The Consequences of Population Health for Economic Performance[1]

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Among the most important recent advances in thinking on international development is the idea that population health has a significant effect on economic performance. Although the effects of individuals' health status on their productivity and earnings are readily observable and widely acknowledged, the consequences of population health for economic performance (at the macro level) and for the well-being of individuals, families, and firms are more difficult to discern and have been, until recently, rather neglected.

This chapter goes beyond the traditional economic thinking about the relationship between health and income – simply stated: wealth is needed to achieve health – by presenting evidence that population health is an important factor in strengthening economies and reducing poverty. The world's overarching framework for reducing poverty is expressed in the UN's eight Millennium Development Goals. Three of these eight goals pertain to health: reducing child mortality, improving maternal health, and combating HIV/AIDS, malaria, and other diseases. These potentially huge improvements in health are extremely important goals in themselves, and they serve as beacons toward which numerous development efforts are oriented. But these potential improvements in health are not only endpoints that we seek through a variety of means. The improvements are actually *instruments* for achieving economic growth and poverty reduction. That is, better health does not have to wait for an improved economy; measures to reduce the burden of disease, to give children healthy childhoods, to increase life expectancy will in themselves contribute to creating healthier economies.

This insight is relatively new and has significant political implications: Finance ministers whose concerns have been tightly tied to national budgets and staving off crises have a new tool to work with, since devoting resources to health improvements can be a powerful means of abetting economic growth and mitigating poverty.

This chapter first looks at some straightforward data about the links between health and income and notes the traditional thinking that explains this connection. It then describes how views are changing and in particular focuses on new evidence that good health can promote economic growth and well-being. After focusing on the specific connections between health and poverty, the chapter explores the mechanisms by which improved health can lead to better economic outcomes. The final sections discuss HIV/AIDS as a window onto the issues addressed throughout the chapter and the policy directions that flow from the research and views presented here.

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Some basic facts and the traditional view of their implications

Table 2.1, which groups countries by their infant mortality rate (IMR – the number of infants who die before reaching 1 year of age per 1000 live births) and income level in 1960, illustrates the general pattern connecting health and economic well-being. It shows that, within a given income classification, countries with higher infant mortality rates in 1960 generally experienced lower rates of economic growth between 1960 and 2000 (though de la Croix and Licandro (1999) offer a cautionary note on a related point, finding that "the effect of life expectancy on growth is positive for economies with a relatively low life expectancy, but could be negative in more advanced economies [where life expectancy is higher on average]"). For example, on average countries that had a GDP per capita between $3,500 and $7,000 in 1960, and IMR less than 50 per 1000, experienced an average annual growth rate of 3.5 percent over the subsequent 40 years. By contrast, a country with a GDP per capita less than $1,000 in 1960 and IMR greater than 150 per 1000 experienced an average of 0.8 percent per capita GDP growth over the subsequent 40 years.

Table 2.1 Annual Growth Rate of Per Capita Income, 1960–2000
(by income per capita and infant mortality rate, 1960)

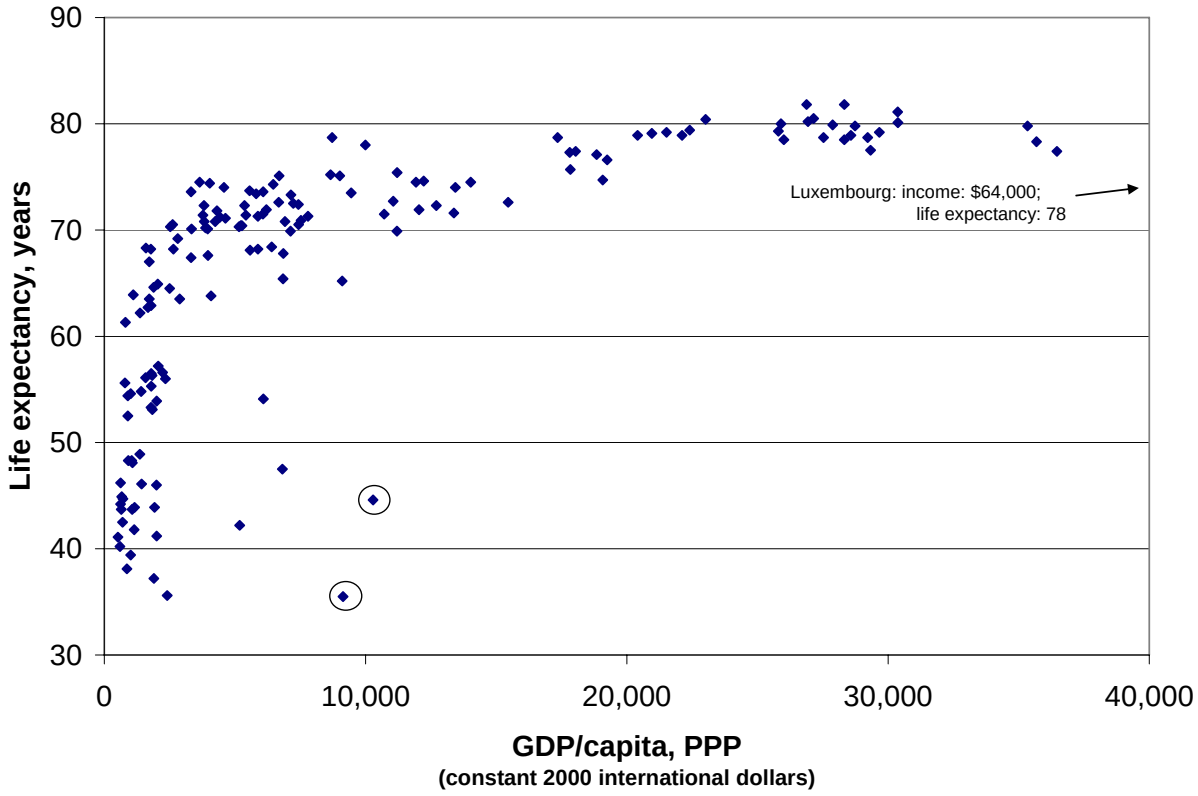
Initial Infant Mortality Rate, 1960	**IMR ≤ 50**	**50 < IMR ≤ 100**	**100 < IMR ≤ 150**	**IMR > 150**
Initial Income, 1960 (Constant 2000 US$, PPP)				
GDP ≤ $1000	–	3.9 (1)	2.0 (11)	0.8 (9)
$1,000 < GDP ≤ $2,000	–	4.8 (3)	1.5 (7)	0.5 (7)
$2,000 < GDP < $3,500	–	1.6 (6)	1.7 (6)	1.0 (4)
$3,500 < GDP ≤ $7,000	3.5 (6)	2.1 (9)	0.7 (2)	1.0 (1)
GDP > $7,000	2.5 (17)	0.9 (1)	–	–

Sources:
Heston, Summers, and Aten (2006) for income and growth rate data.
World Bank (2006) for IMR data.

Notes:
PPP means Purchasing Power Parity
The reported growth rate is the simple average of the GDP growth rates of all countries in the specific cell.
The number of observations in each cell is displayed in parentheses below the average growth rate.

Indeed, the positive correlation between income per capita and good health (the latter often assessed by life expectancy; see Figure 2.1) is one of the best-established facts in the field of international development. However, determining causality in the relationship between high incomes and good health remains a vexing issue. Good health could lead to high incomes, the reverse could be true, both could be true, or some other variables could be driving both health and income thereby creating the appearance of a health-wealth link.

Figure 2.1
Life Expectancy vs. Income, 2004



Source: World Bank (2006), *World Development Indicators* 2006. Data are for 2004.
Note: The circled outliers, from lower to higher income, are Botswana and South Africa.

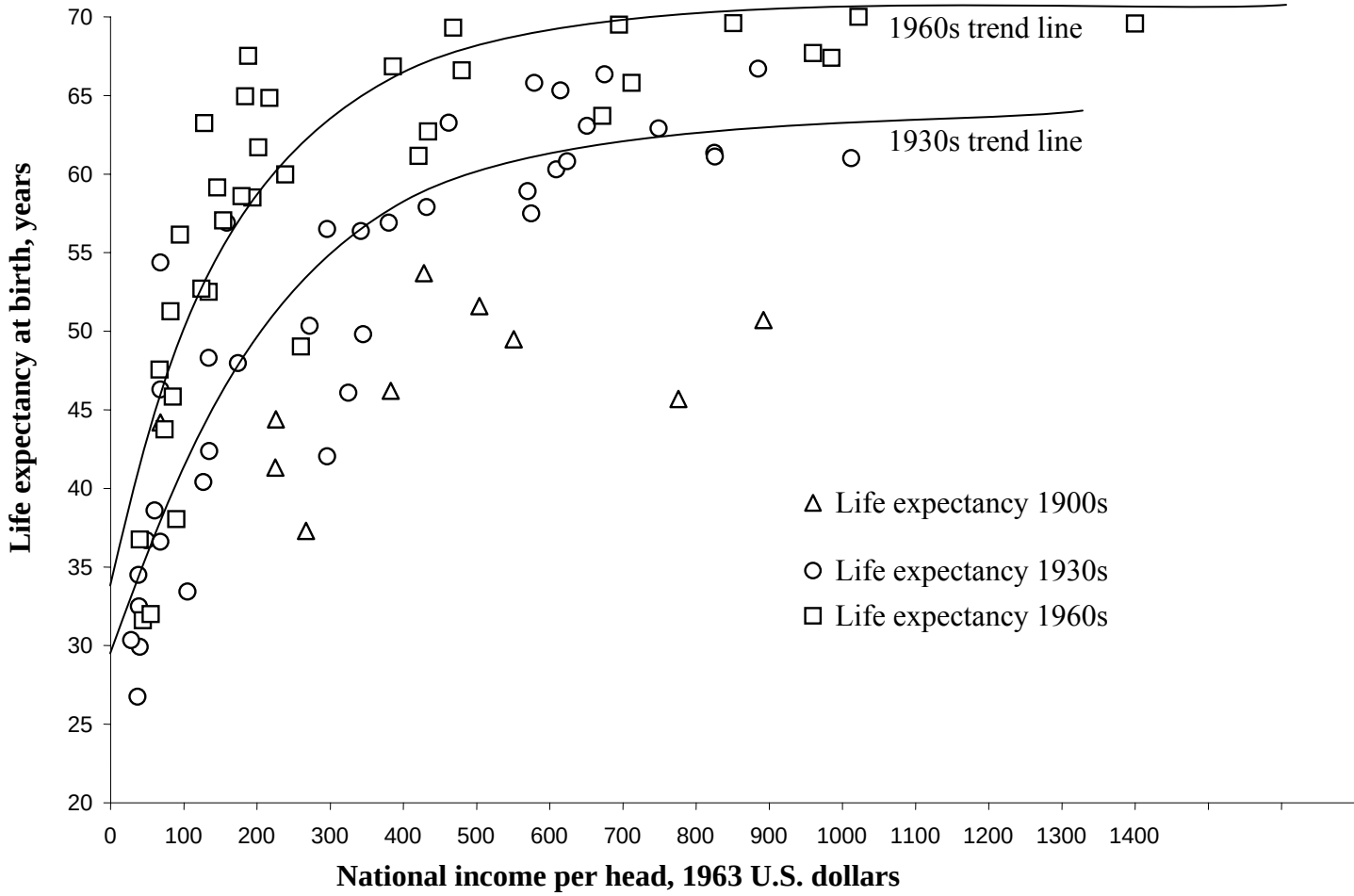
To explain the apparent health-wealth relationship, traditional economic thinking (for example, World Bank 1993a) has asserted that income growth is a key factor underpinning improved population health. The title of a journal article, *Wealthier is Healthier* (Pritchett and Summers 1996), succinctly captures this view. The assertion has a strong theoretical and intuitive basis. Higher incomes lead to greater command over many of the goods and services that promote health, such as better nutrition, safe water, and access to quality health services. Higher incomes also promote technical progress and dissemination of new health technologies, which have been the major force behind health improvements (Easterlin 1999; Cutler, Deaton, and Lleras-Muney 2006). Consistent with this perspective, policies prescribed by international financial institutions

for developing countries have focused on growth in gross domestic product (GDP) to the neglect and even the detriment of population health (Navarro 2004: 1322).

Evolving views of health, wealth, and development

An early and influential analysis suggesting that rising income is not the only driver of health improvements comes from Samuel Preston (1975), who plotted the relationship between life expectancy and national income per capita during the 1900s, 1930s, and 1960s (Figure 2.2). Preston's curves reveal two important insights. First, a rise in per capita GDP is associated with greater gains in life expectancy in poorer countries than in wealthy ones. Second, the curve shifts up over time. For a given level of income per capita, life expectancy rose substantially over the study period. For example, an individual from a country with GDP per capita of $500 could expect to live around 59 years in the 1930s and 68 years in the 1960s. Preston calculated that if income was the sole determinant of mortality, then gains in life expectancy would have been small (2.5 years between 1938 and 1963). Yet, when he accounted for the upward shift of the curve during the same period, significantly larger health gains were predicted (12.2 years). Preston concludes that factors exogenous to a country's level of income accounted for 75–90 per cent of the rise in life expectancy, worldwide, over this period. These exogenous factors include medical and scientific breakthroughs – such as the development of vaccines and antibiotics – as well as advancements in sanitation and hygiene. Income growth per se accounted for only 10–25 per cent of the gain in life expectancy.

Figure 2.2
Relationship between Life Expectancy at Birth and National Income per Capita, for Countries in the 1900s, 1930s, 1960s



Source: Preston (1975).

Preston summarizes his findings: "There is no reason to expect a direct influence of national income per head on mortality… its influence is indirect; a higher income implies and facilitates, though it does not necessarily entail, larger real consumption of items affecting health such as food, housing, medical and public health services, education, leisure and health-related research, and, on the negative side, automobiles, cigarettes, animal fats and physical inertia." (Preston 1975: 232).

Similarly, WHO, analyzing data from 1952–1992, found that income growth is less important to improving health outcomes than are other factors. In the period studied, average per capita income increased from $1530 to $2560 (in 1985 international dollars). If the relationship

between income and infant mortality rate (IMR) had remained as it was in 1952, IMR would have dropped from 144 per thousand to 116 per thousand by 1992. In reality, however, it dropped much more sharply to 55 per thousand. This discrepancy is attributed to factors "exogenous to wealth," namely technological progress and knowledge diffusion (WHO 1999: 5).

Preston's investigations drew the attention of economists and others to the links between income and population health. Bloom and Canning (forthcoming 2007) provide a contemporary take on Preston's seminal work and its continuing importance. They note the importance of technological progress (i.e., not just income growth) in spurring health gains and point out why income per capita is an imperfect proxy of well-being. They also delve into the causality questions raised by the simultaneous improvement of health and income.

Specific inter-country comparisons of health outcomes and GDP levels, such as those given in Table 2.2, also weaken the case for a strict wealth-to-health causal linkage. Despite having an average per capita income that is four times higher than Costa Rica's, the United States has a lower life expectancy. Similarly, South Africa has double the per capita income of Cuba, but life expectancy in South Africa is 32 years less.

Table 2.2
Cross-Country Comparison of Life Expectancy and GDP Per Capita

Country	Life expectancy (2004)	GDP per capita (2004 PPP)
United States	77.4	36,465
Costa Rica	78.7	8,714
South Africa	44.6	10,286
Cuba	77.0	5,259

Source: World Bank, *World Development Indicators* 2006. Data for GDP per capita for Cuba are from UNDP (2003), *Human Development Report*.
Note: PPP = Purchasing Power Parity

Juxtaposing Cuba and the United States further illustrates this point. The two countries have similar life expectancies and equivalent IMRs (7 per 1000). Yet these countries differ significantly in terms of income per capita. The *World Development Report* 2003 characterized Cuba as a "puzzle" of "good health without growth." Cuba's impressive health outcomes are thought to be attributable to the priority assigned by the government to health care, as evidenced by the establishment of well-staffed community clinics, immunization campaigns, vector control, and a commitment to minimizing inequality in access to health care.

Higher incomes *can* lead to improvements in population health, but sometimes they do not. Presumably, the distribution of income among members of society, a country's economic and social policies, and the strength of its institutions are also important.

In recent years, economists have focused increasingly on the links between population health and economic growth. Such research has been spurred by recognition of the global transformation in human health of the last 150 years, during which people have lived longer, and led healthier, more productive lives. Between the sixteenth and the mid-nineteenth century, life expectancy around the world fluctuated, but averaged less than 40 years, with no upward trend. Lifespan slowly but steadily increased in the second half of the nineteenth century and then jumped markedly in the twentieth century, initially in Europe and then in the rest of the world. Although there is still debate about the cause of these changes, demographers and economists increasingly attribute the modest declines in nineteenth century mortality rates to rising incomes. During the latter half of the twentieth century, global life expectancy increased by almost 20 years, from 46.6 years in 1950–1955 to 66.5 years in 2005–2010 (UN 2005). This represents a global average increase in life expectancy of more than 4 months per year. Technical advancements appear to be the catalyst for this more recent, more dramatic decline.

How have these improvements in population health affected economies? Fogel (1990) states, "Improvement in nutrition and health may account for as much as 30 per cent of the growth in conventionally measured per capita income between 1790–1980 in Western Europe." Arora (2001) investigates the influence of health on the growth paths of 10 industrialized countries between the 1870s and the 1990s. Arora finds that changes in health increased the pace of income growth by 30 to 40 percent, altering permanently the slope of these countries' income trajectories. The reported results hold for five different measures of long-term health and are largely unchanged when controlling for investment in physical capital. Fogel (1994) presents evidence of the historical impact of improved health on labor productivity. Using data from France circa 1790, he estimates that the bottom 10 per cent of the French labor force lacked the energy for regular work and the next 10 per cent only had enough energy for three hours per day of light work.

Econometric studies that build on data from a large set of countries provide strong evidence that health is a significant predictor of income growth. Economists have expended a great deal of effort determining why growth in some countries is faster than it is in others. Studies have identified many determinants of economic growth, e.g., initial level of income per capita, geographic location, institutional environment, economic policy, and investments in education. To this list, health has recently been added. A substantial body of evidence demonstrates that health, as measured by life expectancy or adult survival rates, has a significant effect on the pace of subsequent economic growth (e.g., Barro 1996, 1997; Barro and Sala-i-Martin 1995; Bhargava *et al.* 2001, Bloom, Canning and Sevilla 2004; and Hamoudi and Sachs 1999). The work of Knowles and Owen (1997) is also consistent with the positive effect of health status on productivity. Taken together, these studies provide compelling evidence of a strong causal relationship from health to wealth. The effect is in addition to other influences on economic growth, emerges consistently across studies, and is strikingly large. Suppose we compare two countries that are identical save for a five-year difference in life expectancy. Several studies have shown that real income per capita in the healthier country will grow 0.3 to 0.5 percentage points per year faster than in its less healthy counterpart. This represents a sizeable boost to growth given that global per capita income grew by roughly 2 per cent per year from 1965 to 1990. Bloom, Canning, and Sevilla (2004) show that one extra year of life expectancy raises steady-state income by about 4 per cent.

To be complete, we must note that the case for the effect of health on economic well-being is still a matter of dispute. For example, Acemoglu, Johnson, and Robinson (2003) argue that health differences are not large enough to account for much of the cross-country differences in incomes, and that the variation in political, economic, and social institutions is a more central factor. Acemoglu and Johnson (2006) go further, finding that "there is no evidence that the large exogenous increase in life expectancy led to a significant increase in per capita economic growth." For a detailed critique of their paper, see Bleakley (2006). In an effort to arrive at policy recommendations, Webber (2002) argues that life expectancy does not necessarily reflect investments in health. He uses nutrition, instead, as a proxy for health and finds that "reducing undernutrition would only make a modest contribution to economic growth . . . ."

Practical experience provides some relevant evidence about the links between health and economic performance. During the 1980s and 1990s, health sector budgets in developing countries were reduced as part of a package of austerity measures designed to promote economic growth (Périn and Attaran 2003: 1216). These austerity measures took the form of Structural Adjustment Programs and were adopted by many developing countries during the 1980s and 1990s. Périn and Attaran (2004) describe the evolution and content of such programs as follows: "With the 1982 Mexico debt crisis, development became dominated by an obsession with macroeconomic fundamentals (tellingly, since the same donor countries were also the creditors whose unpaid loans were at risk)…The World Bank became the leading purveyor of structural adjustment…economic stability and development were best achieved through disciplined privatisation, deregulation, and trade liberalisation, often at the expense of social spending" (Périn and Attaran 2004: 1216).

The belief that income growth is necessary for health improvements underlay the formulation and enactment of many of these policies. However, in practice these measures have often proven unsuccessful. In Africa, for example, where many countries adopted austerity measures, life expectancy reversals occurred while the economy stagnated (McMichael *et al*. 2004: 1155). By contrast, in Southeast Asia, prioritization of investment in the health of populations contributed to the economic prosperity this region enjoyed (Bloom, Canning, and Malaney 2000: 257). The work of Easterly (1999) also weakens the argument for a focus on increasing incomes as a strategy for improving health. In an examination of outcomes over a reasonable period of time, Easterly finds only a weak effect of changes in income on population health.

Views that acknowledge the economic value of health improvements have gained greater currency in recent years. In 2000, then-Director-General of the World Health Organization (WHO), Gro Harlem Brundtland, established the Commission on Macroeconomics and Health (CMH). The commission's mandate was to "assess the place of health in global economic development." The CMH Report, released in 2001, underscores the importance of health as an instrument for economic development and poverty reduction. The Commission notes that modest investments in health could save 8 million lives per year, resulting in an estimated 330 million disability-adjusted life years (DALYs) saved and about $200 billion in direct economic benefits *per year* by 2010 (CMH 2001: 12). The CMH report suggests that good health is not just a consequence but also a cause of economic development.

Of course, the conventional view that wealthier implies healthier (i.e., the opposite causal relationship from that discussed above) is also true. These two views – that health promotes wealth and vice versa – are compatible. Causality running in each direction can give rise to cumulative causality, a so-called virtuous circle in which health improvements promote economic growth, which in turn promotes health.

The mutual reinforcement between health and income can also operate in reverse: sick people are more likely to become poor, and those who are poor are more vulnerable to disease. Often, the poor suffer from ill health because they lack access to clean water and sanitation, live in the most environmentally fragile areas, and have difficulty getting medical care and information. Because many of the poor earn their livelihood by engaging in manual labor, health setbacks experienced by the breadwinner of a poor family may prove economically devastating. The household not only loses income, but may also be forced to sell off assets to pay for medical costs. Health problems can also plunge non-poor families into poverty; in countries that provide some level of safety net for the poor, downturns in health will increase the burden on the state while reducing state revenue. Increasingly, economists are recognizing that disease itself may thwart the economic growth that is presumed to prevent it. The vicious circle of poverty and disease is readily observable. Bloom and Canning (2001) describe the process of cumulative causality that can lead to the scenarios described here. An estimated eight million children under the age of five die each year from easily preventable and treatable conditions, almost exclusively within the developing world (WHO 2003). Lorentzen, McMillan, and Wacziarg (2005) focus on adult mortality and find that it is such a large factor in reducing economic growth that it "explains almost all of Africa's growth tragedy."

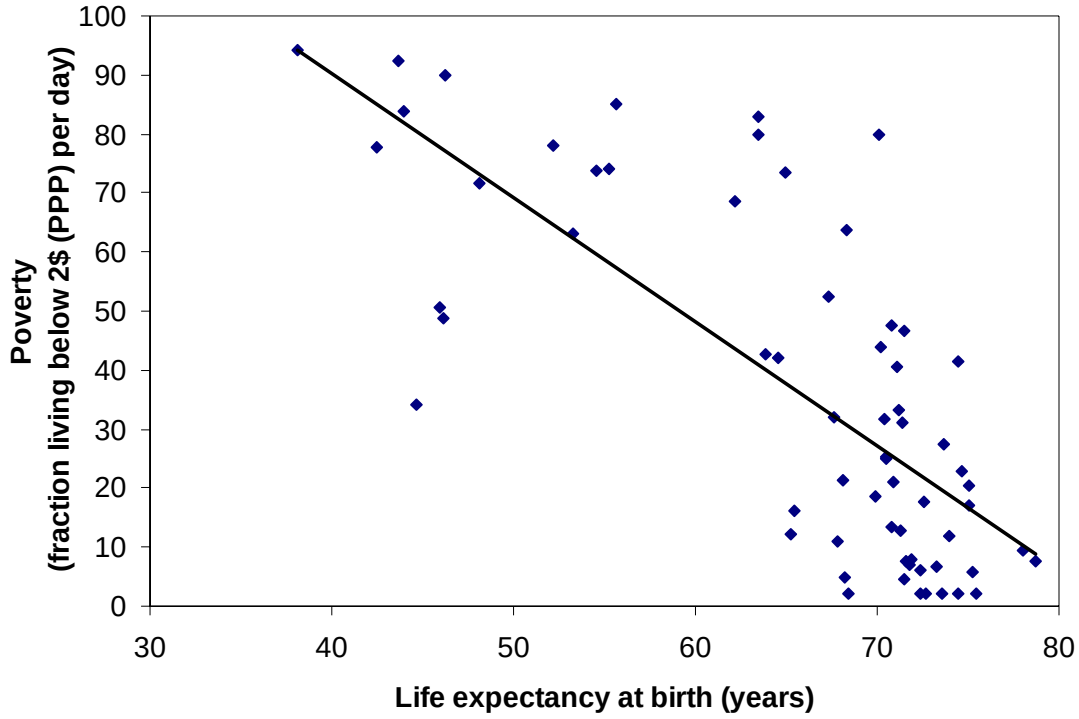
The intrinsic value of health merits increased attention in economic analyses (see Marks and Mahal 2006). Health is enshrined as a fundamental human right and a component of individual freedom in numerous national and international legal frameworks. For example, Article 25 of the Universal Declaration of Human Rights states: “Everyone has the right to a standard of living adequate for the health and well-being of himself and his family, including food, clothing, housing and medical care, and necessary social services and security in times of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.” The International Covenant on Economic, Social and Cultural Rights (ICESCR), Article 12, states: “The State Parties to the present Covenant recognize the right of everyone to the enjoyment of the highest attainable standard of physical and mental health” (Centre for the Study of Human Rights 2001). Kinney (2001) documents that 110 national constitutions reference a right to health care. Amartya Sen characterizes unnecessary morbidity and premature mortality as “unfreedoms” that constrain human capability (Sen 1999: 24). Both equity- and rights-based approaches to development strongly support devoting additional resources to health.

To these perspectives we now add the macroeconomic argument: investing in population health can spur economic growth. We can therefore view health, along with education, as a form of human capital and an essential investment in a productive society. Chakraborty (2003) expresses this point quite succinctly: "When human capital drives economic growth, countries differing in health capital do not converge to similar living standards . . . ."

Health and poverty

A simple scatterplot shows the relationship between life expectancy and the poverty rate. Using the widely cited criterion of a $2/day (PPP-adjusted) poverty level, Figure 2.3 shows that countries with higher life expectancy have lower poverty rates. The correlation is not exceptionally strong, but the overall pattern is clear and unsurprising. This chart does not in itself imply causality.

Figure 2.3
Life Expectancy and Poverty



Source:
World Bank (2006)
Notes:
Life expectancy data are for 2004.
Poverty data are for most recent year since 2000.
PPP means Purchasing Power Parity

Bloom et al (2006) report on the relationship between health and poverty, finding that the effect of improved health on economic growth extends to the positive effect of health improvements on reducing poverty. They review and detail some of the mechanisms by which this effect can occur and offer evidence about the possible scale of the effect. Poverty reduction is a function of two separate phenomena: the overall growth of income and changes in the dispersion of that income (which is a reflection of the extent to which the poor benefit from economic growth). Overall growth itself, in the absence of any change in the dispersion of income, will lower the number of people in poverty. Independently of this fact, a changing dispersion of income will change the

number of people in poverty. If this distribution is in the direction of greater equality, the poverty rate will fall as those below the poverty line see their incomes rise.

The authors examine three different health scenarios to investigate the possible effect of improved health (as proxied by improved life expectancy) on poverty reduction. (The three scenarios are life expectancy, as estimated and predicted by the United Nations, and two scenarios with higher-than-observed-and-predicted life expectancy.) The simulations cover 31 countries with a combined population of 3.1 billion in 1990. With a dollar-a-day poverty rate of 30 per cent at that time, roughly 900 million people in those countries were living in poverty. The simulation results show that if life expectancy in 1990 had been 10 percent higher in 1990 and had followed a path leading to its being 10 percent higher in 2015, then 30 million more people would have risen out of poverty than in the scenario that follows actual life expectancy data and current projections. This change is not as sizable as the effect of health on economic growth rates, but it is definitely not negligible. The authors point out that because the poor rely disproportionately on manual labor, it makes sense that they should benefit disproportionately from improvements in health.

Broader arguments support the importance of the link between health and poverty. Since the poor rely on their good health in order to work, any diminution of their health can make them fall even further into poverty; health shocks to a family or community can quickly reverse years of improved health and income gains. Large and unanticipated healthcare costs can quickly appropriate a significant portion of a family's income and make it impossible for the family to maintain even the often-low standard of living it formerly experienced. By contrast, health improvements can offer the poor a chance to work more productively and to be able to pay for schooling, both of which offer a path out of poverty.

Bloom and Canning (2003) point out that health improvements reduce poverty at the national level and also help families emerge from poverty. With better health having the potential to reduce poverty, there is a new rationale for greater spending on health. A new emphasis in this direction will require significant institutional changes at the international, national, and local levels.

Healthier to wealthier: mechanisms

There are several channels through which health may contribute to economic growth and poverty reduction. Healthier populations tend to have higher labor productivity because their workers are physically and mentally more robust than those suffering from disease or disability. As detailed below, health improvements in a population change the age structure of society, offering a potentially substantial, albeit time-limited, boost to the productive capacity of an economy (on a per capita basis). Investment in physical and human capital, as well as research and development, is augmented as longer-lived individuals tend to increase their savings for retirement and foreign investment inflows tend to gravitate toward a healthy labor force. Improved health encourages stability in society and can increase the return to other forms of human capital, such as education and job experience. These mechanisms are explored in greater detail below.

Health to family welfare and labor and firm productivity

Health has a direct effect on the productivity of the labor force. Case studies compiled by the World Bank that involved interviews with over 60,000 people living in poverty revealed that their single greatest concern was the health of the household breadwinner. If he or she dies or requires expensive medical care, a family can be financially or economically crippled (World Bank and WHO 2002), possibly entering a vicious circle of poverty and disease from which it cannot escape.

Studying the effects of health on households and individuals is the purview of microeconomics. Such analyses employ anthropometric measures and indexes of morbidity as measures of health human capital. The results consistently indicate that health affects worker earnings and productivity. Many studies use adult stature as a proxy for long-term health. Although there is clearly a genetic component to height determination, bouts of infirmity throughout childhood arrest growth, leaving height as an indicator of the frequency and duration of childhood illness. Microeconomic analyses attempt to isolate the wage effects of height variations due to environmental health differences (see Schultz 1999). Using this method, Schultz and Tansel (1997) along with Ribero and Nunez (2000) demonstrate that one centimeter of additional height due to health inputs when young adds about 6 per cent to wages. Health interventions to overcome specific health problems can also boost labor productivity. Thomas *et al.* (2005) find improvements in the health and economic productivity of men who received treatment for iron deficiency; after treatment, they "are more likely to be working, sleep less, lose less work time to illness, are more energetic, more able to conduct physically arduous activities, and their psycho-social health is better."

In addition to the costs to individuals and households, disease has spillover effects that can impose a high cost on the larger economy. For firms, disease can have dire consequences for both productivity and profitability, and thereby decrease competitiveness. The labor force in a society with a high burden of disease experiences higher rates of turnover and absenteeism. Strategic management of the firm can be compromised if its managerial staff becomes ill. Although it has been argued that surplus labor makes sick workers easily replaceable, this case may be overstated. A study of the effect of HIV on nearly one thousand firms in sub-Saharan Africa found that replacing the skilled staff presented a serious problem (Biggs and Shah 1997). Death of a worker represents lost human capital investment in job training and worker experience. Worker morale may plummet as friends and co-workers fall sick and die, further diminishing firm productivity.

Firm profitability generally suffers as health costs rise. When workers get sick, they claim more health benefits. Expenditures may shift from productive inputs toward health services or funeral costs. As a precautionary measure, some businesses in sub-Saharan Africa have reportedly started training each skilled laborer in numerous jobs so that the company can more easily operate when skilled workers fall ill. Other firms are hiring multiple workers for each skilled position, to ensure trained replacements when incumbents die (*Economist* 2001). Disease may also affect the demand for a firm’s product. A declining consumer base translates into a small

market for the firm's products. In the aggregate and over time, these firm and household level effects could contribute to a slowdown in the national economy.

Health to demography

Health improvements also affect demography, in ways that can possibly offer a boost to developing economies. There is a strong association between infant and child mortality and fertility. (In this chapter, "fertility" is used as demographers define it: the number of children a woman bears, rather than how likely or how easy it is for her to become pregnant and bear children.) Families in unhealthy societies tend to compensate for expected and actual child deaths by having more children. Although many other factors contribute to fertility, such as mother's level of education, access to reproductive health services, and entrenched gender inequalities, the relationship between fertility and IMR is compelling. Countries with an IMR of less than 20 have an average total fertility rate (TFR) of 1.7. (A country's total fertility rate is defined as the average number of children women would bear if they follow the age-specific childbearing patterns that characterize a country at a particular time" (see Menken and Rahman 2001: 83).) By contrast, the TFR is 6.3 for countries with an IMR over 100 (CMH 2001: 36). In many instances, high fertility rates reflect purposeful attempts by parents to achieve desired family size: having many children increases the likelihood that at least one or two will survive into adulthood. Bearing a high number of children taxes a mother's health. Large family size also taxes household resources, which must be spread more thinly with less investment in the education of each child. High fertility (in a context of overall diminished mortality, and hence, rising population) increases the dependency ratio, i.e., the ratio of the dependent population (those aged 0–14 and aged 65 plus) to the working-age population (aged 15–64). A high dependency ratio resulting from high fertility means that a larger proportion of earnings are channeled into supporting children.

When childhood survival rates rise, families tend to have fewer children. Low-cost interventions such as vaccinations, vitamin A supplementation, oral rehydration therapy (ORT), and breastfeeding have ushered in dramatic reductions in infant and child mortality over the past four decades. Globally, child mortality has declined from 192 per 1000 live births in 1960 to 79 per 1000 live births in 2004 (World Bank 2006). The reduction in child mortality has been particularly dramatic in South-East Asia, the Eastern Mediterranean, and Latin America regions (WHO 2003: 9). As noted above, when infant and child mortality fall and survival to adulthood becomes more likely, parents can feel more confident having fewer children. The combination of an initial drop in the infant mortality rate (resulting in there being more children) and the subsequent fall in fertility (leading eventually to smaller age cohorts) creates a "bulge" generation that moves through the age structure of the population. This bulge is the inevitable result of the "demographic transition" (i.e., the move toward lower mortality, followed by a move toward lower fertility). When the bulge generation represents a large number of working-age people, their contribution to the economy can cause income per capita to rise dramatically. This effect is called the demographic dividend and its realization is heavily reliant on policies that allow extra workers to be absorbed into the workforce (Bloom and Canning 2001: 187; Bloom, Canning, and Sevilla 2004; Lee and Mason, 2006).

East Asia provides a compelling example of how improvements in public health contribute to economic growth via demographic change. A growing body of evidence suggests that the East Asian countries that sustained high rates of economic growth in the second half of the twentieth century did so thanks to high rates of growth of labor and capital. Growth in labor supply largely resulted from changes in the age structure of the population that followed from improved sanitation, safer water, and the development of antibiotics and the anti-malarial insecticide DDT. Life expectancy increased from 39 years in 1960 to 67 years in 1990. Infant mortality also declined, from 175 per 1,000 in 1950 to 52 per 1,000 in 1995 (Asian Development Bank 1997), followed by a precipitous drop in fertility. A greater number of surviving children, followed by smaller birth cohorts, created relatively large "baby boom" cohorts in a number of countries. When these cohorts reached working age, the dependency ratio was dramatically lower than in the past. The working-age population share rose from about 55 per cent of East Asia's total population in 1965 to 70 per cent in 2001. A beneficial policy environment, which focused on education and selective openness to trade, allowed this "boom" generation to be integrated into the economy. East Asia reaped the productivity benefits of the swollen workforce. Between 1965 and 1990 per capita income rose by over 6 per cent per year. This phenomenal growth was given the name the East Asian "miracle" (World Bank 1993b). However, Bloom and Williamson (1998) and Bloom, Canning, and Malaney (2000) demonstrate that no less than a third of the "miracle" could be explained by the demographic dividend.

Health to savings and investment

Another key element in East Asia's economic success was the region's high rate of capital accumulation, driven by an extraordinarily high savings rate of around 30 per cent of income. There are two channels, one accounting and one behavioral, through which the health of East Asia's population contributed to this high level of savings. Common to both channels is the well-established life-cycle theory for how consumption and savings decisions are made at the household level (see Modigliani and Brumberg 1954). According to this model, households earn an income stream over their lifetime and must choose a consumption path consistent with these earnings. It is assumed that, in general, people save when they are young to finance their retirement. Peak savings typically occur between the ages of 40 and 65. Absent a bequest motive, the dissaving of the old should offset the saving of the young in a stationary population (i.e., a population with a stable age distribution and no population growth). In this situation, there are no aggregate savings.

If the age structure of the population is unstable, aggregate savings or dissavings may occur according to the rise or fall of the share of the population at the high-savings ages – this is the effect considered by the accounting channel. In the case of East Asia, the demographic dividend resulted in a large fraction of its population being in the peak savings range of 40–65 years of age. Furthermore, this was the first cohort in the region to be living in a low-mortality environment and to be saving for retirement on a large scale (Bloom, Canning and Jamison 2004: 12). Age structure effects appear to account for perhaps one-fourth of East Asia's savings boom (Bloom, Canning, and Graham 2003).

The behavioral channel highlights the fact that improvements in health and longevity likely affect life-cycle behavior as individuals look forward to longer, healthier lives (see Bloom, Canning, Mansfield, and Moore, forthcoming 2007). Increases in longevity tend to increase the relative length of retirement, thereby raising the need for retirement income and generating higher savings rates among the young. Bloom, Canning, and Graham (2003) model and empirically investigate the effect of increasing longevity on the national savings rate. They report that a 10-year rise in life expectancy is associated with about a 4-percentage point rise in the savings rate. Lee, Mason, and Miller (2000) argue that rising life expectancy can account for the boom in savings in Taiwan since the 1960s. Rising longevity in developing countries could therefore magnify the current generation's incentive to save – a development that may have sizable effects on domestic investment. Although this saving and investment boom may only last for one generation and is offset by the needs of the elderly once the population ages, it can substantially boost economic growth rates while it lasts.

Health also affects foreign direct investment (FDI). A high burden of disease enervates the labor force. Perhaps also for fear of endangering their own health, foreign investors and executives tend to shun areas where disease is rampant and where access to health care is limited. By contrast, a healthy, productive workforce will tend to attract FDI inflows. Research has demonstrated that life expectancy exerts an independent influence on FDI: every additional year of life expectancy contributes to about a 9 per cent increase in gross FDI inflows in low- and middle- income countries (Alsan, Bloom, and Canning 2004: 11). These empirical results are supported by historical evidence. The textbook instance of disease interference in investment is that of the building of the Panama Canal. Yellow fever and communicable diseases claimed the lives of 10,000 to 20,000 workers between 1882 and 1888, forcing Ferdinand de Lesseps and the French to abandon the construction project (Jones 1990).

Health to education

Another mechanism by which health affects income is through its relationship to education. There is an extensive and longstanding literature demonstrating that education increases productivity and wages. A typical estimate is that a year of education increases wages by about 10 per cent (Psacharopoulos and Patrinos 2004). Healthier households generally have more income for many of the reasons discussed above. Their enhanced productivity allows them to earn higher wages, they have fewer health-related expenses, and they are able to attain desired family size at lower fertility rates. Healthy families can therefore afford to spend more on their children's education. Given the importance of education to income, it is significant that health can serve as a complementary input to education. In this regard, Finlay (2006) makes a significant finding: that the effect of health on economic growth is stronger in countries where education is weak, because a population that relies more on unskilled labor is more dependent on good health.

Healthier children have enhanced cognitive function and higher school attendance, allowing them to become better-educated, higher-earning adults. Bleakley (2003) finds that deworming of children in the American South had an effect on their educational achievements while in school. Miguel and Kremer (2004) find that deworming of children in Kenya increased school

attendance (though it did not enhance academic performance). In a study in India, Bobonis, Miguel, and Puri-Sharma (forthcoming 2006) find that deworming and treating anemia promoted school attendance.

Increased longevity can make investing in education more attractive because it affords a longer time horizon over which to reap the benefits of more schooling (Kalemli-Ozcan, Ryder, and Weil 2000). Bils and Klenow (2000) find an effect of life expectancy on investments in education at the national level. In addition, lower infant mortality may encourage parents to invest more resources in fewer children, leading to low fertility but high levels of human capital investment (including in education) in each child (Kalemli-Ozcan 2002).

There are numerous paths from impaired health to the inadequate education of children. Leslie and Jamison (1990) review the links between health conditions and what they see as the three main educational problems in developing countries: children who are unprepared to attend school, the failure of many students to learn in school, and the unequal participation of girls in schooling.

Children's readiness for school may be hindered by cognitive and physical impairments. These problems may begin *in utero* due to inadequate nutrition and poor health of the mother. An estimated 30 million infants are born each year in developing countries with impaired growth due to poor nutrition during fetal life (UN 2000). For example, cretinism, which can be avoided if iodized salt is provided to the mother, is the most common preventable cause of mental retardation worldwide (Cao *et al.* 1994: 1739). Moreover, malnourished children are less likely to enroll in school; those who do enroll do so at a later age (UN 2004).

The failure of children in developing countries to learn in school is often attributable to illness. The most important causes of morbidity among school-age children include helminthic infections, micronutrient deficiencies, and chronic protein malnutrition. (Estimates of mortality may be inadequate in assessing the burden of disease among school children because most illnesses are non-fatal.) When not fatal, these conditions impair children's ability to learn by directly contributing to disease, absenteeism, and inattention among children. Micronutrient deficiencies have a variety of adverse health effects. Vitamin A deficiency contributes to measles mortality and diarrheal illness (WHO 2004a) and is the leading cause of preventable pediatric blindness in low-income countries (Sommer and West 1996: 649ff). Impaired vision is a huge barrier to receiving an education, particularly in resource-poor settings. Globally, 4.4 million children and 6.2 million women of childbearing age manifest varying degrees of vision impairment from vitamin A deficiency (UN 2004). Iron deficiency is a well-documented cause of impaired cognitive development and lowered school achievement, and has a high economic cost (Grantham-McGregor and Ani 2001). It is also one of the most prevalent nutrient deficiencies in the world, affecting an estimated two billion people (WHO 2004a). Horton and Ross (2003) estimate that income forgone due to iron deficiency ranges from 2 per cent of GDP in Honduras to 7.9 per cent in Bangladesh. The higher estimates are associated with severe iron deficiency and higher returns to educational attainment in the labor market for a given country.

Biological and cultural forces affect the health of girls and can impede their educational attainment. Attending to remediable medical problems could help keep girls in school.

Menstruation exacerbates iron-deficiency anemia and at around the same developmental stage, iodine deficiency disorders also begin to affect more girls. Pregnancy increases nutrient demands and the risk of morbidity and mortality from a multitude of associated causes. An estimated 15 per cent of women develop potentially life-threatening complications associated with pregnancy, such as hemorrhage, infection, unsafe abortion, eclampsia, and obstructed labor (WHO 2004b). Early marriage and child-bearing may account for the drop-off in number of girls enrolled in secondary and tertiary school. A ubiquitous and disturbing pattern is that when illness strikes a family, girls often discontinue studies to assume responsibilities for household chores. Overviews of the interaction between health and education appear in Bloom (2005) and Bloom (2006).

The AIDS epidemic demonstrates particularly starkly the interplay between disease and education. Educational opportunities erode as families are forced to pay more for medical and burial costs. A study in rural districts in Uganda found that one in five children living in HIV/AIDS-affected households was removed from school because school fees could not be paid or the child was required to work (Topouzis 1994). The generation of orphans HIV is creating (14 million, mostly in Africa) strains household resources and affects educational attainment (WHO 2004c). Orphans have lower school enrollment rates and live in more impoverished households. Families who receive orphans often cannot afford to send all children in the household to school and must decide which children to enroll. Boys are usually chosen over girls and biological children are selected over orphans (Ableidinger, Case, and Paxson 2002). (The study finds that school enrollment rates reflect the degree of kinship between the child and the head of the household.) HIV/AIDS also affects the supply of education, damaging both its quantity and quality. A sharp increase in mortality rates among teachers and administrators accounts for this setback. 12 per cent of teachers in South Africa, 19 per cent of teachers in Zambia, and more than 30 per cent of teachers in Botswana are infected with HIV (BBC 2002). In Zambia, the number of teachers killed by AIDS in 1998 was equivalent to two-thirds of the number of teachers trained in the same year (WHO 2004c). Even where teachers are present, they may be sick and ineffective.

HIV/AIDS as a window into the relationship between health and economic outcomes

Economists have studied not only the role that HIV/AIDS can play in economic outcomes via its detrimental effect on educational attainment; much more broadly, the epidemic provides an interesting perspective on the standard economic view of the relationship between health and wealth.

The argument that population health is an important determinant of income growth implies that countries with waning health due to high rates of HIV/AIDS have poor economic prospects. For example, Haacker (2004) argues that HIV/AIDS "is the most serious impediment to economic growth and development" in countries with severe epidemics. However, a number of other analyses conclude that HIV/AIDS has had no measurable effect on income per capita (Bloom and Mahal 1997a; Mahal 2004; Werker, Ahuja, and Wendell 2006). Still others, such as Young (2005), suggest that, despite the obvious human cost, HIV/AIDS might actually promote growth of income per capita. According to this last argument, the reduction in the labor force resulting

from AIDS may increase worker productivity because surviving workers have more land and capital at their disposal, and because the capital/labor balance is pushed in a direction that benefits workers. Thus, the heightened mortality from disease may boost living standards. (The origins of this view can be traced to Thomas Malthus (1798), who believed epidemics and famines were "natural checks" on unfettered population growth. This bleak outlook led economics to be labeled "the dismal science.")

The description of events provided by Young may accurately describe the mortality "shocks" that characterized epidemics throughout history. (See Bloom and Mahal 1997b for detail on AIDS, influenza, and the Black Death). Yet the short-lived epidemics of the past, such as epidemic cholera or the 1918 Spanish flu, bear little resemblance to the current epidemic of HIV/AIDS. The AIDS virus kills, but does so slowly. Because it is most frequently transmitted via sexual activity, it preferentially infects young and middle-age adults. As a result, HIV/AIDS affects societies in different ways than other epidemics and leads to higher burdens of youth (orphan) and elderly dependency. Because the possibility of contracting HIV reduces the incentives and opportunities for education and savings, it likely magnifies the intergenerational transmission of poverty.

It is estimated that approximately 39 million people are infected with HIV (UNAIDS 2006), and that AIDS is now the world's leading killer of adults ages 15–59 (WHO 2003). Co-infections of HIV and malaria or tuberculosis can exacerbate an already dire health situation. A high prevalence of some diseases negatively impacts economies and is associated with lower economic growth rates. Gallup and Sachs (2001) demonstrate that countries heavily burdened with malaria experienced an average growth rate in per capita GDP of about 0.4 per cent per year between 1965 and 1990, in comparison with an average growth rate of 2.3 per cent in other countries. Moreover, a consideration of GDP per capita alone does not fully express the economic losses; it refers to the effects of disease on the income of survivors, but does not reflect the monetary value of the loss of life.

Because GDP per capita is not a complete measure of well-being, a "full income" indicator can be used to convey a more accurate picture of the economic effect of AIDS. Full income consists of two components: GDP per capita for survivors and the estimated value of life for decedents. The latter is derived from the "value of a statistical life" (VSL) literature. This literature places a dollar value on human life using information from individuals' choices to take life-threatening risks, no matter how small. This method has drawbacks, but it enables governments to compare public health and other development interventions that reduce mortality risks.

Estimates of the monetary value of life are often very large (Viscusi and Aldy 2003). A typical range for a country's VSL is around 100–200 times GDP per capita, with richer countries located at the higher end of the range. Using full income, a conservative estimate of the cost of Africa's mortality change due to AIDS is 1.7 per cent of Africa's income per year from 1990–2000, which is a far higher number than earlier estimates for the effect of AIDS on GDP over the same period (Bloom, Canning and Jamison 2004: 14). More broadly, using techniques that do not rely solely on GDP per capita as the outcome of interest, studies of many countries have shown the intrinsic value of health gains to have been comparable to or higher than the value of income gains due to health improvements (Nordhaus 2003; Becker, Philipson and Soares 2005).

The way forward

This chapter summarizes the evidence on the contribution of population health to economic growth and poverty reduction and the mechanisms through which this takes place.

The next logical step is to determine what fraction of societal resources should be allocated to the health sector. We do not attempt to provide an answer to that question, but the CMH Report makes explicit recommendations regarding domestic and international financial contributions towards health. The Report estimates that total health outlays for improving population health among low- and middle-income countries would approach $57 billion by 2007 and $94 billion by 2015. The low- and middle-income countries could commit an additional $35 billion per year by 2007 and $63 billion by 2015. In addition, the Report calls for concessional grants totaling $22 billion by 2007 and $31 billion by 2015 from wealthy countries and international development banks. The recommended rise in donor funding for health represents 0.1 per cent of donor country GDP.

In any case, it is clear that where disease is most rampant, among poor populations within and across countries, the resources necessary to improve health are most scarce. Wealthy countries could contribute more financial resources toward reducing the burden of disease in the developing world. Low- and middle-income countries could also do much more to improve the transparency, accountability, and equity of national health systems. Health is proving to be a worthwhile investment. Improved health will allow developing countries to enjoy higher rates of economic growth and faster poverty reduction; wealthy nations will benefit from reduced expenditures on global public health threats, expanding markets, and enhanced global security.

If history serves as a harbinger of things to come, the financial rewards of global health investments are reaped many times over. Smallpox eradication obviates the need for preventive measures and treatment facilities. The cost to the United States for the successful 13-year campaign was about $30 million; since smallpox was eradicated in 1977, the total investment has been returned to the United States every 26 days (CISET 1994).

In sum, investments in population health can be considered integral to economic development and to promoting the wealth of nations. Improving the health of nations is a powerful instrument to this end.

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