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The Untold Standards of Living Story: The GDP value of Twentieth Century Health Improvements in Developed Economies

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THE UNTOLD STANDARDS OF LIVING STORY: THE GDP VALUE OF TWENTIETH CENTURY HEALTH IMPROVEMENTS IN DEVELOPED ECONOMIES

Abstract

Economists are aware that conventional measures of national income do not capture everything that is important to individuals. In particular, the value of huge improvments in health over the twentieth century has gone uncalculated. Usher (1980) and Nordhaus (2002) have emphasised the virtues of including mortality improvments in some form of extended national income measure. This paper therefore sets out a methodology that can be used to calculate the value of mortality and morbidity improvements. The results indicate that health improvements in developed economies have been worth at least $1 trillion. As such not accounting for historical health gains leads to a significant underestimate of improvements in standards of living and economic development.

1. Introduction

The economic performance of a nation is usually measured as the change in national income per head. It is widely known, however, that this approach excludes a large number of different aspects of the standard of living that people value. One aspect that is at best poorly included is the reduction in mortality and morbidity that has been an important feature of development since 1900 (Usher, 1980; Nordhaus, 2002; Murphy & Topel, 2005; Crafts, 2005; Hickson, 2009). This article will, for the first time, set out a methodology by which we can assess the value of reductions in mortality and morbidity as a proportion of GDP. It will also apply this methodology to England for the period 1900 – 2000[1].

The concept, nature and methodology of calculating GDP goes back to Simon Kuznets. Kuznets never intended GDP to be an indicator of general well-being. He fully recognised the limitations of focusing only on market activities, and excluding nonmarket activities, such as household production and voluntary work. In addition, by measuring marketed output at market prices GDP also excludes quality improvements. This issue was addressed to an extent in the US context by the Boskin Commission (1998). Furthermore, as societies become richer the proportion of a lifetime that is spent undertaking paid work has fallen. The length of the typical working week has fallen, holidays entitlements have increased, and the retirement age has fallen as a proportion of life expectancy. There have been short periods of time in which these have not been true, but over the twentieth century the amount of leisure time available to those in the labour force has increased nearly fourfold. The proportion of people who live to retire has increased sevenfold, and the average length of retirement has increased fivefold (Fogel, 2004). These important gains in welfare are not captured in national income.

Improvements in health have clearly made a major difference to the standard of living. DeLong (2000) highlights the value of twentieth century health gains by considering how much material wealth would be necessary to compensate an individual going back to the health conditions in 1890. *'Given the absence in 1890 of modern inoculations, modern antibiotics, and other technologies of the past century, it is hard to argue that anything less than an astronomical income back in 1890 could compensate'* (DeLong, 2000: 22). Not only can we cure any number of diseases, such as tuberculosis, but we can now vaccinate people so that they do not suffer from many diseases in the first place. For those conditions that we cannot cure, such as diabetes, the treatments that are available today are much more effective than was the case in the past. Even simple medicines, such as painkillers and antibiotics, have had life transforming effects for many, in both the developed and the developing world.

[1] England and Wales will be summarised as England throughout the paper.

Improvements in healthcare are included in changes in GDP only when they occur as a market transaction. Thus a new surgical procedure that leads more people to seek treatment will appear as a rise in national income, valued at the cost of providing the service. In contrast, a new and improved surgical procedure that replaces an existing one will not change national income unless it also raises the cost. And a new procedure, or medicine, that is as effective or more effective and costs less will certainly not appear to have raised GDP, even though it will clearly increase the standard of living.

The idea that we should include improvements in health care in measures of economic performance goes back to the work of Usher (1980). He claimed that *'statistics of economic growth may be seriously misleading as indicators of whether people are becoming better off in the course of time if changes in longevity are not taken into account'* (Usher, 1980: 228). Nordhaus (2002) built on Usher's work with claims that twentieth century improvements in health have provided a substantial contribution to standards of living. And that *'the economic value of increases in longevity in the last hundred years is about as large as the value of measured growth in non-health goods and services'* (Nordhaus, 2002: 37-38). Both of these, however, concentrate entirely on mortality. Mortality is clearly important, but it is not the only story that is relevant here. Falls in morbidity, the extent to which we are ill while we are alive, are also important. This article sets out a methodology to value reductions in morbidity that is similar in approach to that set out by Nordhaus for the reductions in mortality.

As well as setting out the methodology in this article, we apply it to England between 1900 and 2000. England is chosen because it has particularly good data for the entire century. It would be possible to apply this methodology to other countries, but in many cases data constraints would limit such studies to the post-war era. We find that the value of improved mortality and morbidity is, as an order of magnitude, equal to growth of 0.3 percent per annum over the century. There is no reason to believe that this figure would be dramatically different for any other developed country.

In Section 2 we provide an outline of the methodology. This comprises the existing mortality measure and our novel morbidity measure, and an outline about how these are combined to provide an original health measurement methodology. In Section 3 we apply the methodology to the data for twenteith century England. In Section 4 we discuss the implications of the results in terms of what the original methodology lends to the existing literature, the significance of the results, and the magnitude of health gains.

2. Methodology

The key point that is accounted for by the methodology is that the same annual GDP per capita with a long life should be recognised as a higher living standard that that income with a short life (Crafts, 2005). For example, an economy in which the population has a GDP per capita of $20,000 with lives that are short and in poor health would be ranked the same as people having income of $20,000 with a long and healthy life by existing national income measures (Nordhaus, 2002)[2].

Neo-classical growth models would predict that a healthier workforce enables the labour aspect of the production function to be more effective and as such would lead to an increase in productivity and all things being equal, economic output, which would be captured as increased GDP per capita. However, the methodology presented here accounts for the utility value of improved health and as such there is no existing proxy for this in measures of GDP per capita. This means that the results presented below are not double counting any of the value already contained in national income. Moreover, in this approach, gains from improved mortality and morbidity are treated as an imputation for a change in the environment, because improved health has been largely a result of the accumulation of knowledge on how to cure and prevent diseases that affect all individuals (rich and poor, educated and uneducated), which represents further reasons why these improvements are not included in income measures and therefore not double counted by the calculations made here.

2.1 Mortality

Usher (1980) proposed a method for imputing national income measures to account for increases in life expectancy. Nordhaus (2002) refined this measure and outlines the willingness to pay for improved mortality approach used in this paper. Equations (1) to (3) summarise this methodology. An individual is assumed to value consumption and health according to a lifetime utility function:

$$V[c_t;\theta,\rho,\mu_t] = \int_{\theta}^{\infty} u(c_t)e^{-\rho(t-\theta)}S[\mu_t]dt \tag{1}$$

Where $V[c_t;\theta,\rho,\mu_t]$ is the value at time t of the consumption stream, now and in the future, faced by an individual of age θ; $u(c_t)$ is the stream of instantaneous utility or felicity of consumption; ρ is the pure rate of individual time preference; $S[\mu_t]$ is the set of survival probabilities; and μ_t is the set of mortality rates. The key assumption here is that utility is a function of the expected value of consumption weighted by the probability of survival. Nordhaus (2002) also

2 Dollars used here represent a hypothetical value. Dollars used in the Results and Discussion sections of the paper represent current (2012) US dollar prices.

assumed that an individual will choose a consumption annuity that yields constant consumption during the individual's lifetime, $c_t = c^*$, in line with the lifecycle model of consumption.

$$V[c_t;\theta,\rho,\mu_t] = \frac{u(c^*)}{(\rho+\mu)} \qquad (2)$$

Nordhaus (2002) further highlights that an individual faces a trade-off between health and wealth; and hence the relative value of consumption and mortality:

$$\frac{dc^*}{d\mu} = \frac{-u(c^*)}{[u'(c^*)(\rho+\mu)]} \qquad (3)$$

Nordhaus (2005: 376) makes two normalisations in order to simplify the discussion without loss of generality. First the simplification produced by selecting a goods metric utility function, which provides a metric in which utility is measured in terms of goods at the equilibrium, which implies that u'(c*) = 1. Second, the implication that there is no utility after death and as such zero is the utility at which the individual is indifferent between life and death (ibid: 377).

Following this methodology, the additional life years (due to improved mortality) need to be valued. We value additional life years by estimating the amount that society would be willing to pay for reduced mortality. Estimates about this value range widely: from less than $100,000 to several million dollars (Dillingham, 1985: 277)[3]. We use Miller's (2000) 'best estimate' value of a statistical life (VSL) as a conservative estimate, derived from some of the most robust UK studies[4]. To put this into context, our value of a statistical life estimate is about half as valuable as that used by Nordhaus (2005) for the USA over the twentieth century. We also include considerations about the changing income elasticity of demand for improved health over the twentieth century. Costa & Kahn (2003: 1) highlight that as an economy develops the health and well-being of the population increases along with the demand for safety and the subsequent compensating wage differential. They estimate that between 1940 and 1980 the value of a statistical life increased by 300 to 400 percent, indicating a VSL income elasticity of between 1.5 and 1.7 (ibid: 13). Conversely, Viscusi & Aldy (2003: 44) estimates income elasticity as being between 0.5 and 0.7. The large variation in estimated income elasticities in different meta-analyses may reflect differences in sample construction (Costa & Khan, 2003: 13), as well as differing assumptions about the relationship between income and the demand for safety and how this changes over the long run. These estimates of the value of a statistical life with differing elasticity and dynamic values over the twentieth century are presented in Table 1.

[3] There is a vast literature that considers the value of a statistical life. See Jones-Lee (1989) for a comprehensive overview. For a more recent consideration about some of the most fundamental problems associated with valuing a statistical life see Kniesner et al (2007). See Miller (2000) for considerations about country variance. See Aldy & Viscusi (2008) for considerations about variance across age groups and cohort effects. For further considerations of age effects (and also the influence of health status) see Alberini et al (2004). For one of the only studies to explicitly consider the value of a statistical life in developing countries see Bowland & Beghin (2001).

[4] For the VSL studies upon which Miller's best estimate is based see: Ghosh et al (1975), Jones-Lee et al (1987), Jones-Lee et al (1995), Maclean (1979), Marin & Psacharopoulos (1982), and Melinek (1974).

They will be combined with death rate data in order to calculate the value of these extra life years (in Section 3).

[Table 1]

2.2 Morbidity

Cutler & Richardson (1999) outlined a health measure which we use to define morbidity in the paper. Combining estimates of the share of people who are alive, the prevalence of people with particular conditions, and the quality of life for people with those conditions, Cutler & Richardson estimate quality of life as:

$$H_{t+k} = \Pr[\text{Alive at } t+k] \times (\textstyle\sum_d \Pr[\text{Condition } d \text{ at } t+k] \times [\text{QALY for } d \text{ at } t+k]) \quad (4)$$

This approach attaches quality adjusted life year (QALY) weights to living with each of a range of particular conditions, and sums the probability of each condition multiplied by the quality adjusted life year weight of the condition to give the value of health (Cutler & Richardson, 1999: 18). Changes in the value of health (largely as a result of improved quality adjusted life year weights) can then be estimated by using a value of a statistical healthy life year estimate. This is a function of the value of a statistical life adjusted for the burden of illness.

As outlined in equation (4), we estimate the burden of illness by combining data about the prevalence and quality of life of each illness. Prevalence data exists in some basic form for prominent illnesses over the twentieth century in England. However, data does not exist about the quality of life associated with different illnesses over the twentieth century in England, with the exception of a study by Hickson (2006). That study estimated a series of quality adjusted life year weights for different illnesses and eras of the twentieth century in England. The methods were based on a study by Murray & Lopez (1996) that pioneered an approach for estimating illness quality of life for countries where this data does not exist. Both entail an expert study to determine the likely burden of different illnesses, and the final result is generated through arriving at expert consensus. Quantitative studies about the historical quality of life are limited: in addition to Murray & Lopez (1996) and Hickson (2006), Cutler & Richardson (1999) have calculated quality adjusted life year weights for the USA from 1970 to 1990. It is noteworthy that the quality adjusted life year weights generated by Hickson (2006) are of a similar magnitude to those generated by both Cutler & Richardson (1999) and Murray & Lopez (1996) for comparable illnesses and eras.

None of these three studies estimate quality adjusted life year weights for a broad sample of illnesses. When trying to account for all diseases a number of assumptions have to be made. This detracts from the precision of the results. In fact, all that can be said with certainty is that the overall results presented here are an underestimate. The biggest contention associated with this approach is how to proxy a broad morbidity state, such as infectious disease, with a limited number of estimates for specific infectious diseases, such as tuberculosis or influenza. This problem is compounded by changes in the classification of disease. For example, in 1900 there were about 160 causes of death associated with preceding illness. In 2000 a 'Tabulation List for Morbidity' was published for the first time, it contained 298 different states of morbidity[5]. Because it is impossible to proxy all or even many diseases, the approach used here is to use a limited number of sample morbidity quality adjusted life year weights, that are more pessimistic than the 'average' disease burden in each of the three broad morbidity states: infectious, non-infectious, and disability. These are presented in Table 2. Section 4 generates significant results, which provides some reassurance for this approach. The key message is that, even at a lower bound estimate, the results are significant.

[Table 2]

In Table 2 we present the quality adjusted life year weights as a number that is a fraction of one. Any value between zero (which represents death) and one (which represents full health) is the fraction of a life year lived. A mild illness or disability would achieve a score near to 1, such as 0.9 or 0.8. For a severe illness the quality adjusted life year weight could be as low as 0.1. In addition to summarising the quality of life for morbidity data, we use the quality adjusted life year weights in Table 2 to adjust the value of a statistical life. This is necessary to value improvements in morbidity. Essentially we are reducing the value of a statistical life year to represent the fraction of a year lived in less than full health. The results concerning the value of a statistical healthy life year are presented in Table 3.

[Table 3]

3.3 Health (mortality and morbidity)

The above considerations about the value of improvements in mortality (equations 1 to 3) and morbidity (equation 4) will be combined in a single measure of health (equation 5). The result is a novel methodology that considers the magnitude and value of improvement in health, in terms of

[5] The International Classification of Disease (ICD) is the coding system used to define all causes of mortality. It has been in use since 1900 and is updated (to include a more sophisticated array of entries) every 10 years. The ICD became substantially more detailed after the World Health Organisation (WHO) assumed responsibility for managing this system in 1948.

additional life years due to improvements in mortality and the quality of those additional life years by also considering morbidity.

$$\frac{dc*}{d\mu+\lambda} = \frac{-u(c*)}{(\rho+[\mu+\lambda])}$$

(5)

In equation (5) $u(c^*)$ = the goods value of life and c^* = consumption (cf. equation 1); μ represents the set of mortality rates; λ = the morbidity consideration outlined in equation (4), thus μ + λ accounts for the population who are alive and their probability of living with a certain illness and the corresponding quality of life burden of that illness; ρ = the pure rate of individual time preference. Finally, it should be noted that the left hand side of equation (5) is greater than zero because individuals are likely to forego some consumption in return for improved health. The results of applying this methodology to the data for twentieth century England are outlined below.

3. Results

We value health improvements by first calculating the monetary value of reduced mortality. This is summarised in Table 4, where the decline in the death rate (referred to as mortality burden change) is valued. By applying the value of a statistical life to the number of additional life years we can estimate the value of mortality improvements. The results in Table 4 are striking: estimates about the value of improved mortality range from $840 billion to $1.14 trillion. This equates to twentieth century improvements in life expectancy being as valuable as all economic activity in England in the year 2000, as measured by GDP. Or, as being many times more valuable than all economic activity for earlier years, such as 1900 and 1950 when GDP in England was approximately $200 billion and $350 billion, respectively.

[Table 4]

Next we calculate the approximate value of improvements in morbidity. The first stage in Table 5 is the calculation of the change in illness prevalence adjusted by the corresponding quality of life illness burden for broad morbidity categories. This corresponds with equation (4) and is presented as morbidity burden change, in the second column in Table 5. The negative results for non-infectious diseases (-18802) and disability (-7976) are not surprising because there has been an increase in prevalence of these conditions over the twentieth century. This is not entirely the result of worse health: in many cases the reported prevalence of disease increases as more treatments become available, diagnostic capability improves, or awareness of the disease rises (Cutler & Richardson, 1998: 18). Likewise, improvements in medical technology enable people to live for longer, albeit with the disease. It therefore especially noteworthy that the decline in infectious morbidity has outweighed the increase in non-infectious and disability related morbidity, albeit with a small number of additional life years, relative to the size of the population. The overall result is an improvement in the morbidity burden by 24, 816 life years. Next we apply the value of a statistical healthy life year to these 24,816 additional healthy life years in order to estimate the monetary value of improved morbidity over the twentieth century. This is presented in the final row of Table 5 and is estimated to be worth at least $24 billion.

[Table 5]

Following equation (5), the results presented in Table 5 are combined with the equivalent for mortality (from Table 4), in order to estimate the value of overall health gains. This result, in Table 6, is shown to be in the region of $1 trillion. One of the noteworthy features in Table 6 is the size of the mortality gain versus morbidity. This is driven by three factors. First, for morbidity we make lower bound assumptions to generate defendable (lower bound) results in the absence of detailed morbidity data. Second, the value of a statistical life is greater than the value of a statistical healthy life year. Third, twentieth century trends in mortality have been overwhelmingly positive. In England life expectancy increased from 46 years in 1900 to 78 years in 2000 (Office for National Statistics, 2006). This trend has not been as positive for morbidity. Overall morbidity has improved, but there have been increases in the prevalence of chronic diseases and disabilities.

[Table 6]

The final stage of estimating the value of health gains includes the use of a chain Fisher quantity index to calculate real GDP growth rates. Fisherian growth requires the result presented in Table 6 to be summed with national income. Table 7 outlines the compound average growth rate of: GDP, the value of health improvements and the sum of these two, which equates to Fisherian growth. The most noteworthy point from Table 7, and the message of the paper, is the magnitude of health gains. The lower bound estimates in Table 7 indicate that health improvements have added at least 0.3 percent per annum to compound average annual GDP growth.

[Table 7]

4. Discussion

By developing a novel methodology we have generated more comprehensive results about the value of health gains. We add detailed to existing mortality studies by also considering morbidity. This has generated some results that could not have been predicted. Most noteworthy is the point that although the prevalence of certain disease groups has increase the quality of life gains associated with these illnesses has gone some way towards counteracting their prevalence. And that the decline in the burden of infectious diseases has counteracted the increase in non-infectious and disability. This has resulted in valuable improvements in morbidity as well as mortality.

By generating estimates about the magnitude of health gains for developed economies the paper provides a contribution to the existing literature about the value of improved mortality, particularly the findings of Usher (1980) and Nordhaus (2002), discussed above. Given the magnitude of health gains reported here it is clear that not accounting for historical improvements in health seriously underestimates standards of living and long run economic development. The importance of good health is well documented in the literature. The results presented here corroborate this theory by estimating that the value of improved health over the twentieth century in England adds an additional 0.3 percent to per annum GDP growth; or an additional 30 percent to GDP growth between 1900 and 2000.

This trend is not unique to England. In fact it is reasonable to assume that all other developed countries have experienced similar health gains. Developed countries have similar health profiles as they have experienced the transformation in health, referred to as the 'epidemiological transition'[6]. This is associated with substantial improvements in life expectancy and a shift in the cause of illness from infectious to non-infectious. For developing countries it is not possible to use the results for England to draw any inferences. Not only are these countries at an earlier stage of the epidemiological transition, but there is also a much greater degree of heterogeneity between them.

Owing to the tentative nature of this study there are aspects that could benefit from a more precise approach. Many of these problems are insurmountable (and not just within the confines of this paper), but still ought to be recognised. The most obvious features for improvement are the methodological variables. We have used lower bound estimates to try to enhance the reliability of the findings. However, the value of a statistical life, the value of a statistical healthy life year, and especially the quality adjusted life year weights would benefit from being more precise and universally acceptable. Although verging on the impossible, it would be ideal to employ a much

[6] Omran (1971) defined the epidemiological transition as the transformation of the mortality pattern from a world dominated by infectious and acute diseases to one dominated by chronic and degenerative diseases.

greater number of morbidity state quality adjusted life year weights. This would certainly increase the magnitude of the results and reiterate the key message of the paper: that twentieth century health gains have been extremely valuable in developed countries, and that only valuing life expectancy does not lead to an overestimate about the value of these health gains.

Tables and Figures

Table 1: Twentieth century value of a statistical life (VSL) income elasticities and values (2011 $, millions)

Study	VSL income elasticity	VSL value
Costa & Kahn (C&K)	1.6	1.17
Miller, 2000 (M)	1	1.18
Viscusi & Aldy (V&A)	0.6	1.58

Sources: Costa & Kahn, 2003; Miller, 2000; Viscusi & Aldy, 2003. Costa & Kahn and Viscusi & Aldy value of a statistical life values are calculated from Miller.

Table 2: Twentieth century quality adjusted life year weights (QALY) for broad morbidity categories, England

Morbidity state	Quality Adjusted Life Year weight (QALY)
Infectious	0.68
Non-infectious	0.56
Disabilities	0.50

Sources: Hickson, 2006

Table 3: Twentieth century value of a statistical healthy life year (VSHLY) values for broad morbidity categories (2011 $, millions)

Morbidity	VSL			QALY	VSHLY		
	C & K	M	V&A		C & K	M	V&A
Infectious				0.68	0.80	0.80	1.10
Non-infectious	1.17	1.18	1.58	0.56	0.66	0.66	0.88
Disability				0.50	0.56	0.59	0.79

Sources: see Table 1 for VSL values; see Table 2 for QALY values; VSHLY is calculated as the VSL adjusted for the QALY (VSL*QALY)

Table 4: Willingness to pay for improved mortality (WTP mortality) calculation, England, 1900-2000 (2011 $, millions)

Mortality	Mortality burden change	VSL			WTP mortality		
		C&K	M	V&A	C&K	M	V&A
Σ mortality	678875	1.17	1.18	1.58	794285	801073	1072623

Sources: Mortality burden change calculated from Office for National Statistics, 2003; see Table 1 for VSL values

Table 5: Willingness to pay for improved morbidity (WTP morbidity) calculation, England, 1900-2000 (2011 $, millions)

Morbidity state	**Morbidity burden change**	**VSHLY**			**WTP morbidity**		
		C&K	M	V&A	C&K	M	V&A
Infectious	51594	0.80	0.80	1.10	41275	41275	56735
Non- infectious	-18802	0.66	0.66	0.88	-12410	-12410	-16546
Disability	-7976	0.56	0.59	0.79	-4467	-4467	-6301
Σ morbidity	24816				24398	24398	33906

Sources: Morbidity burden change calculated from Hickson 2006; see Tables 2 and 3 for VSHLY calculation

Table 6: Willingness to pay for improved health (WTP health) calculation, England, 1900-2000 (2011 $, millions)

Quality adjusted life expectancy	**WTP mortality**			**WTP morbidity**			**WTP health**		
	C&K	M	V&A	C&K	M	V&A	C&K	M	V&A
Σ mortality + Σ morbidity	794285	801073	1072623	24398	24398	33906	818682	826011	1106529

Sources: WTP QALE is calculated as the sum of WTP mortality + WTP morbidity, for these calculations see Table 4 and Table 5

Table 7: Compound average annual rates of Fisherian growth, England, 1900-2000 (%)

GDP growth	**WTP health growth**			**Fisherian growth (GDP + WTP health)**		
	C&K	M	V&A	C&K	M	V&A
1.8	0.3	0.3	0.4	**2.1**	**2.1**	**2.2**

Sources: GDP growth calculated from Maddison, 2001; see Table 6 for WTP calculation

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