

# Commentary: Samuel Preston's 'The changing relation between mortality and level of economic development'

Stephen J Kunitz

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Professor Preston's article<sup>1</sup> is rightly regarded as an important contribution to the debate about the role of economic development and health services (broadly defined) in the decline of mortality. Like so much of his other work, it combines imaginative and innovative use of data with methodological rigour, in this case to argue the point that public and personal health interventions have had a measurable impact upon mortality over and above what would have been expected from economic expansion alone. In addition to this main point, however, the article touches on several related issues that are also of continuing importance: the association between income inequality and mortality, and the diffusion of innovations. I shall discuss the latter briefly, leaving for others a consideration of the former, but first I should like to consider the influence this article has, or hasn't, had.

Shortly after Professor Preston's article appeared, Thomas McKeown's two influential books that argued the other side were published.<sup>2,3</sup> In them, he elaborated on the argument he had made in earlier articles, and against which Professor Preston had argued: that the modern rise of population had virtually nothing to do with personal or public health services and almost everything to do with economic growth and a rising standard of living. Despite what I think are persuasive arguments, Professor Preston's article and the book in which the same material appeared<sup>4</sup> have been less widely known, and I believe less influential in respect of policy, than Professor McKeown's have been. For instance, a search of the Science Citation Index in early 2006 indicates that the article had been cited 131 times and book slightly more than 300. This does not indicate neglect by any means, but it is substantially less than the citations of Professor McKeown's two books: 489 (*The Modern Rise of Population*) and 466 (*The Role of Medicine*). And this doesn't include all of Professor McKeown's other articles on the same or similar topics. It was not the elegance of the analyses that account for the difference. If that had been the case, the numbers would certainly have been reversed. It was, rather, the audience and changing views of the importance of personal and public health services that account for it.

It is useful to distinguish between health policy in economically advanced nations such as the UK and the USA and international health policy with regard to poor countries. Professor McKeown's work struck a responsive chord in the UK and the USA in the 1970s and perhaps even more so in

the 1980s for at least two reasons. First, among many influential policy-makers, it was understood to provide a historically informed rationale for reducing access to services at a time when health care costs were increasing rapidly and when both governments were backing away from commitments to the provision of services. For if health care had not had any impact in the distant or even recent past, why should large amounts be spent on it in the present? This was clearly an oversimplification of Professor McKeown's views, but that is another matter that I cannot deal with here.<sup>5</sup> Second, on the political left Professor McKeown's argument also struck a responsive chord because it served to discredit a dominant profession. In contrast, Professor Preston's argument, which made a case for the measurably beneficial consequences of health services (public but also personal), did not lend itself to the same kind of policies, for if taken seriously, it would have justified increasing expenditures, or at least not reductions in services.

Health policy in poor countries in the late 1970s was moving in a very different direction, as the Declaration of Alma Ata demonstrates.<sup>6</sup> The conferees at Alma Ata defined primary health care (including public health) as but one component of community development, and in that context Professor McKeown's work also struck a responsive chord because it gave pride of place to development. On the other hand, Professor Preston's work could have been understood to justify technical interventions that were separate from economic and community development.

In the event, the 1980s saw the redefinition of primary health care to selective primary health care,<sup>7</sup> which ultimately came to mean that governments should provide only a limited range of services for poor children and people of working age, and user fees should be charged for what were considered discretionary services, as the World Bank's 1993 *World Development Report* advocated.<sup>8</sup> In this new climate, Professor McKeown's advocacy of economic expansion as the underlying cause of better health was regarded as impossibly expensive for international lending agencies to support.<sup>9</sup> The position that Professor Preston's article supported would also not have been especially attractive, for it could have been understood to justify very broad-based and potentially expensive interventions that would benefit entire populations. These observations are of course speculative, but they are consistent with the development of health policy as I understand it, and I believe they continue to be accurate.<sup>10</sup>

There are two additional points I should like to make. The first is that, like Professor McKeown's argument,

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Professor Preston's relies heavily on the position taken by Sherlock Holmes, who Professor McKeown cited in defence of his method: once several competing explanations have been shown to be impossible, then the improbable must be true. This is not an entirely satisfying sort of argument and would be considerably strengthened if evidence of a strong association between health care interventions and national levels of life expectancy could have been shown to be associated temporally.

The second is that Professor Preston invoked a set of universally shared values to account for the diffusion of health-promoting technologies among countries. This is at best short-hand for what I think Professor Preston would agree is a far more complex phenomenon. The diffusion of innovations has been studied in great detail at the individual level of analysis, and much is known about it.<sup>11</sup> Less is understood about the diffusion process as it operates among institutions and countries. But surely he is correct that in the 19th century a variety of important innovations spread among European nations at very different levels of economic development. These included not only systems for the delivery of clean water and the disposal of sewage,<sup>12,13</sup> but legal changes having to do with quarantine<sup>14</sup> as well as with health insurance.<sup>15</sup> But the spread of these institutional and technological innovations involved political processes in the 19th century, as they do today and as my discussion of health policy was meant to suggest. That they also involve universally shared values is not so obvious. If they did, in the United States there would be a universal entitlement to health care.

Despite this caveat, it should be clear that Professor Preston's article is a rich one. While it does not slight the importance of economic development for the improvement of the health of populations, it provides support for the importance of social interventions. Sadly, the policy implications have not been acted upon as thoroughly as one might have wished.

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- 15 Dawson WH. *Social Insurance in Germany, 1883–1911: Its History, Operation, Results*. London: T. Fisher Unwin, 1912, reprinted in 1979.

# Commentary: The changing relation between mortality and income

Richard G Wilkinson

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Understanding the relation between economic development and health is one of the most intriguing problems facing public health. Living standards and longevity have improved together, but the relation between them is not straight forward.

Preston<sup>1</sup> provided us with the bare bones of the puzzle: there are very close cross-sectional relationships (correlation coefficients of between 0.8 and 0.9) between the log of national income per head and life expectancy at birth. Yet while this cross-sectional relation is maintained over time, only between 10 and 25% of the improvement in life expectancy over time is attributable to increases in income. Preston's analysis centred on the period 1930 to 1960, but The World Bank<sup>2</sup> added curves

Professor Preston's relies heavily on the position taken by Sherlock Holmes, who Professor McKeown cited in defence of his method: once several competing explanations have been shown to be impossible, then the improbable must be true. This is not an entirely satisfying sort of argument and would be considerably strengthened if evidence of a strong association between health care interventions and national levels of life expectancy could have been shown to be associated temporally.

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for 1900 and 1990 to those Preston drew relating life expectancy to national income per head. They show that the explanatory problem he set is not a special case.

So what are the possible explanations? After showing that the historical decline in infectious causes of death in Britain came long before effective medical interventions, McKeown and Lowe<sup>3</sup> came down in favour of improvements in nutrition. Their conclusions were based less on positive evidence as on the elimination of medical and public health alternatives. However, Preston reports that improvements in calorie intake (and literacy levels) fail, like income, to explain rising longevity over time.

What we have to explain is why, with the passage of time, the same amount of income buys progressively more health. It is as if the price of health goes down or, as I once put it,<sup>4</sup> there is a change of gearing between income and health. I will suggest four possibilities. The first, the *assets* explanation, is that health is affected by living standards which depend on material assets as much as income. We need to distinguish between income as a flow or rate of consumption, and the element of living standards which is more a matter of the stock of goods in use which contribute to wellbeing. At any given income level, people may, over the years, be able to improve their housing, install central heating, buy a washing machine, a fridge-freezer, and other consumer durables, all of which increase living standards and may sometimes do so even without higher incomes. In rich countries even poorer people have managed to improve their stock of goods even in periods when incomes have not risen. This is shown by the continued rise in ownership of consumer durables among the poorest 20% of the British population even in periods when incomes failed to increase.<sup>5</sup> A large majority of the poorest quintile now own goods—including microwaves and cell phones—which were once regarded as luxuries. Contributions to the change in gearing between income and health almost certainly come from improvements in living standards brought by the growing stock of goods we own.

A second contribution, the *qualitative improvements* explanation, reflects the fact that economic growth is more a process of qualitative change than of simple quantitative increases in consumption. Instead of consuming more of the same goods that our great grandparents consumed, we change from heating with open coal fires to gas central heating, from candles to electric lighting, from woollen and cotton clothes to artificial fibres, from larders to fridge-freezers.<sup>6</sup> Incomes in one period are used to buy new kinds of goods that were not available earlier. We live better because we live differently. Yet we persist in the vain attempt to express qualitative change in quantitative terms by adjusting incomes for changes not only in prices but also in the quality of goods. Inevitably, the 'real' value of incomes in different periods depends on the standpoint with which we view qualitative change. For instance, replacing clothes made from natural fibres with clothes made from artificial fibres is regarded by some as a regressive step, but others who emphasise the ease of washing artificial fibres and the fact that they have led to the manufacture of clothing which is 'breathable' and waterproof, regard it as beneficial. Replacing open fires with central heating may seem less cosy and romantic, but central heating boilers are hugely more

energy efficient, they save labour and fuel, reduce indoor air pollution and decrease fire risks.

So a second contribution to the change in gearing between income and health may come from qualitative changes which mean that what incomes in each period are able to buy is better for health than what the same 'real' incomes could have bought earlier.

A third contribution to the change in gearing may come from unmeasured *psychosocial* changes which piggy-back on economic growth. As populations become more affluent, there is a tendency towards a psychosocial and emotional liberalization. Beyond the epidemiological transition, this is perhaps one of the most important benefits of economic growth. As absolute poverty and want decline, societies become not only less harsh materially, but also less repressive and cruel in terms of what we inflict on each other. Indicative of this process is the fact that increasing numbers of countries have abolished all forms of judicial corporal and capital punishment. Amnesty International estimate that there has been a 5-fold increase in the number of countries that have abolished the death penalty in the last 30 years.<sup>7</sup> The most progressive have also abolished parents' and teachers' corporal punishment of children. This is part of a larger change in child rearing practices reflecting the recognition of children's need for love. As one historian of childhood said, 'the history of childhood is a nightmare from which we have only recently begun to awaken.' In the past, children were abandoned, beaten and terrorized to such an extent that 'most children were what we would now consider abused'.<sup>8</sup> These and other examples testify to a softening of the quality of social relations in society, to the development of more permissive attitudes and laws, and a decreasing reliance on threat and fear as the basis of social order. At the structural level, these tendencies have been aided by the growth of democracy, the rule of law, equality before the law, the development of welfare states, and legislation to protect people from unfair dismissal from work and eviction from housing.

Related to these political processes has been the huge redistribution of wealth that has taken place in many countries during the 20th century. In Britain the share of marketable personal wealth owned by the richest 1% of the population declined from 70% just before the First World War to around 20% by the end of the century.<sup>9</sup> From the 1950s to the end of the century, the share of the richest 10% declined from around 80% to about 50%. Much of this change was brought about by death duties and it is has almost certainly made a key contribution to the sense that modern societies have, in some respects, become more egalitarian, despite the failure to narrow income differentials.<sup>10</sup>

The last possible explanation of the picture presented by Preston is the *adaptive response* explanation. Let us imagine that there are two major kinds of influence on health. Let the first consist of all those factors related to income which account for the close cross-sectional relationships demonstrated by Preston. The second is a source of improvements in health over time operating independently of changes in income. Potentially plausible candidates for the latter are the biological processes of acclimatization to both the diseases of urban life and to the unfamiliar diseases imported from other parts of the world.

During the course of economic development, populations have become increasingly urban and geographically mobile. Cities created a new ecology for disease, and colonization brought unfamiliar diseases to colonizers and colonized alike. Urban death rates were usually very much higher than rural ones, and mortality rates from infections were often catastrophically high when new diseases were first introduced to populations. That economic development led to increased rates of urbanization may explain why economic growth rates were sometimes *positively* correlated with mortality.<sup>11</sup> However, there have also been processes of biological adaptation to the new risks. With new (as distinct from endemic) diseases, people lack the benefit of immunity acquired in early childhood, and selective process have not yet taken their toll of the most genetically susceptible sections of the population.

After citing evidence that there were important genetic differences in susceptibility to tuberculosis, Burnett and White<sup>12</sup> gave examples of populations such as American Indians and Mauritians amongst whom it took—largely unaided by economic growth—around a 100 years for mortality rates from TB to fall from initially very high rates to rates as low as Europeans living in similar circumstances. These changes reflect some combination of the benefits of immunity acquired in early life to disease which have become endemic, and a process of genetic selection. Diseases in which there are both genetic differences in resistance, and high death rates before people reach reproductive ages, will tend to remove the most vulnerable sections of the population from the gene pool. Although McKeown and Lowe<sup>3</sup> thought economic growth was the most likely cause of the decline in infectious disease mortality, these process may account for why they also thought some diseases had become less severe.

The four explanations I have suggested—increased assets, qualitative improvement, psychosocial liberalization and biological adaptation—may have worked singly or together. Surprisingly, 30 years after Preston's article we know very little of the balance between them.

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# Commentary: Missed Opportunities

James C Riley

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If only we could sometimes go back and redirect the path of scholarship. Of course we cannot. Even when lives are at stake, as they are in finding the most effective policies to enhance survival, all we can do is to make the best judgments we can at each moment.

Consider some alternative paths suggested by Samuel Preston's 1975 essay, 'The Changing Relationship between Mortality and Level of Economic Development'<sup>1</sup> with its ISI

Web of Knowledge record of 132 citations as of April 24, 2006. Preston suggests that, in the real world of living longer or dying earlier, many factors impinge, some pushing towards higher and some towards lower survival. Average income per person encapsulates a vast number of these factors; moreover, those very factors differ depending on a country's stage of development. Survival researchers might have set out, much more determinedly than we have, to learn about how people make decisions about spending and allocating household and individual resources. Instead for the most part we have concentrated on aggregate, country-level measures of per capita income and income distribution, and tried in various

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During the course of economic development, populations have become increasingly urban and geographically mobile. Cities created a new ecology for disease, and colonization brought unfamiliar diseases to colonizers and colonized alike. Urban death rates were usually very much higher than rural ones, and mortality rates from infections were often catastrophically high when new diseases were first introduced to populations. That economic development led to increased rates of urbanization may explain why economic growth rates were sometimes *positively* correlated with mortality.<sup>11</sup> However, there have also been processes of biological adaptation to the new risks. With new (as distinct from endemic) diseases, people lack the benefit of immunity acquired in early childhood, and selective process have not yet taken their toll of the most genetically susceptible sections of the population.

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ways to identify the most effective things that people did in high-income countries and the magic behind attaining high survival in a few low and middle-income countries. The orientations followed have produced many useful findings and insights. Still, this particular gap in our knowledge—about how people spend their incomes and how health bulks in their decisions—looks significant.

Preston infers from his 1930–60 comparison that income level and gains in income played a smaller part in life expectancy than many researchers had argued or assumed. This leads him to discuss orientations requiring more research: (i) factors affecting mortality other than income, and (ii) the mortality histories of countries not already studied closely. Considering income, Preston suggests the need for more research into how and why low-income countries, those in the range of some \$200 to \$800 in 1963 US dollars, managed to modify their survival positions so sharply between 1930 and 1960. At that time he apparently believed that some low-income countries benefited from medical advances made and paid for in high-income countries. Research on that issue might have shown that low-income countries obtained biomedical innovations—medicines, vaccines and equipment—slowly and sparingly rather than broadly and quickly. But at least research in that direction might have led us to look more closely at how often quite spectacularly rapid gains in life expectancy were made, not just in a few cases, such as Sri Lanka and Mauritius, but in many other countries.

Instead most of the research agendas that I see in Preston's essay remain unfulfilled. The Comité international de Coopération dans les Recherches Nationales en Démographie tried, seizing on 1974, the world population year, to induce specialists to reconstruct the population history of each country. That was an excellent idea, but most of the monographs coming out of that project treated mortality cursorily. Demographers and scholars working in historical demography continue to focus their attention on the best studied rather than the least well-known cases. Some scholars have examined 'routes to low mortality in poor countries', but I cannot think of

anyone who has yet studied in detail the paths to continued high mortality in the more numerous countries where survival is still abridged.<sup>2</sup>

Thomas McKeown's work, especially two books published in the mid-1970s, had greater influence than Preston's article.<sup>3,4</sup> One of those books, *The Modern Rise of Population*, attained 491 citations, according to the ISI Web of Knowledge. McKeown asserted that economic development should be expected to precede the attainment of high survivorship. Scholars continue to take inspiration from this claim even though we have, in the meantime, become aware of a growing number of contrary cases of low income countries matching the rich lands in life expectancy (Sri Lanka, Kerala state in India, Cuba, Costa Rica, Jamaica and others). Mortality research continues to focus on the successes of a few rich countries as though poor countries might actually have the option of following the routes to low mortality in rich lands. Meanwhile the problem of economic development itself remains largely unresolved; even the World Bank has begun trying to sponsor development in other forms.

Looking back over the last 30 years, it must be said that we specialists in the field of human survival have often spent a lot of our time and a lot of other people's money on research issues that do not, in retrospect, look like having been efficacious. Too bad we cannot go back and reallocate.

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# Commentary: Did Preston underestimate the effect of economic development on mortality?

Johan P Mackenbach

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## A welcome antidote to medical nihilism...

In the mid-1970s, when Preston's classic article<sup>1</sup> appeared, the field of population health research was in the spell of Thomas McKeown, who persuasively argued that advances in medical care and public health had not made important contributions to the secular decline of mortality in Western Europe and North America. On the basis of largely indirect evidence, McKeown suggested that increased living standards were the main driving force behind mortality declines, particularly through improved nutrition.<sup>2</sup>

Preston's article concluded that world-wide increases in life expectancy between the 1930s and 1960s were unlikely to be wholly explained by increases in living standards, and suggested that advances in medical care and public health did make important contributions to mortality decline, at least world-wide and in the 20th century. Although Preston's article could have been a welcome antidote against McKeown's medical nihilism, it had little influence on this debate, and McKeown's view that improved living standards had been the main driver behind mortality decline became the conventional wisdom in public health and epidemiology.<sup>3</sup>

Over the years, many of McKeown's claims have come under serious attack, and it has even recently been argued that it is time for a decent burial.<sup>4</sup> The criticism includes his views about the negligible role of medical care in the decline of mortality in the Western world. While McKeown's assessment of the role of medical care was largely qualitative, and based on a visual inspection of changes in cause-specific mortality trends coinciding with the introduction of certain medical advances, several quantitative analyses have shown that these effects were far from negligible, apparently in line with Preston's hypothesis.

Between 1950–54 and 1980–84, declines in mortality from conditions which had become amenable to medical intervention added 3 years to life expectancy at birth of Dutch men, and 4 years to that of Dutch women.<sup>5</sup> In another analysis of cause-specific mortality, it was shown that between 1875 and 1970 improvements in medical care accounted for between 5 and 18% of total mortality decline in The Netherlands.<sup>6</sup> On the basis of documented gains in survival from medically preventable or treatable diseases, and of the reach of these interventions in the population, the gain in life expectancy at birth in the United States during the 20th century which was attributable

to advances in medical care, was estimated to be 5 years, out of a total gain of around 30 years.<sup>7</sup>

While these estimates are likely to be on the generous side, they still fall far short of filling the gap which Preston's analysis brought to light. Between the 1930s and 1960s, average life expectancy at birth in the world rose by 12 years, of which Preston's analysis attributed only 2 years to rises in national income.<sup>1</sup> Although this was a period of rapid declines in mortality due to advances in medical care in the First world,<sup>8</sup> and due to advances in public health in the Third world,<sup>9</sup> it seems implausible that these advances contributed 10 years to average life expectancy at birth.

## ...but likely to underestimate the effects of economic development...

This raises the question whether Preston's analysis may have underestimated the mortality effects of economic development. I argue that, although Preston's article is admirable for utilizing 'readily available evidence in a new but obvious way to estimate the relative contribution of economic factors to increases in life expectancy during the twentieth century', its main conclusion, that 'income has been a trivial factor in recent mortality trends',<sup>1</sup> is indeed likely to be exaggerated.

Helped by Preston's own critical discussion of the findings, most epidemiologists will have little difficulty in identifying the main weakness of the analysis. While the article is consistently couched in causal language (e.g. 'contribution' to mortality decline, 'sources' of mortality decline, 'influence' on mortality decline), it is based on a cross-sectional study design, without control for confounding variables. It translates the crude cross-sectional association (between variations in national income and variations in national life expectancy) into a longitudinal inference (about how growth in income leads (or does not lead) to growth in life expectancy).

The article concludes that 'factors exogenous to a country's current level of income probably account for 75–90% of the growth in life expectancy for the world as a whole between the 1930s and 1960s. Income growth per se accounts for only 10–25%'. Preston carefully explains some of the main assumptions behind this analysis (e.g. 'that the curves fitted to the 1930s and 1960s data accurately represent the relationship for all countries in those years, including those for which data are not available'). He also lists some sources of uncertainty (e.g. 'a large but unspecifiable margin of error should be attached to this estimate because of faulty data and the simplicity of assumptions'). He even notes that the formulation

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of his conclusion is inevitably 'cumbersome', because 'the analysis does not account for the possibility that the shift in the curve itself [of life expectancy versus income] may be partly a produce of growth in income'.

Although these points are relevant, they skew the main problem, which is that historical growth in income is a phenomenon which is not necessarily approximated by between-country differences in income. There is no guarantee that the cross-sectional association between variations in national income ('the value of all final products produced in a certain period') and variations in life expectancy accurately captures the effects of economic development on declines of mortality.

The first reason is that economic development is a historical process which leaves memories in the population. Populations with a relatively high income in the 1930s and 1960s, such as countries in Western Europe and North America, had gone through this process for half a century or more. Improvements in living standards which already occurred in earlier stages may have positively affected the health status of people born in those years, and these changes in health status may partly explain the mortality declines observed around the middle of the 20th century.

The second reason is that economic development actually implied that countries became more dependent on each other, so that cross-sectional associations between income and mortality became less reliable as indicators for the effect of economic growth on mortality. Part of the world-wide growth in income between the 1930s and 1960s was based on international trade and other flows of goods and services, and the economies of the First and Third world became increasingly interconnected. As Preston notes, transfer of goods and services from high-income to low-income countries may effectively have increased the availability of goods and services in low-income countries beyond what would have been expected on the basis of their national incomes.

### ...and of course based on a false dichotomy

While it seems likely that Preston's analysis underestimated the mortality-lowering effects of economic development, a more obvious but also more fundamental problem is, that the opposition between economic development on the one hand, and medical and public health advances on the other hand, is based on an unnecessarily crude conceptualization of the relationship between the two.

The lack of a well-articulated conceptual model underlying this analysis is already evident from the fact that the

independent variable is variously referred to as 'economic development', 'economic factors', 'income', and 'standards of living'. 'Economic development' is a much broader concept than 'standards of living', and refers to changes in the way goods and services are being produced. These do not only lead to changes in the quantity and quality of goods and services available to the population, captured by the concept of 'living standards', but also require *and* facilitate changes in technology. Because of their overlapping bases, it is difficult to separate advances in medical and public health technology from advances in other technologies. It would indeed be difficult to imagine 20th century advances in medical and public health technology without 'economic development' in this broader sense.

In any case, although one cannot safely conclude from Preston's analyses that 'income has been a trivial factor in recent mortality trends', this article certainly shook the foundations of simple economic determinism, and helped to start investigating economic determinants of population health in a more sophisticated manner.

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# Commentary: The Preston Curve 30 years on: still sparking fires

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Samuel H Preston's classic paper,<sup>1</sup> 'The Changing Relation between Mortality and Level of Economic Development', published in 1975, remains a cornerstone of both global public health policy and academic discussion of public health. Preston's paper illuminates two central 'stylized facts'. The first is a strong, positive relationship between national income levels and life expectancy in poorer countries, though the relationship is non-linear as life expectancy levels in richer countries are less sensitive to variations in average income. The second is that the relationship is changing, with life expectancy increasing over time at all income levels.

Preston examined the relationship between life expectancy and income in three different decades: the 1900s, 1930s and 1960s. In each decade the association between the two measures held true; more recent research shows that the income–life expectancy relationship still applies and continues to move upwards (although the AIDS epidemic in Sub-Saharan Africa has reduced life expectancy at the low end of the income scale in recent years). Although the basic facts set out by Preston are generally accepted, there is still a great deal of dispute about the mechanisms that lie behind the relationships and the policy implications we can draw from them.

Preston proposes a number of possible mechanisms through which income may affect health, including improvements in nutrition, access to clean water and sanitation, and medical treatment. There is still debate about the relative importance of these different factors. Fogel<sup>2</sup> emphasizes the historical effect of rising incomes on nutrition while Preston<sup>3</sup> and Deaton<sup>4</sup> put more weight on public health measures such as clean water and sanitation,<sup>5</sup> and medical care in modern populations.<sup>6</sup> The relative importance of these mechanisms clearly varies in different times and places, and the interaction between them makes a precise accounting difficult. Although there is a strong case for the direct effect of income on health due to nutrition and health interventions becoming more affordable, it may be that income is also acting as a proxy for a wider measure of socioeconomic status and development and that the causal effect is due to other mechanisms, for example, education.<sup>7</sup>

The link between income and health holds for individuals as well as countries. Although the same direct mechanisms may operate, another possible explanation for the link at the individual

level is that it is relative, and not absolute, income that matters. A low position in the social hierarchy may induce psychosocial stress that is linked to increased behaviours that put people at risk of ill health and to physiological reactions in the immune system that directly lead to worse health.<sup>8–10</sup> The relative income hypothesis suggests that inequality has a direct negative effect on health but the evidence for such a direct effect is contested.<sup>11–13</sup>

The curvature of the relationship between income and health suggests that a policy of redistributing income from the rich to the poor will improve average health outcomes since the gains in health of those with low incomes will outweigh the losses of those with high incomes.<sup>14</sup> However, this policy prescription depends on the relationship being causal rather than income merely acting as a proxy for some broader notion of socioeconomic status, and needs to be balanced against the negative incentive effects of redistributive taxation.<sup>15</sup>

The upward slope of the Preston curve gave birth to the idea that increased wealth leads causally to increased health. Pritchett and Summers<sup>16</sup> argue that focusing on economic growth in developing countries will lead directly to reductions in infant mortality rates and improvements in life expectancy, as they see improved health as a by-product of higher income levels. The problem with this argument is that, as shown by Preston's paper, most of the health gains we have experienced have been due to improvements in health at each level of income, which is likely to be due to technological progress, i.e. using resources more effectively. Bloom and Canning<sup>17</sup> found that before 1870 health in rich and poor countries was very similar, but after 1870 health improved in rich countries whereas improvements in poor countries only began after 1930. This is consistent with the view that technological advances are employed first in rich countries before eventually diffusing to poorer societies. Relatively little work has been done that focuses directly on the contribution of technological progress to population health, though Jamison *et al.*<sup>18</sup> identify technological progress in health and study its determinants, and Cutler *et al.*<sup>19</sup> conclude that scientific and technical advance is 'the ultimate determinant of health'. A further argument against focusing on income growth as a method of alleviating health burdens is that although income levels and population health are closely linked, the connection between periods of economic growth and periods of improvement in population health is very weak, suggesting that if the relationship is causal it has long and variable lags.<sup>20</sup> Although rising incomes mean that society has greater resources, these resources are not always applied to health.

Preston's diagram has been taken by many to imply a causal link from wealth to health. In the years since the paper was

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written, however, the possibility that the link could also run in the reverse direction, from improved health to higher incomes, has been investigated. Healthier workers are more productive, and longer lifespans create incentives to invest in schooling and save for retirement.<sup>21</sup> In addition, of course, healthier children are likely to attend school more regularly,<sup>22</sup> more easily absorb knowledge while in school, and increase their cognitive ability.<sup>23</sup> The health-to-wealth idea has important policy implications because it suggests that health is a cause as well as a consequence of income growth, and can be a powerful instrument of economic development and poverty reduction.<sup>24</sup> Micro-level studies such as those reported by Strauss and Thomas<sup>25</sup> and Schultz<sup>26</sup> support this thesis, although work to estimate the size of the effect of health on wealth at the aggregate level is still ongoing.<sup>27,28</sup>

The impacts of Preston's study have not been limited to discussion of the links between income and health. It has also supported the notion of broadening the very definition of development. Steady improvements in health, independent of income level, mean that income per capita is an imperfect proxy for human wellbeing. Becker *et al.*<sup>29</sup> compute a growth rate of welfare that incorporates both health and income improvements and found that life expectancy improvements contributed significantly to gains in global welfare between 1960 and 2000. Even with the advent of AIDS, which has cut life expectancy in parts of Africa, these gains have been particularly large in much of the developing world, and were helping to reduce inequality in welfare between poor and rich countries.

In sum, many discussions and insights that are at the heart of economic and human development would not have arisen, or would have arisen much later, without Samuel Preston's paper. Indeed, this paper demonstrates well the aptness of Oliver Wendell Holmes' famous line: 'One's mind once stretched by a new idea, never regains its original dimensions.'

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