mother and Father Education	Educated and Urban Women
tall1	-0.008**	-0.007**	0.199**	0.208**
	[0.001]	[0.001]	[0.021]	[0.017]
tall2	-0.006*	-0.004	0.143**	0.135**
	[0.003]	[0.002]	[0.031]	[0.023]
short1	0.012**	0.012**	-0.233**	-0.227**
	[0.002]	[0.002]	[0.014]	[0.013]
short2	0.018**	0.018**	-0.153**	-0.162**
	[0.004]	[0.003]	[0.021]	[0.017]
Yrs_educ_ma_tall1	0		-0.001	
	[0.001]		[0.006]	
Yrs_educ_ma_tall2	0		0.01	
	[0.002]		[0.017]	
Yrs_educ_ma_short1	0.001		-0.007	
	[0.001]		[0.007]	
Ys_educ_ma_short2	0.001		-0.011	
	[0.003]		[0.019]	
Yrs_educ_fa_tall1	0.001		0.009	

	[0.001]		[0.006]	
Yrs_educ_fa_tall2	0.002		-0.018	
	[0.001]		[0.012]	
Yrs_educ_fa_short1	-0.001		0.008	
	[0.001]		[0.005]	
Yrs_educ_fa_short2	-0.001		-0.002	
	[0.002]		[0.013]	
Educated_urban_tall1		0.005*		0.021
		[0.002]		[0.031]
Educated_urban_tall2		-0.001		-0.043
		[0.005]		[0.042]
Educated_urban_short1		-0.003		-0.024
		[0.003]		[0.019]
Educated_urban_short2		-0.004		-0.015
		[0.010]		[0.061]
Observations	1207555	1207555	195106	195106
Sample IMR	0.110	0.110		
Sample mean z-score			-0.002	-0.002
Sample mean tall1	0.145	0.145	0.174	0.174
Sample mean tall2	0.027	0.027	0.036	0.036
Sample mean short1	0.146	0.146	0.170	0.170
Sample mean short2	0.022	0.022	0.029	0.029

See Notes to Table 6.1.

Table 6.7: Do GDP shocks influence the intergenerational correlation of health?

	Infant Mortality			Child Height		
	Above Median	Below Median	GDP Interactions	Above Median	Below Median	GDP Interactions
tall1	-0.004**	-0.008**	-0.035**	0.198**	0.205**	0.322*
	[0.001]	[0.001]	[0.011]	[0.019]	[0.028]	[0.128]
tall2	-0.006	-0.003	0.004	0.104**	0.172**	0.214
	[0.004]	[0.003]	[0.020]	[0.013]	[0.031]	[0.190]
short1	0.012**	0.011**	0.008	-0.222**	-0.246**	-0.517**
	[0.002]	[0.002]	[0.016]	[0.023]	[0.015]	[0.122]
short2	0.014**	0.018**	0.037	-0.149**	-0.153**	-0.161
	[0.003]	[0.005]	[0.026]	[0.018]	[0.028]	[0.134]
lgdp	-0.068**	-0.052**	-0.016**	0.132	0.091	0.088
	[0.013]	[0.012]	[0.002]	[0.148]	[0.071]	[0.075]
tall1_lgdp			0.004**			-0.016
			[0.001]			[0.016]
tall2_lgdp			-0.001			-0.012
			[0.003]			[0.026]
short1_lgdp			0			0.040*
			[0.002]			[0.017]
short2_lgdp			-0.003			0
			[0.003]			[0.018]
obs				77819	75563	
Sample IMR	0.098	0.126				
Sample z-score	443027	590636		-0.003	0.000	
Sample tall1	0.142	0.145		0.171	0.176	
Sample tall2	0.026	0.028		0.036	0.036	
Sample short1	0.150	0.144		0.173	0.170	
Sample short2	0.023	0.021		0.029	0.028	

Columns 1 and 2 are estimated on sub-samples defined according to whether average GDP over the period is above or below the median level. Column 3 is estimated on the full sample and interactions with GDP are included. Robust standard errors in brackets, * significant at 5% level, ** significant at 10% level. The estimator is LPM.

Table 6.8

Infant Mortality		
	chi-squared statistic	probability > chi-squared statistic
tall1	1.63	0.20
tall2	0.51	0.47
short1	1.47	0.22
short2	0.02	0.87

* significant at 5% level, ** significant at 1% level

Child Height	
tall1	0.220** [0.025]
tall2	0.124** [0.028]
short1	-0.251** [0.014]
short2	-0.180** [0.028]
tall1*above_med	-0.024 [0.027]
tall2*above_med	0.003 [0.039]
short1*above_med	0.046 [0.023]
short2*above_med	0.038 [0.035]

note: above_med = 1 if country GDP is above the median
Robust standard errors in brackets

Appendix

Figure 5.1: Average IMR, and height of mothers

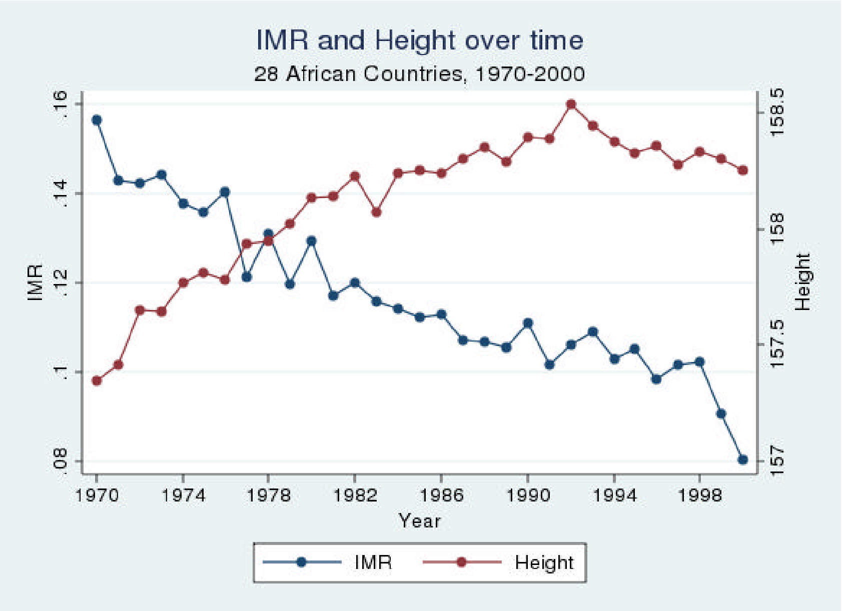

Figure 5.2: GDP over time

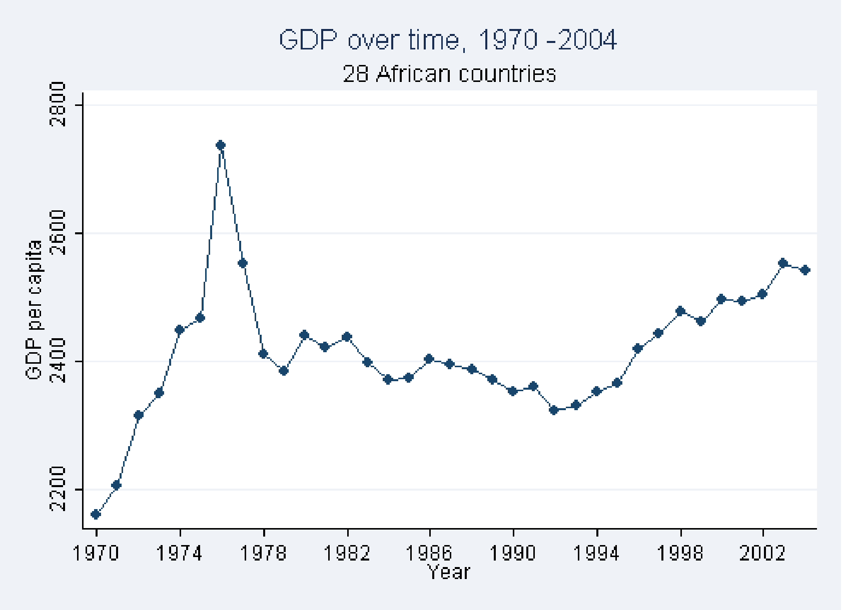

Figure 5.3: Infant mortality over time, by country

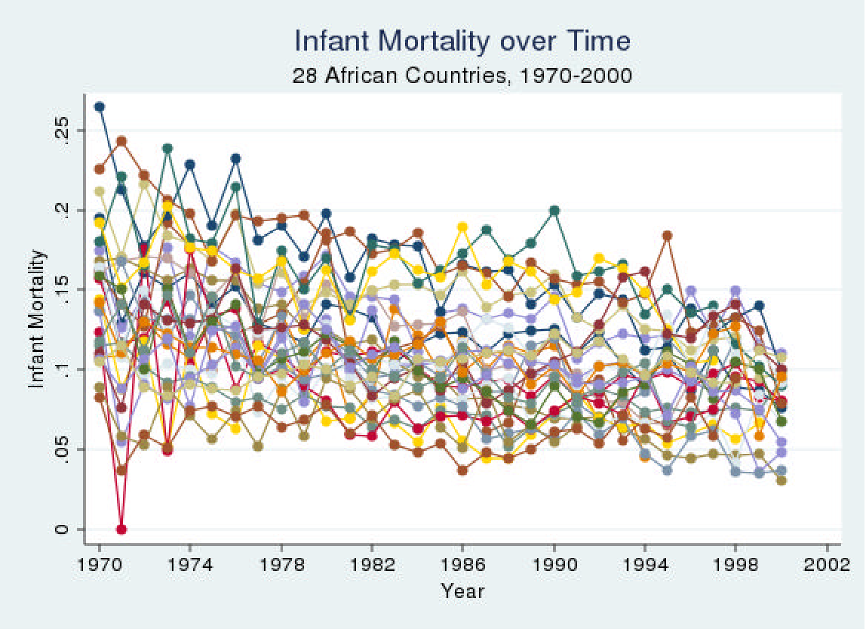

Figure 5.4 Height over time, by country

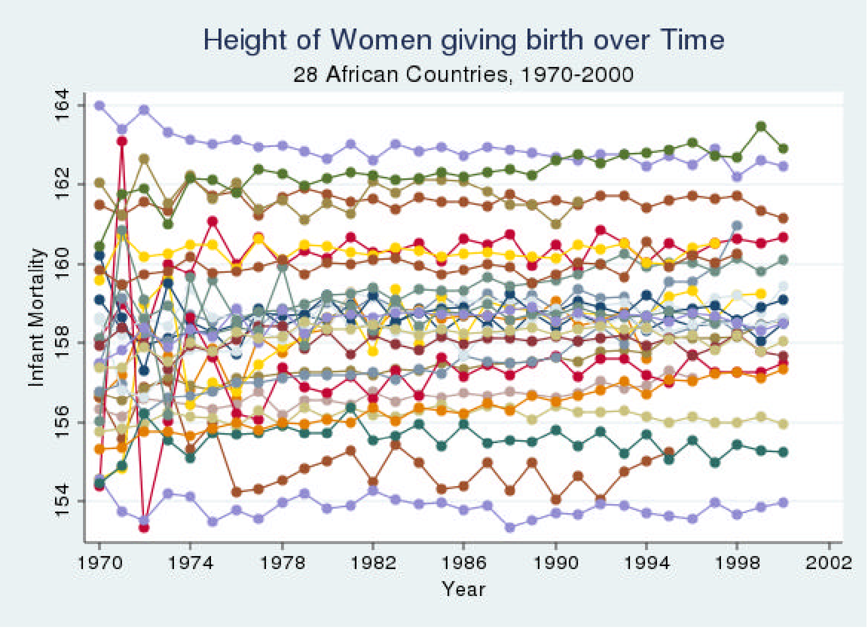

Figure 5.5: GDP over time, by country

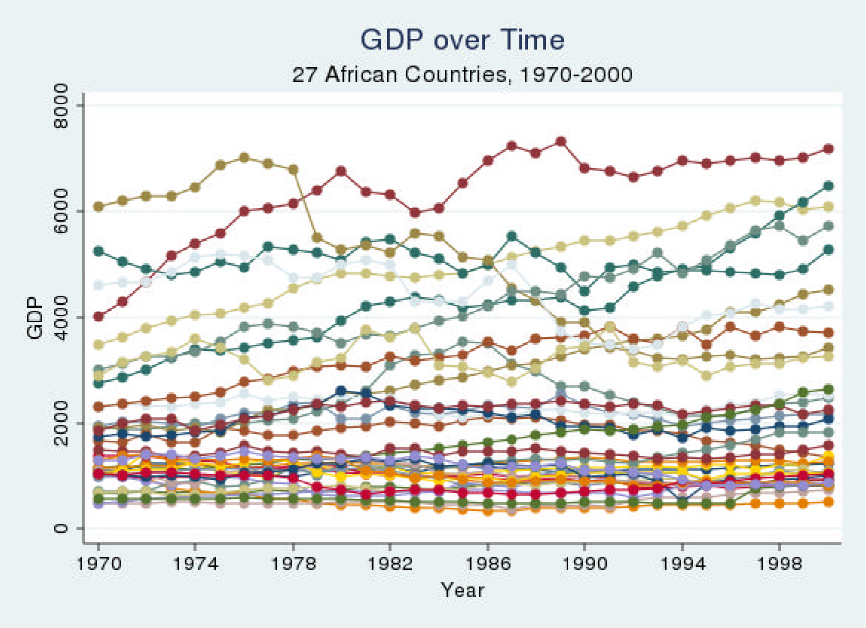

Figure 5.6: Predicted infant mortality, from a lowess plot performed on a random sample of 30% of observations, against height

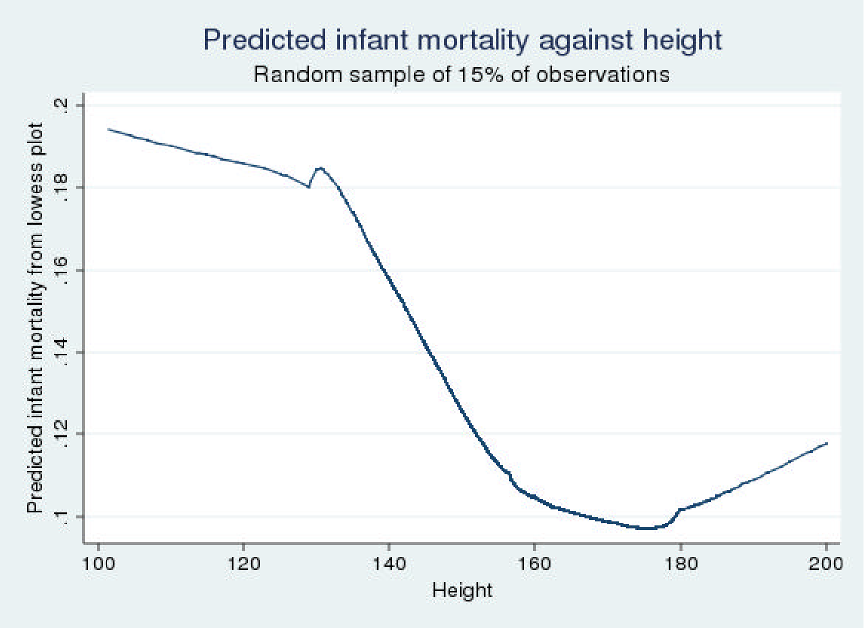

Figure 5.7: Predicted standardised child height, from a lowess plot, against height.

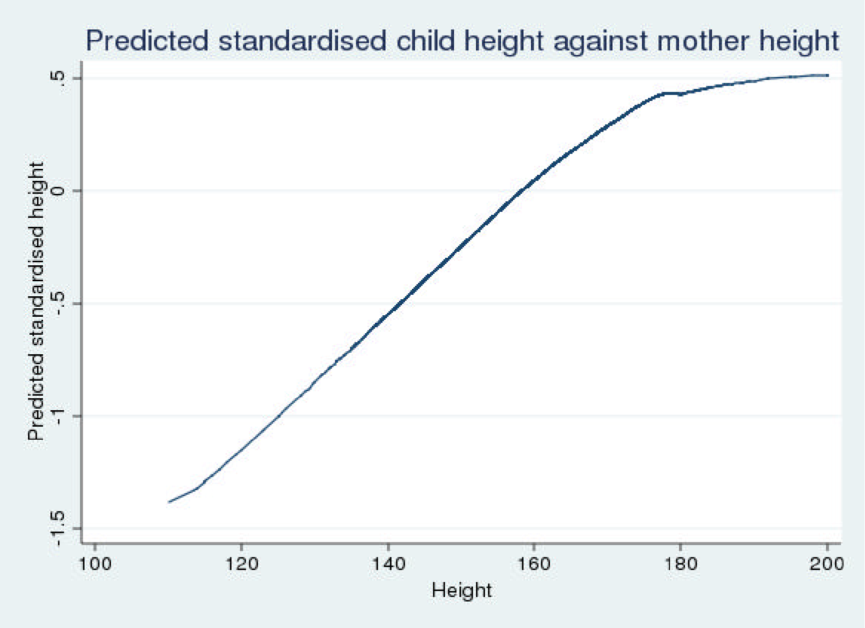

Figure 5.8: Predicted infant mortality against mother height for each country

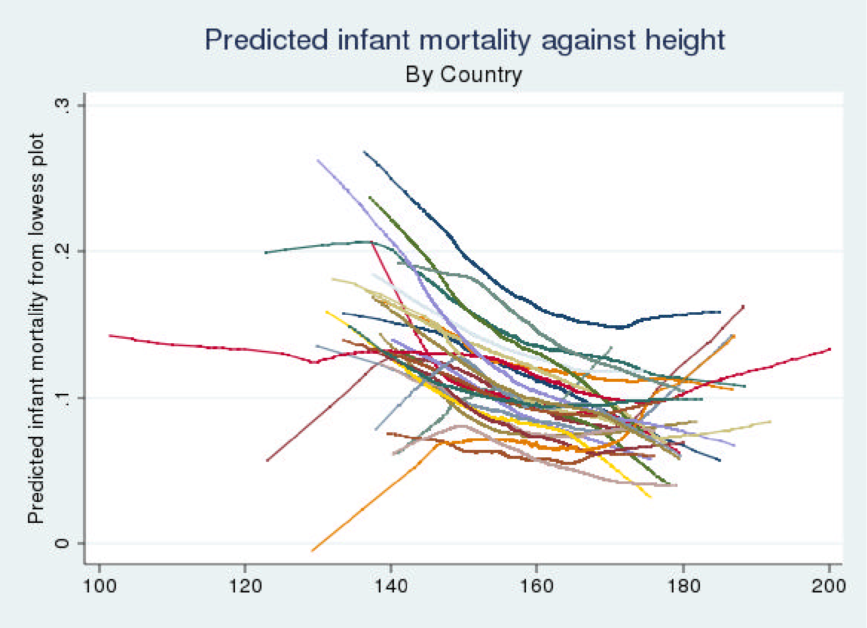

Figure 5.9: Predicted standardised child height against mother height, for each country.

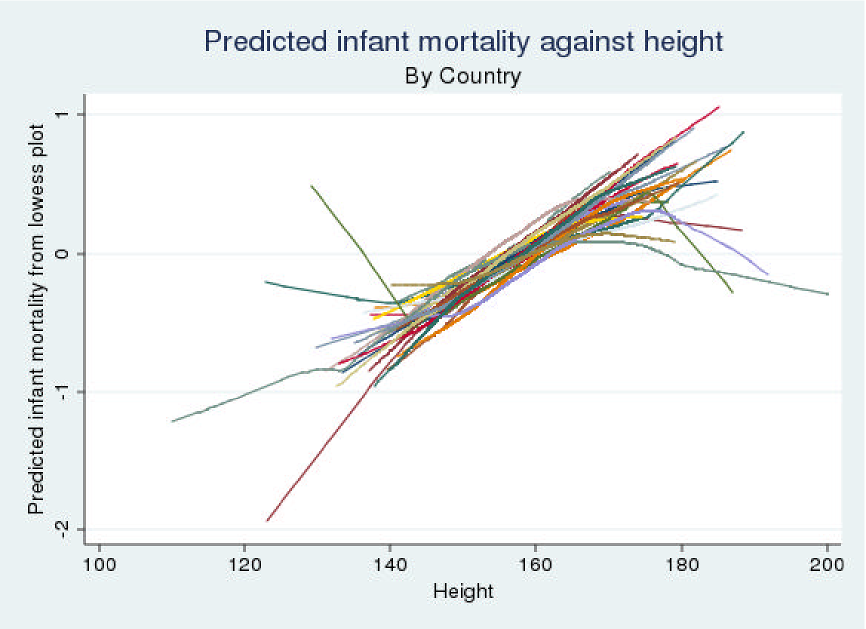

Figure 5.10: Scatter plot, average IMR and average height, above and below median countries.

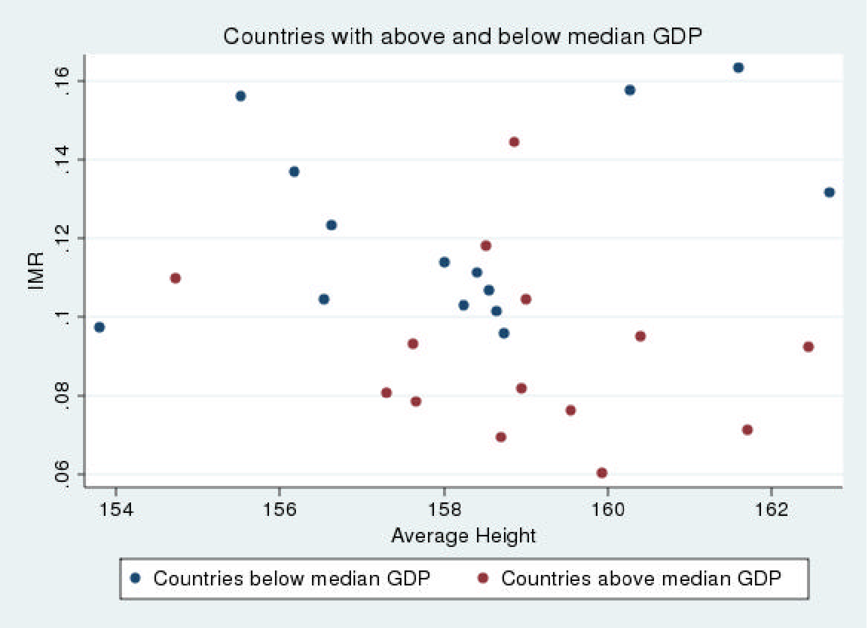

Figure 6.1 density plots of log GDP, for sub-samples of countries which have sig or insignificant coefficients for tall1 in the infant mortality regression

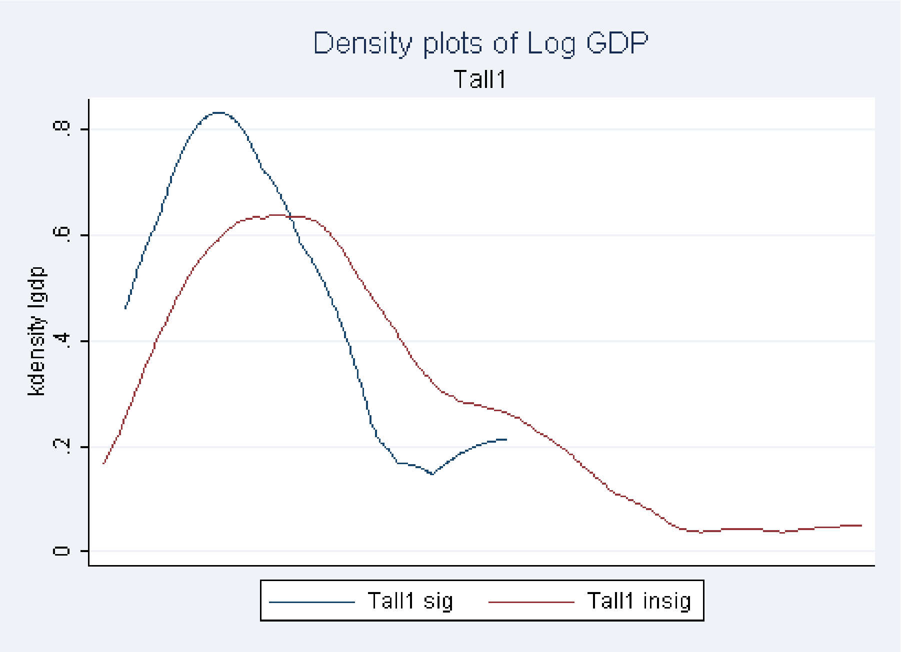

Figure 6.2 density plots of log GDP, for sub-samples of countries which have sig or insignificant coefficients for short1 in the infant mortality regression

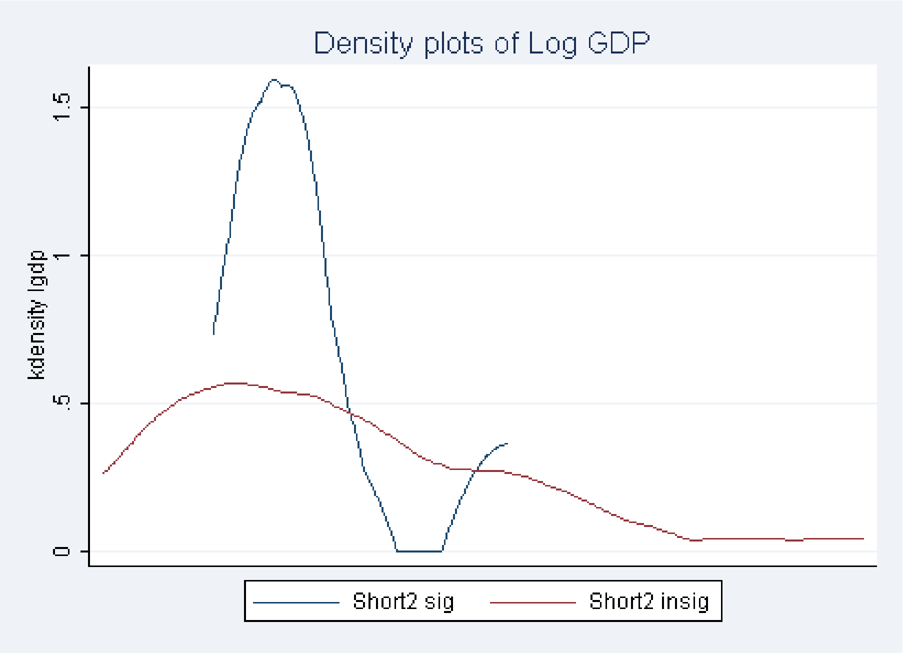

Figure 6.3: Scatter plot of log GDP against estimate coefficient on tall1, for significant countries.

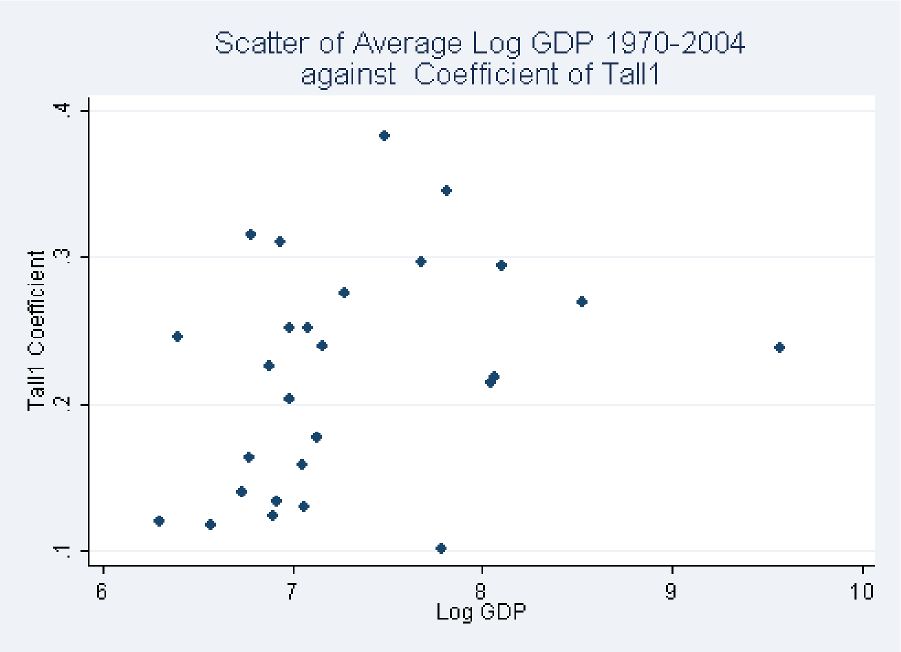

Figure 6.4: Scatter plot of log GDP against the magnitude of the estimated coefficient on short1, for significant countries.

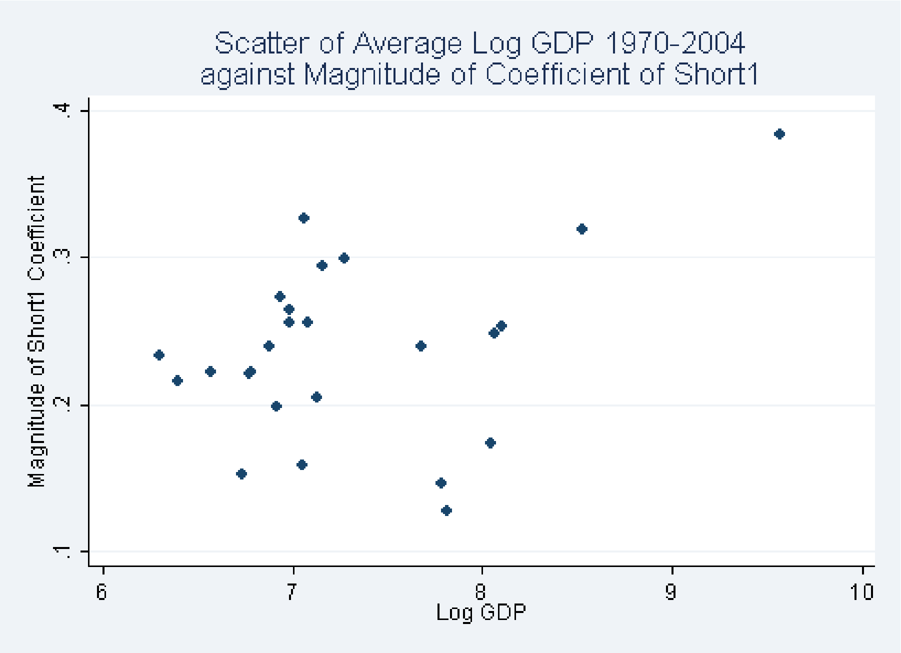

Table 6.5: Regressions by country; dependant variable: Infant Mortality

	Benin	CAR	Cameroon	Chad	Comoros	Cote d'Ivoire	Egypt	Ethiopia	Gabon	Ghana
tall1	-0.008	0.007	-0.002	-0.007	-0.007	-0.01	-0.004*	-0.006	-0.003	-0.007
	[0.006]	[0.010]	[0.005]	[0.005]	[0.011]	[0.007]	[0.002]	[0.004]	[0.008]	[0.005]
tall2	-0.027*	0.003	-0.020*	-0.005	0.016	0.005	-0.008	-0.015*	-0.003	0.003
	[0.011]	[0.021]	[0.010]	[0.011]	[0.026]	[0.019]	[0.005]	[0.008]	[0.016]	[0.010]
short1	0.023**	-0.003	-0.005	0.001	-0.002	0.006	0.014**	0.007*	0	0.008
	[0.006]	[0.009]	[0.005]	[0.005]	[0.012]	[0.007]	[0.002]	[0.004]	[0.008]	[0.005]
short2	-0.003	0.03	0.016	0.02	-0.031	0.013	0.010*	0.016	0.022	0.021
	[0.012]	[0.023]	[0.012]	[0.012]	[0.022]	[0.020]	[0.005]	[0.009]	[0.020]	[0.012]
Observations	31024	11819	34340	40499	6457	16798	178640	69529	10040	33590
mean IMR	0.120	0.107	0.093	0.126	0.109	0.104	0.096	0.120	0.069	0.085
mean tall1	0.146	0.133	0.141	0.142	0.138	0.124	0.150	0.151	0.141	0.140
mean tall2	0.028	0.023	0.024	0.028	0.028	0.020	0.027	0.027	0.028	0.028
mean short1	0.152	0.129	0.143	0.148	0.148	0.136	0.154	0.154	0.138	0.143
mean short2	0.024	0.020	0.024	0.027	0.027	0.017	0.024	0.024	0.025	0.021

	Guinea	Kenya	Lesotho	Madagascar	Malawi	Mali	Morocco	Mozambique	Namibia	Niger
tall1	0	-0.008*	-0.01	-0.008	-0.008*	-0.007	-0.005	-0.009	0.019	-0.015**
	[0.005]	[0.003]	[0.008]	[0.005]	[0.004]	[0.004]	[0.004]	[0.005]	[0.012]	[0.005]
tall2	-0.004	0.007	0.011	-0.006	0.001	0.013	0.005	-0.005	0.017	-0.001
	[0.012]	[0.008]	[0.018]	[0.011]	[0.008]	[0.010]	[0.009]	[0.011]	[0.026]	[0.011]
short1	0.012*	0.006	0.006	0.007	0.013**	0.013**	0.017**	0.018**	0.005	0.018**
	[0.005]	[0.003]	[0.008]	[0.005]	[0.004]	[0.004]	[0.004]	[0.005]	[0.011]	[0.005]
short2	0.022	0.024**	0.021	0.015	0.008	0.035**	0.003	0.029*	-0.005	0.01
	[0.012]	[0.009]	[0.020]	[0.012]	[0.009]	[0.010]	[0.008]	[0.012]	[0.022]	[0.012]
Observations	43660	55216	12106	32194	76331	73409	47070	47796	5388	44656
mean IMR	0.144	0.076	0.084	0.092	0.135	0.164	0.080	0.144	0.077	0.149
mean tall1	0.141	0.151	0.141	0.145	0.157	0.151	0.143	0.152	0.139	0.148
mean tall2	0.024	0.027	0.031	0.026	0.029	0.025	0.025	0.029	0.025	0.029
mean short1	0.139	0.145	0.146	0.145	0.154	0.148	0.148	0.153	0.139	0.144
mean short2	0.023	0.021	0.021	0.022	0.021	0.022	0.022	0.023	0.029	0.022

Robust standard errors in brackets. * significant at 5%, ** significant at 1%

Table 6.5 (cont.)

	Nigeria	Rwanda	Senegal	Tanzania	Togo	Uganda	Zambia	Zimbabwe
tall1	-0.012*	-0.008	-0.002	-0.012**	0.007	0.001	-0.001	-0.007
	[0.006]	[0.004]	[0.004]	[0.004]	[0.007]	[0.005]	[0.004]	[0.005]
tall2	-0.01	0.001	-0.016	0.009	-0.018	-0.01	-0.016	-0.013
	[0.011]	[0.010]	[0.008]	[0.008]	[0.012]	[0.010]	[0.009]	[0.009]
short1	0.006	0.016**	0.001	0.012**	0.026**	0.001	0.007	0.011*
	[0.006]	[0.005]	[0.004]	[0.004]	[0.007]	[0.005]	[0.004]	[0.005]
short2	-0.017	0.053**	0.037**	0	-0.018	0.018	0.029**	0.002
	[0.012]	[0.012]	[0.011]	[0.009]	[0.012]	[0.012]	[0.010]	[0.010]
Observations	38598	49112	47281	65421	21182	35285	56278	23451
mean IMR	0.109	0.111	0.096	0.103	0.099	0.099	0.105	0.059
mean tall1	0.093	0.147	0.134	0.151	0.148	0.144	0.144	0.149
mean tall2	0.023	0.031	0.027	0.029	0.029	0.028	0.028	0.028
mean short1	0.089	0.031	0.139	0.147	0.146	0.143	0.143	0.145
mean short2	0.016	0.021	0.021	0.020	0.022	0.022	0.022	0.023

* significant at 5% level, ** significant at 1% level

The dependent variable is 1 if the index child died before his or her first birthday. Sample is restricted to children born at least 12 months before the date of the survey. The estimator is probit and these are marginal effects. Robust standard errors are in brackets. Tall1 is an indicator for whether the mother is at least one standard deviation taller than the country-specific mean. Tall2 is similarly defined for two standard deviations and, conditional upon tall2, tall1 will capture the effects of the mother being between one and two standard deviations above mean height. Short1 and short2 are similarly defined, but for negative deviations from the mean. We also include time dummies to allow for country trends, as well as child- and household-level controls. The child-level controls are birth month, gender, and mother's age at birth. The household level controls are mother's education, father's education, ethnicity, religion and whether living in a rural or urban area.

Table 6.6

	Benin	CAR	Cameroon	Chad	Comoros	Cote d'Ivoire	Egypt	Ethiopia	Gabon	Ghana
tall1	0.130**	0.226**	0.346**	0.140**	0.383**	0.297**	0.215**	0.120**	0.238**	0.252**
	[0.041]	[0.071]	[0.046]	[0.031]	[0.110]	[0.062]	[0.018]	[0.028]	[0.071]	[0.039]
tall2	0.171	-0.141	0.042	0.173**	-0.062	0.253*	0.076*	0.134*	0.17	0.177*
	[0.089]	[0.132]	[0.101]	[0.063]	[0.200]	[0.110]	[0.035]	[0.058]	[0.142]	[0.077]
short1	-0.327**	-0.239**	-0.127**	-0.152**	-0.119	-0.240**	-0.173**	-0.233**	-0.384**	-0.256**
	[0.039]	[0.074]	[0.046]	[0.030]	[0.110]	[0.067]	[0.016]	[0.025]	[0.077]	[0.037]
short2	-0.152	-0.327	-0.227*	-0.155*	-0.141	-0.088	-0.187**	-0.155*	0.02	-0.121
	[0.080]	[0.188]	[0.094]	[0.061]	[0.177]	[0.171]	[0.035]	[0.061]	[0.163]	[0.076]
Observations	5228	1434	3090	8437	691	1726	29223	11251	1281	5654
mean z-score	-0.002	-0.015	0.016	-0.002	0.009	-0.037	0.000	0.000	0.006	-0.003
mean tall1	0.171	0.212	0.216	0.176	0.182	0.189	0.170	0.182	0.207	0.170
mean tall2	0.033	0.046	0.043	0.038	0.052	0.039	0.035	0.042	0.053	0.037
mean short1	0.175	0.177	0.196	0.192	0.198	0.171	0.170	0.176	0.176	0.170
mean short2	0.028	0.040	0.039	0.041	0.043	0.028	0.028	0.026	0.040	0.027

	Guinea	Kenya	Lesotho	Madagascar	Malawi	Mali	Morocco	Mozambique	Namibia	Niger
tall1	0.101**	0.177**	0.240**	0.133**	0.117**	0.163**	0.294**	0.112	0.269**	0.124**
	[0.039]	[0.029]	[0.045]	[0.024]	[0.026]	[0.031]	[0.031]	[0.114]	[0.034]	[0.042]
tall2	0.177*	0.207**	0.056	0.077	0.054	0.276**	0.083	0.448*	0.111	0.003
	[0.070]	[0.059]	[0.086]	[0.062]	[0.055]	[0.071]	[0.068]	[0.202]	[0.059]	[0.102]
short1	-0.146**	-0.205**	-0.294**	-0.198**	-0.222**	-0.221**	-0.253**	-0.224	-0.319**	-0.096
	[0.036]	[0.030]	[0.038]	[0.024]	[0.027]	[0.031]	[0.032]	[0.121]	[0.032]	[0.050]
short2	-0.139	-0.131	-0.08	-0.102*	-0.059	-0.203**	-0.266**	-0.268	-0.137*	-0.536**
	[0.074]	[0.069]	[0.084]	[0.052]	[0.060]	[0.078]	[0.069]	[0.192]	[0.069]	[0.120]
Observations	5657	8745	4592	15918	12086	7978	7278	635	7775	5318
mean z-score	-0.003	-0.002	0.003	-0.002	-0.007	-0.001	-0.001	0.016	-0.007	-0.004
mean tall1	0.191	0.188	0.165	0.154	0.179	0.157	0.177	0.186	0.183	0.133
mean tall2	0.045	0.035	0.034	0.027	0.032	0.030	0.037	0.043	0.041	0.031
mean short1	0.185	0.172	0.180	0.163	0.167	0.163	0.185	0.184	0.174	0.116
mean short2	0.039	0.026	0.033	0.023	0.027	0.022	0.031	0.046	0.032	0.024

Robust standard errors in brackets. * significant at 5%; ** significant at 1%

Table 6.6 (cont.)

	Nigeria	Rwanda	Senegal	Tanzania	Togo	Uganda	Zambia	Zimbabwe
tall1	0.252**	0.203**	0.276**	0.246**	0.311**	0.316**	0.158**	0.218**
	[0.035]	[0.037]	[0.024]	[0.054]	[0.035]	[0.026]	[0.053]	[0.008]
tall2	0.214**	0.028	0.266**	0.094	0.242**	0.087	-0.102	0.134**
	[0.065]	[0.062]	[0.046]	[0.098]	[0.082]	[0.054]	[0.125]	[0.016]
short1	-0.256**	-0.264**	-0.299**	-0.216**	-0.273**	-0.222**	-0.159**	-0.248**
	[0.031]	[0.038]	[0.025]	[0.052]	[0.036]	[0.026]	[0.058]	[0.008]
short2	-0.225**	-0.021	-0.235**	-0.146	-0.097	-0.222**	-0.017	-0.177**
	[0.075]	[0.080]	[0.055]	[0.090]	[0.083]	[0.057]	[0.117]	[0.017]
Observations	7610	5282	13557	2681	6781	12375	2822	195105
mean z-score	-0.003	-0.020	0.006	-0.001	-0.001	-0.005	0.007	-0.002
mean tall1	0.172	0.213	0.182	0.202	0.165	0.164	0.179	0.171
mean tall2	0.039	0.059	0.037	0.054	0.033	0.029	0.036	0.033
mean short1	0.169	0.191	0.157	0.195	0.160	0.166	0.180	0.175
mean short2	0.026	0.036	0.022	0.037	0.028	0.027	0.038	0.028

* significant at 5%; ** significant at 1%

See notes for Table 6.5.

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