NBER WORKING PAPER SERIES

GLOBAL PATTERNS OF INCOME AND HEALTH:
FACTS, INTERPRETATIONS, AND POLICIES

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Working Paper 12735
http://www.nber.org/papers/w12735

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 2006

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NBER Working Paper No. 12735
December 2006
JEL No. I1,O1,O15

ABSTRACT

People in poor countries live shorter lives than people in rich countries so that, if we scale income by some index of health, there is more inequality in the world than if we consider income alone. Such international inequalities in life expectancy decreased for many years after 1945, and the strong correlation between income and life-expectancy might lead us to hope that economic growth will improve people's health as well as their material living conditions. I argue that the apparent convergence in life expectancies is not as beneficial as might appear, and that, while economic growth is the key to poverty reduction, there is no evidence that it will deliver automatic health improvements in the absence of appropriate conditions. The strong negative correlation between economic growth on the one hand and the proportionate rate of decline of infant and child mortality on the other vanishes altogether if we look at the relationship between growth and the absolute rate of decline in infant and child mortality. In effect, the correlation is between the level of infant mortality and the growth of real incomes, most likely reflecting the importance of factors such as education and the quality of institutions that affect both health and growth.

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1. Introduction: Inequalities in income and inequalities in health

Global inequality takes many dimensions. Not only is there great inequality across the peoples of the world in material standards of living, but there are also dramatic inequalities in health. The inhabitants of poor countries not only have lower real incomes, but they are also more often sick, and they live shorter lives. These international correlations between income and health should affect the way that we think about the level and distribution of global wellbeing. They also need to be understood if we are to be effective in reducing global deprivation in either income or health.

This paper assembles basic facts about global patterns of health and income, about the correlations between them, and the possible interpretations of those correlations. I argue that the convergence in international life-expectancies that was so pronounced between 1950 and 1990 should not be interpreted as demonstrating any similar global convergence in broader measures of living standards that take health and income together, if only because the mortality reductions that underpinned the convergence took place at different age groups in poor and rich countries. Life expectancy is a summary measure of population health that is not suitable for making comparisons of health changes between countries at different income levels and at different points in the epidemiological transition. More generally, looking for convergence or divergence in various health measures is not informative about the welfare consequences of changes in global health.

I also argue that poor health in poor countries is not because of lack of medical or scientific knowledge about effective treatment, because the means of treatment are known, often long known. Low incomes are a more plausible explanation for poor health. Indeed, as first documented by Samuel Preston (1975), income and various measures of

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health are strongly correlated across countries, and there is a widespread popular and professional belief that the diseases of poor countries are indeed diseases that are caused by poverty. Yet there are several well-known examples—Cuba, Sri Lanka, Costa Rica, Kerala—of poor or relatively poor populations with excellent health outcomes. Moreover, I show that international correlations between economic growth on the one hand and reductions in child and infant mortality on the other are difficult to reconcile with the view that economic growth, as well as being beneficial in its own right, is doubly blessed because it automatically yields an improvement in population health. The historical record for India and China is also inconsistent with any close relationship between economic growth and the rate of health improvement. Instead, the most important correlate of economic growth is the *level* of infant or child mortality, not its rate of change, suggesting that the determinants of population health overlap with the determinants of economic growth. Factors such as good governance and education, particularly women's education, are likely candidates for further investigation.

2. Income and health: some facts

Preston's (1975) analysis of the changing relationship between income and health is a good starting point for any discussion of global health inequalities. Preston plotted life expectancy against per capita income for a cross-section of countries to show an increasing and concave relationship, with the relationship itself moving upwards over time, albeit at different rates in different periods. Figure 1 shows a version of the Preston curve for the year 2000. The vertical axis is life expectancy, the horizontal axis is GDP per capita in 2000 purchasing power dollars, and each country is represented by a circle,

whose diameter is proportional to the country's population. The line shows an estimate of average longevity at each level of per capita income.

The current Preston curve has the same general shape as the original, although there are differences in detail. On the left of the graph, among the poorest countries, small changes in income are associated with large increases in life expectancy. These are the countries that are yet to experience the "epidemiological transition," during which infectious diseases, which mostly kill children, give way to chronic diseases, such as cancers and heart diseases, which mostly kill elderly people. Among the rich countries, on the right of the graph and which are beyond the transition, increases in income are associated with smaller, but still positive, increases in life expectancy. The United States, which has poor health relative to other countries that are nearly as rich, is populous enough to pull down the regression line at the top of the world distribution of income.

A recent feature of the Preston curve is the flattening, almost a dip, around the point of the epidemiological transition, just above China, and before we come to Brazil or Russia. This shows the adverse effects on life expectancy of HIV/AIDS, particularly although not exclusively in African countries—note in particular the position of South Africa—as well as the less catastrophic but still significant decline in life expectancy in some of the formerly socialist countries of Eastern Europe and Central Asia. As we shall see, these two events, particularly HIV/AIDS, have wrought major changes in international patterns of health and income over the last ten to twenty years.

If we were to follow Preston and draw the curves for a range of years, we would find, as he did, that the curves move up over time, so that the majority of countries have improved their life expectancies by more than would have been predicted by the growth

of their incomes and their position on the previous curve. There are many forces for better health that do not depend on growth of incomes. That this is the case is well illustrated by the fates of countries in sub-Saharan Africa through successive curves. From the early post-war years until around 1990, most countries had substantial improvements in life-expectancy, even when there was no or negative growth in income. Applications of the germ theory of disease, such as vector control, immunization, and clean water were often effective in improving population health irrespective of economic conditions.

South Africa is something of a special case. It has always been located well below the curve, as in Figure 1, a result which is predicted by the curve itself. Because of its extreme income inequality, and its unique position as a combination of a rich, healthy, minority white population, with a poor, relatively unhealthy, majority black population, and because the curve is concave, average population health in South Africa has always been worse than would be predicted by the curve for a country with its average income. Yet if we follow South Africa from 1960, decade by decade, it follows the curve upwards, moving closer to it as the health of the majority population improved. But this process was brought to an abrupt end by HIV/AIDS when South Africa, along with many of its neighbors, fell back to its present position. Much the same story, although without the peculiar features of *apartheid*, can be told about several other sub-Saharan countries, such as Kenya or Botswana.

3. Income and health: poverty and inequality

The facts of the Preston curve have implications for the way that we think about poverty and justice around the world. Income poverty and health poverty are positively correlated, and those who suffer from material deprivations are also those who suffer from health deprivations. Those with high living standards generally live longer and better than those with low living standards. We can turn this into statement about international inequality if we are prepared to combine income and health into a single measure of well-being, for example, by scaling down incomes for those in poorer than average health, and scaling them up for those in better than average health. The simplest way to do this is to multiply per capita income by life expectancy. For such scaled measures, the correlation between health and income implies that inequality in the composite measure of wellbeing is larger than the separate inequalities in either health or in income. If we think that global income inequalities are too high, and that global health inequalities are too high, we will find the inequality in their combination worse than either.

That people who are desperately lacking material resources are also at greater risk of death is a powerful enhancement to humanitarian arguments for helping the world's poor. Some also regard the gross combined inequalities to be an injustice, which would require remedy even if everyone had minimally acceptable standards of health and of income. Although there is wide acceptance of the humanitarian argument, the argument through justice is more controversial, see Thomas Nagel (2001). Though in the world as it is, with its depths of health and income poverty, the humanitarian argument is likely to be enough for policy.

It should also be noted that income and health are not the only components of wellbeing that are positively correlated across countries. Education, political and civil rights, and democracy are other components of freedom which, with many exceptions, are positively correlated with income and longevity. Those who suffer from one deprivation are also likely to suffer from others, Amartya Sen (1999). While it often makes little sense to try to combine the components of wellbeing into the sort of measure that could support statements about inequality, the general point remains, that the gaps between the worst off and the best off are gaps in many dimensions, and that gaps in income are neither the only nor necessarily the most important.

4. Changes over time: patterns of convergence and divergence

Although broad measures of wellbeing are more unequally distributed than narrowly defined measures based on one component, inequalities may be shrinking over time so that we can perhaps look forward to a more equal world. Certainly, patterns of income and longevity have changed in the past. The global *divergence* in life expectancy dates from around the same time as the global *divergence* in per capita incomes, around the middle of the 18th century, when the countries of northwestern Europe began to pull away from the rest of the world in both income and health, Francois Bourguignon and Christian Morrisson (2002), Lant Pritchett (1997). The original cross-country expansion in income inequality has never been reversed, but the improvement in health spread from northwest Europe and north America, first to eastern and southern Europe at the beginning of the 20th century, and then, with much greater rapidity, to the now developing world after World War II, Davidson Gwatkin (1980). The post-war improvement in life expectancy

in the poorest countries of the world, and the narrowing of the gap with already long-lived countries, can perhaps be thought of as offsetting to an extent the continuing inequality in incomes between countries.

One version of this argument has been put by Gary Becker, Tomas Philipson, and Ricardo Soares (2005), who use a combined health and income indicator that is a more sophisticated version of the measure obtained by multiplying per capita income by life expectancy. They note the standard empirical finding from the literature on economic growth that there is little convergence in average per capita income levels across countries, but argue that when income and life-expectancy are taken together, there has been convergence in their measure, with the poor countries catching up with the rich. If we are not much concerned with income itself, but only with the more comprehensive, broader concept, we should also not be concerned by the failure of international inequality of incomes to shrink, since inequality in the comprehensive measure, although wider, is diminishing over time.

Table 1 shows measures of the dispersion of various measures of income and health. These are all calculated on a country by country basis, so that China and Tanzania, for example, get the same weight. To do otherwise would be to reproduce mostly the experiences of China and India, to which I will return at the end of the paper. Even in principle, it is of interest to think of each country as a unit whose mortality and income experience provides one example from the universe of all possible such histories.

The first column of the table shows the standard deviations of the logarithm of per capita GDP in purchasing power dollars, taken from version 6.2 of the Penn World Table. It reproduces the familiar finding that there is no convergence in log GDP around the

world; indeed, the standard deviation of logarithms rises from 0.98 in 1960 to 1.18 in 2000 and, based on a smaller sample of countries, to 1.23 in 2004, currently the latest available year. A similar pattern is displayed by the differently-calculated PPP series for GDP that is calculated by the World Bank and published in their World Development Indicators (not shown here). The standard deviation of life-expectancy shows a different pattern. From 1960 through to 1990, this measure of dispersion decreased, as countries with low life expectancy caught up with the long-lived countries, whose life expectancies were themselves increasing, albeit at a slower rate. After 1990, with the collapse of the Soviet Union and the deterioration in life expectancy in several ex-socialist countries, and above all, with the onset of HIV/AIDS, convergence turned to divergence. While there is a great deal of uncertainty about the measurement of life expectancy in sub-Saharan Africa, and the precise extent to which it has fallen, there is no doubt about the phenomenon itself, or the widening in international health inequalities that it has wrought.

Across these countries, the logarithm of the product of life-expectancy and per capita income shows growing disparity, because the convergence in life-expectancies up to 1990 is not sufficient to overcome the divergence in the logarithms of GDP. Even so, dispersion increased from 1960 to 1980, and then fell through the decade, rising only in the 1990s. But the general point remains that, at least for some of the post-war period, narrowing of differentials in life-expectancy can be thought of as offsetting the widening differentials in national income per head.

The cross-country standard deviation of infant and child mortality rates has fallen since 1960. The mortality associated with HIV/AIDS is mostly among adults, and

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although there have been negative consequences for children, who may be born HIV-positive, or whose healthcare may deteriorate in the face of the epidemic, mortality among infants and children has continued to decline in even the poorest countries of the world, and its international dispersion has continued its fall. Yet if we move to the *logarithms* of infant and child mortality, shown in the last two columns, standard deviations have *increased* throughout the last half-century, so that by 2004, the standard deviations were around 50 percent higher than they were in 1960.

Whether there is divergence or convergence in infant and child mortality depends on whether we work in ratios or in levels; which of these measures, if any, is most useful is an issue I will address in the next section. But the *factual* reason for the difference is that infant and child mortality rates have continued to decline in the low mortality rich countries of the north and, because the initial levels of mortality were so low, even small absolute reductions are proportionately large. In Sweden, for example, infant mortality fell from 11 per thousand in 1970 to 3.2 in 2000, while in Mali, it fell from 225 to 124 per thousand. The numbers of lives saved in Sweden is small relative to the number in Mali, but the proportional decline is much larger. This is, of course, a general problem in the literature on health inequalities, which tends to focus on ratios of mortality rates which, in this case, show a worsening of health inequality between Sweden and Mali, from a ratio of 20.5 to 38.8, in spite of the fact that many more Malian than Swedish lives have been saved.

5. The welfare consequences of international mortality patterns

Consider a period, such as that between 1950 and 1990, during which life expectancies were converging across the countries of the world. Although this convergence ceased after 1990, we might hope this is a temporary reversal, associated with unusual political and economic events and with the sort of plague that comes only a few times in each millennium, such as the Black Death, cholera, and HIV/AIDS. If so, and if it is normal for differentials in life-expectancy to decline, what are the implications for international well-being? Does it make sense to say that health inequalities are narrowing? The following argument, taken from my earlier 2004 paper, suggests that life expectancy, by itself, can be seriously misleading.

One immediate problem with comparing trends in life expectancy across countries is that the patterns of mortality that underlie the differences in longevity are different between poor, high mortality countries on the one hand, and rich, low mortality countries on the other. In particular, in high mortality countries, a large fraction of deaths are deaths of children, while in low mortality countries, most deaths are deaths of the elderly, see the bottom panel of Table 2. Over the post-war period, trends have also been different across the two groups, with most mortality reduction in poor countries coming from reductions in infant and child mortality whereas, in the rich countries, there have been reductions among both young and old. The elimination of childhood mortality from infectious disease was far from complete in 1945, even in the rich countries, and in more recent years, there have been substantial proportional reductions in mortality rates among infants, albeit from already very low rates. Perhaps the most important and rapid declines in mortality in rich countries have been among adults aged 50 and older, and have been

caused by some combination of three main factors: improvements in the medical treatment of cardiovascular disease, declines in smoking especially among men, and nutritional improvements in the early 20th century. Historical improvements in nutrition arguably contributed to the temporary upsurge and subsequent decline in heart disease which peaked in most rich countries in the late 1970s and early 1980s.

It is far from clear how to compare the value of saving the life of a child with saving the life of someone in middle-age. Yet this is exactly what we must do when if we are to evaluate and compare progress in health between rich and poor countries. Taking life expectancy as the metric provides one solution, but it is one that gives more weight to saving the life of the infant or, more generally, to saving younger people over older people.

Consider a simple example. Suppose that, in the initial state, 50 percent of infants die immediately after they are born, and the rest survive, living to age 60. Life expectancy at birth is 30 years (a half times zero plus a half times 60). Suppose too that each woman bears six children, so that three survive into adulthood. A new preventative technique (clean water or vaccination) is introduced that reduces the infant mortality rate from a half to a third. Life expectancy rises to 40 (a third times zero plus two-thirds times 60). If per capita income were to remain the same (which is a big if, although in fact, per capita incomes grew at faster than normal rates in poor countries during the relevant period), the compound measure of well-being, income times life expectancy, increases by a third. Yet this is not likely to be the end of the story. After the innovation, if fertility is unchanged, women have four surviving children, rather than 3. If women care only about the number of surviving children, and do not wish to go through more births than necessary, they will

then reduce their fertility rate to an average of 4.5. This is not the only thing that could happen, and I am not claiming it is optimal, but some compensating reduction in fertility is likely, and this reduction provides a convenient example. With an infant mortality rate of one third, they will lose 1.5 children on average, and have 3 surviving children, as was the case before the health improvement.

Note that, once this new situation stabilizes (which will take many years in practice) the age structure of the population will be exactly the same as before. Each woman has 3 surviving children who live to age 60. What has changed is that each woman bears only 4.5 children as opposed to 6, and that the 1.5 children per woman who used to die immediately after being born are, in effect, never born at all. One can think of this as a change from 1.5 children ceasing to exist just *after* they are born to 1.5 children ceasing to exist just *before* they are born. So that it is hard to maintain that this change involves any great increase in wellbeing *for the children.* See John Broome's (2003) *Weighing Lives* for a similar argument.

While this kind of adjustment of infant mortality and fertility is going on in poor countries, rich countries are experiencing reductions in mortality among the middle-aged and elderly, which increases their wellbeing (with no argument), so that taking both together, it is unclear that there is any narrowing of inequality because of the more rapid increase in life expectancy in the poorer countries. I say "unclear," because it is certainly possible to argue that saving the lives of children is more valuable than saving the lives of adults, and that it is inappropriate to give any weight to the unlived lives of those who are never born, let alone to use them as an offset to the lives of the newly born who are newly saved.

One important matter that is neglected by focusing on infants is that *women* are clearly better off through reductions in infant mortality and fertility; they bear fewer children, which reduces the risk to their own lives, and they are spared the agony of watching so many of their children die. But these gains are not captured in the increases in life expectancy measures associated with the reduction in infant mortality. A weak version of this argument would be that life expectancy is not necessarily a good measure of health wellbeing, particularly when that life expectancy is used to compare places or times with very different age patterns of mortality. A stronger version is that the narrowing of international inequality in life expectancy overstates the reduction in international health inequality in the post-war period.

6. Convergence, or not, and why should we care?

The fundamental problem with making international comparisons of wellbeing is that there is no natural metric for health, a situation that is in sharp contrast to the measurement of income. In such cases, information on cross-country convergence of various health measures is not likely to be useful. As we have already seen in Table 1, life expectancies were converging until 1990, infant mortality rates converge throughout the period, but the *logarithms* of infant mortality rates have been continuously diverging. This contradictory situation is not some bizarre contemporary happenstance, but can be expected in a wide range of circumstances.

Consider, one again, the example in the previous section where people either die at birth or live to age 60. Suppose too that infant mortality rates are different from country to country, but are declining at the same proportional rate. The ratio of infant mortality

rates between any two countries is then constant over time, and the logarithm of infant mortality rates has a constant variance across countries. (This is contrary to the facts in Table 1, but will illustrate the point.) The constant proportional reduction in infant mortality rates will eventually make them arbitrary small, and life expectancy will converge to 60 years. In this situation, there is convergence in life-expectancy, but no convergence in the logarithms of infant mortality rates. Put another way, while the ratios of infant mortality rates for any two countries remain constant over time, the ratios of *survival* rates are getting smaller, as survival rates converge. This is the famous problem of whether to count the living or the dead, see Mindel Sheps (1958) quoted in Preston and Paul Taubman (1994) who were concerned, as I am, with the ill-defined nature of measures of health inequality. We cannot measure inequality over arbitrary selected measures of health, without more assumptions, and without a clearer idea of what it is that we are trying to do.

Actual life expectancy measures have another serious problem in that they are poorly measured, particularly in the poorest countries, and particularly in sub-Saharan Africa. The accurate estimation of adult mortality rates depend on having a complete vital registration system through which all births and deaths are reported to a government agency. Vital registration became complete in the United States as a whole only in the 1930s, and is still incomplete for most of the world's population. In practice, adult mortality rates are estimated from information on infant and child mortality rates, which are high enough in poor countries to make them amenable to measurement using household surveys, such as the system of Demographic and Health Surveys. Today, life expectancy is calculated from predictive equations with infant and child mortality as

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arguments, see for example Alan Lopez et al (2000), Ian Timæus (2001), or Kenneth Hill (2003). After mortality from AIDS became important, these formulas needed to be adjusted, based on sometimes quite speculative estimates of AIDS mortality.

Figure 2 shows the international relationship between estimated life expectancy and infant mortality rates using data from the United Nations population division. The left-hand panel shows the relationship for the years 1970 to 1975 (the UN provides estimates for five year intervals) and the right-panel the relationship for 1995 to 2000. As there should be, there is a strong negative relationship between life expectancy and infant mortality. The disturbing feature of these data is that, among the high mortality countries, the data points in the left-hand panel lie along visible straight lines that show, not reality, but how the data were created. In the 1970s, life expectancy was calculated using a series of model life tables, one for each of several regions of the world, which gave life expectancy as a function of infant mortality. These lines have vanished in the right hand panel, not because the data are more accurate—although that is undoubtedly the case in some countries—but because the AIDS epidemic requires a country by country adjustment for the affected countries. Given the uncertainty about AIDS mortality, there is little reason to suppose that the right hand panel is any more accurate than the left.

The models that are used to predict life expectancy from infant mortality rates are likely to give a reasonably accurate picture of the international patterns of life expectancy, so that, for example, the Preston curve in Figure 1 would probably not change very much if the world were to have a complete vital registration system. But the same is unlikely to be true for changes over time. Particularly difficult are changes in adult mortality or adult life expectancy in sub-Saharan Africa. Given the urgency of

improving health in Africa, this gap in our knowledge seriously impairs our ability to monitor progress or to evaluate initiatives for improvement. It is also another good reason for being careful about making comparisons of changes in health between rich and poor countries when the measurement of those changes rests on numbers that are projected and interpolated, not measured.

7. Is growth good for health?

So far, I have been concerned with the facts of global health and income, and how those facts might condition our thinking about health and income inequality across nations. But the strong relationship between health and income also holds out another possibility, that growth in incomes improves population health. If so, there is a double benefit from economic growth; not only does it reduce income poverty—the direct effect—but it also reduces health poverty—the indirect effect. That this might be the case was of course the main point of Preston's original analysis, which challenged the then conventional wisdom that health interventions, usually from the outside, had been essentially the only factor in reducing mortality in poor countries. Even so, Preston credited income with only a relative small role compared with public health; in later work, he attributed nearly half of health improvements to the *combined* effects of improvements in income, literacy, and the supply of calories, Preston (1980).

That some combination of the social and economic environment is important for health is almost certainly correct, if only by elimination. While it is possible to argue that the reason so many people die of cancer is because we know so little about the disease, and lack preventative or curative measures, the same cannot be said about most deaths

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around the world. Table 2, adapted from David Cutler, Deaton, and Adriana Lleras-Muney (2006), shows the pattern of mortality across the world. The bottom panel shows the sharp differences in the age structure of deaths between rich and poor. In the World Bank's "high income" countries, less than 1 percent of all deaths are deaths of children before their fifth birthday. In the "low income" countries, more than 30 percent of all deaths are deaths of children. The top half of the panel shows the causes of those deaths and that the vast majority of them are preventable or treatable given current knowledge. For example, more than a million people, mostly children, die from diseases that can be eliminated using vaccines, and which have been so eliminated in the rich countries. Each year nearly 4 million people, again mostly children, die from respiratory infections (mostly pneumonia); of these nearly 3 million live in low income countries, and the third of a million who die in the rich countries are elderly people, among whom deaths from pneumonia are not uncommon. Deaths from HIV/AIDS are now mostly in low income countries, and are treatable although not curable using anti-retroviral drugs. While these drugs are expensive, mostly under patent protection, and difficult to use effectively, the same is not true of the treatments for the other diseases which are generally cheap, off patent, and relatively easy to use in the right circumstances. Whatever is causing people in poor countries to die, and people in rich countries to live, it is not the unavailability of drugs, treatment, or knowledge about the diseases from which poor people die. Something else is standing in the way.

Poverty, the lack of income, is at the least one obvious candidate for explaining mortality in low income countries. On this, data on individual people are qualitatively consistent with the macro data of the Preston curve. For example, Adam Wagstaff (2000)

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shows that child mortality is higher among households with lower total household per capita expenditure in nine developing countries. Kath Moser, David Leon, and Gwatkin (2005), using an index of durable goods ownership based on Deon Filmer and Lant Pritchett (2001) widely interpreted as a measure of wealth or of income, show that this measure of wealth is negatively correlated with infant and child mortality in 44 Demographic and Health Surveys from 22 countries. There is also a substantial and long-established literature on nutritional Engel curves, which generally, if not invariably, finds that better-off households are better nourished. Indicators of child malnutrition, such as wasting and stunting, are also lower among higher expenditure or higher asset-index households, Wagstaff and Naoko Watanabe (2003), At the national level, child malnutrition is less prevalent at higher incomes though, as with the Preston curve, malnutrition decreases even in the absence of income growth, see Lawrence Haddad et al. (2003). These authors also examine both micro and macro data and find quantitatively compatible results in both. The consistent links between income or income-like measures on the one hand and mortality, nutrition, and anthropometrics, on the other, should be contrasted with the inconsistent and often insignificant results from attempts to link the proximity of health clinics to health outcomes. Peter Svedberg (2006, 4) goes so far as to state that "In all investigations of the determinants of inter-country differences in child stunting (and underweight) based on regression analysis, per capita real income has been identified as the crucial variable."

The recent macroeconomic evidence on health and income has taken a much less shaded position than that originally proposed by Preston. Perhaps best known is the paper "Wealthier is healthier," by Pritchett and Lawrence Summers (1996), which argues for a

strong and consistent relationship between growth in per capita incomes and reductions in

child mortality rates. Filmer and Pritchett (1999) extended and replicated this work, and

in addition found little or no evidence of beneficial effects of government spending on

health, a conclusion that contradicted, using a different sample of countries, the earlier

work by Sudhir Anand and Martin Ravallion (1998). But even in this (unresolved)

debate, both sides agreed on the importance of income growth for health, directly in the

Filmer and Pritchett regressions, and indirectly, through poverty reduction, in Anand and

Ravallion. It should, of course, be noted, that these studies can be challenged on their

own terms; for example, all use more or less incredible instrumental variables to separate

the effects of health on income from the effects of income on health. Nor is it clear, in the

absence of a story about why health expenditures are what they are, and why they are so

differentially efficient across countries, whether we should expect to find any

relationship between health expenditures and health outcomes in a cross-country

regression, or indeed, in the micro level regressions discussed in the previous paragraph.

The World Health Organization's Commission on Macroeconomics and Health

(2001) makes the case for the reverse causality, that many of the poorest countries in the

world are poor because they are sick, and that additional public expenditures on health

are the preconditions for poverty reduction, particularly in sub-Saharan Africa. While it is

obvious enough that individuals who are sick are likely to earn less, it is far from clear

that nations with high prevalence of disease should be less able to *grow* than countries

that are less unfortunate. Indeed, the historical record in the now rich countries shows no

acceleration in growth in spite of enormous improvements in health, see Pritchett (2001)

who notes that health *cannot* cause growth, because one is trending upwards and the

other is stationary. Recent work by Daron Acemoglu and Simon Johnson (2005) makes a convincing case that most improvements in health were, in the long run, driven by innovations in preventative and curative methods, and that these improvements, in and of themselves, tended to *reduce* the rate of growth of GDP per head because they reduced infant and child mortality rates and thus increased the number of heads with no corresponding increase in output in the short run. Although the Commission's arguments are hardly convincing, any causality that does indeed run from health to income would strengthen the case for a positive correlation between per capita income and population health, at least in the longer term.

8. Growth and health: another look at the evidence

Figure 3 shows the relationship between infant mortality and economic growth over all ten year periods from 1960 to 2000; note that each country can appear up to four times depending on data availability. The vertical axis shows the annual proportional change in the infant mortality rate so that, for example, a reduction from 60 per thousand to 54 per thousand over a ten year period would show as minus one per cent a year. The horizontal axis shows the annualized rate of growth of real per capita GDP in purchasing power dollars from the Penn World Table. As expected, there is a strong and significant negative relationship with a slope of around −0.25, so that for every percentage point of economic growth, the proportional rate of infant mortality reduction falls by a quarter of a percentage point. This evidence, albeit in more fully specified regressions, lies beneath the results in Pritchett and Summers (1996) and Filmer and Pritchett (1999.)

Figure 4 shows the same information, but I have now superimposed the scatter-plot between per capita GDP growth and the *absolute* reduction in the infant mortality rate per thousand live births. By this, the reduction from 60 to 54 per thousand would be recorded as −0.6 per annum. The proportional changes are labeled on the right-hand axis, the absolute changes on the left-hand axis. Remarkably, the significant negative relationship between growth and infant mortality decline has now vanished. While the new line has a negative slope, it is less pronounced, and its *t*-value is only −1.91, as opposed to −7.85 for the proportional regression.

It is possible that ten year periods might be too short for the relationship to be apparent in all forms and, indeed, many of the mechanisms through which income might affect health (or health affect income) are likely to work more strongly over longer time periods. Figure 5, which shows the same two relationships for the forty year interval from 1960 to 2000, shows that this argument is not the reason behind the contradiction between the proportionate and absolute relationships. Although there are fewer points here, largely because each country can appear (at most) once, the slopes are now of opposite sign, although, once again, the positive slope for the absolute changes in infant mortality is not significantly different from zero.

The reason for the difference in the two regressions is the same as the reason for the divergence in the logarithms of infant mortality rates discussed in Section 6 above. Over all the ten year sub-periods from 1960 to 2000, rich countries have had both higher rates of economic growth and higher proportionate reductions in infant mortality. For countries whose real GDP at the start of the period was less than $5,000, infant mortality fell by 2.2 percent a year in the subsequent decade, and economic growth averaged only 1.0 percent

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a year. For countries whose per capita GDP was above $5,000, the rate of proportionate decline of the infant mortality rate was 4.0 percent a year, and economic growth was 2.6 percent a year. By these measures infant mortality and real GDP per head were separately diverging.

There is another way of looking at these data. If y is the infant mortality rate, and the (negative) change Δy is uncorrelated with the rate of growth of per capita GDP, $\Delta \ln x$, while at the same time, $\Delta \ln y = \Delta y / y$ is negatively correlated with $\Delta \ln x$, then it must be the case that $\Delta \ln x$ is *negatively* correlated with y, so that economic growth is higher in places where infant mortality is lower. This correlation is shown in Figure 6, while Figure 7 shows what, given Figure 2, is essentially the same correlation in a perhaps more familiar form in which growth is positively correlated with life expectancy. In the macro and growth literature, it is often claimed that having a longer time to live is a stimulus to saving and investment, Peter Lorentzen, John McMillan, and Romain Wacziarg (2005), David Bloom, David Canning and Jaypee Sevilla (2004), Bloom, Canning, and Bryan Graham (2006), and the Commission on Macroeconomics and Health (2001). I do not need to challenge that contention—although such accounts need to reconcile the incentives for savings and investment with the fact that international variations in life expectancy as measured are dominated by variations in under-5 mortality so that, at the ages where savings and investment decisions are taken, most mortality uncertainty is already resolved, and international differences in mortality are much attenuated. Instead, my main point is that if it were true that income is the main causal factor for health, we would expect changes in income to be linked with changes in infant mortality rates, and that is not the case. Instead, low levels of mortality are

associated with successful economic growth, which suggests an explanation in which there are common third factors that are good both for growth and for health.

An investigation of the mutual determinants of growth and health is beyond the scope of this paper. But a number of candidates are identified in both literatures. The level of education, particularly women's education, is a leading possibility that has been repeatedly identified as a crucial factor in child malnutrition, infant and child mortality, and in lowering fertility rates, Drèze and Mamta Murthi (2001), John Hobcraft (1993). Many of the institutions that are identified in the growth literature, particularly those relating to governance, are also identified in the recent literature on the delivery of public health services and of healthcare, which emphasizes failures to regulate, failures of absenteeism, and failures of information as among the most important barriers between knowledge about how to prevent and cure disease, and its delivery to the poor of the world, Nazmul Chaudhury et al. (2006), Das and Hammer (2004. 2005a, b).

Finally, a word of caution. Lack of correlation *does not* imply lack of causation, any more than the correlation implies causation. If it were true that faster growth caused better health, then other mechanisms might obscure or attenuate that correlation. Consider, for example, the following simplified model. Improvements in health are caused by growth and by innovations in health technology, so that

$$\Delta H = \alpha_0 + \alpha_1 \Delta \ln x + \alpha_2 I + u_1 \tag{1}$$

where *I* measures health innovations, and both coefficients are positive. The growth in per capita income is also affected by health, according to

$$\Delta \ln x = \beta_0 + \beta_1 \Delta H + u_2 \tag{2}$$

According to Acemoglu and Johnson's findings, who use I to instrument ΔH in (2), the causal effect of health improvements on growth, the parameter β_1, is negative, essentially because of the traditional negative effects of population growth on income per head, especially when the population growth comes through additional children. In this model, other determinants of economic growth, such as investment, better education, or globalization, work through the term u_2, increasing growth and improving health through (1) and the positive parameter α_1. The effect through (1) works against the negative effect of health innovations on growth through (2), and over any particular period, could annihilate or even reverse the negative correlation between health improvements and growth. By the same token, the positive effect of growth on health, the coefficient α_1, will not necessarily show up in the correlation between health improvements and economic growth. Indeed, if Acemoglu and Johnson's results hold for the periods and countries considered here—and their main focus is on an earlier period, and their data do not include any African countries—then there *must* be a positive causal effect of growth on health to explain the zero correlation in the data.

9. India and China

In all of the analysis so far, each country has been treated as an equally important and informative observation, a procedure that gives no recognition to the importance of India and China in the global population. So it is useful to look at the record of growth and mortality in those two countries, to see whether the pattern is different from what we have seen elsewhere.

An excellent discussion of the relative progress in India and China is given by Drèze and Sen (2002, Chapter 3), and Figures 8 and 9 follow their lead using the data used in this paper. Figure 8 shows income and child mortality, Figure 9 shows income and infant mortality; in both cases, income is shown on a logarithmic scale. The solid lines are for India, the broken lines for China; descending lines are infant or child mortality, and ascending lines are GDP per capita.

These graphs show exactly what Sen and Drèze found, that the rate of economic growth and the rate of reduction of infant or child mortality, are *negatively* related. In China, almost all of the improvement in health was prior to the acceleration of economic growth after the reforms and, in the case of infant mortality using the UN data, there has been essentially no improvement since the mid-1970s. While it possible that there are diminishing returns as mortality rates approach the minimum that is feasible, an infant mortality rate of 50 per 1,000 is still high relative to what has been achieved by many countries, and there is certainly no absolute floor at 50. In India, the picture is less extreme than in China, but the Figures show that, during the 1990s, after the economic reforms, when growth was more rapid than previously, the infant and child mortality rates fell *less* rapidly than was the case in the previous decades, see also Deaton and Drèze (2001). This slowdown, and part of the slowdown in China, almost certainly reflects a worldwide slowdown in the rate of decline of infant and child mortality in nearly all countries of the developing world.

10. Conclusions

The poorest people in the world are poor, not only in material living standards, but also in health and longevity. Global income inequalities reinforce global health inequalities, adding (literal) injury to (material) insult. Simple measures of wellbeing that combine health and income, such as life expectancy multiplied by annual per capita income, are more unequally distributed across the world than is income or health taken alone. For much of the last half century, there was a reduction in the contribution to compound inequality from the life expectancy component while life expectancies in the low life-expectancy countries grew closer to life expectancies in the high life-expectancy countries. But these gaps in longevity have opened up again in the last fifteen years, largely because of the effects of HIV/AIDS in sub-Saharan Africa.

But convergence of life expectancies, even should it resume, is not a useful indicator of reduced inequalities in health. Gains in longevity among the already long-lived inhabitants of the world come from reductions in mortality among the middle-aged and the elderly, while the more rapid longevity gains in low life expectancy countries have come from saving the lives of children. The use of life expectancy at birth as an overall measure of benefit is not easily justifiable because its relatively heavy weighting for mortality reductions early in life is arbitrary. There is no clear justification for such weighting that would support the use of life expectancy as a measure of wellbeing for which reductions in international inequality would be desirable. Indeed, it is possible to argue, as I have done above, that recent reductions in mortality in rich countries have widened international health inequalities, not narrowed them.

I have also argued that it dangerous to focus on convergence of health measures, if only because some measures, such as child mortality rates, can be diverging while others, such as life expectancy, are converging, even when variation in life expectancies are entirely due to variations in child mortality. We do not have the kind of axiomatic structure for measuring health that we have for income. In consequence, measures of health inequality, or of health convergence and divergence, are arbitrary. Different measures will lead into a morass of confusion and contradiction, without any well-supported links to national or international wellbeing.

Conceptual difficulties in the measures of health are compounded by practical difficulties. In many of the poorest countries of the world, and particularly in sub-Saharan Africa, measures of adult mortality are little more than projection and conjecture. While the broad international picture is unlikely to be seriously misleading, we have no good measures of change over time, a dire gap in a world where the evaluation of programs for health improvement is a matter of the greatest urgency.

The positive cross-country correlation between health and income can be interpreted (and has been interpreted) as showing that economic growth is the surest remedy for deprivation in health. Others have argued that poor health and difficult disease environments are the most important causes of material deprivation. Yet, as noted earlier, some poor countries have achieved remarkably good health outcomes. More surprisingly, there is no cross-country correlation between reductions in infant and child mortality and rates of economic growth. This is true over ten year periods from 1960 to 2000, and also for the whole 40 year period. Some countries achieved major improvements in mortality without economic growth, while others who grew very rapidly, most notably China after

1980 and India after 1990, showed little improvement in health or slower improvements than in earlier periods of slower economic growth. These results make it very hard to believe that improvements in health are the engines of economic growth. They also present some difficulties for the "wealthier is healthier" view, though if reductions in child mortality reduce economic growth, while sympathetic increases in investment or other growth-inducing factors increase economic growth, which itself improves health, it is conceivable that a zero or inconsistent correlation between health and income improvements might be the result. As of now, we do not know.

Even so, my best guess is that health improvements in poor countries are not primarily driven by income, nor even by improvements in health knowledge and technology. Knowledge has certainly been important in the long run. But over periods as long as decades, it is the social factors that make for effective delivery of health that are vital, particularly levels of education, and the development of population health as a political priority, which itself depends on better education and on the widespread idea that better health is both a possibility and a right.

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Table 1: Convergence and divergence
**Standard deviations of measures of health and income, 1960 to 2004**

	lnGDP	Life Expectancy	Infant mortality	Child mortality	Ln IMR	Ln CMR
1960	0.98	12.0	60.9	105.7	0.72	0.83
1970	1.09	11.2	50.1	94.3	0.80	0.91
1980	1.13	10.5	48.0	80.6	0.89	1.00
1990	1.14	10.5	43.4	71.8	0.98	1.08
2000	1.18	11.7	40.1	67.0	1.11	1.18
2004	1.23	12.4	39.6	65.8	1.15	1.26

Notes: All figures are standard deviations of the series noted in the heading. GDP is real chained gross domestic product per capita in constant 2000 international PPP dollars and is taken from the Penn World Table version 6.2; all other series are from the 2006 World Development Indicators. The GDP series covers 97 countries in 1960, rising to 185 in 2000, but only 79 in 2004. Child and infant mortality rates come from 151 countries in 1960 rising to 186 by 2004. In all calculations, each country is taken as a unit, and there is no weighting by population.

Table 2: Death and poverty around the world

| Millions of deaths per year	Treatments Prevention	World	Low income	High income
Respiratory infections	Antibiotics	3.96	2.90	0.34
HIV/AIDS	HAART	2.78	2.14	0.02
Perinatal deaths	Pre & post-natal care	2.46	1.83	0.03
Diarrheal disease	Oral rehydration therapy	1.80	1.50	0.00
Tuberculosis	Public health: DOTS	1.57	1.09	0.01
Malaria	Partially treatable	1.27	1.24	0.00
DPT/Measles/Polio	Vaccinations	1.12	1.07	0.00
Percent of deaths				
Ages 0 to 4		18.4	30.2	0.9
Ages 60 and above		50.8	34.2	75.9

Notes: HAART stands for Highly-active anti-retroviral therapy, perinatal deaths are deaths in the first seven days of life, and are typically associated with low birthweight, DOTS stands for directly-observed treatment short course, and is treatment combined with community monitoring to ensure full compliance, and DPT stands for diphtheria, pertussis (whooping cough) and tetanus. Low income and high income are World Bank designations and correspond (approximately) to below $5,000 and above $10,000 PPP in Figure 1. Note that the middle-income countries are not shown, so that the world figures are not the sum of the low income and high income figures. Figures are for 2002, are based on WHO data, and are subject to substantial margins of error.
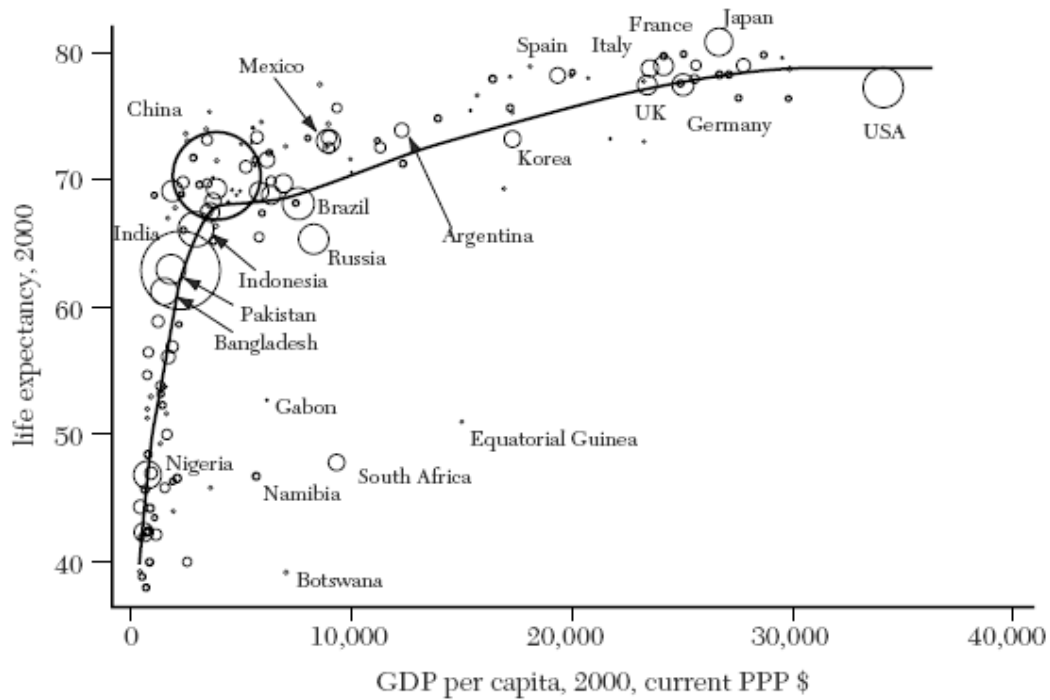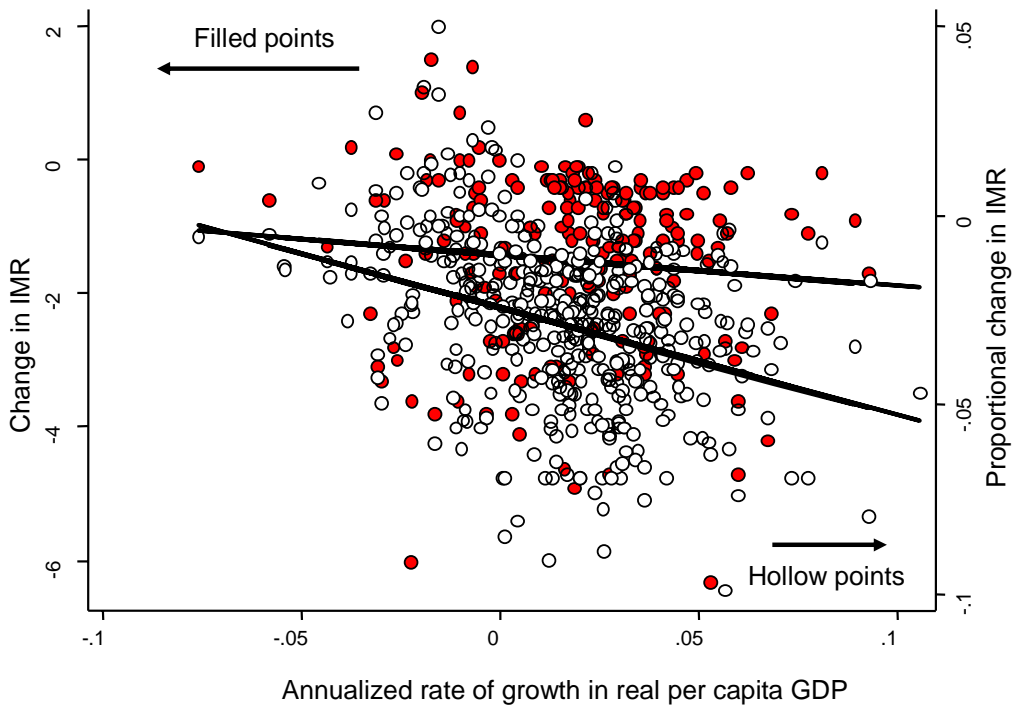
Figure 1: The Preston Curve in 2000
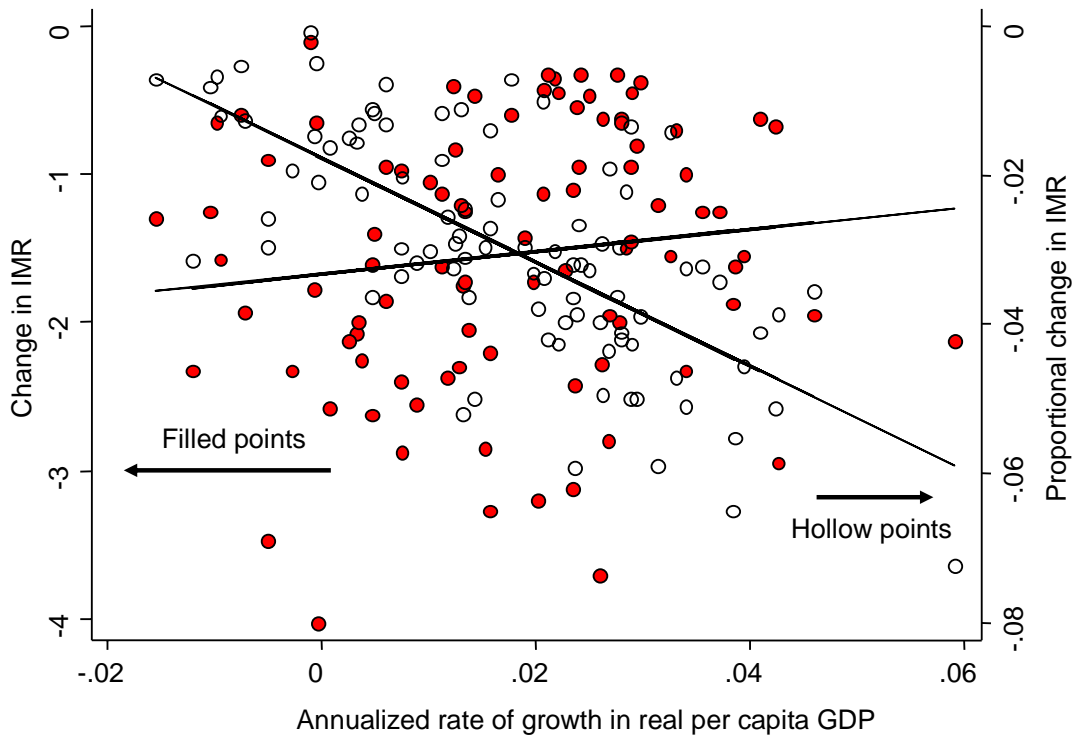(Reproduced from Deaton, 2004.)
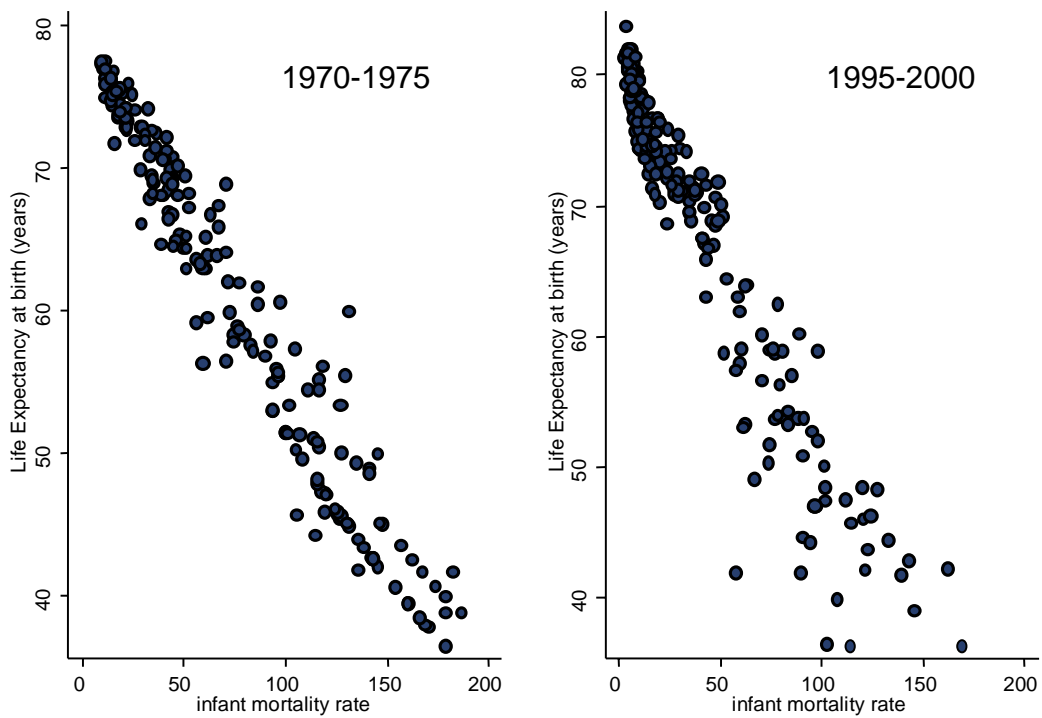
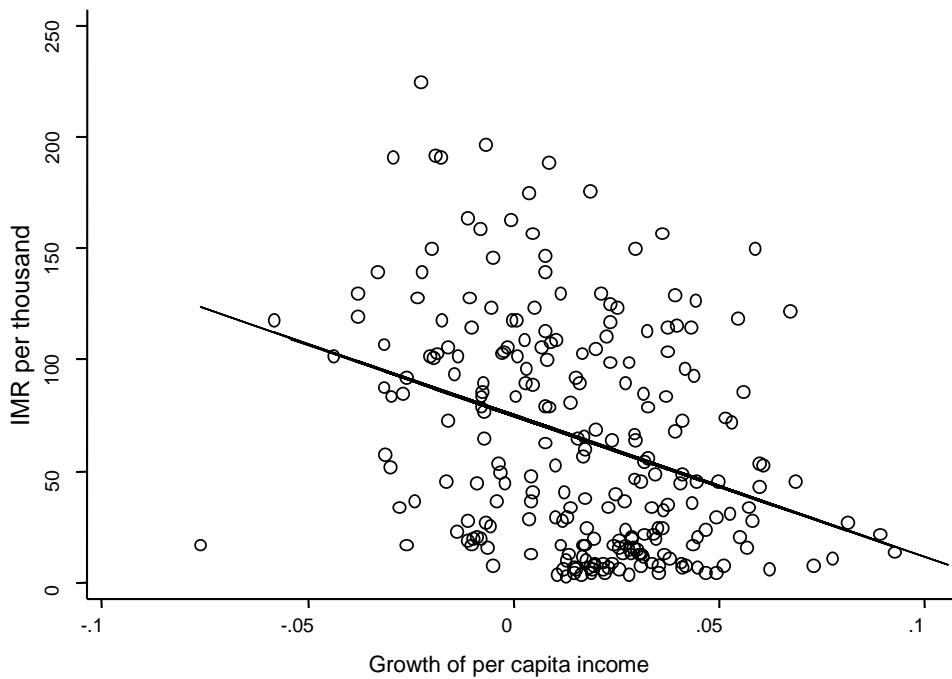**Figure 2: Life expectancy and infant mortality**
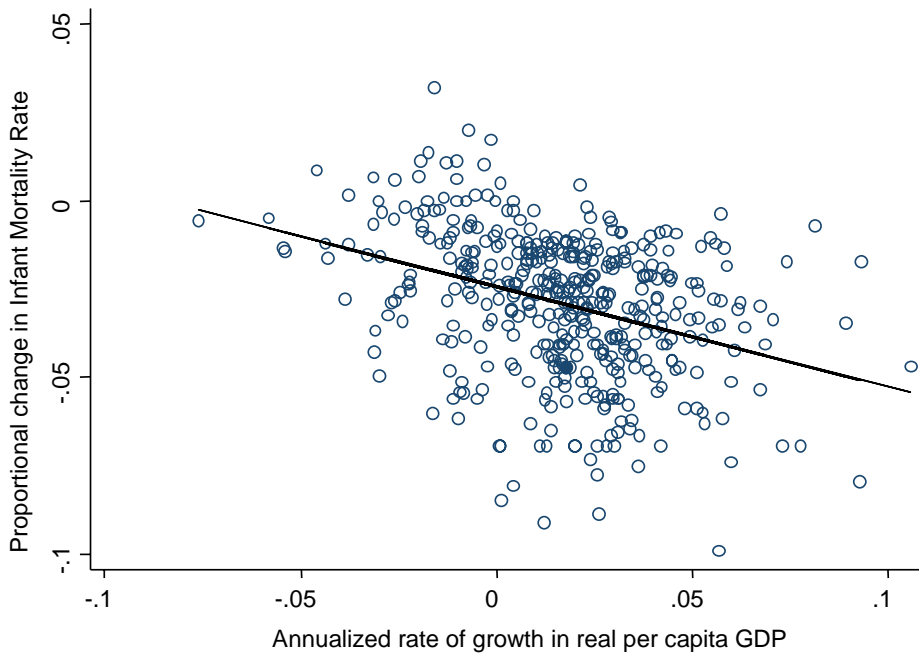
Figure 3: Proportional changes in infant mortality and per capita economic growth
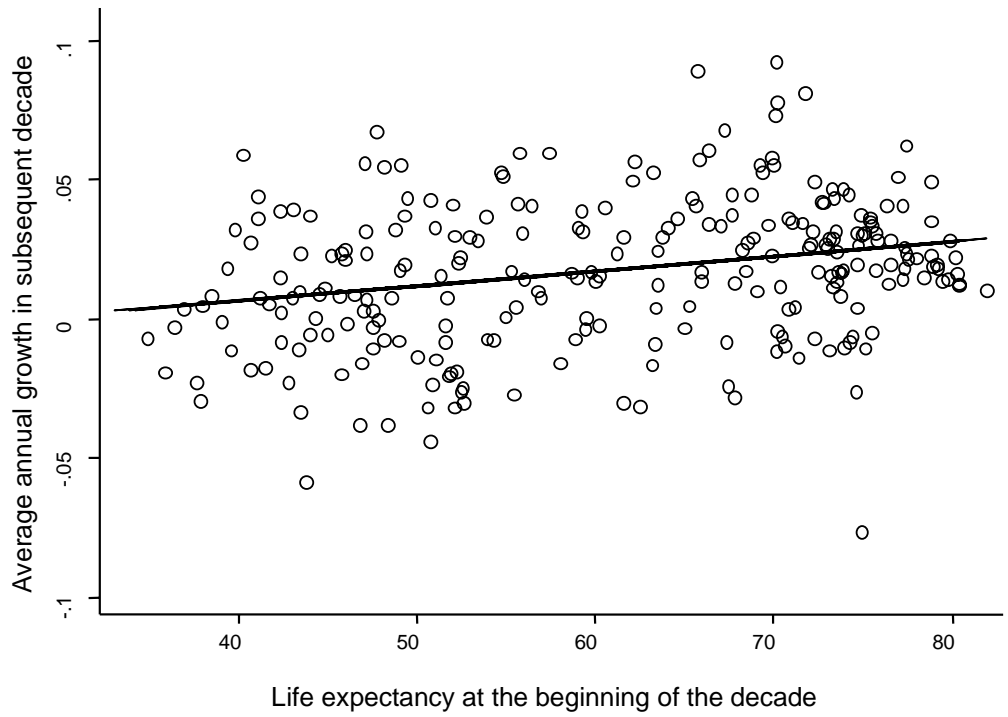(10 year intervals, 1960-2000, Source World Development Indicators.)

Figure 4: Proportional and absolute changes in infant mortality and per capita economic growth
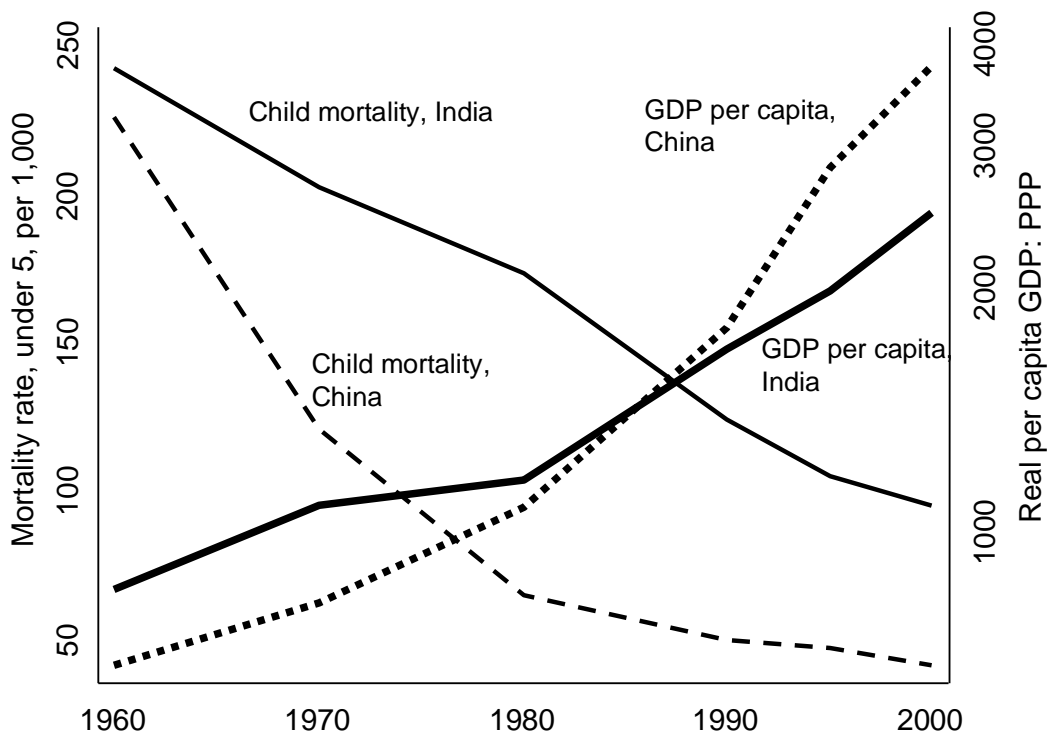
Figure 5: Proportional and absolute changes in infant mortality and per capita economic growth, 1960-2000
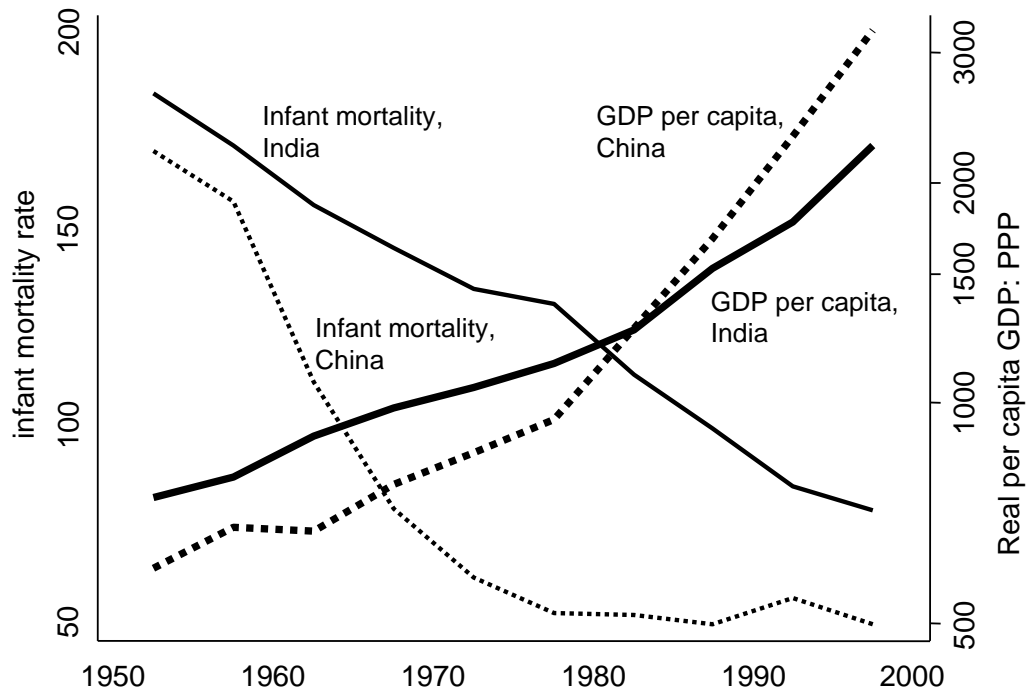

Figure 6: Infant mortality rates and economic growth

Figure 7: Economic growth and life expectancy

Figure 8: Income and child mortality in India and China
(World Bank data)

Figure 9: Income and infant mortality, India and China
(UN data)