The Best Things in Life are (Nearly) Free: Technology, Knowledge, and Global Health

Ursula Casabonne and Charles Kenny

Abstract

Casabonne and Kenny argue that two major factors underlie improved global health outcomes: first, the discovery of cheap technologies that can dramatically improve outcomes; second, the adoption of these technologies, thanks to the spread of knowledge. Other factors have played a role. Increased income not only allows for improved nutrition, but also helps to improve access to more complex preventative technologies. Institutional development is a second key to the spread of such complex technologies. Nonetheless, evidence of dramatic health improvements even in environments of weak institutions and stagnant incomes suggests that the role of these factors may be secondary.

Keywords: health, technology, institutions, income

Center for Global Development
www.cgdev.org

Working Paper 252
May 2011

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The authors thank Michael Clemens for advice and assistance with data, a Center for Global Development brown bag lunch seminar for helpful advice and comments, and four anonymous reviewers for suggestions that have considerably strengthened the article. Remaining errors are the authors'.

CGD is grateful for contributions from the William and Flora Hewlett Foundation and the Swedish Ministry of Foreign Affairs in support of this work.

Ursula Casabonne and Charles Kenny. 2011. "The Best Things in Life are (Nearly) Free: Technology, Knowledge and Global Health." CGD Working Paper 252. Washington, D.C.: Center for Global Development.
http://www.cgdev.org/content/publications/detail/1425144

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1. INTRODUCTION

Over the last one hundred years, the health of the World's population has improved far more than it did in all of the previous natural history of mankind. Global average life expectancy increased from around 31 years in 1900 to 66 by 2000 (Maddison, 2001). This improvement in health outcomes has been close to universal, affecting even the poorest of developing countries, so that there is strong evidence of a global convergence towards a life span above the biblical standard of three score and ten.

The paper suggests that there are two major factors underlying improved global health outcomes. These are, first, the discovery of cheap (and some free) technologies that can dramatically improve outcomes and, second, the adoption of these technologies thanks to the spread of knowledge. Other factors have played important roles. Increased income not only allows for improved nutrition, but also helps to improve access to more complex preventative technologies. Institutional development is a second key to the spread of such complex technologies. Nonetheless, evidence of dramatic health improvements even in environments of weak institutions and stagnant incomes suggests that the role of these factors may be secondary. These findings might suggest 'exogenous' models of development, very much out of fashion with regard to income growth, may still have a role in explaining the global health transition.

There is a large literature attempting to account for health performance across countries and over time. A number of determinants have been put forward and have been tested using cross-country and panel data sets as well as within-country analysis of survey evidence regarding individuals. The majority of them remain contested, however (see Kenny, 2009). The literature on the cross-country determinants of health may have hit declining marginal returns in the same way that the literature on the cross-country determinants of economic growth has --there is insufficient data to properly test potential determinants, and the list of potential determinants is long enough to suggest that, at least in some circumstances, almost anything can be connected to improved performance.[1]

This paper faces the same constraints on (quality) data availability as do other studies. It uses two major approaches in an attempt to relieve these constraints, involving both long-term growth datasets and a cross-quintile, cross-country dataset based on DHS survey data. Nonetheless, the results remain preliminary, partial and (surely) open to dispute.

2. LITERATURE REVIEW

The existing literature has provided considerable evidence for elements of the theory that technology and demand rather than income and institutions play the major role in determining health outcomes. This literature already suggests that at any one time there is a strong link between income and health within and across countries, but across time that link is weaker. It points to a strong trend towards global health, the finding that good health need not be expensive and that demand matters to the uptake of health technologies. The literature suggests a role for adoption curves in technology take-up as well as the potential influence of cultural and educational factors. It also suggests a role for health shocks –not least the spread of HIV— in determining health outcomes. This section outlines these 'stylized facts' in more detail.

(a) At any one time there is a strong link between income and health, but it is weak over time

Rich, well educated people and rich countries are usually first-adopters of new health technologies, with poor countries and households lagging behind. For example, household survey data suggests that, compared to the non-poor, the poor are less likely to see a doctor when sick, they have lower household access to tap water (2 percent in the lowest quintile compared to 63 percent in the richest quintile in rural Tanzania, for example) and lower access to latrines (Banerjee and Duflo, 2010).

This may help to account for the strong correlation between income and health at any one time. Evidence from 44 DHS surveys in 22 countries suggests that wealth is significantly negatively correlated with infant and child mortality (Deaton, 2006; see also Van de Poel et. al., 2007; Feng and Yu, 2007). Across economies, high-income countries see average life expectancies of 78 compared to 58 for low-income countries (World Bank 2006). And there is considerable evidence for a conditional relationship between income growth and health outcomes across and within a range of countries over time (Baird et. al., 2007; Pritchett and Summers, 1996; O'Donnell, Nicolas and van Doorslaer, 2009; Birchenall, 2007; Soares, 2007a).

Nonetheless, income growth and health growth are weakly correlated (Preston, 1975; Kenny, 2009; Easterly, 1999; McGuire, 2001; Szreter, 1997; and Deaton, 2004). Kenny (2009) suggests a negative, if statistically insignificant correlation between income growth and change in life expectancy 1913-1999 for a 27 country sample, and over 1975-2000 for a larger sample of countries, for example. And some of the remaining conditional correlation we do see between health and income change may well be due to reverse-causation –with improved health being a potentially significant factor behind faster growth (Chakraborty, Papageorgiou and Sebastian, 2005; Zhang and Zhang, 2005; Bloom and Canning, 2008; Jack and Lewis, 2009).[2]

(b) There is a trend to global health, which need not be expensive

Furthermore, there is a strong global trend towards improved health outcomes regardless of income, first noted by Preston (1975). Countries with a GDP per capita of $300 in 1999 have approximately the same life expectancy (46 years) as a country with an income of $3,000 in 1870. And countries rich and poor have seen dramatically improved health outcomes whether they have grown or not. For example, Kenny (2005) lists five negative-growth countries where incomes fell by an average of 18 percent over the period 1950-90 yet life expectancies increased in all of them, by an average of 40 percent.

Clemens, Kenny and Moss (2007) report how well a simple model of changes in infant and under-five mortality based on a common global pattern fits the data, suggesting a limited impact of different country circumstances on changes in health over time. Similarly, Riley (2005) points out the stability and homogeneity of the process of mortality reductions across countries in the post war period not just in terms of robustness to difference in income change but also other factors such as water and sanitation access and housing quality.

This evidence suggests that the basics of good health appear to be getting cheaper. There is also direct support for this conclusion. The same amount of nutrition is available at lower incomes than it used to be, in ways that are not fully reflected in purchasing power parity figures. The average America industrial worker in 1889 received nearly twice the income of a rural Indian in 1983 and yet a day's worth of calories (2,300) cost ten percent of the American's wage compared to five percent of the Indian's. This may help to explain the fact that rural Indians in 1983 consumed an average of nearly 500 more calories a day than an average American industrial worker in 1889 (Logan 2005).

Indeed, adequate calorific supply is possible at such low incomes that obesity is becoming a global epidemic, even in households with children reported as undernourished. Of households in Brazil, China and Russia with underweight members, 44%, 23% and 57%, respectively have an overweight member as well (Popkin, 2001). Even amongst the poorest people in Brazil, 24 percent are overweight compared to 4.5 percent underweight (Monasterio and Noguerol, 2005).[3]

Alongside nutrition, health care which allows for dramatically improved outcomes can also be provided at very low cost. The global decline in mortality over the past sixty years is surely linked to the spread of the yellow fever vaccine in the 1940s, of cheap antibiotics by the early 1950s, the use of DDT to spray houses in the 1940s and 50s and, more recently, the spread of a range of newer vaccines (Acemoglu and Johnson, 2007).[4] Between 1974 and 2000, the immunization rate for the six diseases of measles, diptheria, pertussis, tetanus, tuberculosis and polio increased from five to 80 percent of the world's newborns, thanks in considerable part to the United Nations' Expanded Program on Immunization (Soares, 2007b). Between 1999-2005 alone, the number of children who died annually from measles dropped by three quarters from over half a million to around 126,000.[5]

According to Boone and Zhan (2006), 20-40 percent of remaining child deaths in developing countries are neonatal, largely caused by sepsis and birth asphyxiation. The great majority of these deaths can be prevented through better delivery techniques and improved hygiene. Diarrhea, pneumonia and malaria are the main causes of death between the second week and the fifth year of life (between them accounting for 82 percent of deaths) and these can be prevented or cured using better hygiene, vector control, oral rehydration, antimalarials and antibiotics.[6]

As a result of cheap cures for common diseases, it is affordable for even very poor countries to provide health care services that help to dramatically improve health outcomes. The cost of a basic package of primary health services in rural areas ranged from US$2.82 per head per year in Cambodia to US$6.25 per head per year in Guatemala according to a recent survey. In all cases studied, the amounts represent less than 1% of the gross national income (Loevinsohn and Harding, 2005).

The apparent centrality of a few simple interventions to improved outcomes may help to account for the statistically weak influence of macro measures such as doctors per capita or health expenditure per capita on outcomes. Ranis and Stewart (2001) suggest that the link through education is the sole reason for a link between government social expenditures and life expectancy (see also Filmer, Hammer and Pritchett, 2000). Again, Younger (2001) finds that the number of doctors, nurses and hospital beds are not significantly related to changes in infant mortality (see also Federman * Levine, 2005; Leipziger et. al. 2005; Stewart, 1971; Hertz, Hebert and Landon 1994).[7] What may matter most is a limited level of targeted expenditure and a few well placed health professionals who can provide access to antibiotics, immunizations and maternal health services.[8]

Similarly, improvements in health have not required strong governance even if this undoubtedly helps at the margin. Measures of broad institutional quality have been linked with health outcomes (Stroup, 2006; Kiessling, 2007; Lake and Baum, 2001). At the same time, that countries rich and poor, institutionally strong and weak alike have all seen dramatic improvements in health suggests a limit to the role of institutions in determining outcomes as much as it does to income.

(c) The importance of the demand side

If wealth or even institutional fragility are not necessarily strongly significant barriers to health and yet the rich remain considerably healthier than the poor, this suggests a role for an adoption curve regarding new health technologies, with rich and educated people more likely to be first adopters while the poor and illiterate catch up over time (meanwhile the rich and educated are adopting the next technology in turn).

Evidence for an adoption curve attached to health technologies includes the 180 years that passed between Jenner's suggestion that smallpox could be eradicated and that event occurring worldwide –the inoculation and vaccination processes faced considerable popular resistance (Riley, 2001). And evidence that disadvantaged groups lag on adoption for non-monetary reasons includes that in India, scheduled caste and illiterate parents are less likely to seek immunization and antenatal services. These groups tend to be poorer, but the result is robust to the inclusion of income (Hazra et. al., 2006). It is not lack of resources but lack of demand for cheap interventions amongst poor people that may be one of the biggest barriers to improved health.[9]

The importance of the demand side to health outcomes can be further illustrated by the limited existing state of health knowledge in some developing countries and the dramatic returns to acceptance of simple techniques related to health and hygiene. Boone and Zhan (2006) use DHS survey data from 278,000 children in 45 low-income countries to find that the prevalence of common diseases that kill children has little predictive power for child mortality. Instead, they find that actions taken by parents to help sick children are the most important factors determining cross country differences in child survival. They estimate that improvements in treatment-seeking and education could reduce child mortality by roughly 32%. Boone and Zhan suggest, for example, that children whose mothers believed fluids should be reduced during diarrhea episodes faced a 15 percent greater risk of death than a child whose mother was better informed.[10] They find both father's and mother's education significant, while wealth, ethnicity and access to public health facilities were also important determinants of outcomes.[11] It is worth noting that education rates, like measures of health, have been rapidly converging worldwide (Kenny, 2005). They also follow a similar process of diffusion (Clemens, 2004).

Survey evidence also suggests that people in communities where general uptake of health services is low are less likely to seek immunization and antenatal services (Hazra et. al., 2006). Dearden et al. (2003) use data from DHS to find that educated mothers exposed to media are more likely to know that the correct response to diarrheal episodes is to increase liquid intake, but so are mothers in villages where other survey subjects also know the correct response (allowing for these factors, income plays a marginal role).[12]

The role of the demand side to outcomes is also made clear by the apparent success of a number of interventions that focus on demand-stimulation. One example of the role of knowledge-based interventions is the effort to stamp out open-field defecation in Bangladesh. Low access to latrines in rural Bangladesh (less than fifteen percent of households have access) combines with limited usage to make open-field defecation the overwhelmingly ubiquitous method in the country's rural areas. Existing aid-funded mechanisms to subsidize latrine construction appear to have had limited impact. An approach initially piloted with the support of the Village Education Resource Center involves community-led efforts to build latrines and eliminate open defecation. Facilitators help communities understand that as a result of open defecation people are 'in effect, eating their own faeces,' and provide ideas for design of low-cost latrines where necessary. Communities, without subsidy, construct these latrines and motivate usage. The approach is reported to have completely stopped open-field defecation in as many as 2,000 Bangladeshi villages with considerable knock-on effects including dramatically reduced diarrhoea levels. A number of NGOs have adopted the approach including CARE, Plan and World Vision (Pasteur, 2005; Kar, 2003).

A number of studies confirm the importance of demand-stimulation. A randomized controlled trial in the slums of Karachi found that education and soap for improved hygiene reduced respiratory infections by 50 percent and diarrhea by 53 percent (Luby et. al., 2004). A study in Nepal found that neonatal mortality was reduced by 28 percent where intervention groups benefited from improved health knowledge alongside free care rather than free neonatal care alone (Wade et. al., 2006). At the level of states and municipalities in Brazil, Soares (2007a) reports that family health programs teaching management of diarrhea and respiratory infections as well as more general levels of basic education were important drivers of declines in child mortality over the last ten to thirty years.[13]

Additionally, conditional cash transfers (where patients are paid to receive treatment) are based on the model of stimulating demand for services. These have been part of programs to improve health outcomes in a range of countries, and have (inter alia) dramatically reduced default rates in tuberculosis rates (Beith, Eichler and Wiel, 2007) and sustainably increased attendance at clinics providing preventative health care (Regalia and Castro, 2007).[14]

(d) Health shocks also have a role to play

While work by Preston and since then has suggested the importance of a global trend in health improvements, there remains a role for health shocks. Botswana suggests both the fragility of the link between improvements in GDP per capita and health over time as well as the central role of the shock of AIDS to health outcomes. Between 1975-1990, the country's GDP per capita climbed nearly fourfold, from a little over $1,500 to $5,500 in one of the most impressive growth performances of any country in history. Over the same period, life expectancy climbed only six years, from 58 to 64. Ghana, which actually saw significantly negative income growth over the 1975-1990 period, still managed to increase life expectancy from 51 to 56 years – a similar percentage change. Over the period 1990-2005, Botswana's income per capita continued to expand, if at a slower rate –it reached $9,500. Life expectancy almost halved under the influence of the AIDS crisis, however, dropping to 35 years in 2005.[15]

3. EXAMINING HEALTH CHANGE OVER TIME

In the remainder of this paper, we hope to further examine the comparative role of global trends, income change, institutional factors and shocks in health improvement over time. We will also provide illustrative evidence of the role of technology and demand factors. To do this, this section uses a range of datasets covering historical change in health, while the next section uses a cross-quintile, cross-country dataset.

(a) Data

In order to examine the correlates with levels and changes in child health (under five mortality), we construct a dataset with a number of variables, from the World Development Indicators except where noted. Details are in Table 1. The dependent variables are the under-five mortality rate and its change 1975-2005. Independent variables are: real GDP per capita (listed as income) and its growth; initial (1975) child mortality; the percentage of children immunized against DPT in 2005; the prevalence of HIV in the population aged 15-49 in 2005; the percentage of the population that does not speak the official language of the country (reported as Gunn 1, from Easterly and Levine, 1997); initial female adult illiteracy and its change; and an index reflecting the level of democracy or autocracy in a country on a scale from -10 to +10 reported as Polity II. In the polity database, a score of +10 indicates a strongly democratic state; a score of -10 indicates a strongly autocratic state. A fully democratic government under the Polity database has three essential elements: fully competitive political participation, institutionalized constraints on executive power, and a guarantee of civil liberties to all citizens in their daily lives and in political participation.[16]

Table 1: 1975–2005 Dataset

	Average	Standard Deviation	Number
Log Child Mortality 1975	4.52	0.96	88
Log Child Mortality 2005	3.55	1.27	88
Log Income 1975	8.13	1.07	88
Log Income 2005	8.47	1.19	88
Income Change	0.34	0.52	88
Mortality Change	-0.96	0.55	88
Immunization, DPT (% of children ages 12-23 months) 2005	84.72	15.32	86
Prevalence of HIV, total (% of population ages 15-49) 2005	2.8	6.07	86
Gunn1	0.37	0.42	148
Female Adult Literacy, 1975	61.03	33.42	140
Female literacy (absolute) change	16.29	13.82	132
Polity score 1975	-2.15	7.49	131
Polity score (absolute) change	5.57	6.93	123

We do not have data on a number of simple interventions that are known to have a significant impact on outcomes –including hand-washing and water purification practices. Neither do we have measures covering the quality of interventions, itself a significant issue as we have seen. Given this, we do not expect our single (DPT immunization) technology/intervention variable to fully account for health outcomes, but hopefully it will at the least provide some evidence regarding the drivers of the spread of health-improving technologies and the importance of such interventions to outcomes. It is worth noting here that both our 'technology' measure (DPT immunization) and our 'shock' measure (HIV rates) are measured at period end. This raises concerns regarding endogeneity, discussed later in the paper.

Again, we do not have direct health knowledge indicators available at the cross-country level. We use Gunn 1 and female education as two proxy measures of the ease of information transfer. We would expect ethnolinguistic fractionalization to slow the transfer of health knowledge. Female education might be expected to speed knowledge transfer. It should be noted, however, that Gunn 1 has also been used as a proxy for institutional quality in numerous papers (not least Easterly and Levine, 1997). We use the Polity indicator as an alternate institutional variable in order to attempt to tease out the impact of institutions from the effect of knowledge transfer.

In order to further examine the role of global trends in determining outcomes, we have two more comprehensive decadal datasets regarding *infant* mortality, one for a sample of 34 largely wealthy countries 1930-2000 based on data from Clemens et al. (2007) (CKM in the tables) and one for a larger number of countries 1960-2000 based on World Development Indicators (WDI in the data tables). For comparison, we also have an additional dataset of under-five mortality and constant GDP per capita from World Development Indicators for 1960-2000. Table 2 describes the averages, standard deviations and sample sizes for these datasets.

Finally in this section, we have a dataset to better understand the national scale of the shock of the HIV epidemic (as measured by 2005 adult infection rates).   Table 3 describes the dataset, split into global, Sub-Saharan and Non-Sub-Saharan samples. 1975 is chosen as the 'pre-epidemic' level of health and institutional measures because the start date for the epidemic (when it reached levels of one percent of preganant women) was in the late 1970s in East Africa (Oster, 2005). Location (Sub Saharan Africa) and initial values of income (GDPPC) child mortality, female literacy, Gunn 1 and Polity II (all as described above) are used as independent variables.

It is worth noting data quality issues here. Not least, child and infant mortality data includes interpolations (Younger, 2001) while infant mortality is used to estimate under-five mortality and vice-verca. Official and survey-based estimates of infant mortality can vary by as much as two to four times, and even survey-based evidence is subject to reporting and classification errors. The recent cross-country infant and child mortality trends used in the analysis derive from Hill et. al. (1998), which in turn are based on weighted (by perceived accuracy) data largely

Table 2: Decadal Prediction Datasets

	1930	1940	1950	1960	1970	1980	1990	2000
CKM Infant Mortality Dataset								
Average	122	104	71	73	57	38	26	18
Standard deviation	51	47	38	51	42	33	24	18
N	34	32	30	34	34	35	35	35
WDI Infant Mortality Dataset								
Average				105	85	67	52	43
Standard deviation				61	55	48	43	40
N				157	158	176	191	190
WDI Child Mortality Dataset								
Average				165	131	102	78	66
Standard deviation				105	94	82	73	67
N				153	155	171	185	179
WDI Income Dataset								
Average				2799	4263	5170	5123	5972
Standard deviation				3821	6318	7374	7518	9070
N				101	117	141	173	181

Table 3: Correlates of HIV Prevalence Dataset

	2005 Prevalence of HIV, total (% of population ages 15-49)	Sub-Saharan Africa	Log 1975 GDP per capita	Log initial child mortality	Adult female literacy 1975	GUNN1	Polity Score 1975
All							
Average	2.08	0.26	8.30	4.56	60.52	0.37	-2.11
Standard deviation	4.92	0.44	1.07	0.91	33.37	0.41	7.54
Count	167	167	111	124	133	131	129
Sub-Saharan Africa							
Average	6.80		7.28	5.30	26.93	0.78	-5.34
Standard deviation	7.80		0.65	0.35	21.52	0.37	4.99
Count	44	44	31	37	32	42	41
Non- Sub-Saharan Africa							
Average	0.39		8.69	4.25	71.16	0.18	-0.60
Standard deviation	0.75		0.94	0.90	29.17	0.26	8.05
Count	123	123	80	87	101	89	88

Table 4: 1975-2005 Regression Results

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Dependent Variable	***Log child mortality rate 1975***	***Log child mortality rate***	***Child mortality growth 75-05***											
Constant	10.45	11.90	-0.84	-1.93	-1.62	-0.01	0.07	-0.09	-1.72	-0.77	-1.62	-1.972	-0.19	-0.36
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.98*	*0.87*	*0.82*	*0.00*	*0.30*	*0.00*	*0.00*	*0.66*	*0.39*
Log Income	-0.73	-0.99												
	0.00	*0.00*												
Initial mortality			0.21		0.17	0.08	0.01	-0.06	0.18	0.0214	0.18	0.25	-0.08	-0.05
			0.00		*0.01*	*0.20*	*0.82*	*0.21*	*0.05*	*0.86*	*0.01*	*0.00*	*0.27*	*0.48*
Income growth				-0.37	-0.28	-0.21	-0.22	-0.24	-0.18	-0.16	-0.28	-0.29	-0.20	-0.15
				0.00	*-0.01*	*-0.04*	*-0.01*	*0.00*	*-0.16*	*-0.22*	*-0.02*	*-0.01*	*-0.04*	*-0.12*
Immunization, DPT (% of children 12-23 months)						-0.01	-0.01	-0.01					-0.01	-0.01
						0.00	*0.00*	*0.00*					*0.01*	*0.03*
Prevalence of HIV, total (% of population 15-49)							0.05	0.04					0.04	0.04
							0.00	*0.00*					*0.00*	*0.00*
Gunn1								0.43					0.45	0.58
								0.00					*0.00*	*0.00*
Female adult literacy change									0.00				0.00	0.00
									0.88				*0.73*	*0.88*
Initial female adult literacy										-0.01				
										0.17				
Polity score change											-0.01			-0.01
											0.28			*0.22*
Initial polity score												0.02		
												0.10		
R -Square	0.67	0.84	0.12	0.14	0.20	0.32	0.55	0.65	0.14	0.16	0.19	0.22	0.62	0.66
Observations	88	88	88	88	88	86	86	82	75	75	83	85	72	70

Probabilities reported in italics.

from household surveys and censuses. More recent data is therefore likely to be more accurate, but even here quality concerns remain.

(b) Health, income and global trends

In 1975, variance in income correlated with as much as 67 percent of the variation across countries in (reported log) child mortality. This is perhaps a particularly impressive performance given the low quality of mortality data at the time. By 2005 the apparent relationship between income and child mortality had strengthened, with variance in income able to account for 84 percent of the variation across countries in child mortality (See Table 4).

A second feature worthy of note is that the predicted mortality for a given income has dramatically declined. The coefficients in Table 4 suggest that in 1975, predicted child mortality for a country with an income of $1,000 was 224. By 2005 it had dropped to 163. This is the global trend in improvement noted by Preston (1975).

Indeed, a considerable amount of the global change in mortality is accounted for by a process that appears to be similar across countries. The importance of such factors common across countries to global changes in health can best be illustrated by use of a very simple model. This predicts the log of mortality in period two based on the log of mortality in period one and a constant:

$$(\text{mortality})_{t1} = A^*(\text{ mortality})_{t0} + C$$

Using our 1975-2005 database (Table 4, third column), the log of initial level of child mortality is significantly related to a slower decline in child mortality over the next thirty years, but the strong significance of a numerically large constant coefficient suggests evidence of worldwide progress. And while the results presented here suggest *divergence* in ill health (child mortality), there is concurrent *convergence* in good health (child survival, life expectancy) (see Kenny, 2005 for a discussion). That convergence or divergence depends on one's choice of health versus ill-health indicators suggests that we should not be overly impressed with the significance of initial levels as a sign of some sort of 'health trap' –perhaps particularly because we will see it drops out of significance when other explanatory factors are entered.

As further evidence, the coefficient of variation (the standard deviation divided by the mean) for growth in mortality across countries 1975-2005 is 0.58, which is considered low variation. This compares, for example, to a coefficient of variation of income growth between 1975-2005 of 1.53 –considered high variation.

We also use our datasets regarding infant mortality to feed into this model. Table 5, lines 1 and 2 display the results. Both constant and coefficient are highly significant in both cases. And despite the very different data, the constant and coefficient values are very close using the

Table 4: 1975-2005 Regression Results

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Dependent Variable	***Log child mortality rate 1975***	***Log child mortality rate***	***Child mortality growth 75-05***											
Constant	10.45	11.90	-0.84	-1.93	-1.62	-0.01	0.07	-0.09	-1.72	-0.77	-1.62	-1.972	-0.19	-0.36
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.98*	*0.87*	*0.82*	*0.00*	*0.30*	*0.00*	*0.00*	*0.66*	*0.39*
Log Income	-0.73	-0.99												
	0.00	*0.00*												
Initial mortality			0.21		0.17	0.08	0.01	-0.06	0.18	0.0214	0.18	0.25	-0.08	-0.05
			0.00		*0.01*	*0.20*	*0.82*	*0.21*	*0.05*	*0.86*	*0.01*	*0.00*	*0.27*	*0.48*
Income growth				-0.37	-0.28	-0.21	-0.22	-0.24	-0.18	-0.16	-0.28	-0.29	-0.20	-0.15
				0.00	*-0.01*	*-0.04*	*-0.01*	*0.00*	*-0.16*	*-0.22*	*-0.02*	*-0.01*	*-0.04*	*-0.12*
Immunization, DPT (% of children 12-23 months)						-0.01	-0.01	-0.01					-0.01	-0.01
						0.00	*0.00*	*0.00*					*0.01*	*0.03*
Prevalence of HIV, total (% of population 15-49)							0.05	0.04					0.04	0.04
							0.00	*0.00*					*0.00*	*0.00*
Gunn1								0.43					0.45	0.58
								0.00					*0.00*	*0.00*
Female adult literacy change									0.00				0.00	0.00
									0.88				*0.73*	*0.88*
Initial female adult literacy										-0.01				
										0.17				
Polity score change											-0.01			-0.01
											0.28			*0.22*
Initial polity score												0.02		
												0.10		
R -Square	0.67	0.84	0.12	0.14	0.20	0.32	0.55	0.65	0.14	0.16	0.19	0.22	0.62	0.66
Observations	88	88	88	88	88	86	86	82	75	75	83	85	72	70

Probabilities reported in italics.

Table 5: Decade Regressions of Health and Income Against a Constant and Initial Values (in logs)

		Coefficients	*Standard Error*	*T Stat*	N	R
1	CKM Infant Mortality Decade Two 1940-2000 (decades, no decade dummies)					
	Intercept	-0.65	0.06	-10.8	228	0.96
	Decade One	1.08	0.02	71.4		
2	WDI Infant Mortality Decade Two 1970-2000 (decades, no decade dummies)					
	Intercept	-0.68	0.04	-19.1	674	0.96
	Decade One	1.09	0.01	126.4		
3	WDI Child Mortality Decade Two 1970-2000 (decades, no decade dummies)					
	Intercept	-0.67	0.04	-17.0	654	0.96
	Initial value Decade One	1.08	0.01	122.8		
4	WDI GDPPC Decade Two 1970-2000 (decades, no decade dummies)					
	Intercept	-0.05	0.06	-0.9	529	0.97
	Initial value Decade One	1.03	0.01	121.5		
5	WDI Infant Mortality Change Decade Two 1970-2000 (decades, no decade dummies)					
	Intercept	-0.16	0.02	-9.4	484	0.20
	Change Decade One	0.51	0.05	11.1		
6	WDI Infant Mortality Variation from Predicted Change Decade Two 1970-2000 (decades, no decade dummies)					
	Intercept	-0.01	0.01	-0.6	484	0.09
	Variation from Predicted Change Decade One	0.34	0.05	7.1		

(small) 1930-2000 dataset and the (large) 1960-2000 dataset. The same applies to under-five mortality (line 3), although it is very common for under-five and infant mortality to derived one from the other in the data, so that this should not be taken as a strong robustness test. The table also reports the results of performing the same exercise with GDP per capita (line 4). In contrast to infant mortality, the constant is negative (where one would hope it was positive) and not significant, suggesting far less evidence of globally similar progress in income growth.

The power of our simple model to explain infant mortality outcomes is considerable. The average decline in infant mortality over the period 1930-2000 is 87 percent for the countries for which we have data. Using 1930 data and forecasting using the coefficients from our regression on initial mortality and a time trend, the average error on predictions for infant mortality seventy years later is only 7 percentage points.

It is worth comparing this performance to a similar exercise using GDP per capita. Figure 1 displays actual versus predicted percentage change in infant mortality 1960-2000 based on the above regression model and 1960 values for infant mortality.[17] Figure 2 displays the same data for GDP per capita. As can be seen, in contrast to GDP per capita, infant mortality has declined everywhere –graphic evidence of global progress. Furthermore, the model provides some significant help in differentiating comparatively fast and slow progress not explained by the (highly significant) constant term. With GDP per capita, the model fails to predict negative growth and provides no support over the (insignificant) constant in predicting relatively fast or slow growth.[18]

Figure 1: Predicting Infant Mortality 1960-2000

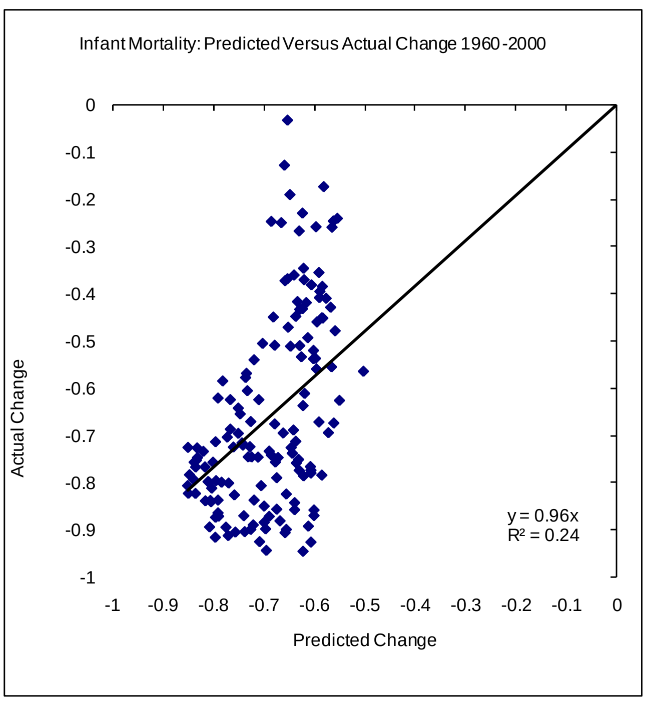
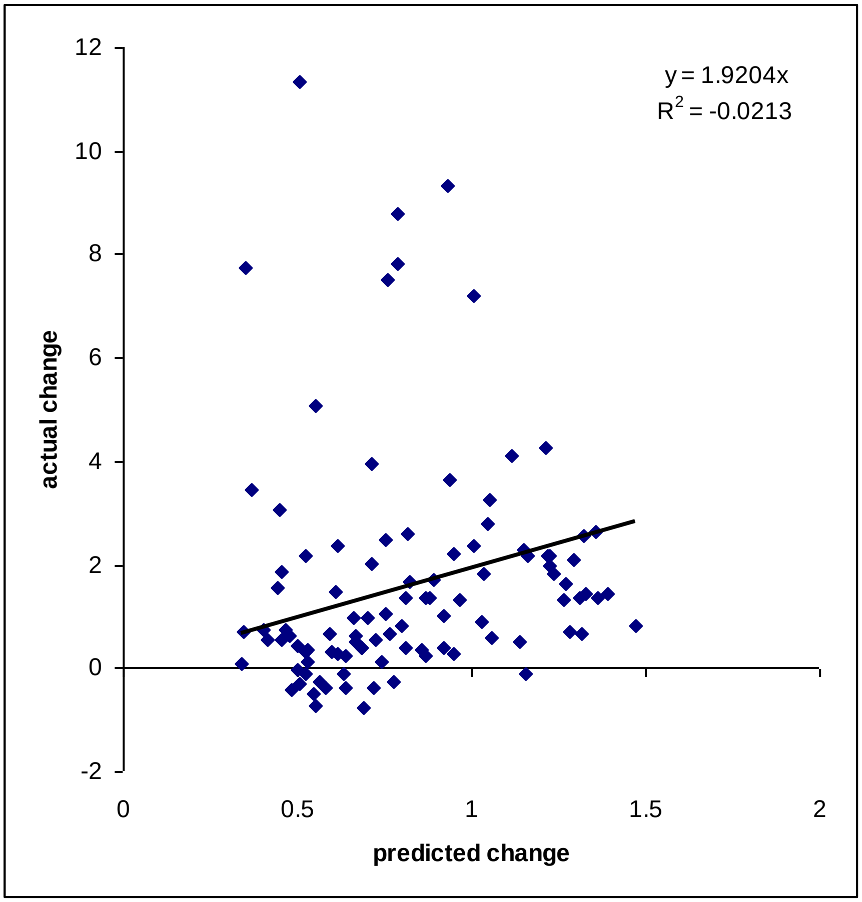


Figure 2: Predicting GDP per Capita 1960-2000



(c) What role for static factors?

Next, we look at the overall change in infant mortality over time:

$$(\text{Infant mortality change})_{p1} = A^*(\text{Infant mortality change})_{p0} + C$$

Correlations are low (Table 5, line 5). The rate of change in infant mortality in decade one is significantly related to the change in decade two, but a regression analysis of correlation across decades has an R-squared of 0.2, suggesting low persistence of relative growth rates (rapid improvers in the first decade seeing rapid improvement in the second, as it might be). We can further correct for the influence of initial mortality on rates of change by correlating predicted minus actual mortality in decade one to predicted minus actual mortality in decade two:

$$((\text{Actual Infant mortality})_{t2} - (-0.68+1.09^*(\text{Infant mortality})_{t1})) =$$
$$A^*((\text{Actual Infant mortality})_{t1} - (-0.68+1.09^*(\text{Infant mortality})_{t0})) + C$$

In this case, the R-squared drops to 0.09 (Table 5, line 6), suggesting a comparatively limited role for explanatory factors that persist over decades in explaining the relative speed of change in mortality rates.

(d) Income only correlates with a part of the variation over time in health outcomes

The importance of global trends also suggests an upper limit to the potential role of income growth –which varies significantly more across countries than do health outcomes, as we have seen. We can examine the potential role of income in explaining variation from global trends using our 1975-2005 database. It appears that variation in income change over that time correlates with a maximum of 14 percent of the *variation* from this powerful global trend in under five mortality change (Table 4, column 4). It is also worth noting that income growth drops out of significance with the inclusion of female literacy or literacy change –although neither variable is significant in that second case (columns 9 and 10).

(e) The global trend is linked with technology diffusion

We have seen that between 1974 and 2000, immunization rates for six common childhood diseases increased from five to 80 percent of the world's newborns. Returning to our simple 1975-2005 dataset, we can see if such rollout can help account for the global trend in improved outcomes. The answer is that perhaps it can. Adding 2005 DPT immunization rates to the growth regression knocks both initial mortality levels and the constant from significance (Table 4 columns 6, 7 and 8). There are concerns with endogeneity here, reduced by the very low rate of developing country immunization in 1975 and the very high average rate in 2005. This suggests we are largely measuring absolute growth in immunization with our DPT variable.

Factors that might influence the diffusion of health technologies include education and language barriers. However, that diffusion of education has been so widespread across countries may help to account for the fact that it is in fact different to find a link between levels or growth in female adult literacy and health outcomes in a global sample (Table 4 columns 9 and 10). At the same time, the importance of the rate of diffusion of health practices through a population might be illustrated by the significance of Gunn1, our measure of linguistic diversity, to declines in child mortality. Here, Table 4 column 8 suggests that the percentage of a country's population which speaks an official language *is* correlated with the speed of the health transition, perhaps because language barriers slow the rate of adoption of health technologies across people within a country. Regarding concerns that ethnic diversity might be proxying for weak institutions, a measure of institutions, Polity II, appears to have little correlation with declines in child mortality 1975-2005 either in terms of initial level or (usually slow) change (Table 4 columns 11 and 12).

(f) The role for health shocks

The health shock of AIDS has had its most significant impact on adult mortality, but it has also affected infant and child mortality directly through maternal transmission of the virus and indirectly through its socioeconomic impact on families. When we add a measure of 2005 HIV prevalence to the global regression of child mortality change 1970-2005 (Table 4, column 7), this enters strongly significant, and considerably increases the R-squared of the equation (from 0.32 to 0.55). Again, we face endogeneity concerns –it is very plausible that HIV spread faster in countries where institutions were weak, growth was slow or initial health was poor. Certainly, there is evidence to suggest that those with low life expectancies are more likely to undertake risky behavior and those with existing sexually-transmitted diseases are more likely to transmit HIV (Oster, 2005). And treatment regimens that extend the life of HIV-infected people are expensive and complex.

However, a number of factors suggest that that poverty or pre-existing ill health alone is not driving rates of HIV prevalence or the link between HIV and changes in child mortality 1975-2005 across countries. Botswana is itself an argument against this, given its comparative wealth and institutional strength in the Sub-Saharan region.

To further examine the role of poverty and pre-existing ill health as compared to other factors including geography, we can examine 2005 HIV prevalence as a function of pre-epidemic (1975) levels of income per capita, child mortality, literacy, Gunn1, and democracy –the polity II score. The HIV rate is significantly higher in Sub-Saharan Africa (SSA) than elsewhere, averaging 6.8 percent in 2005 compared to 0.4 percent outside the region. This is itself a reason to think that geographic location close to the viral origin is an important determinant (see Oster, 2005). But to ensure this high geographic concentration in the region where AIDS first emerged is not driving all results, we split the sample between SSA and non-SSA countries as well as running a global sample with an SSA dummy. The results are reported in Table 6.

Present levels of HIV prevalence appear weakly correlated with 1975 income (Table 6 column 1). Only in the non-SSA sample is 1975 income significant and carrying the right sign, and even here it accounts for less than four percent of the variation in HIV levels (in the SSA sample, wealthier countries in 1975 actually had higher 2005 prevalence rates). Again, both linguistic diversity and our measure of democracy appear to have no explanatory power in determining prevalence. Initial health frequently enters significantly with the expected sign in the non-SSA and full samples, although it does not appear to be a major factor in determining outcomes. Adult female literacy in 1975 is quite robustly *positively* related to the incidence of AIDS in a country in 2005 (column 4).

In short, it appears that geography and perhaps culture may be the more plausible long-term factors related to cross-country levels of HIV prevalence compared to poverty alone. (Cultural factors appear to play a role in that male circumcision appears to be related to lower HIV

Table 6: Correlates with HIV Prevalence

		1	2	3	4	5	6
All countries	Constant	-5.15	2.62	-7.39	-31.71	-23.09	-24.95
		0.23	*0.26*	*0.51*	*0.01*	*0.08*	*0.06*
	Sub-Saharan Africa	7.98	7.64	8.52	10.64	11.95	11.97
		0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
	GDP per capita in 1975	0.65		0.90	0.88	0.02	-0.01
		0.19		*0.32*	*0.28*	*0.99*	*0.99*
	Child mortality in 1975		-0.53	0.02	3.80	3.45	3.96
			0.31	*0.98*	*0.00*	*0.01*	*0.01*
	Adult female literacy in 1975				0.13	0.14	0.14
					0.00	*0.00*	*0.00*
	Gunn1					-2.56	-2.77
						0.14	*0.12*
	Polity score 1975						0.09
							0.38
	R Square	0.35	0.35	0.34	0.52	0.54	0.55
	Observations	111	124	87	81	76	75
	Constant	-29.73	58.75	63.67	-35.65	-36.87	-35.20
Sub-Saharan Africa Sample		*0.07*	*0.00*	*0.21*	*0.44*	*0.44*	*0.48*
	GDP per capita in 1975	5.12		2.33	1.21	1.77	1.88
		0.03		*0.47*	*0.64*	*0.52*	*0.51*
	Child mortality in 1975		-9.68	-13.68	4.94	4.82	4.21
			0.01	*0.03*	*0.44*	*0.47*	*0.56*
	Adult female literacy in 1975				0.38	0.36	0.36
					0.00	*0.00*	*0.00*
	Gunn1					-2.42	-2.32
						0.48	*0.51*
	Polity score in 1975						-0.11
							0.77
	R Square	0.16	0.17	0.35	0.70	0.70	0.70
	Observations	31	37	28	24	23	23
Non-Sub-Saharan Africa Sample	Constant	1.96	0.11	0.50	-1.60	-1.50	-2.16
		0.03	*0.75*	*0.76*	*0.38*	*0.51*	*0.33*
	GDP per capita in 1975	-0.17		-0.04	-0.02	-0.02	-0.03
		0.09		*0.78*	*0.88*	*0.92*	*0.88*
	Child mortality in 1975		0.06	0.06	0.34	0.36	0.53
			0.44	*0.69*	*0.08*	*0.09*	*0.02*
	Adult female literacy in 1975				0.01	0.01	0.01
					0.03	*0.11*	*0.11*
	Gunn1					-0.42	-0.48
						0.26	*0.19*
	Polity score in 1975						0.03
							0.03
	R Square	0.04	0.01	0.02	0.09	0.10	0.18
	Observations	80	87	59	57	53	52

Probabilities reported in italics.

transmission rates, Oster, 2007). And returning to our outcome growth regressions, this suggests that health shocks that are largely unrelated to institutions or income may play a significant role in developing country health outcomes.[19]

To conclude this section, it is worth noting that a regression which correlates the change in child mortality 1975 to 2005 with initial mortality, income, immunization, HIV prevalence and ethnolinguistic fractionalization is associated with two thirds of the variation in changes in under-five mortality between those two years. Income accounts for very little of this change, while the global rate of progress accounts for a considerable part of change worldwide.

4. EXAMINING HEALTH STATUS ACROSS COUNTRIES

(a) Additional variables

In order to further analyze the relationship between supply and demand factors and the spread of health technologies as well as the relationship between those health technologiles and outcomes, we will utilize a cross-country quintile dataset based on DHS survey data covering 51 countries. Table 7 reports on definitions, Table 8 on data characteristics. A single period dataset such as this will be unable to provide insight into many questions regarding the dynamics of change but will allow further analysis of the role of income, institutions and education in the technology adoption process and health outcomes. Again, our priors are that national income and institutions have a comparatively minor role in explaining access to (older and cheaper) health technologies which are a key to outcomes, with knowledge and factors that can impede technology spread another important determinant.

We use under-five mortality as our chosen health indicator, described earlier.[20] Available quintile data on interventions covers DPT and measles immunizations and delivery attendance by trained medical personnel. The available quintile knowledge flow variable is percentage of adult women who have completed fifth grade in school.

In addition to a number of the national-level variables used above to examine changes in health over time, we add some additional cross-country variables to our analysis. We have data on the percentage of the population with access to improved sanitation. We also add a prevalence variable, although it is a proxy –national level population density. Many infectious diseases require large population agglomerations to sustain themselves. It should be noted that population density may also ease service delivery and the transmission of knowledge.

We have data on national gini coefficients which may partially account for demand-side factors related to cost. Again, in addition to the knowledge flow variables used in the cross-country analysis, it may be that trade levels proxy for the level of integration with the global economy, perhaps including the transfer of ideas. Conversely, being landlocked may slow the transfer of

Table 7: Data Sources and Definitions

Variable Name	Definition	Year
Cross country data set		
Health Outcomes		
Under five mortality rate	Mortality rate, under-5 (per 1,000)	2003
Health Interventions		
DPT immunization	Immunization, DPT (% of children ages 12-23 months)	2003
Measles immunization	Immunization, measles (% of children ages 12-23 months)	2003
Improved sanitation facilities	Improved sanitation facilities (% of population with access)	2002
Controls		
Log GDP/capita	Log of real GDP per capita (Constant Prices: Chain series)	2001
Trade as % of GDP	Trade (% of GDP)	2002
Gunn1	Percent of population not speaking the official language	1997
Political Stability	Perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including domestic violence and terrorism	2002
Landlocked	Country is landlocked =1, Not Landlocked=0	-
Gini	GINI index	average 1994-2004
Health expenditure (% GDP)	Health expenditure, total (% of GDP)	2002
Log population density	Log of of population density (people per sq km)	2003
Quintile Dataset		
Health Outcomes		
Under five mortality rate	Mortality rate, under-5 (per 1,000)	1990-2002 varies by country
Health Interventions		
DPT immunization	% of children age 12-23 months who have received DPT vaccination	1990-2002 varies by country
Measles immunization	% of children age 12-23 months who have received measles vaccination	1990-2002 varies by country
Delivery attendance	Delivery attendance by a medically trained person.	1990-2002 varies by country
5th grade school completion female	% of women in household age 15-49 who have completed fifth grade	1990-2002 varies by country

Table 8: Data Descriptions

Cross country data set

	POOLED SAMPLE				
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Under five mortality rate	188	60.83	65.73	3.90	284.00
DPT immunization	188	84.20	16.71	25.00	99.00
Measles immunization	188	83.90	15.78	35.00	100.00
Improved sanitation facilities	154	63.43	28.19	6.00	100.00
Log GDP/capita	182	8.54	1.19	5.85	10.78
Trade as % of GDP	165	86.75	44.91	21.13	293.31
Gunn1	149	0.37	0.41	0.00	1.00
Political Stability	202	-0.06	0.99	-2.82	1.58
Landlocked	208	0.18	0.38	0.00	1.00
Gini	114	39.55	9.62	24.70	63.20
Health expenditure (% GDP)	187	6.15	2.31	1.50	14.60
Log population density	207	4.252	1.600	-2.303	9.959
Residual under five mortality rate	143	-0.07	0.66	-2.11	1.12

Quintile Dataset

	POOLED SAMPLE				
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Under five mortality rate	255	72.35	33.51	11.90	187.70
DPT immunization	249	78.41	28.98	-92.80	100.00
Measles immunization	249	68.10	21.06	4.70	99.00
Delivery attendance	249	55.54	32.39	0.10	100.00
5th grade school completion female	240	52.27	33.04	0.50	99.80

knowledge. On the institutional side, we have an additional measure of political stability which measures perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means.

(b) Correlates with Outcomes

Table 9 shows our results, which are preliminary and by no means unambiguously confirm our predictions --providing at best suggestive evidence in partial support. They do, however, provide additional evidence on the importance of both technological interventions and factors related to demand in terms of health outcomes.

The coefficient on income suggests that a one standard deviation increase in national GDP per capita is associated with a reduction in child mortality of between 38 to 66 per 1,000 live births across the various specifications. This is as much as a standard deviation in child mortality at the quintile level across countries (67 per 1,000). There is, then, a correlation between national income and outcomes, but the evidence in this paper suggests that this a least in part reflects omitted variables correlated with GDP per capita and causally related to outcomes as suggested by Deaton (2006).

In a regression with national income, quintile DPT coverage, quintile trained delivery coverage for childbirth, national access to improved sanitation, national trade as a percentage of GDP, quintile school completion, national Gunn 1, national political stability, and national landlocked status, all but sanitation enter significantly.

The coefficients suggest a standard deviation change in income is associated with a decline in child mortality of 38 per 1,000 –this after controlling for a number of correlated non-income factors, but doubtless still facing considerable omitted variable bias. A one standard deviation change in our institutional variable, political stability, is associated with a 18 per 1,000 lower rate of child mortality.

On the side of interventions, a standard deviation rise in DPT is associated with a decline in mortality of 15 per thousand. It is worth noting that if average coverage rates in developing countries have climbed from around five to around 80 percent between 1974 and 2000, the coefficient from this regression would suggest an associated decline in child mortality of 39 per 1,000.   Again with regard to interventions, a standard deviation rise in trained delivery coverage at childbirth is associated with an 11 per thousand point drop in child mortality.

On the demand side, a standard deviation rise in trade as a percentage of GDP is associated with a decline of 19 per 1,000 in child mortality; the same statistic for schooling completion is 22 per 1,000 and for Gunn 1, it is 12 per 1,000. Landlocked status is associated with a 23 per 1,000 higher rate of child mortality all else constant.

Table 9: Quintile Outcome Correlates (dependent variable: under five mortality rate)

	1	2	3	4	5	6	7	8	9	10
Constant	561.87	557.61	493.10	488.65	498.38	450.42	616.28	491.70	510.50	557.53
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Log GDP/capita	-48.39	-46.41	-43.28	-42.34	-36.96	-31.65	-55.14	-36.43	-37.69	-47.75
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
DPT immunization	-1.16				-0.55	-0.52	-0.35	-0.57	-0.50	-0.46
	0.00				*0.00*	*0.00*	*0.04*	*0.00*	*0.00*	*0.11*
Measles immunization		-1.27								0.01
		0.00								*0.97*
Delivery attendance			-0.84		-0.36	-0.35	-0.08	-0.37	-0.41	-0.03
			0.00		*0.00*	*0.00*	*0.56*	*0.00*	*0.00*	*0.85*
Improved sanitation facilities				-1.01	0.22	0.18	0.61	0.19	0.25	0.49
				0.00	*0.20*	*0.27*	*0.01*	*0.28*	*0.15*	*0.03*
Trade as % of GDP					-0.52	-0.43	-0.68	-0.55	-0.52	-0.59
					0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
5th grade school completion female					-0.65	-0.68	-1.00	-0.64	-0.63	-1.01
					0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Gunn1					33.53	29.00	42.55	33.71	32.53	37.71
					0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Political Stability					17.47	18.06	13.29	17.41	16.30	14.46
					0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Landlocked						23.01				19.52
						0.00				*0.01*
Gini							-0.09			-0.19
							0.79			*0.61*
Health expenditure (% GDP)								1.33	-2.44	-0.05
								0.26	*0.23*	*0.97*
Log population density										2.32
										0.38
Number of observations	243	243	243	249	208	208	169	208	208	169
R-Squared	0.63	0.63	0.62	0.54	0.79	0.81	0.83	0.79	0.79	0.84

Probabilities reported in italics.

When significant, improved sanitation tends to enter with the wrong sign. Our prevalence variable, population density, does not enter significantly, nor does the national gini coefficient or a measure of health expenditure.

The cross-country evidence presented here confirms the noted paradox between a strong relationship between income and health at any one time even if there is a considerably weaker relationship over time. These regression results also suggest a potential reason why: cheap interventions such as immunization are strongly and significantly related to health outcomes. Over time, these interventions have spread very rapidly, and the size of the coefficients from the cross-quintile regression suggest it is plausible to imagine they could account for a considerable proportion of child mortality change over time around the world (which has dropped by an average of a little over 50 per 1,000 births between 1975 and 2005).

These results also suggests a strong role for demand-side factors –and again, education (for example) has been spreading very rapidly over time. While they can hardly be taken as conclusive, then, the cross-country regression results are broadly what might be expected if technology and demand were important factors behind global progress in health.

5. CONCLUSIONS

(a) Conclusions for development research

If global trends are important yet some countries remain so much healthier than others, why did some countries started so far behind in terms of health outcomes in the past? The economic growth literature has thrown up a number of historical variables with regard to long-term determinants of present day income levels. These include the strength of historical institutions of governance, a history of innovation, the extent of slavery and geographic factors including disease prevalence. It may be that similar factors help determine the start date of a transition towards low infant mortality, or they help to explain higher initial rates at the onset of transition.

The importance of long-term factors is highlighted by the evidence that high mortality countries today were high mortality countries in the past (Kenny, 2009). For a sample of developing countries, we can predict 70 percent of variation of modern male life expectancy using data on ethnic fragmentation and the log of mortality rates amongst early colonists.

The good news is that everywhere appears to be on a global path to improved health, with considerable evidence of convergence towards child survival. This suggests history is not destiny in health with nearly the same power that the institutions and growth literature suggests it might be with income. In turn, this suggests something about the class of models that we would want to use to understand changes in health compared to changes in income. In the case of GDP per capita, exogenous models which suggest that growth is (everywhere) driven by global technological change have been confounded by global income divergence. This is what has led to the focus on endogenous models and the role of institutions. But exogenous models fit patterns of global health change far better than they do the income changes for which they were originally designed. This suggests the potential for new life in old models.[21]

(b) Conclusions for development policy

Vietnam has a gross national income per capita of $480, placing it in the low income country category and the bottom quarter of global country incomes. Its people have an average life expectancy of seventy --three score and ten. Around two percent of infants die in their first year, compared to a figure five times that in Sub Saharan Africa. This suggests that strong health outcomes can be achieved in very poor countries. Health does not need to be a luxury good.

A key to more rapid improvement in health outcomes appears to be technology development and technology application. On the side of technology development, if governments and donors want to improve treatment supply, developing cheap treatments for common killers is a key --an AIDS or malaria vaccine being two obvious examples. If this is the case, the role for efforts such as the advance market commitment to purchase such vaccines is clear, and the importance of efforts such as the WHO global campaigns regarding vaccination should be replicated. Developing country governments have a central role in ensuring access to such technologies at the national level.

Meanwhile technology *application* –at least to the extent necessary to dramatically improve outcomes in lagging countries—does not appear to be overwhelmingly an issue of cost. Approaches to increase the demand for healthy practices are clearly vital when so many people are becoming ill or staying ill due to easily prevented or cured diseases –this might involve social marketing and conditional cash transfers, for example. Having said that, Bjorkman, Reinikka and Svensson (2006) find that the introduction of primary health care citizen report cards as part of a randomized trial in Uganda led to higher utilization of services and considerably lower under-five mortality (despite no change in government funding). There remains a role for improving the supply side of health to ensure that it can both create and meet demand for services.

Finally, we should limit expectations of sustained decline at rates more rapid than that suggested by global change, because the underlying forces behind technology diffusion are slow to change. Education changes can be mapped on a similar global diffusion curve as health, for example (Clemens, 2004). We may be able to speed progress, but current performance is already a historical anomaly, and we should not expect too much. This may suggest a need to revisit international targets such as the Millennium Development Goals to analyze if they ask too much of some countries.

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[1] Easterly (2007) notes that about 145 determinants have been tested and this compares to about 100 degrees of freedom in the data.

[2] It is worth noting evidence that both life expectancy and adult height are more closely related to income at birth and in childhood than later (see Lindeboom, Portrait, and van den Berg,2003 and Moradi, 2010).

[3] In Brazil in 1974, there were 50 percent more underweight adults than overweight. In 1989, there were twice as many overweight adults than underweight, with the biggest increase in the poorest families (Riley, 2001).

[4] A full regime of oral antibiotics costs $0.25, and anti-malarials are similarly priced (Boone and Zhan, 2006).

[5] *The Guardian* 01/19/2007 Huge Cut in Measles Death Hailed as Triumph. The importance of such health technologies to outcomes may help to account for the correlation found between proxies for technology transfer such as trade levels and reductions in infant mortality (Levine and Rothman, 2006, see also a review by Soares, 2007b).

[6] Similarly, Jones et. al. (2003) estimate that under-five deaths in the 42 countries which account for 90 percent of global child mortality could be reduced 13 percent if all mothers breastfed their children. Universal application of oral rehydration therapy in cases of diarrhea would reduce deaths by 15 percent. Use of antibiotics for sepsis and pneumonia would reduce deaths by 12 percent. Insecticide-treated bednets would reduce deaths by seven percent. These are not cumulative figures.

[7] The evidence on health expenditure and measures of health sector outputs and outcomes is perhaps a particularly contentious part of the literature. Contrary to the above findings, Wagstaff (2003) argues that children living on a dollar a day do face a higher chance of survival in countries with higher per capita spending on health (see also Baldacci et. al., 2008 and Bhalotra, 2007).

[8] In this regard, there is considerable space to improve the quality of health care (and outcomes) at current budget levels. Overall in Africa, about half of the funds donated for health do not reach hospitals and clinics, and in Ghana the leakage rate is as high as 80 percent (Garrett, 2007).

[9] Related to this, there are intergenerational transfer mechanisms which suggest grandparents of ill health will have grandchildren similarly affected –poor health leads to weaker income and educational outcomes, in turn affecting child health, and so on (Mayer-Foulkes, 2008).

[10]Again, only one third of respondents in a Ghanaian survey understood that ill health related to sanitation was the result of germs rather than heat, smell, feces or dirt, for example (Jenkins and Scott, 2007).

[11] The importance of the (non-income) demand side to outcomes is also suggested by the very weak relationship between the share of public and private health care provision and outcomes. Boone and Zhan (2006) could find no impact of the variation in private and public shares of health expenditure on levels of child mortality, and note a number of countries with large private health shares (for example, Vietnam with a 71% private share) and low child mortality.

[12] Education is strongly correlated with the extent of behavior changes in the face of the HIV epidemic in Sub-Saharan Africa, but overall rates of change appear to be incremental (Oster 2007). Oster reports that the percentage of women having premarital sex in Kenya fell from 32.4% to 31.6% 1988-98, for example.

[13] The health program was the Programa Saude de Familia.

[14] More broadly, the role of cultural factors is emphasized in case studies of rapid health improvements in Kerala, Sri Lanka and Costa Rica in the post-war period –factors including female autonomy, valuing education, and an active civil society in a reasonably open political systems (Caldwell, 1986, see also Riley, 2001).

[15] Again, almost all of the post-war reduction in infant mortality in China occurred prior to the country's growth acceleration in 1980 (Culter et. al., 2006).

[16] Data available at http://www.systemicpeace.org/polity/polity4.htm

[17] It is interesting to look at the outliers on this graph. The countries which saw a decline twenty percent or more larger than would be predicted saw an average decline in infant mortality of 90 percent 1960-2000 these countries were the United Arab Emirates, Oman, Libya, Tunisia, Saudi Arabia, Rep. Korea, Chile, Macedonia, FYR, Syrian Arab Republic, Portugal, Bahrain, Samoa and Kuwait. The countries which saw a decline twenty percentage points or more *smaller* than would be predicted still saw an average decline of 28 percent. These countries were Pakistan, Nigeria, Guyana, Ethiopia, Cameroon, Swaziland, Uganda, Kenya, Botswana, Angola, Sierra Leone, Niger, Dem. Rep. Congo, Tanzania, Burundi, Liberia, Madagascar, Zimbabwe, Zambia, Iraq, and Rwanda.

[18] It is worth emphasizing that the strong evidence of global growth and convergence in health outcomes suggests a limited potential role for 'health poverty traps' or 'health underdevelopment' at the national level. This is in contrast to income, where long term income divergence does not contradict the type of zero-sum interpretations that lie behind theories of underdevelopment, and income stagnation in many poor countries suggests the potential plausibility of income poverty traps.

[19] Reasons to believe that there is not significant reverse causality from poor health to the scale of the AIDS health shock thus include that (i) our regressions include initial health prior to the AIDS outbreak and we have seen that health transitions are relatively uniform, (ii) the pattern of AIDS diffusion, highly concentrated in Sub-Saharan Africa, is clearly driven by far more than initial health alone and (iii) when we run regressions for determinants of AIDS levels, prior health is only a minor explanatory factor.

[20] Korenromp et. al., (2004) suggest that, based on the quality of Demographic and Household Surveys (DHS) in Africa, changes in under five mortality rates of greater than 15 percent should be reliably detected by the data.

[21] Alternately, it might suggest that in health and education, we are further along than in growth in the model proposed by Lucas (2000).