ISS
International
Institute of Social Studies

Working Paper
No. 501

Does inequality in health impede growth?

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May 2010

ISSN 0921-0210

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Abstract

This paper investigates the effects of inequality in health on economic growth in low and middle income countries.* The empirical part of the paper uses an original cross-national panel data set covering 62 low and middle income countries over the period 1985 to 2007. I find a substantial and relatively robust negative effect of health inequality on income levels and income growth controlling for life expectancy, country and time fixed-effects and a large number of other effects that have been shown to matter for growth. The effect also holds if health inequality is instrumented to circumvent a potential problem of reverse causality. Hence, increasing access to health care for the poor can make a substantial contribution to economic growth not only through its effect on life expectancy but also through its effect on reduced health inequality.

JEL Classification: I18, I31, O11

Keywords

Health inequality, health gradient, economic growth

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* This paper is part of a research project on 'Differential Mortality and Welfare'. Financial support from the German Research Foundation (DFG) is gratefully acknowledged. I also thank Bilisuma Bushi Dito and Kerstin Nolte for excellent research assistance.
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1 Introduction

There is an increasing literature studying the effects of health on economic growth.[1] Yet, studying the link between health and income is difficult because of the problem of measuring health, and the potential endogeneity of health. This is extensively discussed by Deaton (2006). Empirical evidence suggests that the relationship is indeed bi-directional, i.e. on the one hand health boosts growth, for instance by increasing the productivity of workers, by enhancing the acquisition of cognitive skills and by raising the incentive to accumulate human and physical capital, and, on the other hand, income fosters health because richer countries can provide better health technology and supply better and more health-related public goods and services.[2] However, a set of recent papers, that deal in different, sometimes quite convincing, ways with the problems mentioned above (Bloom *et al.*, 2004; Weil, 2007; Bloom *et al.*, 2009; Cervelatti and Sunde, 2009; Lorentzen *et al.*, 2009), have challenged previous findings (e.g. Acemoglu and Johnson, 2007) and show that the effect of health on growth is important and probably dominates the effect of income on health. The debate is however not yet settled (see e.g. Deaton, 2006).[3]

A question that has received less attention in this literature is whether the extent of inequality in health conditions across socio-economic groups, i.e. the health gradient, also matters for growth and development.[4] If, as microeconomic evidence suggests (see e.g. Thomas and Strauss, 1997), labor productivity rises with health but at a decreasing rate, a very unequal distribution of health implies a lower average productivity than a less unequal distribution of health. Hence, among two countries with a comparable average population health, the country with larger health inequality will show a lower average productivity. Moreover, it can be argued that a pronounced health gradient reinforces the negative effects of low population health mentioned above. By reducing the capacity of the socio-economically disadvantaged to develop cognitive skills and to acquire and accumulate human and physical capital, health inequality may make poverty traps more likely. Poor parents with pessimistic prospects about their children's health and life expectancy may rather invest in the number of children than in their quality and thus enhance the vicious cycle of intergenerationally persistent poverty.

There is ample evidence that health inequalities are generally quite large, in developed as well as developing countries (see e.g. Van Doorslaer *et al.*, 1997;

[1] For a comprehensive review of this literature see Jack and Lewis (2009).

[2] However, health knowledge and technology can easily cross borders, and may explain why in the last century the world experienced convergence in life expectancy despite the absence of convergence in income levels (Becker *et al.*, 2005).

[3] Deaton (2006) argues in particular, that the empirical evidence suggests rather that third variables drive the correlation between health and income. According to Deaton, the most obvious candidates are education, in particular female education, and the quality of institutions (including the recognition of population health as a political priority). Female education because it has been shown to be conductive to better child nutrition, lower child mortality and lower fertility rates that in turn spur growth. Institutions because they are crucial for a good quality of health services and health care.

[4] The reverse effect, from income to health inequality has received more attention, see e.g. Van Doorslaer *et al.* (1997) and Van Kippersluis *et al.* (2009).

Wagstaff, 2000; Deaton, 2002, 2003; Mackenbach *et al.*, 2003; Cutler *et al.*, 2008; Grimm *et al.*, 2008, 2009; Van de Poel *et al.*, 2008; Elo, 2009). Cutler *et al.* (2008) for instance finds for the US substantial variations in mortality rates across education, income and ethnic groups. He states that the five-year mortality rate for the age group 55 to 64 differs by more than 6 percentage points between the lowest and highest income group. Grimm *et al.* (2008) estimate that life expectancy at birth in the poorest and richest income quintile differs in many low income countries by more than five, sometimes ten, years. Van de Poel *et al.* (2008) shows, also for poorer countries, that the prevalence of stunting and wasting among children in the poorest wealth quintile is often 50 to 100 percent higher than in the richest wealth quintile.

In this paper, I investigate whether inequality in health impedes growth in low and middle income countries. The empirical part of the paper uses an original cross-national panel data set covering 62 low and middle income countries over the period 1985 to 2007. I find a substantial and relatively robust negative effect of health inequality on income levels and income growth controlling for life expectancy, country and time fixed-effects and a large number of other effects that have to been shown to matter for growth. Countries in which the poor have a relatively better health status relative to the rich enjoy higher incomes, and within countries health inequality seems to lower the returns to average population health.

Overall the findings from this study suggest that in order to reduce health inequality, policy makers should target their efforts to improving population health in particular for the poorest population. Well-functioning health-care facilities are in many parts of the world still very much concentrated in urban areas and often exclude the rural poor from their services. Formal health insurance usually exists only for those employed in the public and private formal sector, while the majority of the workforce that is employed in the urban informal and agricultural sector is uninsured. Even HIV/AIDS treatments, which have expanded tremendously in the past few years in Sub-Saharan Africa, still bypass many of the poor rural and remote areas. This potential should be used to boost economic growth. Moreover, such policies should be complemented by policies that focus on health-related behavior and education. Policies that target health inequality directly, for example by reducing health care for the rich, do not seem appropriate.

The remainder of the paper is organized as follows. Section 2 discusses in more detail the theoretical framework of this paper. Section 3 presents the data. Section 4 analyzes first the relationship between income and health inequality levels across and within countries, and, second, estimates a growth model to investigate the impact of initial health inequality and changes in health inequality on income growth. Section 5 concludes.

2 Theoretical Framework

At the microeconomic level, the debate about the positive effects of health on skills acquisition, productivity and earnings is less controversial, although the involved econometric problems are not less complex (see e.g., Schultz, 2005). First, the measurement of health at the individual level is not straightforward and many of the standard household survey tools only provide imperfect health measures such as self-assessed health or the body mass index. Second, there is a sizeable problem of omitted variable bias, i.e. unobservable factors, in particular behavior-related variables that influence both health and earnings. Third, there is the problem of reverse causality, i.e. higher earnings allow higher investments in health. All three problems either call for an experimental design or for some good instrumental variables correlated with health but not directly related to earnings.

Significant positive effects of health on productivity and earnings have been found for instance by Strauss (1986), Deolikar (1988), Sahn and Alderman (1988), Haddad and Bouis (1991), Foster and Rosenzweig (1993), Schultz and Tansel (1997), Schultz (2003, 2005), Thomas and Strauss (1997), Croppenstedt and Mueller (2000), Behrman and Rosenzweig (2004), Case, Fertig and Paxson (2005), Alderman *et al.* (2006) and Maluccio *et al.* (2009). All these studies deal in one or another way with the problems mentioned above. I am not aware of any serious study that has shown a negative effect of health on productivity and earnings.

However, positive effects at the individual level do not exclude the possibility of finding insignificant or even negative effects at the macroeconomic level. First, it could be that healthier workers are only relatively better paid than unhealthier workers and hence average health could be unrelated to aggregate income (Jack and Lewis, 2009). Second, the positive effects of better health at the micro level could be offset through general equilibrium effects. The standard Solow growth model (closed economy, fixed saving rate, homogeneous labor) predicts that an increase in population growth, for instance through better health and longer life expectancy, has in the long-run a negative effect on income per capita. Historical evidence on the Black Plague and the US 1918 influenza (Brainerd and Siegler, 2003) seem somehow to support this hypothesis. However, if the Solow model is augmented with human capital (heterogeneous labor) and assuming that health is an input factor to human capital, one can get exactly the opposite result. Moreover, in the long run, lower infant and child mortality may also lead to an over-proportional decline in fertility which more than offsets the effect of lower mortality on population growth (Bloom and Canning, 2000; Kalemli-Ozcan *et al.*, 2000).

Leaving these effects aside, there is another interesting aspect associated with the aggregation from the micro to the macro level of the health effects. Some of the micro-economic studies mentioned above also analyzed in more detail the pattern of returns to health. Strauss (1986) for instance found that calories driven by food prices raised the marginal product of family labor especially at low calorie levels. Thomas and Strauss (1997) found strong effects of different nutrition and health variables on earnings and also stated that calories are subject to diminishing returns. If health is subject to diminishing returns, it is to be expected that in two countries with the same average health, the country with the higher inequality in health knows a lower average productivity than the country with the lower inequality in health. If aggregate labor productivity matters for growth — what the macroeconomic growth literature suggests — then an economy with a less unequal distribution of health should have better growth prospects than an economy with a more unequal distribution of health.

The following model illustrates this argument. Assume a neoclassical aggregate production function with constant returns to scale of the following form:

$$Y = AK^{\alpha}H^{1-\alpha}, \tag{1}$$

where Y is total output, A is total factor productivity and H is total human capital. Moreover, assume that human capital is determined by the number of workers L times the average efficiency over all workers, $\bar{e}$:

$$H = \bar{e}L, \tag{2}$$

where e is measured in efficiency units. Assume further that efficiency units are solely produced with health capital, h (ignoring for the moment the role of human capital acquired through education). Hence, we have:

$$e = g(h). \tag{3}$$

If now it is assumed, in line with the microeconomic evidence discussed above, that health is subject to positive, but diminishing returns, then

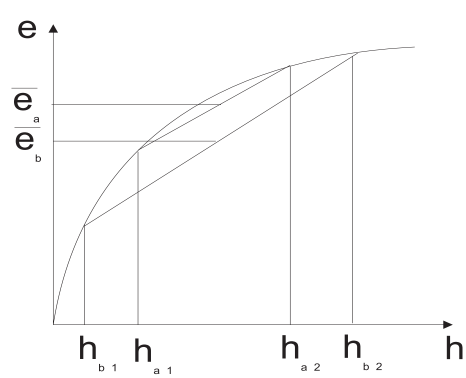
$$\frac{\partial e}{\partial h} > 0 \quad \text{and} \quad \frac{\partial^2 e}{(\partial h)^2} < 0. \tag{4}$$

Assuming a population with heterogeneity in h, average efficiency is given by:

$$\bar{e} = \int_0^{\infty} g(h)f(h)\mathrm{d}h, \tag{5}$$

where $f(h)$ is the population distribution of health. Given (4), we see that for two distributions with equal average health, $\bar{h}$, the population with the lower variance in health, σ_h^2, has the higher average efficiency. Figure 1 illustrates this point. Distribution a leads to a higher labor efficiency, $\bar{e}$, than distribution b.

Figure 1
The average productivity effect



Besides this productivity effect, there may be (in addition) a number of indirect channels between health inequality and aggregate income, that mainly operate over the gradient in health, i.e. are not caused by the variance in health *per se*, but depend on the degree to which health varies with socio-economic status. Given that health is usually bounded at the top of the distribution, a large health gradient means first of all that the poorer population experiences unfavorable health conditions.[5] This in turn can reinforce existing or even cause poverty traps. If poor people face adverse health conditions and experience premature mortality, they are likely, as for instance argued by Lorentzen *et al.* (2009), to under-invest in education and physical capital, because the time horizon over which the reward of such investments could be realized is relatively short (see also Lleras-Muney and Jayachandran, 2009). Poor parents with pessimistic prospects about their children's health and life expectancy may rather invest in the number of children than in their quality and thus enhance the vicious cycle of intergenerationally persistent poverty. The adverse effect on the acquisition on cognitive skills and investment in formal education is reinforced if poor health not only lowers the expected returns to education for the poor, but also makes it more difficult to effectively acquire cognitive skills and formal education, as some of the studies cited above suggest (Behrman *et al.*, 2003; Behrman and Rosenzweig 2004; Case, Fertig and Paxson, 2005; Schultz 2005; and Alderman *et al.*, 2006). A straightforward way to integrate the role of the health gradient in the theoretical model above is to assume that the health status of an individual i, h_i, is a linear function of the maximum population health, $\hat{h}$, the individual's socioeconomic status, x_i and an idiosyncratic shock, η_i, i.e.:

$$h_i = \hat{h} + \beta x_i + \eta_i, \tag{6}$$

where β can be interpreted as the health gradient. I assume, in line with most of the existing empirical evidence, that $\beta > 0$, i.e. $\partial h_i / \partial x_i > 0$, hence health increases with socio-economic status. Moreover, I assume that socio-economic status is continuously measured and bounded between $-\infty$ and 0, i.e. $x \epsilon (-\infty, 0)$. Hence, in a given society, individuals within the highest socio-economic group (i.e. $x = 0$) enjoy $\hat{h}$ corrected by an individual random shock. The individual random shock η_i is assumed to follow a normal distribution $N(0, \sigma_\eta^2)$.

Under these assumptions, and assuming that $g(h)$ is a linear function, the average efficiency in an economy is given by:

$$\bar{e} = \int_{-\infty}^{0} g(h(x; \hat{h})) m(x) \mathrm{d}x, \tag{7}$$

where $m(x)$ is the population distribution of socio-economic status x and $h(x; \hat{h})$ is health status conditional on x and the maximum population health, $\hat{h}$, i.e. $h(x; \hat{h})$ provides the health pattern implied by Equation (6). $g(h(\cdot))$ shows efficiency as a function of health.

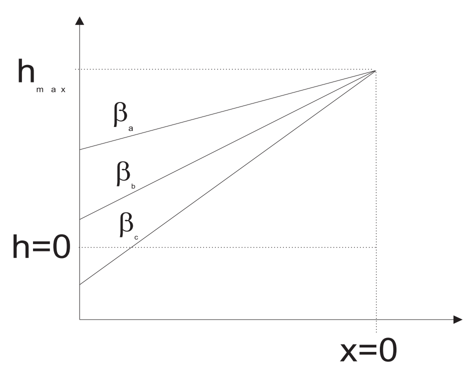
[5] I use the term 'poor' here and hereafter as a synonym for an economically disadvantaged status.

Under these assumptions and assumption (4) specified above, we obtain:

$$\frac{\partial \bar{e}}{\partial \beta}|_{m(x)=const.} < 0, \tag{8}$$

i.e. average labor efficiency declines with the health gradient β holding constant the distribution of socio-economic status. Note that if I assumed that h is not a linear but rather a concave function of x, the effect of the health gradient on $\bar{e}$ would even be larger. Moreover, the assumptions above imply that average labor efficiency increases with the density of individuals with a better socio-economic status. The argument is again illustrated graphically. Figure 2 shows different health gradients over x. In Situation c, where the gradient is the largest, the poorest part of the population, in terms of x, has a health capital that is below the threshold that would have any positive effect on e, translating the idea of a poverty trap.

Figure 2
The health poverty trap effect



However, with regard to life expectancy, there may also be a positive general equilibrium effect associated with higher health inequality. If mortality is higher among the poor and less healthy, the distribution of health improves 'mechanically' over time and average health rises.[6] Hence, the higher differential mortality, the lower poverty and the higher aggregate income (Cogneau and Grimm, 2007). This can be illustrated as follows:

$$\bar{e} = \int_{-\infty}^{0} g(h(x;\hat{h}))s(x)m(x)\mathrm{d}x, \tag{9}$$

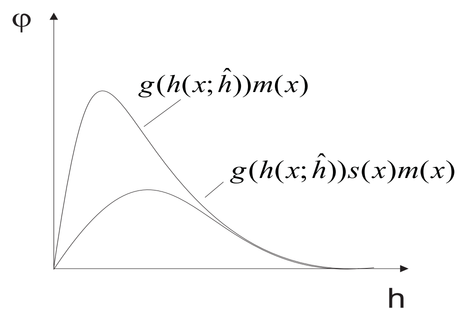
where $s(x)$ is the survival rate of an individual of socio-economic status x. If the gradient in mortality follows the gradient in health, i.e. $s = f(h)$ and $\partial s_i/\partial x_i > 0$, and if the gradient is large enough, then we may observe:

$$\frac{\partial \bar{e}}{\partial \beta}|_{m(x)=const.} > 0, \tag{10}$$

[6] A symmetrical argument has been made by De la Croix and Doepke (2003) for differential fertility and the distribution of education.

i.e. a higher health gradient leads to premature mortality among the less healthy and less productive, overcompensates the effect in Equation (8) and thus increases aggregate labor efficiency. This situation is illustrated in Figure 3. The distribution accounting for mortality implies a higher average labor efficiency than the distribution ignoring it.

Figure 3
The differential mortality effect



In what follows I examine empirically the effect of health inequality on income levels and growth. Obviously, the methodological problems are not less challenging than those that arise when studying the link between health levels and income growth. However, some of these problems can be relatively well dealt with, others must be left for future research. I focus solely on the link between health inequality and aggregate income and growth of income. It is also important to note that the emphasis is not on health status among the poor, although, in practice, reducing health inequality can only imply increasing health status among the poor and certainly not reducing it among the rich. I do not analyze the determinants of health inequality or the health gradient itself; this has been done by other authors before (see e.g. Cutler *et al.*, 2008; Elo, 2009; Van Kippersluis *et al.*, 2009). The essence of these studies is that the health gradient is determined on the one hand by demand side factors such as income, housing, nutrition, education, race and ethnicity, absolute and relative social status, which in turn affect health-related behavior such as investment in health and health care utilisation, and, on the other hand, by supply side factors such as the quality and accessibility of the public health system, the provision of clean water and the inclusion and exclusion in public disease prevention and treatment programs. Given that some of these factors are likely to be determined by aggregate income, I will have to deal with the potential endogeneity of health inequality.

3 Data

The main problem in analyzing the causes and consequences of health inequality is that there is no internationally comparable data available. And even within countries, systematic monitoring systems of inequality in health do not exist; not even mortality rates broken down by socio-economic status. Vital registration systems, where they are in place, usually do not collect any data on socio-economic status, such as education, occupation or income. In order to examine the link between health inequality and income, I use data from the Demographic and Health Surveys (DHS). DHS were initiated in the 1980s by the U.S. Agency for International Development (USAID) and have collected information at the household and individual level, in particular on mothers and children, on fertility, family planning, nutrition, reproductive health and mortality in most of the world's low and middle income countries since then.[7] For my purpose, the DHS data are well adapted since they allow me to estimate child mortality rates disaggregated by mothers' education groups, which I use to measure socio-economic inequality in health. More precisely, I use the absolute difference in the under-five mortality rates experienced by mothers in the lowest education group (usually this means in the group of mothers with no formal education) and mothers with at least secondary education.

This measure is obviously not without shortcomings. First, it is affected by measurement error due to the wrong dating or sometimes even omission of past death events. Second, there may also be measurement error in mothers' education. Third, it is a relatively narrow definition of socio-economic status. Mothers' education can of course differ from fathers' education and the gradient for income, wealth or social rank will probably differ from that measured for education. Fourth, child mortality is only a rough measure of health. Many temporary diseases with lasting effects — for instance on health and cognitive skills development — and chronic disease do not necessarily end in shorter lives and are thus not captured by this variable, although they can imply a lower quality of life, a lower productivity and lower earnings compared to the earnings of healthier people. Fifth, child mortality is affected by many factors which do not directly affect adult mortality. Sixth, the 'absolute difference' is of course only an imperfect measure of the gradient, although it is widely used in the literature. It has to be interpreted as the disparity in health conditions to which a society is exposed. Thus, it does not take into account the actual shares of the population that are affected by favorable or unfavorable health conditions, which would be endogenous in the context of this paper. Despite these caveats, I think that differences in child mortality across different education groups are an acceptable indicator of inequality in health in low and middle income countries. Of course this would not be the case in industrialized countries, where child mortality today is mainly determined by medical factors and only to a minor extent by socio-economic factors.[8]

The DHS also collect anthropometric measurements, allowing for an analysis of nutritional status. Using these data, Van de Poel *et al.* (2008) computed,

[7] See http://www.measuredhs.com.

[8] Another popular measure of health inequality is the (adjusted) concentration index (see e.g. Wagstaff *et al.*, 1991; Erreygers, 2009). This measure would be applicable here, if for all DHS used, we had a continuous measure of social status such as income or wealth and if the health outcome could be measured at the individual level, which is not the case for the mortality probability.

for a subset of the countries and periods used here, inequality in 'wasting' (weight for height), which is a measure of the deficit in tissue and fat mass and is sensitive to temporary food shortages and episodes of illness (World Health Organization, 1995). Instead of mothers' education, Van de Poel *et al.* (2008) defined the gradient over wealth quintiles, i.e. the difference in wasting between the poorest and richest wealth quintile. Wealth itself is measured using a wealth index over various household assets. For the subset of 46 countries, for which Van de Poel *et al.'s* measure is available, the correlation coefficient between this health inequality measure and my measure based on child mortality by education groups is 0.4. This is quite substantial and suggests that the education gradient in under-five mortality is a good and broad-based measure of health inequality.

In total I use DHS data for 62 countries. A few observations had to be discarded because of incomplete information on child mortality. For 47 countries at least 2 DHS are available, for 31 countries at least 3 and for 14 countries 4 or more. In total this yields 158 country-period observations spread over the period 1985 to 2007, i.e. 23 years. The list of included countries and the corresponding survey years are listed in Table A1 (Appendix). I merged this data set with data on income, life expectancy and a large number of potentially relevant control variables.

As a measure of income, I use GDP per capita in constant 2005 international $PPP taken from the World Development Indicator Database (World Bank, 2009). From the same data set, I draw life expectancy at birth, investment as a share of GDP, financial depth (money and quasi money as a share of GDP), trade openness (exports and imports as a share of GDP) and net secondary school enrolment. In addition, I use total fertility rates from the DHS. From the Gallup *et al.* (1999) database, I extract 'a country's share of land within 100km of the coastline' and 'a country's share of land in tropical areas'. Finally, I use Gini coefficients of income inequality from the WIDER inequality data base (WIDER, 2008).

I divide the total observation period from 1985 to 2007 into four five-year spells and one three-year spell. All variables that vary over time are, if available on an annual basis such as GDP, expressed as five-year averages. The data from the DHS comes from specific years and is allocated to the corresponding spell.

Given that I rely on DHS data, the empirical analysis is limited to low and middle income countries. On the one hand this is obviously a rather narrow focus compared to most other studies in the growth literature (although these often focus only on high and middle income countries, leaving out poor countries), but on the other hand, this focus may remove an important part of the unobserved heterogeneity across countries. The demographic literature clearly shows that the demographic transition in Western Europe and its offshoots was very different in terms of timing and speed from the demographic transition currently undergone by most of the low and middle income countries (see e.g. Watkins, 1987). This is a potential source of bias in studies mixing data from rich OCED countries and low income countries. Finally, inequality in health is less pronounced in high income countries (see e.g. Grimm *et al.*, 2008) and, potentially less relevant for growth than in low and middle income countries. In particular, the above-mentioned productivity effect is unlikely to be substantial given that most industrialized countries are probably already situated on the flat part of the health-productivity curve.

Table 1
Description of sample

	1985-89	1990-94	1995-99	2000-04	2005-07
GDP per capita	2809.7	2059.9	2194.4	2546.2	2185.3
StdDev	2064.3	1403.0	1923.7	2631.0	1787.7
Life Expect.	59.2	56.9	58.5	57.3	59.0
StdDev	7.3	8.8	8.1	9.9	9.0
Health Inequal.	86.4	83.6	75.3	67.9	66.3
StdDev	47.2	36.7	34.7	35.5	37.6
Total Fert. Rate.	5.1	5.1	4.7	4.3	4.5
StdDev	1.5	1.4	1.4	1.5	1.6
Pop share 0-14	0.421	0.428	0.417	0.400	0.400
StdDev	0.052	0.046	0.050	0.061	0.069
Pop share 15-64	0.543	0.538	0.547	0.562	0.561
StdDev	0.046	0.041	0.044	0.050	0.053
Perc. secondary enrollment		0.276	0.287	0.385	0.385
StdDev		0.151	0.222	0.232	0.255
Trade Openness	0.536	0.537	0.581	0.703	0.720
StdDev	0.252	0.254	0.226	0.296	0.346
Governm. Consump.	0.134	0.134	0.128	0.143	0.119
StdDev	0.046	0.059	0.072	0.083	0.048
Share Coastal Land	0.266	0.286	0.259	0.244	0.239
StdDev	0.270	0.320	0.266	0.297	0.323
Share Land in Tropics	0.880	0.813	0.792	0.791	0.778
StdDev	0.308	0.350	0.375	0.383	0.395
Latin America and Carib.	0.300	0.188	0.182	0.175	0.182
Sub-Saharan Africa	0.400	0.500	0.500	0.550	0.500
Middle East and North-Africa	0.100	0.094	0.068	0.050	0.045
East. Europe and Central Asia	0	0.031	0.068	0.050	0.045
South Asia	0.050	0.094	0.091	0.050	0.136
East-Asia and Pacific	0.100	0.094	0.068	0.100	0.045
Number of observations	20	32	44	40	12

Table 1 describes the sample used. The statistics are presented separately for each spell, and thus provide some insights into the demographic and economic change experienced by the countries under study. However, changes over time, but in particular between the first and second period, have to be interpreted with caution, since many countries join the data set only in the second spell. This can also explain the variation in the average GDP per capita over time. Life expectancy is relatively stable over time. Health inequality declines from 86 to 66, i.e. the difference in the number of children that die before the age of five to mothers with low education and mothers with high education declines by 20 children per 1,000 or 23 percent. Fertility declines over time showing that almost all countries have now entered the second phase of their demographic transition. Secondary school enrollment increases from 28 percent to 39 percent. Regarding the composition of the sample, we see that from 1990 onwards about 50 percent of all observations belong to Sub-Saharan African countries. About 18 percent belong to Latin American and Caribbean countries. The shares of the remaining regions vary between 5 percent and 10 percent.

4 Findings - Health Inequality and Development

In a first step I analyze the partial correlation between health inequality and income using the full set of 158 country-period observations. I also analyze the within-country variance by introducing country fixed-effects into the model, however, given that some countries enter the data set with only few observations and given that demographic change is rather slow, the analysis of between-country variance is preferred. Then, in a second step, I analyze the effect of initial health inequality and changes in health inequality on long term growth. To do so, I define for each country, conditional on the data availability, spells of maximal length and compute the average annual growth rate over these spells.

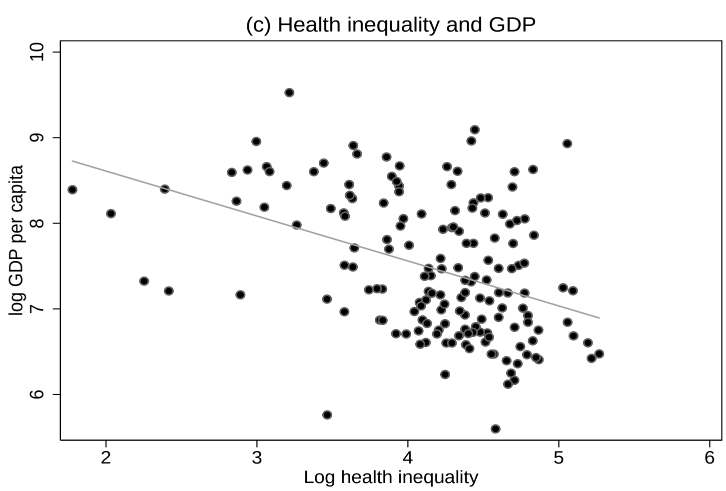
4.1 Level regressions

Before running any regressions, it is useful to examine graphically the correlations between the main variables of interest. Figures 4a-c show the pairwise scatter plots between log GDP per capita, log life expectancy at birth and log health inequality. Figure 4a shows what is well-known: a clear positive correlation between live expectancy and GDP. This is the inverse and logarithmic version of the famous Preston curve (Preston, 1975). However, the correlation is far from perfect. In the early nineties, for instance, Bolivia and Bangladesh had a similar level of life expectancy of about 56 years, but Bolivia was four times richer at that time than Bangladesh. Other countries, such as South-Africa and Botswana, have relatively high levels of income but, due to the HIV/AIDS epidemic, low levels of life expectancy.

Figure 4b shows a negative but relatively weak correlation between log life expectancy and log health inequality. The relationship seems to be non-linear with particular low levels of health inequality in high life-expectancy countries. However, the variance in that part of the distribution is large. Many of the countries with high life expectancy experience a high health inequality, higher than many of the low life expectancy countries. In the mid-eighties for instance, Brazil and Tunisia had about the same life expectancy of 65 years but health inequality was 30 percent larger in Brazil compared to Tunisia.

Finally, Figure 4c shows a clear negative correlation between health inequality and GDP per capita. The slope of the linear regression line is –0.53 and is highly significant, suggesting that on average a one percent decline in the difference between the number of children per 1,000 children who died before the age of five in the low and high education group lowers income per capita by 0.5 percent. It is again interesting to see that countries with relatively high income levels do not necessarily have lower health inequality. They can be found over the total range of the health inequality distribution.

Figure 4
Cross-country scatter plots of GDP per capita, life expectancy and health inequality



Notes: Multiple observations by country.

I now turn to multivariate regression analysis using the following specification:

$$\ln GDP_{it} = \beta_0 + \beta_1 \ln LEXP_{it} + \beta_2 \ln HI_{it} + X'_{it}\beta_3 + Z'_i\beta_4 + \lambda_i + T'_t\tau + \varepsilon_{it}, \quad (11)$$

where $\ln GDP_{it}$ stands for the log real GDP per capita in international \$PPP of country i in period t, $\ln LEXP_{it}$ for the log life expectancy at birth, $\ln HI_{it}$ for log health inequality measured as described above, the vector X_{it} for other time-varying control variables such as trade openness and government consumption over GDP, the vector Z_i for time-constant controls such as geography, the vector T_t for period-specific fixed-effects and ε_{it} for country and time-specific random shocks. The parameter λ_i stands alternatively for country random or country fixed-effects. If the latter is used, the vector Z_i has of course to be dropped from the equation. As mentioned above, given that demographic change is rather slow and given that I deal with a rather short (and unbalanced) panel, random effects are preferred to fixed-effects, however I will present the results for both.

The control for country random or alternatively country fixed-effects as well as time-shocks and many other variables that might be correlated with both health inequality and income, should reduce the problem of omitted variable bias, but of course it always remains a concern in cross-country regressions of this type. However, a more worrying problem is reverse causality, in particular in a regression in levels. Richer countries probably provide more health services and health-related public goods to the poor population and therefore health inequality may be smaller in richer countries. However, an argument could also be made that in richer countries, more health technology and services are offered by the private sector, and hence, in these countries richer people have more possibilities to invest individually in their health, which may increase health inequality. Within countries, economic downturns, whether caused by economic factors or climatic fluctuations, may first of all hurt the poor and therefore also increase health inequality. In the absence of any convincing instrument for health inequality (and life expectancy), the only remedy I apply here is to also estimate Equation (11) with GMM (Arellano and Bond, 1991) in the hope that this fixes the problem and yields coherent results with the standard random and fixed-effects estimates.

Column (1) in Table 2 shows the results of a regression of GDP per capita on life expectancy with random effects and a reduced set of controls. The effect of life expectancy is highly significant. The estimated elasticity is 0.74, i.e. on average, across countries an increase in life expectancy by one percent leads to an increase in income by 0.74 percent. The sample mean of life expectancy is about 58 years, one percent of that is seven months. That would mean if Sub-Saharan Africa, for example, had the life expectancy of Latin America and the Caribbean, the income gap between both would narrow by about 10%. In other words a one-year improvement in a population's life expectancy contributes to an increase of 1.25 percent in output. The total fertility rate and trade openness have the expected signs. The positive sign of government consumption over GDP may surprise, but is in a sample of low and middle income countries not unusual. The regression in Column (1) explains 44 percent of the total variance between countries and almost 20 percent of the within-country variance.

Table 2
GDP per capita, five-year spells, 1985-2007

	(1) (GLS)			(2) (GLS)			(3) (FE (within))			(4) (GLS)		
	Coeff.		S.E.	Coeff.		S.E.	Coeff.		S.E.	Coeff.		S.E.
Log Life Expect.	0.729	***	0.26	0.652	**	0.26	-0.042		0.28	0.581	**	0.27
Log Health Inequal.				-0.093	*	0.05	-0.108	**	0.05	-0.093	*	0.05
Log Total Fert. Rate.	-0.602	***	0.15	-0.502	***	0.15	-0.073		0.18	-0.443	***	0.16
Trade Openness	0.328	**	0.15	0.284	*	0.15	0.325	*	0.17	0.271	*	0.15
Governm. Consump.	1.244	**	0.56	1.088	*	0.56	1.529	**	0.59	1.116	**	0.56
Share Coastal Land										0.306		0.32
Share Land in Tropics										-0.195		0.24
Time Effects		Yes			Yes			Yes			Yes	
Country Effects		RE			RE			FE			RE	
No. of Spells		158			158			158			158	
No. of Countries		62			62			62			62	
R-squared		0.494			0.483			0.306 (within)			0.428	
	(5) (GLS)			(6) (GMM)			(7) (OLS)					
	Coeff.		S.E.	Coeff.		S.E.	Coeff.		S.E.			
Log Life Expect.	0.684	**	0.38	1.163	***	0.44	1.725	**	0.77			
Log Health Inequal.	-0.084	**	0.04	-0.091	**	0.04						
Log Inequality Wasting							-0.176	**	0.07			
Log Total Fert. Rate.	-0.290		0.18	0.259		0.19	-0.910	**	0.39			
Secondary Enroll.	1.328	***	0.36									
Trade Openness	0.197		0.14	-0.043		0.12	0.324		0.51			
Governm. Consump.	-0.459		0.67	0.125		0.42	2.438		1.94			
Share Coastal Land	0.068		0.34				0.161		0.34			
Share Land in Tropics	-0.217		0.25				0.495		0.35			
Time Effects		Yes			Yes			Yes				
Country Effects		RE			FE			No				
No. of Spells		79			60			41				
No. of Countries		43			30			41				
R-squared		0.619						0.628				

Notes: Intercept omitted from Table. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

If health inequality is added to the list of regressors (column (2)), I find a significant and negative coefficient. The size of the coefficient suggests that a one percent increase in health inequality reduces income per capita by about 0.1 percent. The sample mean of the under-five mortality gradient is 72.7. Thus, a reduction of 10 percent implies that the number of children who die before the age of five born to mothers with a low education level decreases by about seven children per 1,000 children and this leads to an increase in income by about one percent. It is important to emphasize again that the gradient in child mortality is used as a proxy for the gradient in health. If the focus was on the direct effects of child mortality, we would have to use lagged values, to relate the productive years of these children to income.

If I use the log of under-five mortality instead of the health inequality measure as a regressor, I find an insignificant effect and the coefficient of life expectancy is reduced and loses significance. This shows that the chosen measure of health inequality does not simply pick up the effect of child mortality on life-expectancy. If Equation (11) is estimated with fixed-effects (column (3)) instead of random-effects, the effect of health inequality is more or less unchanged, suggesting that omitted variable bias is probably not a substantial problem. However, life expectancy and fertility become insignificant, which is not surprising given that both variables move only slowly and thus do not exhibit enough within-country variation over such a short period of time in order to identify their effects on income. In column (4), I add further geographic variables to the list of controls but those are not significant and change only slightly the coefficients of life expectancy and fertility. The coefficient of health inequality is unchanged.

The lack of data on secondary school enrolment only allows me to introduce this variable in a sub-sample comprising 78 out of the 158 country-year observations (column (5)). Secondary school enrolment has a positive and highly significant impact. The effect of fertility becomes insignificant, but the effects of life expectancy and health inequality are again more or less unchanged. I also tested whether investment over GDP has any impact on GDP per capita and whether its introduction changes the effects of the other included variables, but this was not the case. Finally, one may wonder whether health inequality is just a proxy for income inequality. I tested this possibility by using Gini coefficients from the WIDER data base. As for school enrollment, not all country-year observations are covered, but when introduced in a regression without health inequality as an additional regressor, income inequality enters with a positive sign and is insignificant ($p = 0.56$). Hence, I can exclude the possibility that health inequality is just a proxy of income inequality.

In column (6) I use GMM for estimation to account for the possible endogeneity of health inequality, life expectancy and fertility with respect to income. Given that GMM implies to instrument first differences of the endogenous variables by their lagged values, I can only use those countries that enter the data set at least with three observations. The coefficient of life expectancy is significant and larger than in the random effects estimations above. The point estimate implies that an increase in life expectancy by one year, increases GDP per capita by about 2 percent. This is half the size estimated by Bloom *et al.* (2004). The effect of health inequality is also significant and with respect to its size almost unchanged in comparison to the RE and FE estimates reported above. Thus, independent of the estimation method, I find a fairly robust negative effect of health inequality on income.

Before estimating the model in growth rates, I do another robustness check. Instead of measuring health inequality by the gradient in under-five mortality, I use the gradient in wasting (weight for height), which is, as explained above, a measure of the deficit of tissue and fat mass and is sensitive to temporary food shortages and episodes of illness. This is thus a completely different measure of health. In addition, the gradient will be defined not over low and high education groups but over the poorest and richest wealth quintiles. This measure is taken from Van de Poel *et al.* (2008) and only available for the most recent DHS and hence I use a simple OLS estimator. Column (7) shows the results. I find again a significant negative coefficient, suggesting that health inequality is associated with lower income.

4.2 Growth regressions

Whereas the analysis above focused on short term effects of health inequality on income across and within countries, I now focus on the longer term relationship. I regress growth rates in income, not income levels, as in the previous section, on changes in life expectancy and changes in health inequality, controlling for initial life expectancy, initial health inequality and initial income.[9] The advantage of analyzing growth rates and controlling for initial conditions is that the problem of reverse causality is mitigated, but it may of course not eliminate it altogether. Countries that experience low growth over a longer period may not have the capacity to invest the necessary resources in health infrastructure to cope with diseases.

However, controlling for initial conditions in health and health inequality is important for another reason. Bloom *et al.* (2009) argue and empirically show that countries with good initial health are the countries that benefited least from subsequent global health technology improvements. At the same time these were the countries whose economies have grown fastest in the post World War II period. Therefore, ignoring the initial health means to ignore the pronounced convergence in health and this can introduce a negative bias in the effect of health on income, since the fast growing economies with better initial health conditions experienced the lowest health gains. A similar argument may apply to health inequality, i.e. countries with higher initial health inequality may have experienced larger reductions in health inequality.

Hence, I specify the growth model between two periods, 0 and 1, as:

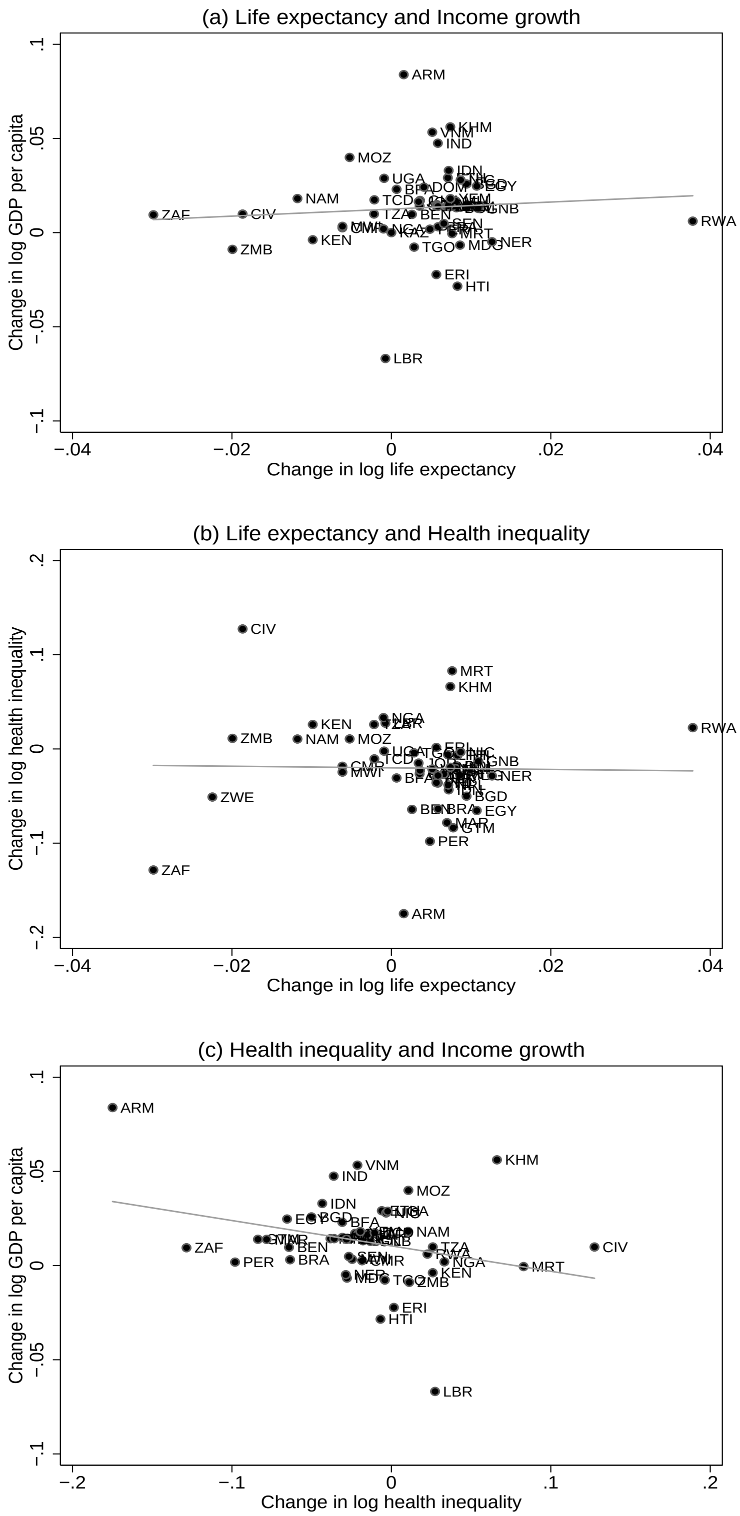
$$\Delta \ln GDP_i = \beta_0 + \beta_1 \Delta \ln LEXP_i + \beta_2 \Delta \ln HI_i + \Delta X_i' \beta_3 +$$
$$\beta_4 \ln LEXP_{i0} + \beta_5 \ln HI_{i0} + \beta_6 \ln GDP_{i0} + Z_i' \beta_7 + \beta_8 S_i + \nu_i, \qquad (12)$$

where the variables have the same meaning as in Equation (11). As usual the Greek letter Δ refers to the difference. The growth rate in GDP is defined as follows: for each country with at least two observations in the data set, I retain the period of maximum length covered by the data and compute the average annual growth rate, i.e. for a country with DHS data in the periods 1985/90, 1995/2000 and 2000/2005, I retain the period 1985/90 to 2000/05 and define the growth rate as the difference between the log average income in the final period and the log average income in the initial period. Then, I divide this growth rate by the number of years covered by that period. To avoid any bias due to the different length of these spells across countries, I control in addition for the country-specific spell length S_i. The average spell length is 12 years.

[9] Note that improvements in health inequality that increase aggregate efficiency would raise the growth rate of an economy during the transition to the new steady-state, but it may not necessarily raise the long run steady-state growth rate. However, the results below suggest that most of the countries in the sample have not (yet) attained their steady-state.

Figure 5

Cross-country scatter plots of changes in GDP per capita, life expectancy and health inequality



Again, I start with some scatter plots. There are 46 countries included in this sample. Figure 5a shows that in this data set there is virtually no (unconditional) relationship between changes in life expectancy and changes in income. There is also no relationship between changes in life expectancy and changes in health inequality (Figure 5b). However, there is a relatively clear negative relationship between changes in health inequality and changes in income (Figure 5c).

Table 3
Growth of GDP per capita, 1985-2007

	(1) (OLS)			(2) (OLS)			(3) (OLS)		
	Coeff.		S.E.	Coeff.		S.E.	Coeff.		S.E.
Δ Log Life Expect.	0.420		0.29	0.345		0.28	0.638	*	0.28
Δ Log Health Inequal.				-0.149	*	0.07	-0.174	***	0.06
Δ Log Total Fert. Rate.	0.094		0.31	0.112		0.23	0.232		0.19
Initial Log Life Expect.	0.071	**	0.03	0.061	**	0.03	0.072	***	0.02
Initial Log Health Inequal.				-0.001		0.005	-0.001		0.01
Initial Log GDP per capita	-0.006		0.01	-0.009	*	0.001	-0.007	*	0.004
Δ Trade Openness							0.520	***	0.18
Δ Governm. Consump.							-0.861	*	0.36
Share Coastal Land							-0.037	**	0.01
Share Land in Tropics							-0.006		0.01
Spell length	-0.002		0.001	-0.002	**	0.00	-0.002	**	0.001
No. of Countries	46			46			46		
R-squared	0.270			0.349			0.589		

	(4) (2SLS)			(5) (2SLS)		
	Coeff.		S.E.	Coeff.		S.E.
Δ Log Life Expect.	0.289		0.32	0.316		0.25
Δ Log Health Inequal.	-0.314	***	0.07	-0.240	*	0.14
Initial Log Life Expect.	0.046	*	0.03	0.033	**	0.02
Initial Log Health Inequal.	-0.004		0.01	-0.011	***	0.002
Initial Log GDP per capita	-0.014	***	0.005	-0.013	***	0.003
Spell length	-0.002	***	0.001	-0.001	***	0.008
No. of Countries	44			44		
R-squared	0.436			0.506		
IVs used	Climate zone variables			Malaria index 1966 Vaccinations		
Test statistics						
First stage F-Statistic	11.8			3.6		
Hansen J-statistic	3.239			1.187		
p-value	0.862			0.552		

Notes: Intercept omitted from Table. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 3 shows the regression results. In column (1) health inequality is excluded. Initial life expectancy has a significant positive impact on subsequent growth, i.e. countries that started with a higher life expectancy experienced higher economic growth. The point estimate is 0.071. This implies that an increase in life expectancy of five years at the sample mean (here 56 years) is associated with a growth effect of 0.6. This estimate is fully in line with other estimates in the literature (see Bloom *et al.*, 2004.) Changes in life expectancy are also positively associated with growth, but the coefficient is in this regression only significant at 15 percent. Initial income has the expected negative sign, but is insignificant. Changes in the total fertility rate are also insignificant.

Column (2) shows the regression results when I add initial health inequality and changes in health inequality. Initial health inequality is not significant but changes in health inequality enter with a significant negative sign. The estimated coefficient implies that a country that reduces health inequality by 1 percent per year, increases its annual rate of economic growth by 0.15 percent. The sample mean of the under-five mortality gradient is 85.2. Thus, a reduction of 5 percent per year would mean that the number of children who die before the age of five of mothers with a low education level decreases by about 4.25 children per 1,000 children per year. Over a period of ten years this would imply a GDP per capita that is higher by almost 8 percent compared to a situation without such an improvement in health inequality. Note that if the relevant channel between health inequality and economic growth is via the average productivity effect discussed in Section 2, continuous improvements in health inequality are needed to get a growth effect in the long-run steady-state. This may be possible over a certain period, but will probably no longer be possible if the total population of a country has adequate access to health services. Probably, none of the countries in the sample has achieved that state yet. Anyway, the significant coefficient of initial income per capita suggests that the countries in the sample are rather in the process of transition than close to their steady-state.

Finally in Column (3), I add the change of government consumption, the change of trade openness and two additional geographical control variables — the share of the land within 100km of the coastline and the share of land in tropical areas — to the list of regressors. Trade openness has the expected positive effect and government consumption now a negative effect. The share of land within 100km of the coast enters negatively, which is not as expected. The 'tropics' variable is insignificant. But more importantly, the effect of initial life expectancy and of changes in life expectancy are now significant. The effect of changes in health inequality is also highly significant ($p < 0.01$ and is slightly higher than in Column (2). This means that improvements in life expectancy that are accompanied by reductions in health inequality imply a double dividend for growth. Initial income is now also significant, but its effect is very small. This is however no surprise, given that I also control for initial life expectancy. I also tested whether income inequality as measured by the Gini coefficient plays any role or even annuls the effect associated with health inequality. However, the obtained coefficient for income inequality was insignificant (results not shown). All other effects were robust to the inclusion of income inequality, even though due to the reduced sample size – the Gini coefficient is not available for all countries in my sample – changes in life-expectancy and some of the other controls were no longer significant.

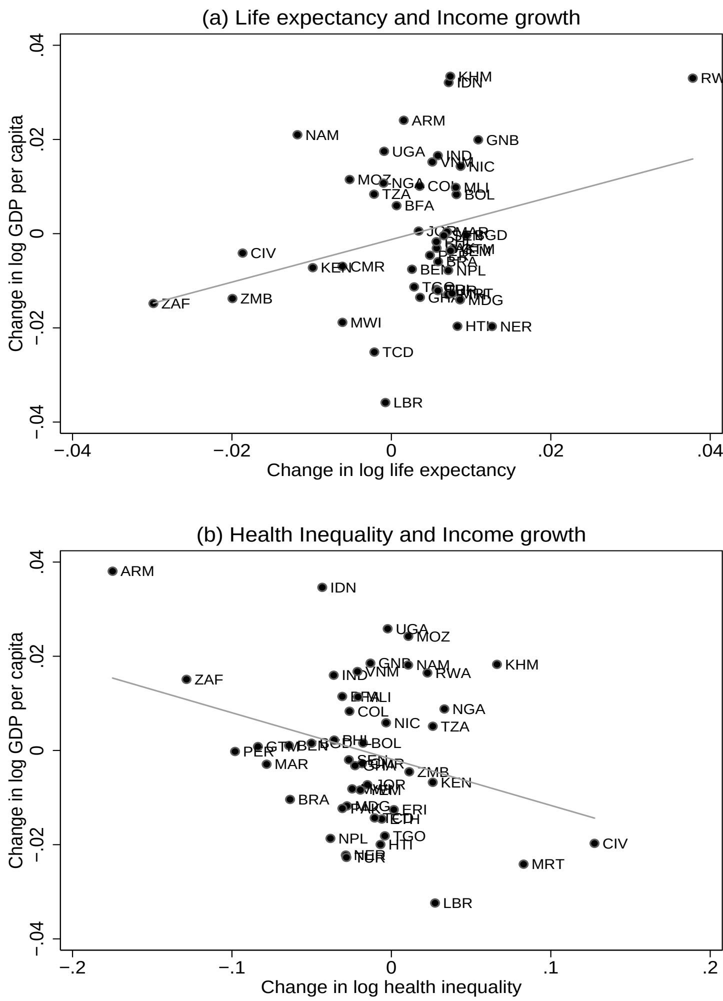
To address the potential problem of reverse causality, I now re-estimate Equation (12) by instrumenting the change in differential mortality observed in each country ($\Delta \ln HI_i$) with two sets of instruments. First, I use the 'Falciparam Malaria Index' for 1966 taken from the Gallup *et al.* (1999) data base. Malaria incidence should be relevant because countries strongly affected by malaria have higher mortality levels and a larger differential mortality and hence there is also more scope for reductions in differential mortality. Using the index for 1966 should ensure that the variable is largely exogenous to growth rates in the 1980s and later. Second, I use the current share of children vaccinated against Measles and DPT (diphtheria, pertussis and tetanus). Both measures are taken from the World Bank Development Indicator Data Base (World Bank, 2009). The assumption is that vaccination campaigns in low income countries are often financed by foreign aid and thus are exogenous to economic growth. The variables should be relevant because the higher the proportion of benefitting children, the faster health inequality can be reduced. Third, I use nine variables measuring the shares of a country's land located in nine different climate zones (polar non-desert, boreal regions, temperate desert, tropical and subtropical desert, dry temperate, wet temperate, subtropics, tropics and water). These variables are also taken from the Gallup *et al.* (1999) data base. Climate should have an influence on the prevalence of certain diseases, given that many diseases require specific ranges of temperature, humidity and water to survive and spread. The disease environment in turn should have an effect on the extent of health inequality and the potential to reduce the same. For all three sets of variables I then assume that they mainly affect economic growth through their effect on health and health inequality but do not affect growth directly. Note that I do not address here the potential endogeneity of changes in life expectancy. I just focus on the role of health inequality.

Columns (4) and (5) in Table 4 show the results. In column (4) I use the climate zone variables. The first-stage F-statistic is 11.8 and thus slightly above the required critical level of about 10, suggesting that the instrument is indeed relevant. The effect of changes in health inequality on growth is still negative and significant and even higher than in Columns (2) and (3). If reverse causality was a problem, one would expect that the coefficient of health inequality would be reduced in its absolute size when instrumented. So either reverse causality is not a problem, but measurement error is, which would be consistent with a downward bias, or the instrument is not powerful enough. Again, the latter seems rather unlikely, since the $F-$statistic is satisfying, the standard error is fairly low and the coefficient significant at the 1 percent level. The overidentification test is also passed, suggesting that the instrument can be considered as exogenous. Moreover, if economic growth is regressed on the nine climate zone variables directly, the joint F-Test yields a p-value of only 27 percent, what also suggests that the impact is mainly via health inequality and not directly on growth. Alternatively, if I use the vaccination variables and malaria prevalence in 1966 as instruments, I also find a relatively high effect of health inequality, but the standard error is relatively large and the F-statistic is, with a value of 3.6, very low. Thus this result should be interpreted with the necessary caution.

Figure 6 presents the partial scatter plots associated with the estimated coefficients in Column (3). Figure 6a shows the partial correlation between changes in life expectancy and economic growth once the effect of all other variables is netted out.[10] The relationship is now clearly positive, in contrast to what the unconditional relationship in Figure 5a suggested. Figure 6b shows the partial relationship between changes in health inequality and economic growth. Again, the slope is clearly negative.

Figure 6

Partial relationship between changes in GDP per capita, life expectancy and health inequality



5 Conclusion

This paper presents a first attempt in analyzing the effects of inequality in health on economic growth. Health inequality is measured by the gradient in child mortality over mothers' education groups and is used as a proxy for the

[10]These growth rates are computed by estimating the growth equation in Table 3, Column (3), without the changes in life expectancy variable. The estimates are then used to predict economic growth. The predicted values are then subtracted from the observed growth rates which provides growth rates where the effect of all other variables is netted out.

disparity in health conditions to which different socio-economic groups in a society are exposed. Despite the obvious limits of such a narrow definition and the practical problems in measuring life expectancy and child mortality in low and middle income countries, I find a relatively robust negative effect of health inequality on economic growth. This result holds whether I estimate an income regression in levels or growth rates, whether I use repeated short spells and control alternatively for fixed or random-effects or whether I analyze a single long spell per country. It is also robust when health inequality is instrumented either using GMM or simply using classical instrumental variables. A conservative estimate is that a reduction in the number of children who die before the age of five by about 4.25 per 1,000 children per year (i.e. by five percent) born to mothers with a low education level leads to an almost eight percent increase in GDP per capita after a period of 10 years. I also find a positive effect of life expectancy on economic growth that is – in terms of its magnitude – in line with other estimates in the literature.

The channels by which health inequality affects growth need further analysis. The theoretical discussion that motivated the empirical analysis in this paper suggests that lower inequality in health and a lower gradient in health may increase aggregate labor productivity and may make it less likely that households are locked in health-related poverty traps. These effects seem not to be offset by the direct effect of differential mortality on the composition of the labor force. Disaggregated data is needed to investigate these channels further.

The results of this paper raise another important issue regarding the link between health and economic growth. Some of the studies analyzing this link take estimates of the effect of health from microeconomic studies and use these to calibrate the size of the effects at the aggregate level (see e.g. Shastry and Weil, 2003; Weil, 2007). If inequality in health indeed lowers the growth effects of average health, this approach may overestimate the benefits of health improvements.

What are the policy implications of this study? Given that health always has an upper boundary regardless of how it is measured, reducing health inequality means in particular improving health conditions for the poor. Hence, increasing access to health care for the poor and increasing health care utilization through affordable health insurance are policy options that can be considered in this context. Such policies can be complemented by policies that improve education and raise income among the poor. Education raises the awareness of health benefits and the capability to deal with health problems. Income is important because it usually improves nutrition and housing that are both important factors in adult and child excess mortality among the poor. Attacking the gradient directly by preventing the rich from care they need and can afford is certainly not an appropriate policy.[11]

[11] See on this issue the discussion in Deaton (2002).

Appendix

List of used DHS (years in parentheses)

Armenia (2000, 2005), Bangladesh (1993, 1996, 1999, 2004), Benin (1996, 2001, 2006), Bolivia (1989, 1994, 1998, 2003), Botswana (1988), Brazil (1986, 1996), Burkina Faso (1992, 1998, 2003), Burundi (1987), Cambodia (2000, 2005), Cameroon (1991, 1998, 2004), Chad (1996, 2004), Colombia (1986, 1990, 1995, 2000, 2005), Congo Democratic Republic (2007), Congo/Brazaville (2005), Cote d'Ivore (1994, 1998), Dominican Republic (1991, 2002, 2007), Ecuador (1987), Eritrea (1995, 2002), Ethiopia (2000, 2005), Gabon (2000), Ghana (1988, 1993, 1998, 2003), Guatemala (1987, 1995, 1998), Guinea (1992, 1999, 2005), Haiti (1994, 2000, 2005), Honduras (2005), India (1992, 1998, 2005), Indonesia (1987, 1991, 1994, 1997, 2002), Jordan (1990, 1997, 2004, 2007), Kenya (1989, 1993, 1998, 2003), Kyrgyz Republic (1997), Lesotho (2004), Liberia (1986, 2007), Madagascar (1992, 1997, 2003), Malawi (1992, 2000, 2004), Mali (1987, 1995, 2001, 2006), Mauritania (1999, 2003), Morocco (1987, 1992, 1995 2003), Mozambique (1997, 2003), Nambia (1992, 2000, 2006), Nepal (1996, 2001, 2006), Nicaragua (1997, 2001), Niger (1992, 1998, 2006), Nigeria (1990, 1999, 2003), Pakistan (1990, 2006), Paraguay (1990), Peru (1986, 1991, 1996, 2000, 2004), Philippines (1993, 1998, 2003), Rwanda (1992, 2000, 2005), Senegal (1986, 1992, 1997, 1999, 2005), South-Africa (1998, 2003), Sri Lanka (1987), Sudan (1990), Tanzania (1992, 1996, 1999, 2004), Thailand (1987), Togo (1988, 1998), Tunisia (1988), Turkey (1993, 1998, 2003), Uganda (1988, 1995, 2000, 2006), Uzbekistan (1996), Vietnam (1997, 2002), Yemen (1991, 1997), Zambia (1992, 1996, 2001).

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