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# The Role of Knowledge Accumulation in Health and Longevity: The Puzzling Case of Suicide

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Abstract *Many Western countries have experienced the 'rectangularisation of the [demographic] survival curve', leading to a rise in life expectancy. This process is the result of falling death rates, which leads to increasing longevity. In this article, suicide is placed within the general perspective of declining All Causes mortality. It is shown that suicide is atypical when compared with other causes of death. Which ever way it is measured, whether by an unweighted headcount measure or a weighted Potential Years of Life Lost measure, the suicide rate is not subject to secular decline. In fact, it has become (numerically) a relatively more important cause of death. This article puts some emphasis on the arguments by Joel Mokyr, an economic historian, about the importance of knowledge accumulation. It is argued that, in the case of suicide, there is a deficiency in knowledge of the causes of suicide and the prevention of suicide.*

Keywords: Australia; knowledge; longevity; mortality; suicide.

## Introduction

> The desire for the prolongation of life … we may take to be one of the most universal of all human motives.[1]

The prospect that the poverty of populations could ever be alleviated must have seemed far-flung in pre-Industrial society. Seventeenth century English philosopher, Thomas Hobbes, describes prospects at the time: 'the life of man, solitary, poor, nasty, brutish and short'.[2] (Hobbes's own lifespan of 91 years was an exception for the times.) However, clear improvements in the material conditions of life have been occurring since the 1700s. Various accounts are available of this phenomenon.[3] The following perspective by Easterly suggests that an historical view of the improvements experienced by the current generations is relevant: 'When those of us from rich countries look at poor countries today, we see our own past poverty. We are all descendents of poverty'.[4] In this context, it is starkly

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apparent that pessimism and passivity generally exist, in the current era, over suicide and its prevention.[5]

Suicide is puzzling. Whilst longevity is steadily improving, the suicide rate has been worsening in the developed world.[6] This is particularly the case among the relatively younger age groups: 'Suicide is now the second or third leading cause of death for youth in the US, Canada, Australia, New Zealand, and many countries of Western Europe'.[7] Clearly, some individuals have not shared in the longevity gains experienced generally in the population.

Several studies demonstrate that the suicide rate is not constant across space, time or gender.[8] The fact that variation exists is suggestive that an attitude of passivity or pessimism about the prevention of suicide is not a reasonable position. Clearly, for variation to occur, broad societal factors are bearing upon the suicide rate.

Hence, the study of suicide and the forces that lengthen life at the societal level is a suitable topic of economic study. A further motivation for this article is that several Western countries have identified suicide as a public issue already, and have formed policies and strategies to avert the trend.[9] For this reason also, it is critically important that the process of policy making about suicide prevention be well informed.

The structure of this article is as follows. Several of the following sections place suicide into the context of a number of different economic literatures concerned with the factors in longevity, and in mortality reduction. Particular attention is drawn to the conceptual framework of the different types of knowledge outlined by Joel Mokyr, whose concern is, in part, to find the origins of 'the knowledge economy'. Attention then turns to some empirical matters, in particular, the importance of appropriate empirical measurement of the societal analysis of suicide. A suitable (additional) measure for such analysis is the Potential Years of Life Lost (PYLL) due to suicide. The article then presents some trends in suicide PYLLs for Australia from 1917 to 2004. The welfare implications of the trends are discussed in another section. A final section concludes the article. A key implication is that a seriously low stock of knowledge exists about the factors behind Australia's suicide trend.

## Economic Processes in Industrialisation and Longevity

It is helpful to provide a context by reconsidering briefly the economic forces in industrialisation.

As a result of many decades of economic scholarship, it is widely believed that a nation's material well-being is improved by investment and technological change, the contributions of science and knowledge, a supportive institutional framework, and a culture that fosters daily economic activity towards better aggregate levels of well-being.[10] A recent (1980s onwards) advance in understanding about the factors in economic growth has given prominence to the role of knowledge and innovation in the process of economic growth.[11] Endogenous growth theory also focuses attention on the process by which new ideas and new processes form, and become embodied in human capital. This process generates positive externalities, and enhances economic growth. Thus, according to endogenous growth theory, total factor productivity is the critical component in the engine of economic growth. This view contrasts with the prior emphasis (in exogenous growth theory), which was on the productivity of a single factor, e.g. capital.[12]

Attention turns now to how economic approaches assist in the understanding of another aspect of prosperity: longevity. The distribution of national output has a long history of economic scholarship,[13] but longevity suffers from general neglect in economic scholarship, and the topic of its distribution more so. Yet the distribution of longevity is important, and suicide is not an exception.

It was mentioned above briefly that 'the contributions of science and knowledge' were, in part, a factor in material well-being. In the context of rising longevity, it is relevant to consider the issue of knowledge in more detail, and a useful starting point is the conceptual framework outlined by Mokyr.[14]

Mokyr develops a theory of knowledge that answers some new questions about the role of knowledge in economic and technological change: 'What is meant by a society "knowing" something and what kind of knowledge really matters? *Who* knew that which was "known"? What was done with that knowledge?' (emphasis in original).[15]

According to Mokyr, 'useful knowledge' (which is a term employed in 1965 by Kuznets[16]) 'deals with natural phenomena that potentially lend themselves to manipulation, such as artefacts, materials energy, and living beings'.[17] But there is then a fundamental distinction between types of knowledge: Mokyr distinguishes between knowledge 'what' or *propositional* knowledge (i.e. beliefs), which is about the laws and phenomena. This knowledge can lead to knowledge 'how' or *prescriptive* knowledge, which embodies techniques and technologies that form solutions to human problems.

In Mokyr's classification, propositional knowledge is *episteme*, which he refers to as Ω-knowledge, and prescriptive knowledge is *techne* referred to as λ-knowledge. He then argues that discovery is 'simply the addition of a piece of knowledge hitherto not in' the Ω-set.[18] Also, society '"knows" something if at least one individual does … [L]earning or diffusion would be defined as the transmission from one individual or device to another'.[19] However, it is 'collective knowledge' that 'counts': collective knowledge 'raises the question of how society moves from individual knowledge to collective knowledge'.[20]

It is not possible to develop Mokyr's theory any further here, despite the fact that he also develops very important notions about the access costs of knowledge, as well as a distinction about 'tightness' or 'looseness' in knowledge. Rather, the point here is this: Mokyr uses this theory of knowledge to explain the roots of the Industrial Revolution in Great Britain. For Mokyr, the roots are *not* in the conventional foci such as institutions, markets and resources, but in epistemy. Thus, the Industrial Revolution, though not the beginning of economic growth in human history, was the 'stage in which the weight of the knowledge-induced component of economic growth increased markedly'.[21]

Our present interest in Mokyr's work is that it provides a conceptual framework to comprehend the forces at work that have produced longevity. We move from the abstract to an account of some landmarks in knowledge of preventive health, which illustrate Mokyr's conception.

The human body requires essential (albeit small) quantities of substances for normal functioning. The range of 'normal' can be relatively narrow, e.g. people can develop anaemia (iron deficiency) or hemochromatosis (excessive iron deposits). With very few exceptions, these substances must be obtained from the diet, or by dietary supplements. A general problem arises because no one food contains all the necessary vitamins and, if particular foods that contain the necessary vitamins are not available, then a vitamin deficiency will arise.

A well-known example is iodine deficiency, which can cause goitre or cretinism (indicated by dwarfism, mental deficiency, muscular coordination problems etc.). Although cretinism is generally rare, the prevalence can be greater than 5% in some isolated communities in New Guinea, Ecuador, the Himalayas and Zaire. However, the discovery of the use of iodised salt, first put into practice in 1920,[22] dramatically reduced the incidence of cretinism.

Another well-known example involves vitamin $B_1$, or thiamine, deficiency. This causes problems not only of the gastrointestinal tract and of blood circulation, but also of the nervous system. *In extremis*, thiamine deficiency can produce the irreversible effects of the Wernicke–Korsakoff syndrome.[23]

Beriberi (a debilitating condition associated with physical weakening, nerve pain and heart failure) has been endemic in south and east Asia, and is also a result of thiamine deficiency. This is often a result of a diet limited to polished white rice. This connection was made by Dutch medical practitioner, Christiaan Eijkmann (1856–1950), working alone in the Dutch East Indies in 1886. Eijkmann demonstrated that beriberi could be produced in chickens by feeding them on polished rice rather than whole grains. It took many years until it was established that the removal of the husk, in the process of polishing rice, removed vitamin $B_1$, which is in the husk. A similar story is associated with rickets, a disease of bone malformation, and dietary deficiency in vitamin D.

A third, quite contemporary issue relates to folate (vitamin $B_9$) and neural tube defects, predominantly spina bifida. The detection of dietary deficiency as the cause of 'pernicious anaemia' during pregnancy among low-income women in Mumbai is due to Lucy Wills, an English medical practitioner, in the late 1920s. After some success with brewer's yeast being administered to rats, clinical trials on yeast, or yeast extract (Marmite) were undertaken on Mumbai women with a diagnosis of pernicious anaemia.[24] Subsequently, the active ingredient was isolated in 1941 and named 'folic acid'.[25] We now know that folate is important for the maintenance and production of new cells, especially during pregnancy and when there is rapid cell division. This fact has been verified by a number of studies in the US,[26] Australia[27] and the United Kingdom.[28] The latter study is an example of a 'gold-standard' piece of research: it is a multi-centred, randomised (double-blind) control trial, which thus is able to conclude strongly that, 'Folic acid supplementation … can now be firmly recommended … and public health measures should be taken to ensure that the diet of all women who may bear children contains an adequate amount of folic acid'.[29] Australia and New Zealand mandated fortification of wheat flour for the making of bread on 22 June 2007.[30]

Clearly, these illustrations of Mokyr's conceptions show that knowledge that is deficient in, or excessive of, some essential dietary substance, is deleterious to human health. Such knowledge is of the Ω-type. In all these cases, the λ-type knowledge is dietary supplementation.

It is worth noting that the adage about knowledge being a 'dangerous thing' can be applicable in the development of policy from λ-type knowledge: policy about supplements in water[31] or food is typically a controversial issue. An example is found in the fascinating account of various battles that have been waged in Australia over knowledge about thiamine and folic acid by Kamien.[32] He came to the fortification debate early in his career (the early 1970s) in Bourke, New South Wales, when a controversy erupted because he advocated supplementing flour (in baking white bread) to reverse the various vitamin deficiencies afflicting the local Aboriginal community.

Let us now consider a more complex case, such as a medical or a surgical intervention, say, open-heart surgery, as performed in an advanced, tertiary hospital. In this case, useful knowledge is gathered upon admission to the hospital, e.g. with blood typing on the patient, and also with complications (allergies, diabetes, AIDS status, etc.) anticipated by numerous diagnostic tests; also, numerous medical instruments and other items of capital equipment subjected to stringent sterilisation procedures, such as autoclaving, in the operating theatre, whilst other equipment will be on stand-by in the Intensive Care Unit. Also, various people (surgeons, anaesthetists, theatre nurses etc.) embody the knowledge of human processes and various skills that bring about the necessary outcome, *viz.* successful open-heart surgery. The concern with the sterile environment and sterile equipment is an application of, or the technological implication of, the germ theory of disease.

In other words, what occurs in a surgical procedure is the outcome of large quantities of Ω-type knowledge. There are many, many more pieces of relevant knowledge, far more than we could even mention in passing, although to mention also Harvey's theory about blood circulation as well as the properties of electricity and the knowledge of magnetism for electrical equipment to operate in theatre imparts the flavour of how broadly-sweeping is the relevant knowledge.

We will now consider briefly the antecedents of the germ theory of disease: a Dutch draper in the small town of Delft, Antony van Leeuwenhoek (1632–1723), being obsessional about grinding lenses and then arranging them in such a way that he saw things that no-one had seen before, resulted in what we now call a microscope. When van Leeuwenhoek examined a drop of water, he saw what he called 'little beasties', which '… stop, they stand still as 'twere upon a point, and they turn themselves round with that swiftness, as we see a top turn round, the circumference they make no bigger than that of a fine grain of sand'.[33]

Van Leeuwenhoek was the first person to see bacteria; without his invention micro-organisms would have remained invisible. Moreover, without this invention, Pasteur (1822–95) could not have discovered that microbes could be kept out of healthy wines by gently heating the wine after fermentation. Further, it could not have been explained that the disease afflicting silk worms was associated with microbial infection. It was Pasteur's work that then influenced a Glasgow surgeon, Joseph Lister (1827–1912) to use antiseptics in hospitals. Other major figures in the 'war on germs'[34] were Paul Erlich (1854–1915), who demonstrated that Arsphenamine (or Salvarsan) was effective for treating syphillus, and Gerhard Domagk (1895–1964) who demonstrated the antibacterial efficacy of Prontosil, or what we now call sulfarilamide.

One other major breakthrough in the twentieth century was the advent of penicillin, and antibiotics in general. The main parts of the penicillin story are well-known, particularly the accidental growth of mould one week-end in 1928, by Alexander Fleming[35] and the dedicated hard work of Howard Florey, Eric Chain and other members of the Oxford University team at the Williams Dunn School of Pathology in the late 1930s and early 1940s.[36] This work led to the awarding of the Nobel prize in 1945, shared by Florey, Chain and Fleming. However, an added connection to this story is the account, above, about open-heart surgery: modern antibiotics are also a critical component in the success of this procedure.

The point here of re-telling the antibiotic story is to see that, behind curative medicine, lies an enormous stock of knowledge, of both the Ω-type and λ-type.

Essentially, the purpose of the above discussion is to illustrate three major scientific revolutions in the past two centuries that, according to Mokyr, occurred in the

health sector. The first revolution was the 'sanitarian or hygienic movement', the second was the germ theory of disease, and the third revolution involved the discovery of knowledge about small traces of substances that are vital to human health. The overall impact of all these advances in knowledge is, according to Mokyr, as follows: 'Changes in useful knowledge were thus responsible for many of the changes in household behavior *[sic.]* in the period between 1815 and 1945. These changes account for a substantial portion of the decline in morbidity and mortality rates in the West'.[37]

We turn our attention from Mokyr now to the contributions of others.

Unlike Mokyr, economists who have specialised in economic growth have not transferred their analytical tools to the improvement of health and longevity, and its sources. One exception occurred in the early years of the twentieth century, when a single economist, Irving Fisher, considered the topic of health to be of central importance. Fisher argued that significant economic value is gained by improving health, and in extending the length of life. It seems remarkable now that, for nine decades, economists' ears have been almost universally deaf to Fisher's perspective.[38] There is another exception: Usher developed a utility function incorporating length of life.[39] Usher's recent textbook on political economy is also noteworthy, and somewhat atypical, when one considers his analysis in the first chapter (entitled, 'How Dreadful Life Used to Be') on the achievement in longevity.[40]

The implication for the present article of this culture of neglect is that a literature specifically to support the economic study of suicide is barely formed, and attention must turn to the literature about the societal forces bearing upon the decline in the rate of total mortality.

In the account of the literature about total mortality, we commence with the work of Thomas McKeown. A social epidemiologist, McKeown undertook a series of detailed studies on the causes of death in England and Wales in the eighteenth century;[41] the nineteenth century;[42] and the twentieth century.[43] The tenor of the results of McKeown is that the lengthening of life was the outcome of sequential advances due to the rise in income: first, nutritional improvements (such a fresh fruit and vegetables and high-protein foods); then public investment in waste disposal and safe drinking water, to counter water- and food-borne diseases; next, immunisation; and finally medical/pharmaceutical therapies (though these did not have an impact before the twentieth century). He noted also that the change in reproductive practice lowered the birth rate and was a critical factor in avoiding the 'Malthusian trap'.[44] The most influential conclusion from these studies has remained the subject of vigorous debate: that the decline in mortality rates is the result of improved living standards.

During the 1970s and 1980s, there was another contributor, Ivan Illich, to the study of health. Illich added an angry critique of the impact of professionalised medicine on health, and the institutional causes of illnesses.[45] This led him to consider iatrogenic factors in illness, particularly 'social iatrogenesis'. Illich argued that social institutions, standardised health care and medical bureaucracies redefine the individual response to illness and social iatrogenesis results.

> Better health care will depend not on some new therapeutic standard, but on … personal activities [that] are shaped and conditioned by the culture in which the individual grows up: patterns of work and leisure, of celebration and sleep, of production of food and drink, of family relations and politics.[46]

For Illich, natural and human causes are but one source of human suffering, death and disability.[47] The other is perverse heroism, which results when 'professionalisation' of medicine and health service bureaucracies inhibit the private actions of individuals for generating good health.

The ideas of Illich and McKeown have together been highly influential, particularly amongst some providers and scholars of health sector services. For example, the health services research 'movement' is borne of their ideas. Finding the 'social determinants of health' is predominant in that research agendum.[48]

These conclusions are not held consensually. Subsequent studies on the role of public health measures have shown conclusively that McKeown understated the importance of public health measures in mortality decline.[49] Preston[50] and Gwatkin[51] also demonstrate clearly that the discovery of the germ theory of disease was a critical factor in extending the length of life, as does Mokyr.

**A Connection with the Early Greeks**

It is noteworthy that the titles of the monographs of both McKeown and Illich involve a reference to the attitudes and gods of the early Greeks. These titles both refer to Nemesis. This is a reference to the encounter between Prometheus, Zeus and Nemesis in Homer's *The Iliad*. In a journal entitled *Prometheus*, it is appropriate to reconsider Homer's account of Prometheus and Nemesis. (The following account 'goes beyond' the somewhat limited perspective on this myth that Illich conveyed.)

In *The Iliad*, Prometheus falls foul of Nemesis who is the god that enacts divine justice and vengeance when humans transgress the natural order. Prometheus wanted Earth to have the benefit of fire to fix coldness and darkness. Though fire is *per se* a good solution, Prometheus brings fire by thieving from Zeus, by trickery, presumption and hubris. The gift of fire made Prometheus a hero from the human perspective. However, he was not a hero from the gods' perspective: the lack of humility and of respect for the gods in Prometheus, regarding his place in relation to the gods, was not acceptable. Prometheus acted 'out of order' and thus came into a struggle at the boundaries of the *conditio humana*. Prometheus brought Nemesis upon himself.

Homer's myth provides a cautionary note relevant to this era: the choices underlying human actions, in the process of the discovery of the knowledge that can be applied to human problems, affect both the solutions that are applied and the overall outcome. While knowledge *per se* (i.e. irrespective of whether that knowledge applies to public or private health-generating actions) is a powerful factor in alleviating human problems, the process of deriving knowledge affects the knowledge that is discovered, and what is overlooked when solutions are applied.

In the search for knowledge about societal processes that can enhance health, this caution is relevant.

Mokyr also alludes to a 'Greek connection' in *The Gifts of Athena*. Athena, the goddess of knowledge and wisdom, is a suitable symbol for Mokyr's general argument. In his preface, Mokyr refers to Athena's invaluable gift of the olive tree to Cecrops. Also in his preface, Mokyr defines the nature of the gains in human well-being of economic growth: 'longer, healthier, and more secure lives, of more leisure and material comfort, of reducing mortality, morbidity, pain, and sorrow'.[52] Nevertheless, Mokyr's concluding paragraph (of his book) refers also to Athena, but there is a cautious note:

> Athena's gifts were many: she gave King Cecrops the olive tree, but she gave the city of Troy the wooden horse that led to its destruction. … Technology makes people more powerful in exploiting nature, but how and for what purpose they do so remains indeterminate. If the twentieth century has shown us anything, it is that the capacity of humans for intolerance, stupidity, and selfishness has not declined as their technological power has increased.[53]

The 'Greek connection' that has been suggested in this section is that the study of mortality underscores some of the most severe extremes of the human condition. The human race is empowered by an endowment of creative ability for developing the knowledge and technology that achieves good ends; and yet humans also are constrained by 'what to do' about the worst in human nature. Greed, jealousy and pride can impede progress in the development of scientific knowledge, and its beneficial application.

Having now suggested that some ancient Greek insights are helpful in the present context, let it be clear that a crucial problem for the economic study of suicide and for improving the life expectancy of the sub-population prone to suicide, is this: 'Prometheus' has not yet even brought his spirit of endeavour to this human problem.

Few Australian economists are applying the 'tools of the trade' to the study of Australia's mortality experience, and suicide is just overlooked. The propensity for some topics or issues which nations face to be neglected, relatively speaking, is not new: in the nineteenth century, Alfred Marshall noted 'the tardy growth of economic science'.[54] He made this observation despite the fact that economics 'deals with questions so vital for the wellbeing of mankind'.[55]

For Marshall, a cause of this relative neglect was that 'the bearing of economics on the higher wellbeing of a man has been overlooked'.[56] Marshall's conception (or definition) of economics is broad: '… a study of mankind in the ordinary business of life; it examines that part of individual and social action which is most closely connected with the attainment and with the use of the material requisites of wellbeing'.[57]

Clearly, Marshall would approve of seeking orderly solutions to improving the health status of populations and, thus, to applying economic tools of analysis to mortality, and so to suicide.

Attention will move now from the ancient Greeks, and the focus will turn to the pressing work of the present era. The current work of economists and economic historians about the mortality trend will be the next matter of attention.

### The More Recent Literature about Longevity

There is a recent literature emerging from within economics and economic history which considers various types of questions about longevity, such as the following: How were such unprecedented gains in longevity that have occured in the modern era achieved in such a relatively short space of human history? Why did the 'demographic transition' happen at all? Has the diffusion of the technology that leads to longevity been more rapid and widespread than the diffusion of the technology that alleviates poverty?

For economic historian and 1993 Nobel prize winner, Robert Fogel, 'failure to take account of [economic] history … has often led to a misunderstanding of current economic problems by investigators who have not realized that their

generalizations rested upon transient circumstances'.[58] One of Fogel's empirical studies is about mortality, in which he examines physiological data on height, weight and mortality in eighteenth-century Britain and France.[59] He finds diets to have been barely sufficient for basic physiological survival, people significantly smaller in stature than at the present (the 1990s) and the tendency to die younger.

While his detailed analyses have been admired, a line of argument implied in Fogel's conclusions, *viz.* that higher income enables better nutrition and thus longer life, has not gone undisputed. For example, Easterlin provides a cogent case that Fogel's conclusions overemphasise the role of nutrition. Essentially, the process by which a raft of public health measures overcame the various market failures through the course of history is not accounted for by Fogel's data.[60]

In a review of Fogel's recent book, *The Escape from Hunger and Premature Death, 1700–2100*, Angus Deaton observes the tendency among some scholars (though not Fogel) to underestimate the 'primacy' of germ theory and of public health:

> In a country by country examination of mortality decline … we sometimes find that economic growth is correlated with improvements in longevity, but just as often not. Whilst it is hard to imagine the absence of a correlation between health and income in the longest of long runs, the relationship can vanish for substantial periods of time … Economic growth frequently needs help to guarantee an improvement in population health.[61]

In the context of views being divided over the factors, at the societal level, in longevity, it is noteworthy that, in the late 1990s, Easterlin asked an entirely different question: is life expectancy totally, or even largely, due to economic growth at all?[62] According to Easterlin, 'The history of science suggests that it was primarily the internal evolution of *knowledge*, not *the resources provided* by economic growth, that was responsible for the great discoveries leading to the control of infectious disease' (emphasis added) and

> The improvement of life expectancy, like economic growth, has been based on a new technology involving new institutional, capital, and labor requirements. But for life expectancy, the nature of the new technology and associated requirements is quite different from those for economic growth.

Hence, Easterlin disputes the widespread belief among economists and historians that the so-called Mortality Revolution was the result of the Industrial Revolution. Easterlin proposes that both the Industrial Revolution and the Mortality Revolution have been joint outcomes of '*something else*', and that this occurred *in both* industry and medicine from around the time of the Industrial Revolution, *viz.* 'the growing dominance of a scientific approach to the quest for human knowledge' (see also Lichtenberg's empirical study).[63] It is quite unsurprising that Mokyr cites Easterlin. He also attributes an intellectual debt to Easterlin in his Preface.

To add some empirical evidence to this argument, an extensive review of the empirical literature by Deaton, Cutler and Llenas-Meuras examines the contributions of all the factors under study that are thought to be linked to the decline in the mortality rate.[64] They also concern themselves with the respective roles of private and public action, reviewing studies about nutrition, hygiene, education and public health initiatives. Their conclusion is that, although several broadly ranging factors are likely to contribute to the decline in the mortality rate, no

evidence exists of consensus over the causal mechanism. They suggest that scientific advance and technical progress are joint factors in determining health status. According to Deaton, Cutler and Llenas-Meuras, arguing that a direct causal mechanism exists from income to health is spurious.

Despite this tardy turning of economic scholarship, there is now an emergence in economics of a new perspective on health and longevity. According to Easterlin: 'Increasing length of life and associated reduction in morbidity brought about by the "Mortality Revolution" has meant *at least as much* for human welfare as the improvement in living levels due to modern economic growth' (emphasis added).[65]

Various scholars, Nordhaus included, are now turning their attention to a 'new view of the economics of health'.[66] Also, there is a new literature concerned with determining whether or not reductions in mortality are exogenous or endogenous to economic growth and development, and whether the rate of human biological deterioration is an additional engine of growth.[67]

Despite the gains achieved in longevity in many countries, it is surprising that few economists have studied the distribution of age-at-mortality with fervour similar to that of studying the distribution of income. Only two economists, Silber[68] and Le Grand,[69] applied conventional economic measures of inequality (such as Gini coefficients, standard deviations, coefficients of variation and so forth) to data on age-at-death in the 1980s. They also showed that Lorenz curves can be derived from such data, using procedures that are analogous to the study of income distribution. Some applications have been undertaken on Australian data.[70]

With all this background in mind, attention will turn now to some Australian data about longevity and suicide.

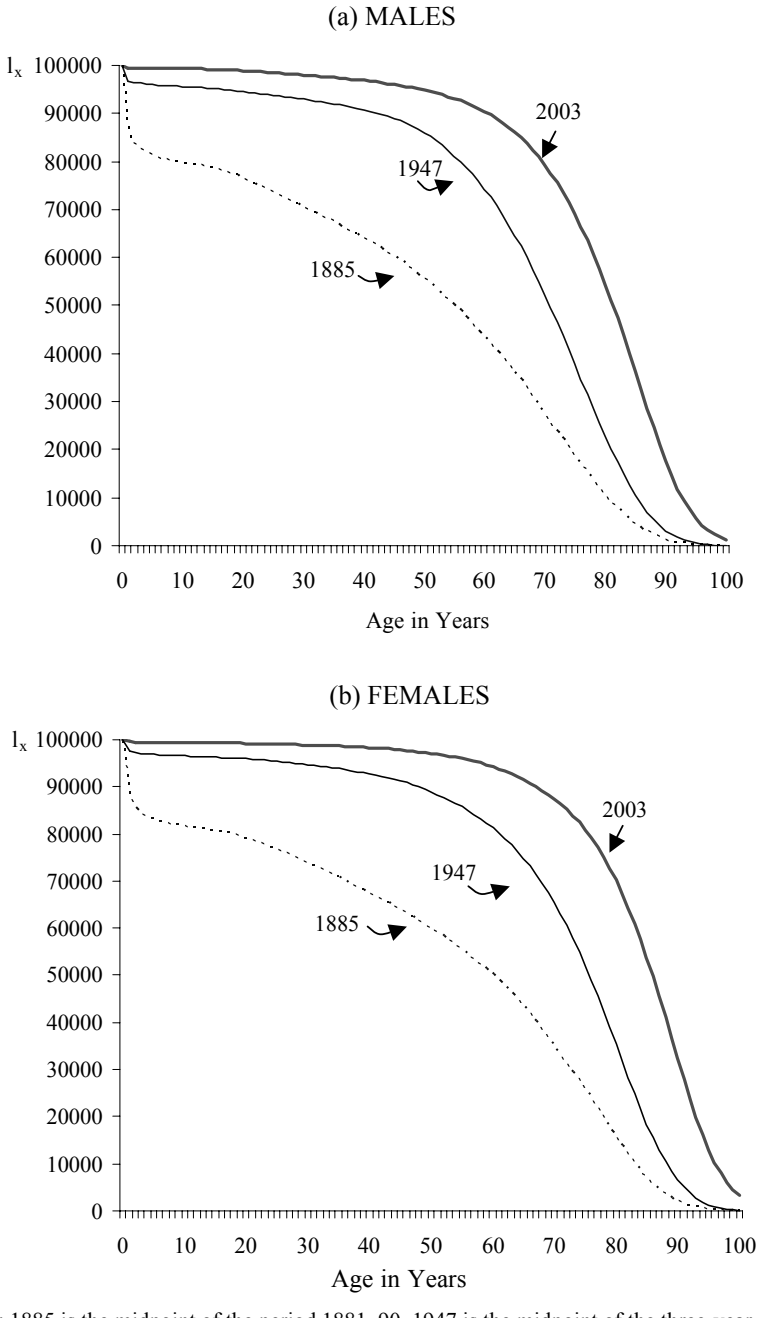
**The Australian Demographic Transition**

Epidemiologists and demographers refer to the secular decline in the mortality rate and the change in the major causes of mortality post-1800s in various ways, according to the purpose/s of the exercise: the 'rectangularisation of the survival curve'; the 'epidemiological transition'; or the 'demographic transition'.[71]

The demographic transition is presented for Australia in Figure 1, which depicts survival curves for males and females. Both diagrams clearly indicate the 'rectangularisation of the survival curve', a process common to many Western countries in the twentieth century. Male and female life expectancy (at birth, age 20, 40 and 60) are shown in Figure 2. Both diagrams show rising life expectancy at all four ages.

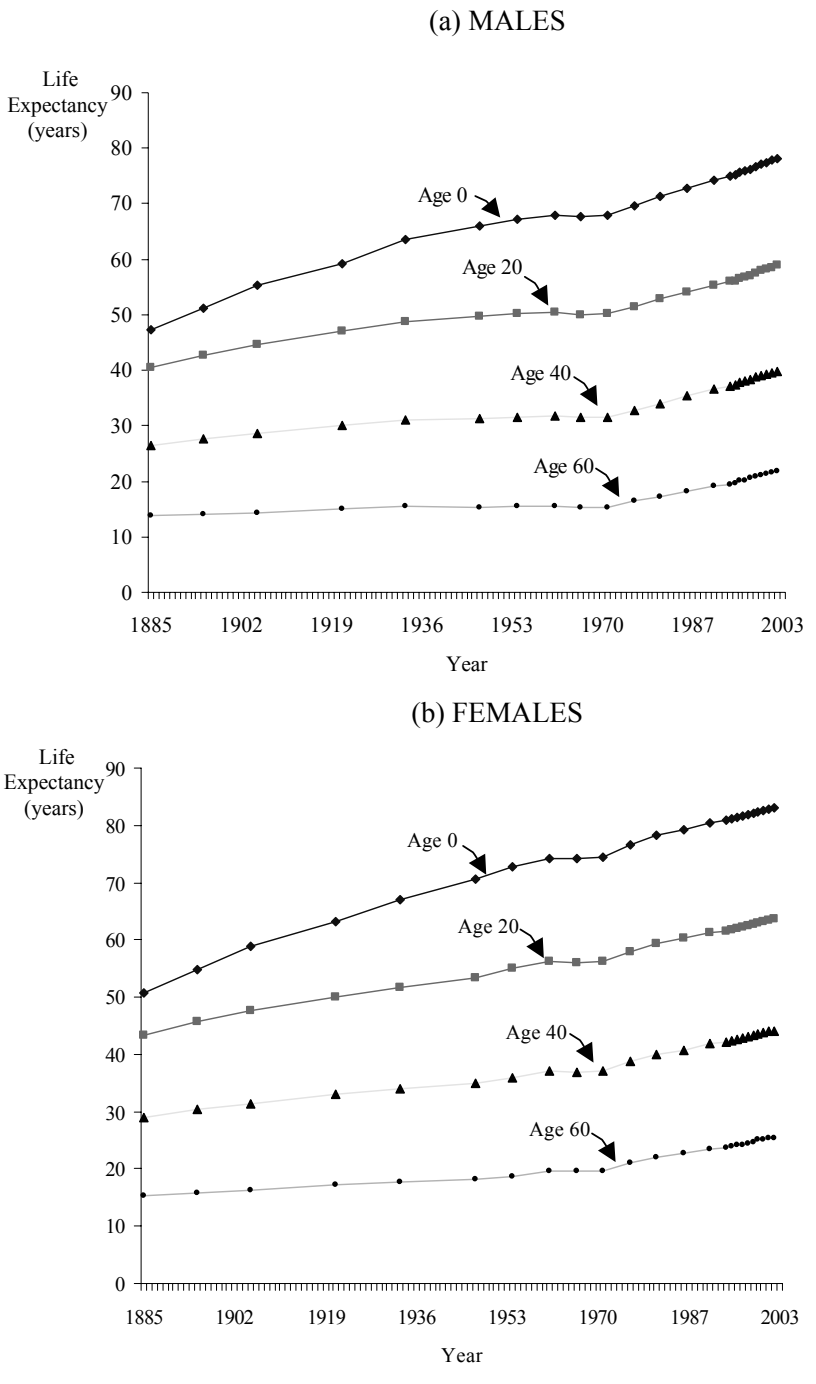
One result of the demographic transition is that mortality from acute infectious diseases and deficiency illnesses, which once characterised the developed world, is being replaced by morbidity from chronic, non-communicable diseases, generally speaking. Despite these overall gains in longevity, some groups in the population have not shared in these gains: suicide, and suicidal morbidity, in a world in 'demographic transition' is a puzzle.

Headcount data on the rate of Australian suicide per 100,000 population for the period 1907–2004 are presented in Figure 3, along with some other causes of death and also All Causes mortality. The other causes of death that are depicted are circulatory diseases (by far the largest single cause of death), cancer (the second most numerous cause of death), and two relatively 'small' causes of death (motor vehicle accidents and suicide).



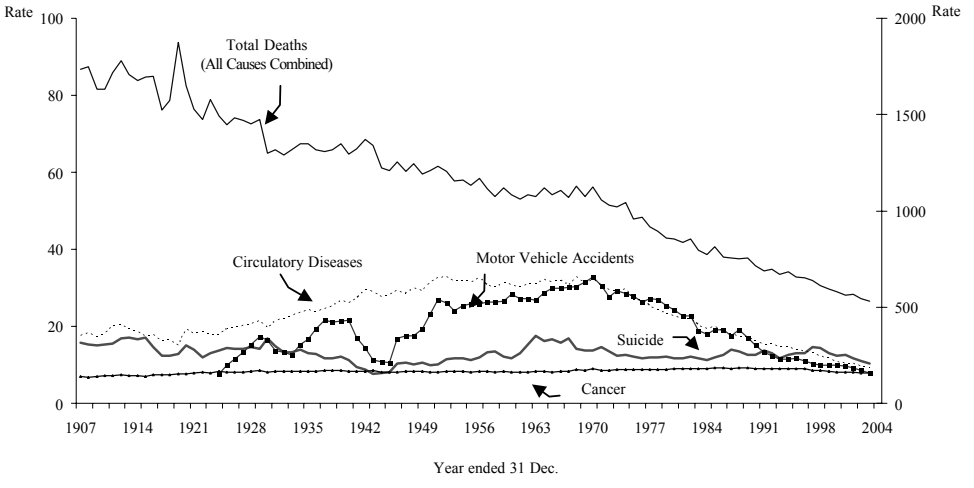

*Notes*: 1885 is the midpoint of the period 1881–90, 1947 is the midpoint of the three-year period 1946–48, 2003 is the midpoint of the three year period of 2002–4.
$l_x$ is the number of persons surviving to the exact age $x$ out of 100,000 births.
*Source*: Australian Bureau of Statistics, *Australian Historical Population Statistics, 2006*. Cat. 3105.0.65.0, Tables 50 and 54. Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3105.0.65.0012006?OpenDocument, accessed 12 October 2006.

**Figure 1.** Survival curves for Australian males and females, 1885, 1947 and 2003.




*Source*: Australian Bureau of Statistics, *Australian Historical Population Statistics, 2006.* Cat. 3105.0.65.0, Tables 49 and 53. Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3105.0.65.0012006?OpenDocument, accessed 12 October 2006.

**Figure 2.** Life expectancy for Australian males and females at four separate ages from 1885 to 2003.




*Notes*: These rates have been standardised to the age distribution of the 1991 Australian population.
The left-hand Y-axis is relevant for the mortality rates for Suicide and Motor Vehicle Accidents, whereas the right-hand Y-axis indicates the scale for the mortality rates for Total Deaths (All Causes combined), All Cancers and All Circulatory Diseases.
ASR: Age-standardised rate per 100,000.
*Source*: Calculated from Australian Institute of Health and Welfare, *State & Territories GRIM (General Record of Incidence of Mortality) Books*, AIHW, Canberra, 2006.

**Figure 3.** Age-standardised mortality rates for suicide, motor vehicle accidents, circulatory diseases, cancers, and total mortality (all causes combined), Australia, persons, 1907–2004.

Several observations can be noted from this figure. The cancer mortality rate is virtually constant. The mortality rate for circulatory diseases initially rose but has, since 1968, been in secular decline. Mortality arising from motor vehicle accidents (data on which were first recorded in 1924) increased until 1978, and has declined since then. The temporal trend associated with suicide is unlike that for the other three causes in Figure 3. There was a relatively high level in the 1920s and early 1930s, a fall during the World War II period, and since then it has increased, reaching a local maximum during the 1990s. From the mid-1980s to 2004 there is a higher level of mortality from suicide compared to the post-WWII period. While mortality from motor vehicle accidents exceeds that for suicide in the 1930s–80s (often by a substantial margin), ultimately it has become less than the suicide rate.

The purpose of this article does not extend to determining the factors in these trends. However, it is relevant to consider in broad terms some factors that have affected the trends just observed. The rise of motor vehicle transport from the early decades of the twentieth century resulted first in a rise in accident mortality, but various government interventions (seat-belt legislation, crash helmets, safely-designed roads, drink-driving legislation etc.) were developed and some such interventions have been shown to be efficacious.[72] Efficacious interventions for ischaemic heart disease and related conditions have also been developed.[73]

The data depicted in Figure 3 present a partial picture of Australia's mortality experience in the twentieth century. The major causes of death (infectious diseases) in the early years of the twentieth century which experienced very large decreases since the 1900s are not shown.[74] Public health measures of one kind or another were implemented,[75] such as public investments in reticulated and waste

water systems, as well as rising standards of living, better nutrition, the use of chemotherapy etc.[76]

It should be noted that there is one important aspect of suicide: its distribution is not depicted in Figure 3. It is important to depict the distribution of suicide because suicide prevention policy ought to affect not just the trend in the suicide rate, but also the distribution of suicide. Since the World Health Report of 2000, *Health For All*,[77] it has been increasingly recognised that health policy ought to be pursuing goals concerned with more health *and* fairer health. Both goals apply also to longevity. There is a single study available which analyses statistically the trend through time in the distribution of suicide in Australia for males and females, and which applies the alternative (PYLL) measure to Australian suicide data.[78]

Attention will turn now to the PYLL as the appropriate measure of the extent of suicide.

### 'The Extent of Suicide' as an Economic Concept

It is being argued here that one aspect of suicide is that it exists as a consequence of the scientific revolution not yet having come to suicide. An initial step in any scientific approach to solving human problems is to measure, appropriately, the phenomenon, i.e. to determine its size or extent. Consequently, there is a crucial measurement issue in any study of mortality: 'What is an appropriate measure of mortality?' The choice of suicide measure is governed by the purpose to which the measure is put.

Consider the perspective of a parent with two children both of whom take their own lives. One child is 35 years old and the other is 15 years of age. A parent may take the view that each suicide involves the same loss, irrespective of age. However, where a social perspective is being adopted, then it can be argued that the two cases do not involve the same loss: a 'public issue' perspective may weigh the death of the younger person more highly than the older person.[79]

The highly influential work of Grossman[80] and Becker[81] clearly established that the time lived prior to mortality is economically relevant (and also that the stock of health in a population is valuable because it yields a flow of services). In the context of suicide, Doessel *et al.* have derived the relevant utility functions.[82]

Recently, some scholars have advocated an alternative measure of suicide to the headcount measure, the PYLL.[83] This measure was first used by Dempsey in 1947 in respect of tuberculosis prevention programmes.[84] She was concerned with measuring 'the relative importance of diseases' or 'the seriousness of a disease'.[85] The PYLL gained greater prominence when it was incorporated into the burden of disease concept.[86]

Equation (1) gives the method of calculation of the PYLL. It is for total $\mathrm{PYLL}(75)_{\mathrm{AS}}$ in year $t$ for an assumed life expectancy of 75 years, denoted PYLL(75):

$$\text{Suicide PYLL } (75)^{\mathrm{AS}}{}_t \quad = \sum_{i=1}^{n} [D_s(75 - A_s)] \tag{1}$$

where Suicide $\mathrm{PYLL}(75)^{\mathrm{AS}}{}_t$ is the total PYLLs due to suicide age standardised at time period $t$; $D_s$ is the number of suicides per age group; $A_s$ is the adjusted age at death due to suicide per age group; and $i$ is the number of age groups for $i=1 \ldots n$. Note that conventional age standardisation is required for time series studies of

PYLLs. One account of PYLL calculation is provided by the Australian Bureau of Statistics.[87]

The quantification of unemployment involves a similar type of measurement issue. While there is 'personal trouble' arising from being unemployed, a social loss occurs also, referred to as the 'GDP gap'.[88] A social implication of this gap is that the average aggregate output is less than it otherwise would be if the economy were at 'full employment'. Whilst the unemployment rate is the most widely reported variable in the media, a raft of measures exists to inform policy analysis. For example, it is commonplace for statistical agencies (e.g. the Australian Bureau of Statistics) to publish data on the duration of unemployment since the time spent unemployed is regarded to be not only a personal loss but a social loss.

All available instruments/indices for measuring the social perspective of a phenomenon are imperfect, and it is useful to regard them as *proxy variables*, a distinction which is commonplace in the literature on latent variables.[89] The PYLL measure may be imperfect, but is not as imperfect as is the count measure of suicide.

Another characteristic of the PYLL is that an important distinction needs to be made, when undertaking measurement, between what Runciman refers to as deprivation and attainment in the standard of living.[90] For example, Runciman would regard the years of life that a person lives, i.e. their life span, as an attainment measure of health, whilst the years of life not lived due to 'early death' is a measure of deprivation. The PYLL is a 'deprivation' type of measure, i.e. it measures the years of life lost. It is thus not a measure of 'attainment', in terms of measuring the years of life lived beyond birth. A deprivation measure is relevant to suicide since suicide generally involves 'early death', i.e. the loss of years of life earlier than lifer expectancy.

Figure 4 presents the suicide rate (per 100,000 population) in Australia for males and females, calculated on both PYLL and count data for the period 1907–2004. Disaggregation by gender is important because of the marked difference in suicide rates by gender.[91]

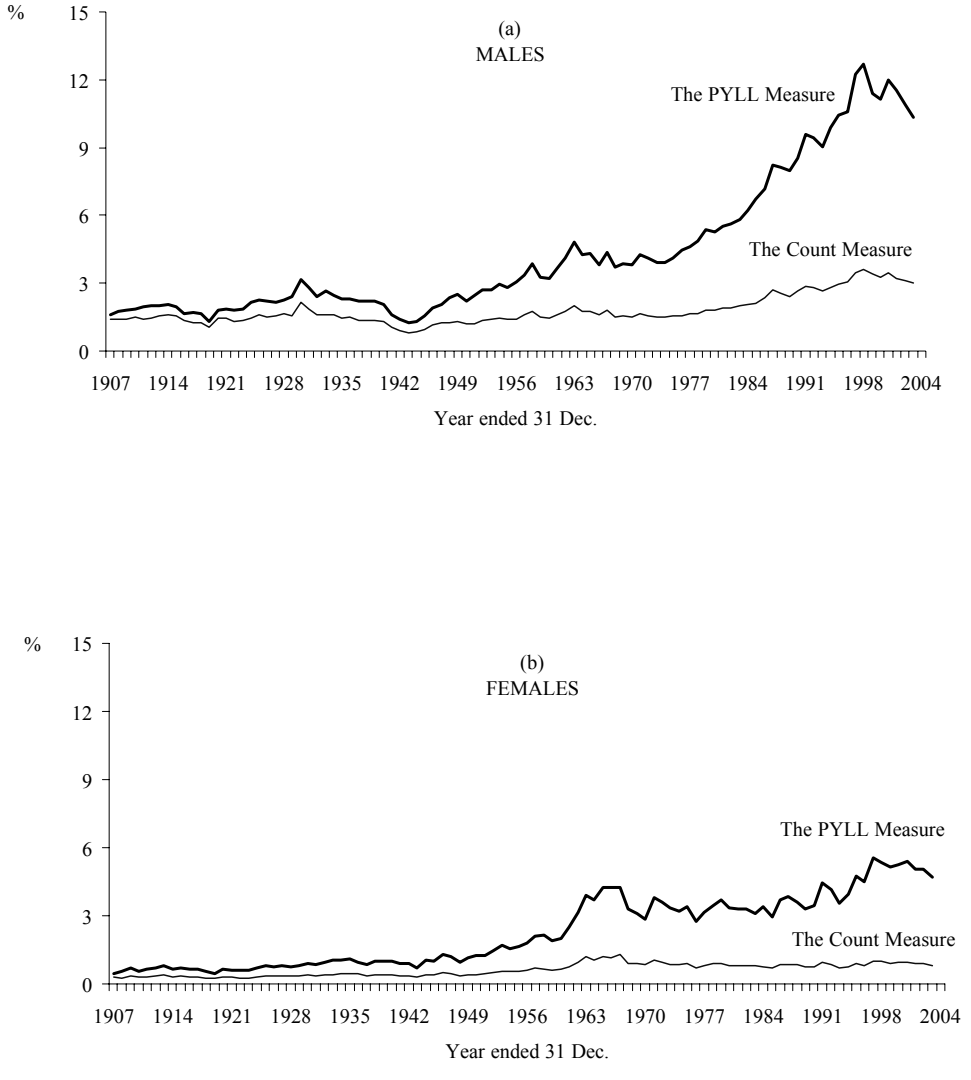
There are two important conclusions to be drawn from this figure. First, for both males and females, the PYLL measure of suicide lies above the count measure, thus indicating that suicide is relatively more important as a cause of death, when measured by PYLLs than when measured with the simple count measure. The figure also suggests that the difference in the two measures has widened since the 1960s, reflecting the rise in suicide by younger people. We also calculated the ratio through time of the percentage shares of the PYLL measure and the count measure of suicide to total deaths, by gender, from 1907 to 2004. We found the relative importance of suicide increased more with the PYLL measure than when the count measure is applied, both for males and females. That figure is available from the authors on request.

Second, both measures indicate that suicide has become relatively more important as a cause of death since 1907. This is not surprising as Figure 3 shows that suicide has not been subject to a secular decline, as has All Cause mortality.

## Conclusion

Two conclusions can be drawn from the historical data reported here.

First, given that the temporal trend of suicide (however measured) is subject to change through time, there is no reason to respond to suicide with acquiescence: if




*Source*: Calculated from AIHW, *op. cit.*

**Figure 4.** Suicide as a percentage of all deaths measured by the count measure (no.) and the potential years of life lost (PYLL) measure, Australia, 1907–2004, males and females.

the suicide rate varies through time, then it is clearly not the mortality equivalent of the gravitational constant.

Second, the historical data indicate that the suicide rate is atypical in comparison to the All Causes mortality rate. In a 98-year period from 1907, there has been a secular decrease in total mortality, which is explained by the virtual elimination of some causes of deaths, such as water-borne diseases, deaths in pregnancy, infectious diseases etc. Moreover, in recent times, the decrease in mortality associated with circulatory diseases is notable. In stark contrast to these gains, the relative

share of suicides to all deaths has risen throughout the whole period, irrespective of how we measure suicide.

Some reflection indicates that those areas of medicine in which there have been reductions in the mortality rate are those areas where both Ω-type and λ-type knowledge have accumulated. By comparison, suicide is a 'black hole': there is little propositional and little prescriptive knowledge. It is clear that a scientific revolution has yet to come to suicide.

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