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Abstract

Relationships between health and economic prosperity or economic growth are difficult to assess. The direction of the causality is often questioned and the subject of a vigorous debate. For some authors, diseases or poor health had contributed to poor growth performances especially in low-income countries. For other authors, the effect of health on growth is relatively small, even if one considers that human capital accumulation needs also health investments. It is argued in this paper that commonly used health indicators in macroeconomic studies (e. g. life expectancy, infant mortality or prevalence rates for specific diseases such as malaria or HIV/AIDS) imperfectly represent the global health status of population. Health is rather a complex notion and includes several dimensions which concern fatal (deaths) and non-fatal issues (prevalence and severity of cases) of illness. The reported effects of health on economic growth vary accordingly with health indicators and countries included in existing analyses. The purpose of the paper is to assess the effect of health on growth, by using a global health indicator, the so-called disability-adjusted life year (DALY) that was proposed by the World Bank and the WHO in 1993. Growth convergence equations are run on 159 countries over the 1999-2004's period, where the potential endogeneity of the health indicator is dealt for. The negative effect of poor health on economic growth is not rejected thus reinforcing the importance of achieving MDGs.

JEL Classification: E22, E24, I19, I18, O47

Key Words: Disease Global Burden, DALYs, economic growth, macroeconomic health impact, cross-country analysis

Introduction

Human capital investments are known for a long time as basic candidates explaining growth performances (e. g. Schultz, 1961). Sen's works on human capabilities and the emergence of AIDS have renewed the interest given to the link between health, welfare, and prosperity. At a microeconomic level, several studies found that poor health have negative effects on economic prosperity and living conditions.[1] At a macroeconomic level, the Commission on Macroeconomics and Health (2001) concluded that diseases raise barriers to economic growth and that countries have to invest in health. Several authors have considered that communicable diseases, among others, had contributed to slow down economic development of low income countries. The latter proposition is still hotly debated as some methodological issues are not satisfactorily addressed (see the comprehensive and critical review of Packard, 2009). Acemoglu and Johnson (2006), using international data from the epidemiological transition period, find that an increase in life expectancy generated by a decrease in mortality rates had a small positive effect which grows over the post epidemiological transition. The latter was not enough important to compensate for increases in population. Consequently, life expectancy increases do not lead to a significant increase in per capita economic growth. This study makes reminiscent previous results of Barlow (1968) with regard to malaria eradication and of Over (1992) with regard to economic effects of AIDS as well. In the same vein, Bell, Bruhns and Gersbach (2006), using an overlapping generations model simulate relaxed effects of AIDS on economic growth in Kenya by 2050.

There are at least three reasons that could explain difficulties to assess health impacts at the macroeconomic level and therefore fuel the debate. First, links between health and development or growth are complex and health effect could also be channelled into education levels, the environment, and cultural behaviours as well. When, due to missing adequate indicators, these behaviours are not included in the model, the estimated health effect will be biased or hidden by unobserved heterogeneity (Thomas, 2009; Strauss and Thomas, 2007). Second, health is subject to measurement errors either due to poor measurement facilities such as lack of good equipment and materials for setting appropriate diagnosis, low human resource training, deficient registration, measurement variability over the day (e.g. blood pressure) or the year (e. g. malaria indicators). Third, health status is a rather complex notion that includes several dimensions. Researchers face a wide array of health indicators

[1] The literature on links between health and economic well-being or prosperity at microeconomic level is abundant. See Strauss and Thomas (2007) for an exhaustive literature review.

addressing one specific dimension of health. Consequently, using one or the other is not equivalent.

Partly due to these difficulties of measuring multiple dimensions of health and therefore global health, macroeconomic effects of health have been more still studied using health indicators such as life expectancy at birth, infant mortality rates, or nutritional status measures. Existing results can be questioned by addressing specifically the choice of health status indicators, which is the subject of this study.

The rest of the paper is organized as follows. Section 2 is devoted to health measurement issue. Different measures of health indicators used in the growth literature are discussed before exploring the more global one on which is focused this study. Section 3 reviews the theoretical and empirical literature on the link between health outcomes and economic performances. The empirical setting and the results are presented in section 4 and 5. Section 6 concludes.

1. *Looking for a global health indicator*

Health measurement is a hard task since, contrary to economic indicators, health is multi-dimensional,[2] and measured with errors. Moreover, researchers, either in a perspective of public health initiatives, health research, or economic health research, have developed a wide array of health indicators, among which few however are satisfactorily measured (Murray and Frenk, 2008; Murray, 2007).[3] If it is crucial to understand what each indicator measures (Strauss and Thomas, 2008), it is also important to insure that health indicators fit the purposes of studies

The most commonly used indicators of health conditions at the macroeconomic level are life expectancy at birth and infant mortality rates (Strauss and Thomas, 2008). Those indicators are considered reflecting the general health conditions and supposed to be positively associated with economic growth. It is true that life expectancy is higher and infant mortality lower in richer countries than in poorer countries. Indeed, the correlation between life expectancy at birth and GDP per capita is not systematic as life expectancy is lower (or

[2] Whatever the approach chosen (medical, self-assessment or functional) for measuring health, poor health is considering as a deviation between the observed health and a norm. This deviation may occur into either, physical, mental, or social well-being dimension.

[3] For a discussion on the issue and challenge of health measurement, see Mwabu, 2007; Strauss and Thomas, 2008; Murray and Frenk, 2008; Audibert, 2009).

higher) than expected given GDP per capita in countries like Southern Africa, Gabon or Indonesia (for examples, see Strauss and Thomas, 2008). Per capita incomes have diverged over time while life expectancy and infant mortality have converged (Deaton, 2006; Jack and Lewis, 2009). Life expectancy and infant mortality are inadequate indicators of the population's health in high income countries and for several upper middle income countries where life expectancy is high and infant mortality is very low or low. For low and lower middle income countries, those indicators are more adequate due to their poor levels. For that reason, studying the relationships between health and economic development or growth in cross-country studies using infant mortality or life expectancy at birth is not really appropriate.

As underlined by Jack and Lewis (2009), the effect of a population's health status on national income varies accordingly with the health indicator used. Most health indicators used in the literature capture one dimension of the population health. They either relate to fatal (life expectancy,[4] mortality indicators) or to non-fatal (morbidity indicators) issue of illness (Audibert, 2009). For example, the emergence of HIV/AIDS and its high prevalence (more than 15%) in some southern African countries (Botswana, Lesotho, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe, UNAIDS[5]), have motivated several studies focusing on their economic effects. But, little evidence of a correlation between HIV/AIDS and GDP per capita was found (Strauss and Thomas, 2008). With the renewed interest for malaria, some authors (Sachs and Malaney, 2002; McCarthy, Wolf and Wu, 2000) have investigated its effect on African countries growth. But, those indicators neither take into account other dimensions of health, such as invalidity, handicap or social consequences, nor multidimensional characteristics of health.

The main thesis of this paper is that macroeconomic effects of the global health status are accurately caught by the Disability-Adjusted Life Year (DALY) per capita calculated by the World Health Organization (WHO). This indicator is proposed by the World Bank and WHO since 1993 (the World Bank, 1993). Its represents "a one lost year of healthy life and extends the concept of potential years of life lost due to premature death to include equivalent years of

[4] In low income countries, life expectancy is mainly determined by infant mortality, and also in countries where AIDS prevalence is high, by AIDS mortality.

[5] http://www.unaids.org/en/CountryResponses/Regions/SubSaharanAfrica.asp.

healthy life lost by virtue of being in states of poor health or disability" (WHO, 2008).[6] "The sum of these DALYs across the population represents the burden of disease and can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability" (WHO, 2008). DALYs were calculated initially for about one hundred causes and diseases and over the whole world and were not updated since 2000. From 2000 to 2004 however, DALYs are also available on a regional basis. DALYs are commonly used in cost-effectiveness analyses but, to the best of our knowledge, have never been used in macroeconomic analyses since DALYs at the country level are only available for 2002 and 2004.

Any indicator, including DALYs, is amenable to criticism with a particular emphasis on weighting (namely age and disease severity) and discounting (e.g. Anand and Hanson, 1998). A large revision has been however implemented, mainly by the Institute of Health Metrics, which is in charge DALYs calculations updates and improvements (Lopez *et al*, 2006). This does not prevent however this indicator from being a serious candidate for representing population global health status, deriving from illness consequences which are taken into consideration in a single indicator.

Figures 1B, 2B, 3B and 4B, Appendix B, present the relationships between different DALY indicators and traditional health measures (Life expectancy, Infant Mortality Rate and Child Mortality Rate) as well as GDP per capita. It appears clearly that even though there is a tight association between DALYs and traditional health indicators, the correlation between them is far from perfect.

2. Relationship between health and growth

This paper builds on the idea of health being a capital: people are endowed an initial stock which can depreciate through time with age but which is the subject of investments (Grossman, 1972; see Mwabu, 2007 for a literature review on the concept of health capital).

[6] The DALYs for each health condition are the sum of the years of life lost (YLL) due to premature mortality and the years lost due to disability (YLD) for incident cases of the health condition. YLL are calculated from the number of deaths at each age multiplied by a global standard life expectancy for each age. YLD is the number of incident cases in a particular period × average duration of the disease × weight factor. The weight factor reflects the severity of the disease on a scale from 0 (perfect health) to 1 (death). For additional information, see WHO, http://www.who.int/healthinfo/global_burden disease/metrics_daly/en/.

From such a perspective, Van Zon and Muysken (2005) mention two positive effects of health on economic growth. First, the health status of population increases the efficiency of labour; second, human capital accumulation requires “health hours”. These effects add to those of Bloom and Canning (2000) who argue that improvements in longevity increase savings and in turn investments; moreover there exists a demographic dividend generated by a decline in child mortality. The effect of health on economic growth has also been the subject of theoretical investigations. One may refer to the augmented Solow model developed and tested by Mankiw et al. (1992). Other authors have included health in optimal Cass-Koopmans like growth models and thereby justified its inclusion in conditional convergence analyses as well: the productivity in the health sector has a positive impact on all steady state variables (Muysken et al. 2003). At last, health investments are taken into account in endogenous growth models *à la Lucas* (1988) with two characteristics: health is produced with decreasing returns whereas human capital is built with increasing returns. Health can either be a complement or a substitute to growth when the effect of health on longevity is internalised (van Zon & Muysken, 2001). Neo-schumpeterian growth models also allow identifying several channels through which population health impacts their long run growth performance. One of these channels puts forward the ability of health improvements to stabilise the gap in living standards relatively to technology leaders (Howitt, 2005).

If at a micro-level, empirical studies found that poor health has an economic effect through several channels (e.g. Audibert 2010), this effect is less evident at a macro-level. The Preston’s curb (1975) establishes an upward shifting relationship between life expectancy and national income per capita between 1900 and 1960. This correlation however neither gives pieces information on the sense of the causality nor on the different channels through which health may impact economic growth.

These channels may be identified. The first is that healthier people are more productive and supply labour more efficiently. Indeed, they can work harder and longer, and think more clearly. Health status may also improve economic outcomes through its effect on education. Improvements in health raise the motivation to attend high level schooling, since the returns to investments in schooling are valuable over a longer working life. Healthier children and students also have more attendance and higher cognitive functioning, and thus receive a better education for a given level of schooling. Furthermore lower mortality rates and higher life expectancy encourage savings for retirement, and thus raise investment levels and capital per worker. Table A8 in Appendix A gives a synthesis of some of the main studies that explored the connection between health and economic prosperity. We discuss here some major results.

Some scholars assess empirically how health indicators may influence economic returns in a specific region using individual or household data while others measure the same effect at more aggregated level, between countries or regions. All these studies could be divided according to the health indicators considered. Indeed, a number of studies utilize health inputs whereas others used health outcomes. Health inputs are the physical factors that influence an individual's health and comprise nutrition variables, exposure to pathogens, and the availability of medical care (Weil, 2007). Health outcomes are related to the health status of an individual or a given population. These include health indicators broadly considered such as life expectancy, mortality indicators, the ability to work hard, and cognitive functioning as well as specific illness prevalence such as malaria, AIDS/HIV, Guinea worm, etc.

Researchers generally conclude that population health remains an important predictor of economic outcomes. Life expectancy at birth positively impact economic performances (Barro & Lee, 1994; Cuddington & Hancock, 1994; Barro & Sala-I-Martin, 1995; Barro, 1996; Sach & Warner, 1997; Bloom & Malaney, 1998; Bloom et al., 2000, 2005, 2009; Arora, 2001; Acemoglu & Johnson, 2007, 2009). Bloom et al. (2004) show that life expectancy has a positive, sizable, and statistically significant effect on aggregate output even when experience of the workforce is controlled for. Sala-i-Martin et al. 2004 departing from the numerous potential explanatory variables in cross-country growth regressions, implement a model selection criterion. The set of explanatory variables which emerges from the analysis includes human capital variables and more especially life expectancy at birth. Acemoglu and Johnson's results (2007) are less conclusive with results indicating that increases in life expectancy have no significant effect on output per capita.[7]

Mortality or survival variables are also used in the literature as overall health outcome indicators that impact economic growth (Hamoudi & Sachs, 1999; Bhargava et al. 2001; Weil, 2007; Lorentzen et al. 2005). Using cross-national and sub-national data, Lorentzen et al. (2005) argue that high adult mortality rates reduce economic growth by shortening time horizons since they favour riskier behaviours, higher fertility rates, and lower investments in physical capital. Other authors are interested in the impact of specific diseases on economic

[7] Even though, Bloom, Canning & Fink (2009) disagree with their results, Acemoglu and Johnson still maintained their position in their 2009 paper.

returns. In fact, many diseases like HIV/AIDS and malaria are found to have a negative effect on the economy (Cuddington & Hancock, 1994; Gallup & al, 1999; Bonnel, 2000; Gallup & Sachs, 2001; Sachs, 2003; Bell, Devarajan and Gerbasch 2003; McDonald & Roberts, 2006; Audibert *et al.*, 1998, 1999, 2003, 2006, 2009). McDonald & Roberts (2006) have calculated that the elasticity of economic growth to HIV/AIDS prevalence in Africa is -0.59. Carstensen & Gundlach (2006) found that malaria prevalence causes quantitatively important negative effects on income even after controlling for institutional quality. Wiping out malaria from sub-Saharan Africa could increase that continent's per capita growth rate by as much as 2.6% a year (Gallup and Sachs, 2001).

The results of the literature on the effect of poor health on economic growth are not clear-cut, some authors finding a negative and significant effect, while others did not. The fact that traditional health measures (prevalence, incidence, mortality rate, life expectancy at birth) do not give a good indication of the disease burden, may explain that. By including diseases that cause early death but little disability such as diseases that do not cause death but do cause disability, the DALY gives a good indication of the disease burden (WHO, 2008) whatever the main causes of this burden.[8]

3. Empirical framework

The analysis of the effect of health on economic growth is based on the augmented neoclassical growth equation, which includes the global health status variable as a regressor combined with initial GDP per capita as catch up variable and other exogenous variables.

$$y_i = \alpha + \beta Health_i + \mathbf{X}'_i\delta + \epsilon_i$$

Where y_i is the annual growth rate of GDP per capita with subscript i designating the country; $Health_i$ is the global health indicator; $\mathbf{X}_i$ is the matrix of the k control variables and ε_i is the independently and identically distributed error terms; α, β and δ are parameters to be estimated. Regional dummy variables are included to control for regional specific effects.

3.1. Data and variables

DALYs are available on the 2000-2004 period for 153 WHO member states (see countries' list in Table A6). y_i is thus the annual average growth rate on the 2000-2004 period; control

[8] 70% of the disease burden is from communicable diseases in Africa, 70% is from non-communicable diseases in high income countries while the part of communicable and non-communicable diseases is equal in middle-income countries (WHO, 2008).

variables are average values over the same period. DALYs per capita at the country level are not available on the whole period. DALYs are available for each WHO country (*country DALY*) in 2002 and 2004; and from 2000 to 2002 and 2004 at a regional level according to the WHO's classification (*regional DALY*). In order to have comparable periods, we have several opportunities.

First we can use country DALYs in 2002 or in 2004 (*DALY 2002*; *DALY 2004*) assuming that the figures are representative of the health status over the period under study (Columns 1 and 2 in Table 1). Second, we can also use the average country DALY value, calculated with the 2002 and 2004 data (*DALY 2002-2004,* Column 3 in Table 1). Third, we calculate a *corrected DALY*. Under the hypothesis that the gap between the DALY of a country and the DALY of the WHO region is constant on the 2000-2004's period, the regional DALY is weighted by the ratio of the 2004 country level DALY over the 2004 regional DALY (Column 4 in Table 1). It allows generating DALY at the country level over the whole period and then generates the average value for DALYs. More precisely:

$$Corrected\ Daly\ in\ t = Regional\ DALY\ in\ t \times \frac{Country\ DALY\ in\ 2004}{Regional\ DALY\ in\ 2004} \text{ with }$$
$$t = 2000, 2001, 2002, 2004$$

The causes of the disease burden differ according to income levels (see footnote 8). This characteristic is taken into account while calculating DALYs with respect to communicable diseases and to non-communicable diseases as well. Finally as malaria and HIV/AIDS constitute respectively a large part of the disease burden in low income countries, and are the fifth main diseases in the world (WHO, 2008), DALYs with respect to both diseases are also considered in the econometric analysis.

We consider several control variables **X**, which are either assumed from the theoretical model or inferred from other cross-country analyses of Solow augmented growth regressions. Initial GDP per capita allows considering conditional convergence when it exhibits a negative effect on growth; annual growth rates of population and investment ratio to GDP have resp. a negative and positive effect on growth (e.g. Mankiw et al. 1992). In addition to the global health indicator, other human capital variables are included. Lagged female school enrollment rates are preferred to male school enrollment as it may also reflect the inequality level that has an impact on growth. Lagged variables may cope with endogeneity bias.

Our second group of control variables includes the Government consumption ratio to GDP, openness and inflation rates. The government consumption does not have a clear-cut effect on growth (Barro, 1992). Openness and inflation allows taking economic policy variables with resp. a positive and a negative effect on growth. A variable taken from Kaufmann and al. (2009) allows including institutional quality which positively affects growth.

Summary statistics are reported in Table A1 and A2, Appendix A.

3.2. Econometric specification

OLS estimation of equation (1) is potentially biased. First there can be a simultaneity bias between global health status and growth (e.g. Bonnel 2000; Bloom, Canning and Malaney 2000; Sachs et al. 1999, 2003; Strauss and Thomas, 2008; Schultz, 2008). Under the hypothesis that faster growing economies have a better health outcome, OLS estimates of health effects on growth are positively biased. Measurement errors of the global health indicator may also induce downward biased estimators (attenuation bias). To deal with these problems, we draw on instrumental variables techniques and therefore several instruments.

The first is malaria ecology developed by Kiszewski et al. (2004) and first used in cross-country regressions by Sachs (2003) and Carstensen and Gundlach (2006). Malaria ecology is built upon climatic factors and specific biological properties of each regionally dominant malaria vector which only reflects the forces of biological evolution and is thus independent from present health interventions and economic conditions. Moreover germs likely to be affected by economic conditions or public health interventions (like mosquito abundance, for example) do not enter the calculation of the index (Kiszewski et al. 2004; Carstensen and Gundlach 2006).

The other instrument used in this paper is the proportion of each country's population threatened by a risk of malaria transmission in 1994 (Sachs 2003). This indicator affects current economic growth only through health status and is unlikely affected by current economic conditions.

4. Econometric results

Equation (1) is estimated with the heteroskedastic-efficient two-step generalized method of moments (IV-GMM) estimator which generates efficient coefficients as well as consistent standard errors estimates. The efficiency gains of this estimator relative to the traditional

IV/2SLS estimator derive from the use of the optimal weighting matrix, the over-identifying restrictions of the model, and the relaxation of the independently and identically distributed (i.i.d.) assumption. For an exactly-identified model, the efficient GMM and traditional IV/2SLS estimators coincide, and under the assumptions of conditional homoskedasticity and independence, the efficient GMM estimator is the traditional IV/2SLS estimator (Hayashi 2000 pp.206-13 and 226-27; Baum et al. 2007).

4.1. Results

Our results stress that health status is an important predictor of economic development on a large sample of poor and rich countries. Efficient-GMM estimations are presented in Table 1 below. The quality of the instruments is either validated by the Shea R^2, or the statistic of Fisher and the Hansen over-identification test of the first stage estimation results presented in Table A4 (Appendix A).

The effect of DALYs due to HIV/AIDS on economic development is not estimated for two reasons. First, we did not find a valid and relevant instrument for HIV/AIDS. The instrument used in the literature is the lagged HIV/AIDS variable (McDonald and Roberts, 2006) and we do not have relevant data for that. The second reason is that HIV/AIDS is always associated to co-infections that enter into the group of communicable and non-communicable diseases such as tuberculosis, hepatitis C, liver disease (see for example Sharifi-Mood and Metanat, 2006; Amin et al. 2004). We may thus suppose that the effect of HIV/AIDS may be caught by communicable and non-communicable DALYs.

The first four columns report estimates with a global health indicator. Contrary to OLS estimates,[9] *Health* is found to have a negative and statistically significant effect on economic growth thus validating the attenuation bias. This result is robust to variants of DALYs (columns 1 to 4). The marginal effect of DALY on growth is significant whatever its calculation (Table 1). Contrary to what expected, the coefficient and then the effect of DALYs for communicable diseases (Column 5) are not different to that of global DALYs. It may reflect the importance of communicable diseases in health status in the world and as a barrier to economic development. Malaria has however a strong negative effect on economic growth: the coefficient of DALYs for malaria is higher (-0.365) than the coefficients of

[9] OLS estimates of equation (1) are reported in Table A3, Appendix A.

global DALYs or communicable DALY, also indicating that malaria is one among other health main causes.

These results are in conformity with some important previous works. Moreover, the other explanatory variables present the expected signs apart from the population growth rate and the education variable. The convergence hypothesis is not rejected, inflation rate reduces economic growth and investment rate improves it. We also found that Government spending is negatively related to economic growth (Landau, 1983). As found in the literature (Knowles and Owen 1994, Berthélemy *et al*. 1997), education is not significant.

Table 1. Two-step GMM estimation of economic effects of DALYs per capita

	Dependent variable: GDP per capita growth						
Independent variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DALY in 2002	-0.111**						
	(2.47)						
DALY in 2004		-0.108**					
		(2.55)					
DALY 2002-2004			-0.110**				
			(2.53)				
Corrected DALYs				-0.108***			
				(2.61)			
Communicable DALY					-0.119***		
					(2.64)		
Infectious DALY						-0.157**	
						(2.54)	
Malaria DALY							-0.365**
							(2.36)
Log initial GDP per capita	-0.010***	-0.008**	-0.009**	-0.009***	-0.009**	-0.008**	-0.005*
	(2.61)	(2.49)	(2.57)	(2.59)	(2.56)	(2.44)	(1.74)
Investment ratio to GDP	0.127***	0.105***	0.116***	0.102**	0.110***	0.123***	0.129***
	(3.71)	(2.58)	(3.13)	(2.54)	(2.86)	(3.27)	(3.38)
Population growth rate	0.002	0.002	0.002	0.002	0.003	0.002	0.004*
	(0.55)	(0.87)	(0.71)	(0.82)	(1.31)	(0.60)	(1.77)
Government consumption	-0.108***	-0.119***	-0.114***	-0.117***	-0.117***	-0.111***	-0.134***
	(2.94)	(3.26)	(3.12)	(3.21)	(3.14)	(3.02)	(3.76)
Openness	0.006	0.004	0.005	0.004	0.003	0.005	0.002
	(1.60)	(1.34)	(1.52)	(1.27)	(1.03)	(1.33)	(0.62)
Inflation rate	-0.018**	-0.018**	-0.018**	-0.016**	-0.014*	-0.009	-0.026**
	(2.13)	(2.29)	(2.22)	(2.04)	(1.91)	(1.09)	(2.10)
School enrolment lagged	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.97)	(1.21)	(1.09)	(1.18)	(1.06)	(0.35)	(1.25)
Institutions	-0.001	-0.003	-0.002	-0.002	-0.001	-0.000	-0.003
	(0.19)	(0.73)	(0.45)	(0.61)	(0.16)	(0.09)	(0.64)
Constant	0.147***	0.136***	0.141***	0.141***	0.127***	0.111***	0.080***
	(2.93)	(2.92)	(2.95)	(2.99)	(3.00)	(2.91)	(2.65)
Observations	138	138	138	138	138	138	138
R^2	0.345	0.396	0.380	0.393	0.410	0.374	0.411
Shea R2	0.146	0.232	0.190	0.208	0.191	0.157	0.483
Fisher F statistic	6.811	13.726	9.750	11.984	10.924	8.869	54.800
(p-value)	0.0016	0.0000	0.0001	0.0000	0.0000	0.0003	0.0000
Hansen OID p-value	0.467	0.481	0.470	0.624	0.764	0.708	0.274

Note: Health variables are instrumented by Malaria Ecology and Malaria Risk.
***significant at 1%, **significant at 5%, *significant at 10%. Robust t-statistics in parentheses.

4.2. Robustness analyses

Our previous results may still be questioned. First, they may be due to the large health outcome gap between developed and developing countries, and may not satisfactorily explain development levels gaps between developing or developed countries. Secondly, it is relevant to investigate the role of health in the explanation of development differential within countries which share a common characteristic related to poor basic health infrastructures. Our growth regression is therefore estimated on a low and middle-income countries sub-sample of which results are presented in Table 2 and the first stage estimation results are presented in Table A5 Appendix A. They are similar to those obtained for the whole sample, namely, health remains an important determinant of economic growth. Coefficients are smaller than those previously obtained on the whole sample (0.083 against 0.108 for Corrected DALYs; 0.324 against 0.365 for Malaria DALYs).

These results suppose that there are other limiting global factors to growth other than health such as education quality which is not satisfactorily measured. We cannot show evidence of a complementarity between health and education which is probably the result of a poor measurement of education.

Table 2: Two-steps GMM estimation of economic effect of DALYs per capita, developing countries

	Dependent variable: GDP per capita growth						
Independent. variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DALY in 2002	-0.077**						
	(2.01)						
DALY in 2004		-0.084**					
		(2.07)					
DALY 2002-2004			-0.080**				
			(2.05)				
Corrected DALYs				-0.083**			
				(2.10)			
Communicable DALY					-0.091**		
					(2.05)		
Infectious DALY						-0.108**	
						(2.06)	
Malaria DALY							-0.324*
							(1.88)
Log initial GDP per capita	-0.008**	-0.008*	-0.008*	-0.008**	-0.008*	-0.007*	-0.005
	(1.98)	(1.91)	(1.95)	(1.97)	(1.95)	(1.86)	(1.44)
Investment ratio to GDP	0.128***	0.110**	0.119***	0.109**	0.117***	0.127***	0.124***
	(3.25)	(2.45)	(2.86)	(2.46)	(2.78)	(3.02)	(2.62)
Population growth rate	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.002
	(0.71)	(0.92)	(0.81)	(0.86)	(0.19)	(0.56)	(0.96)
Government consumption	-0.098***	-0.109***	-0.103***	-0.107***	-0.109***	-0.102***	-0.130***
	(2.66)	(2.90)	(2.80)	(2.86)	(2.85)	(2.76)	(3.21)
Openness	0.001	-0.001	0.000	-0.001	-0.001	-0.000	-0.001
	(0.15)	(0.10)	(0.04)	(0.15)	(0.18)	(0.06)	(0.21)
Inflation rate	-0.021**	-0.021**	-0.021**	-0.019**	-0.018**	-0.015*	-0.028*
	(2.14)	(2.17)	(2.16)	(2.04)	(1.98)	(1.67)	(1.94)
School enrolment lagged	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.70)	(0.93)	(0.81)	(0.88)	(0.72)	(0.15)	(1.01)
Institutions	0.002	0.001	0.002	0.001	0.002	0.003	0.002
	(0.52)	(0.18)	(0.36)	(0.21)	(0.45)	(0.60)	(0.35)
Constant	0.130***	0.134***	0.132***	0.137***	0.124***	0.104***	0.102***
	(3.11)	(3.05)	(3.09)	(3.08)	(3.13)	(3.24)	(2.90)
Observations	103	103	103	103	103	103	103
R^2	0.447	0.446	0.452	0.447	0.464	0.468	0.421
SheacR2	0.189	0.265	0.229	0.241	0.211	0.199	0.486
Fisher F statistic	7.748	13.360	10.178	11.784	10.090	9.725	48.174
(p-value)	0.0008	0.0000	0.0001	0.0000	0.0001	0.0002	0.0000
Hansen OID p-value	0.689	0.671	0.679	0.796	0.876	0.862	0.381

Note: Health variables are instrumented by Malaria Ecology and Malaria Risk.
***significant at 1%, **significant at 5%, *significant at 10%. Robust t-statistics in parentheses.

4.3. Effect of a standard deviation decrease of the DALYs on growth

In the previous subsection, we showed that population health measured by the global burden of disease has a negative impact on economic development. This result can be quantified by simulating the effect of a one standard deviation increase of the DALYs on economic growth. The first and third columns of Table 3 present respectively the change in economic growth due to one standard deviation decrease of the different measures of DALYs for the whole sample and that of developing countries. For the total DALYs and communicable diseases DALYs, the effect ranges from 0.44 to 0.50 percentage points on the whole sample and around 0.30 percentage points on the developing countries sample. More importantly, this health impact doubles for infectious diseases and is multiplied by ten for malaria DALYs. The second column of Table 3 shows the average economic growth level for the whole samples after experiencing one standard deviation decrease of the DALYs. The average economic growth changes from 4% to around 5.5%, and is even around 10% for malaria DALYs. A similar figure is observed for developing countries sample in the last column. This is largely due to high standard deviation of malaria indicator (around 0.154 against 0.062).

Table 3: Effect of a standard deviation decrease of the global burden of disease on economic growth

	Whole sample		Developing countries sample	
	Change (Δy)	Effect ($y+\Delta y$)	Change (Δy)	Effect ($y+\Delta y$)
DALY in 2002	0.00504	0,04537	0.00297	0,04547
DALY in 2004	0.00455	0,04488	0.00337	0,04587
DALY 2002-2004	0.00473	0,04507	0.00315	0,04565
Corrected DALYs	0.00442	0,04476	0.00324	0,04574
Communicable DALY	0.00534	0,04568	0.00405	0,04655
Infectious DALY	0.00976	0,05010	0.00566	0,04816
Malaria DALY	0.05630	0,09663	0.05609	0,09859

5. Concluding remarks

This article contributes to the debate on the relationship between health outcomes and economic performance by paying a particular attention to global health status measurement issues. We argue that, traditional health indicators such as life expectancy and mortality rates are inadequate to explain the overall health status in a population since they present many drawbacks and are devoted to a particular health problem. An accurate health indicator must measure the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability. This is what the disability-adjusted life year (DALY) proposed by the World Bank and WHO since 1993 tries to measure.

Several remarks can be drawn from our results. First, as the results were very similar whatever the estimation of DALYs used (corrected DALYs, country DALYs or regional DALYs), it appears that regional DALYs represent correctly the disease burden of each country inside the considered region. Estimating country DALYs each year does not seem to be necessary. Secondly we highlight and confirm the role of poor health in the economic development. This result has been showed by using a global health outcome which takes into consideration mortality, morbidity, and disability consequences of health as well. Thus, we estimated the effect of global health, and not only of a specific disease or disease fatal consequence. However, this indicator that can be calculated for a group of particular diseases such as communicable diseases, or for a specific disease, such as malaria, allowed us to estimate the economic burden of diseases that remain an important impediment to economic development especially in low income countries.

These results call for important and relevant policy recommendations, especially for the developing world. Given the low health status in poor countries, health issues represent a challenge rather than a handicap since it offers them more rooms and possibilities to boost their economic growth and reduce their poverty levels.

For this challenge to be transformed into an opportunity, accurate health policies should be implemented, such as efficient health spending. More attention should be paid to water and sanitation that are the main determinants of communicable diseases such as diarrheal diseases. International community should also help national health policy makers through their support and pressure. This could be done through increasing health sector assistance and the promotion of good institutions. Brain drain in health sector also should be transformed into brain gain through support to physicians from poor countries.

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6. Appendix A: Tables

Table A1: Variables characteristics and sources

	mean	min	max	Coef of Var.	Std error	Source
GDP. growth	0,04	-0,06	0,13	0,65	0,03	WDI
Corrected DALYs	0,27	0,10	0,83	0,65	0,17	WHO
DALY 2002-2004	0,27	0,10	0,89	0,66	0,18	WHO
DALY in 2002	0,28	0,10	0,95	0,68	0,19	WHO
DALY in 2004	0,26	0,10	0,82	0,64	0,17	WHO
Communicable DALY	0,13	0,004	0,64	1,30	0,17	WHO
Infectious DALY	0,08	0,001	0,56	1,47	0,12	WHO
Malaria DALY	0,01	0,00	0,09	1,95	0,02	WHO
Malaria Ecology	3,86	0,00	31,55	1,77	6,85	Sachs 2003
Malaria Risk	0,37	0,00	1,00	1,18	0,44	Sachs 2003
Investment ratio to GDP	0,21	0,08	0,57	0,33	0,07	WDI
Population growth rate	1,38	-1,10	7,07	0,86	1,20	WDI
Government consumption	0,16	0,05	0,53	0,40	0,07	WDI
Openness	0,86	0,22	2,68	0,48	0,42	WDI
Inflation rate	0,10	-0,01	2,03	2,36	0,23	WDI
School enrollment	100,77	36,53	144,52	0,17	16,75	WDI
rule of law	-0,05	-1,90	2,01	-19,93	0,96	Kaufmann Kraay

Table A2: Correlation between the main variables

	GDP Growth	Corrected DALYs	DALY 2002-2004	DALY in 2002	DALY in 2004	Communicable DALY	Infectious DALY
Corrected DALYs	0,005	1,00					
DALY 2002-2004	0,03	0,99*	1,00				
DALY in 2002	0,03	0,97*	0,99*	1,00			
DALY in 2004	0,03	1,00*	0,99*	0,97*	1,00		
Commun. DALY	-0,02	0,99*	0,98*	0,97*	0,98*	1,00	
Infectious DALY	-0,08	0,95*	0,96*	0,95*	0,94*	0,97*	1,00
Malaria DALY	0,03	0,84*	0,83*	0,80*	0,84*	0,84*	0,78*

Table A3: OLS estimation of the economic effects of health status

	Dependent variable: GDP per capita growth						
Independent. variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DALY in 2002	-0.013						
	(0.49)						
DALY in 2004		-0.019					
		(0.60)					
DALY 02-04			-0.016				
			(0.54)				
Corrected DALYs				-0.023			
				(0.81)			
Communicable DALY					-0.034		
					(1.20)		
Infectious DALY						-0.044	
						(1.43)	
Malaria DALY							-0.183
							(1.62)
Log initial GDP per capita	-0.004	-0.004	-0.004	-0.005*	-0.005**	-0.005*	-0.005*
	(1.55)	(1.57)	(1.56)	(1.72)	(1.99)	(1.98)	(1.85)
Investment ratio to GDP	0.119***	0.116***	0.118***	0.115***	0.114***	0.117***	0.116***
	(3.71)	(3.64)	(3.69)	(3.61)	(3.59)	(3.62)	(3.54)
Population growth rate	0.005*	0.005**	0.005**	0.005**	0.006**	0.005*	0.006**
	(1.96)	(2.02)	(1.99)	(2.01)	(2.16)	(1.93)	(2.36)
Government consumption	-0.088***	-0.089***	-0.089***	-0.089***	-0.091***	-0.091***	-0.100***
	(2.84)	(2.81)	(2.82)	(2.81)	(2.80)	(2.86)	(2.97)
Openness	0.004	0.004	0.004	0.004	0.004	0.004	0.003
	(1.26)	(1.19)	(1.23)	(1.17)	(1.07)	(1.14)	(0.93)
Inflation rate	-0.025**	-0.025**	-0.025**	-0.024**	-0.023**	-0.021**	-0.026**
	(2.46)	(2.40)	(2.43)	(2.36)	(2.36)	(2.34)	(2.31)
School enrolment lag	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.28)	(0.34)	(0.31)	(0.40)	(0.45)	(0.28)	(0.62)
Institutions	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004
	(1.19)	(1.21)	(1.19)	(1.18)	(1.02)	(1.05)	(0.98)
Constant	0.051*	0.055*	0.053*	0.060**	0.064***	0.058***	0.060***
	(1.76)	(1.82)	(1.77)	(2.10)	(2.65)	(2.83)	(2.62)
Regional dummies	yes	yes	yes	yes	yes	yes	yes
Observations	153	153	153	153	153	153	153
R^2	0.378	0.380	0.379	0.382	0.389	0.391	0.388

Note: ***significant at 1%, **significant at 5%, *significant at 10%. Robust t-statistics in parentheses.

Table A4: first stage estimation results (whole sample) ++

	(1) DALY 2002	(2) DALY 2004	(3) DALY 02-04	(4) Corr. DALY	(5) Comm. DALY	(6) Infect. DALY	(7) Mal. DALY
Malaria Ecology	0.006**	0.006**	0.006**	0.005*	0.004	0.003*	0.002***
	(2.16)	(2.43)	(2.36)	(1.97)	(1.64)	(1.77)	(5.54)
Malaria Risk	0.084*	0.087**	0.085**	0.102**	0.104***	0.075**	0.015***
	(1.82)	(2.44)	(2.13)	(2.56)	(2.76)	(2.33)	(2.96)
Regional dummies	yes	yes	yes	yes	yes	yes	yes
Observations	138	138	138	138	138	138	138
Fisher F-Stat.	6.81	13.72	9.75	11.98	10.92	8.86	54.80
Shea partial R²	0.14	0.23	0.19	0.20	0.19	0.15	0.48
Hansen OID p-val.	0.46	0.48	0.47	0.62	0.76	0.70	0.27

Note: ***significant at 1%; **significant at 5%; *significant at 10%. t-statistics in parentheses.
++ We show only the coefficients of the instruments, but all the exogenous variables are included in the regressions

Table A5: first stage estimation results (Developing countries) ++

	(3) DALY 2002	(4) DALY 2004	(2) DALY 02-04	(1) Corr. DALY	(5) Comm. DALY	(6) Infect. DALY	(7) Mal. DALY
Malaria Ecology	0.006**	0.006**	0.006**	0.005**	0.004*	0.004*	0.002***
	(2.40)	(2.61)	(2.58)	(2.11)	(1.75)	(1.95)	(5.36)
Malaria Risk	0.123**	0.110***	0.117***	0.128***	0.125***	0.104***	0.015**
	(2.44)	(2.97)	(2.72)	(3.14)	(3.08)	(2.90)	(2.50)
Regional dummies	yes	yes	yes	yes	yes	yes	yes
Observations	103	103	103	103	103	103	103
Fisher F-Stat.	7.74	13.36	10.17	11.78	10.09	9.72	48.17
Shea partial R²	0.19	0.26	0.23	0.24	0.21	0.20	0.48
Hansen OID p-val.	0.69	0.67	0.68	0.79	0.87	0.86	0.38

Note: ***significant at 1%; **significant at 5%; *significant at 10%. t-statistics in parentheses.
++ We show only the coefficients of the instruments, but all the exogenous variables are included in the regressions

Table A6: List of countries

Low-income		**Lower-middle-income**		**Upper-middle-income**		**High-income**
Benin		Albania		Argentina		Bahrain
Burkina Faso		Algeria		Belarus		Estonia
Burundi		Armenia		Belize		Israel
Cambodia		Azerbaijan		Botswana		Kuwait
Central African Republic		Bhutan		Brazil		Malta
Chad		Bolivia		Bulgaria		Oman
Comoros		Cameroon		Chile		Slovenia
Congo, Dem. Rep.		Cape Verde		Costa Rica		Trinidad and Tobago
Cote d'Ivoire		China		Croatia		United Arab Emirates
Eritrea		Colombia		Dominica		Australia
Ethiopia		Congo, Rep.		Fiji		Austria
Gambia, The		Djibouti		Gabon		Belgium
Ghana		Dominican Republic		Grenada		Canada
Guinea		Ecuador		Jamaica		Czech Republic
Guinea-Bissau		Egypt, Arab Rep.		Kazakhstan		Denmark
Kenya		El Salvador		Latvia		Finland
Kyrgyz Republic		Georgia		Libya		France
Liberia		Guatemala		Lithuania		Germany
Madagascar		Guyana		Malaysia		Greece
Malawi		Honduras		Mauritius		Hungary
Mali		India		Mexico		Iceland
Mauritania		Indonesia		Panama		Ireland
Mozambique		Iran, Islamic Rep.		Poland		Italy
Nepal		Jordan		Romania		Japan
Niger		Lesotho		Russian Federation		Korea, Rep.
Nigeria		Macedonia, FYR		Seychelles		Luxembourg
Pakistan		Maldives		South Africa		Netherlands
Rwanda		Moldova		St. Kitts and Nevis		New Zealand
Sao Tome and Principe		Mongolia		St. Lucia		Norway
Senegal		Morocco		St. Vincent and the Grenadines		Portugal
Sierra Leone		Namibia		Suriname		Slovak Republic
Tajikistan		Nicaragua		Turkey		Spain
Tanzania		Paraguay		Uruguay		Sweden
Togo		Peru		Venezuela, RB		Switzerland
Uganda		Philippines				United Kingdom
Uzbekistan		Sri Lanka				United States
Vietnam		Sudan				
Yemen, Rep.		Swaziland				
Zambia		Syrian Arab Republic				
Zimbabwe		Thailand				
		Tonga				
		Tunisia				
		Ukraine				

Table A7: Literature review on the effect of health on economic growth

Study	Health indicator	Coefficient (standard error)	data	Estimator	Other covariates
Barro and Lee (1994)	Life expectancy	0.073 (0.013)	Two periods n=85 for 1965–75, n=95 for 1975–85	SUR with country random effects	Male and female secondary schooling, I/GDP, G/GDP, log(1+black market premium), revolutions
Cuddington and Hancock (1994)	AIDS	0.2- 0.3% points lost in the medium case and 1.2-1.5 in the lower case	Each five year age cohort from 1985-2010 in Malawi	simulation	Na
Barro and Sala IMartin (1995)	Life expectancy	0.058 (0.013)	Two periods n=87 for 1965–75, n=97 for 1975–85	SUR with country random effects	Male and female secondary and higher education, log(GDP) · human capital, public spending on education/ GDP, investment/GDP, government consumption/GDP, log(1+black market premium), political instability, growth rate in terms of trade
Barro (1996)	Life expectancy	0.042 (0.014)	Three periods 1965–75, n=80; 1975–85, n=87; 1985–90, N=84	3SLS using lagged values of some regressions as instruments, period random effects	Male secondary and higher schooling, log(GDP) · male schooling, log fertility rate, government consumption ratio, rule of law index, terms of trade change, democracy index, demo- cracy index squared, inflation rate, continental dummies
Caselli, Esquivel, and Lefort (1996)	Life expectancy	-0.001 (0.032)	25-year panel at 5-year intervals, 1960–85, n=91	GMM (Arellano- Bond method)	Male and female schooling, I/GDP, G/GDP, black market premium, revolutions
Sachs and Warner (1997)	Life expectancy	45.48 (2.60)	25-year cross-section, N=79	OLS	Openness, openness xlog(GDP), land-locked, government saving, tropical climate, institutional quality, natural resource exports, growth in economically active population minus population growth
	life expectancy squared	-5.40 (2.41)			

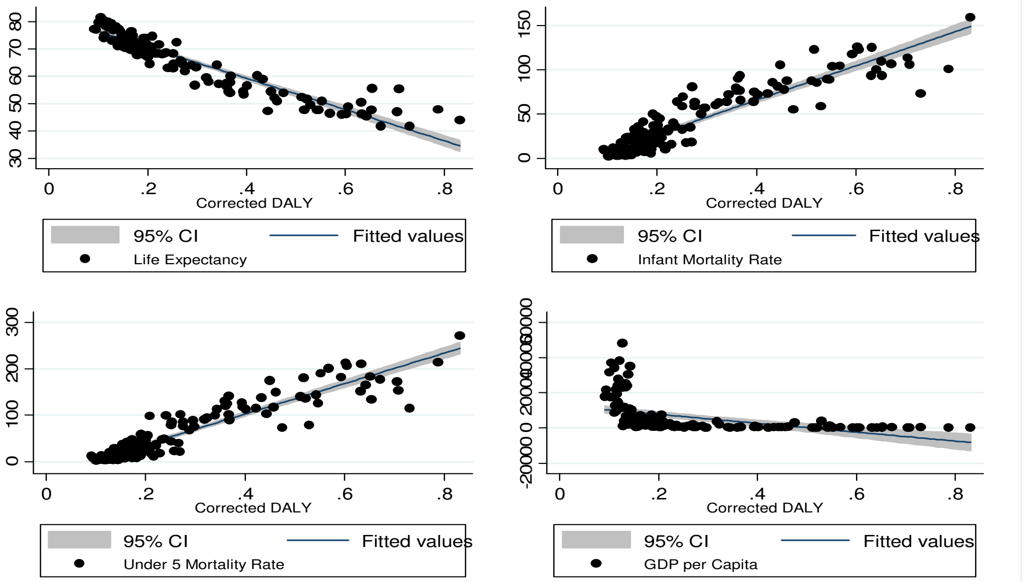
Study	Health indicator	Coefficient (standard error)	data	Estimator	Other covariates
Bloom and Sachs (1998)	Life expectancy	0.037 (0.011)	25-year cross-section, 1965–90, n=65	OLS	Log secondary schooling, openness, institutional quality, central government deficit, percentage area in tropics, log coastal population density, log inland population density, total population growth rate, working- age population growth rate, Africa dummy
Bloom and Malaney (1998)	Life expectancy	0.027 (0.107)	25-year cross-section, 1965–90, n=77	OLS	Population growth, growth of economically active populations, log years of secondary schooling, natural resource abundance, openness, institutional quality, access to ports, average government savings, tropics, ratio of coastline distance to land area
Bloom and Williamson (1998)	Life expectancy	0.040 (0.010)	25-year cross-section, 1965–90, n=78	OLS	Population growth rate, working-age population growth rate, log years of secondary schooling, natural resource abundance, openness, institutional quality, access to port, average government savings rate, tropics dummy, ratio of coastline to land area
Gallup, Sachs. and Mellinger (1999)	life expectancy	2.4 (1.34)	25-year cross-section, 1965–90, n=75	2SLS with malaria index instrument by temperate (temperate, boreal, and polar eco-zones), desert (tropical and subtropical deserts), subtropical (non desert subtropical), and tropical (non desert tropical)	Years of secondary schooling, openness, quality of public institutions, population within 100 kilometers of the coast, malaria index in 1966, change in malaria index from 1966 to 1994
	Malaria index 1966	-2.6 (0.67)			
Hamoudi and Sachs (1999)	Life expectancy	0.072 (0.020)	15-year cross-section, 1980–95, n=78	OLS	Institutional quality, openness, net government savings, tropics land area, log coastal population density, population growth rate, working-age population growth rate, Africa dummy
	Infant mortality rate	-0.0002 (0.00008)			

Study	Health indicator	Coefficient (standard error)	data	Estimator	Other covariates
Bloom, Canning and Malaney (2000)	Life expectancy	0.019 (0.012)	25-year cross section, 1965–90, n=80	2SLS	Log of ratio of total population to working-age population, tropics, log of years of secondary schooling, openness, institutional quality, population growth rate, working age population growth rate
Bonnel (2000)	HIV/AIDS	-0.7% points per year	1990- 1997 African countries	OLS and 2SLS	Log GDP 1990, Log phone per capita, Macro rating, Law rating, Primary enrollment rate, Malaria morbidity and dummy
Ranis and Steward (2000)	Life expectancy	0.06 (0.016)	N=73 developing countries Cross country 1960-1992	2SLS using lagged values as instruments	change in the log of life expectancy 1962-82, gross domestic investment, income distribution, regional dummies,
Bhargava, Jamison, Lau, and Murray (2001)	Adult survival rate	0.358 (0.114)	25-year panel at 5-year intervals, 1965–90, n= 92	Dynamic random effects	Tropics, openness, log fertility, log (Investment/GDP)
	ASR xlog (GDPC)	-0.048 (0.016)			
Mayer (2001)	Probability of survival by age and gender groups	0,8 and 1,5%	Panel of 18 countries over 1975, 1980 and 1985	Granger-type causality tests	Schooling, investment, Government consumption and fertility
Gallup and Sachs (2001)	falciparum malaria index	-2.5 (0.71)	25-year cross-section, 1965–90, n=75	2SLS with the prevalence of 53 different Anopheles mosquito vectors in each country in 1952 as instrument	Years of secondary schooling, openness, quality of public institutions, population within 100 kilometers of the coast, malaria index in 1966, change in malaria index from 1966 to 1994
	life expectancy	3.0 (0.84)			
Arora (2001)	Stature at Adulthood, Life Expectancy	30- 40%	10 developed countries over the course of 100 to 125 years	Cointegration and Error-Correction	Na
Sachs (2003)	Malaria Risk	-1.43 (0.35)	Cross- country regression in 1995, N=101	2SLS with Malaria Ecology as instrument	rules of law
Bloom, Canning and Sevilla (2004)	Life expectancy	0.040 (0.019)	every 10 years from 1960 to 1990	Nonlinear two stage least squares with lagged as instrument	Capital, labor, Schooling, Experience, Technological catch-up coefficient, Percentage of land area in the tropics and Governance

Study	Health indicator	Coefficient (standard error)	data	Estimator	Other covariates
Aguayo-Rico, and Guerra-Turrubiates (2005)	Health services,	0,0021 (0.006)	N=104 panel 1970, 1980 and 1990	OLS	capital, labor, schooling, Environment
	Lifestyles	0.0016 (0.0002)			
	total health index	0.0015 (0.0001)			
Bloom and Canning (2005)	Adult survival rate	0.03 (0.009)	5 years panel from 1960 to 1995	OLS	capital, labor, schooling, Environment, Technological catch-up coefficient, Percentage of land area in the tropics, Openness, Percentage oft land within 100 kilometers of the coast, Ethno-linguistic fractionalization, Institutional quality
Lorentzen, McMillan and Wacziarg (2005)°	adult mortality rate	-8.564 (2.23)	cross-country 1960-2000	2SLS with malaria ecology, climatic factors and geographic characteristic as instruments	investment, education, Government consumption, openness, population, interstate battle death
	crude death rate	-145.765 (64.78)			
	infant mortality rate	-31.644 (6.92)			
Acemoglu and Johnson (2006)	Life expectancy	-1.43 (2.24)	Panel 1940-1980, N=234 and 47 countries	2SLS with predicted mortality, as instrument	Population, investment, education
Carstensen and Gundlach (2006)	Malaria risk	-1.31 (0.42)	Cross country of 45 countries	2SLS with malaria ecology as instrument	Institutional quality, climatic factors and geographic characteristic
McDonald and Roberts (2006)	HIV/AIDS	-0.59%	Panel of each five year from 1960 to 1998 for all countries.	2SLS with lagged as instruments and GMM	Income per capita, investment, population growth, schooling, proteins, malaria, infant mortality, life expectancy.
Weil (2007)	height, adult survival rates, and age at menarche	9.9-12.3% income variation explained by health	cross- country regression in 1996, N=73	2SLS with health inputs as instruments	investment, education

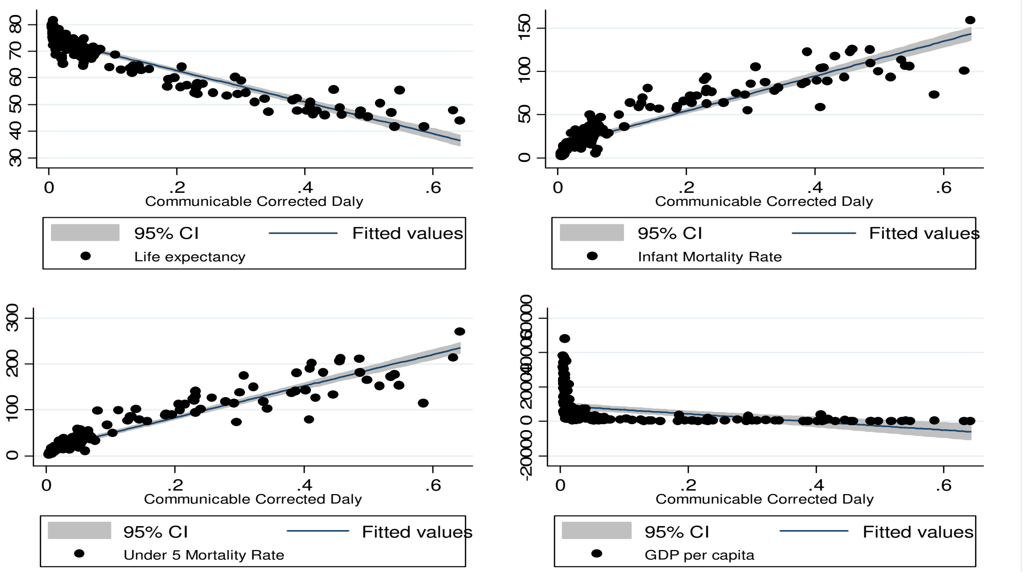
7. Appendix B: Figures

Figure 1B: Relationship between Corrected DALY, traditional health indicators and GDP per capita.



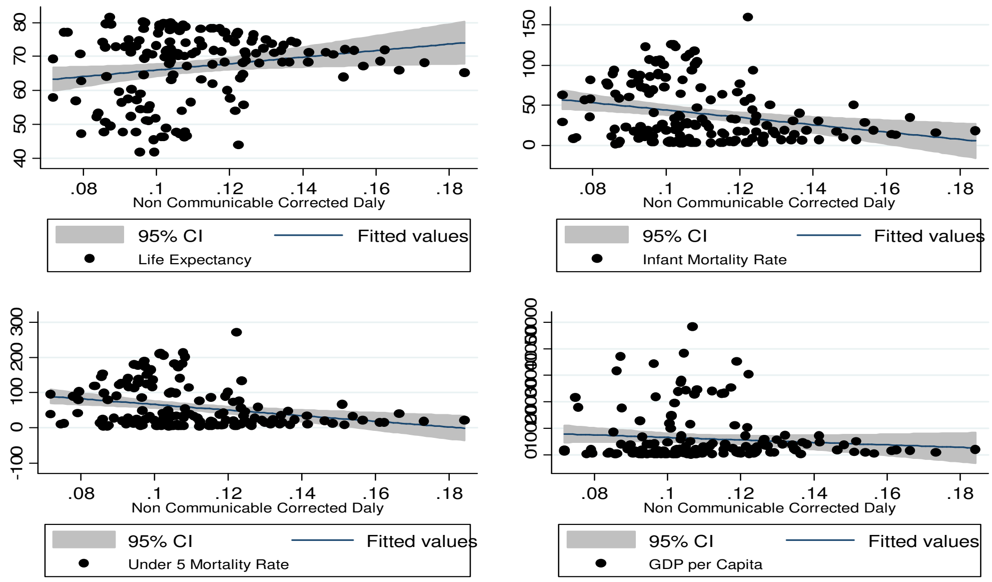
Source: Authors' construction with data from World Bank and WHO.

Figure 2B: Relationship between Communicable Corrected DALY, traditional health indicators and GDP per capita.



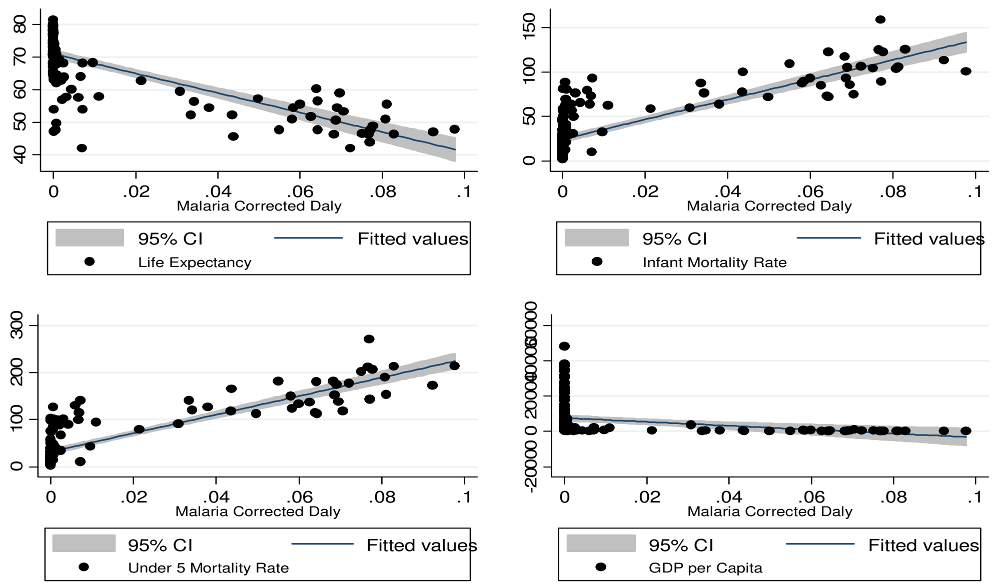
Source: Authors' construction with data from World Bank and WHO.

Figure 3B: Relationship between Non Communicable Corrected DALY, traditional health indicators and GDP per capita.



Source: Author's construction with data from World Bank and WHO.

Figure 4B: Relationship between Malaria Corrected DALY, traditional health indicators and GDP per capita.



Source: Authors' construction with data from World Bank and WHO.