Response: On economic growth, business fluctuations, and health progress

José A Tapia Granados

Demographic research on preindustrial societies has documented links between harvest yields, grain prices, real wages, and changes in mortality, but mortality hikes as a result of agricultural failures or grain price inflation become more muted as the level of development increases.[1–5] During the early industrialization period in the 19th century, decades of rapid economic growth coincided with stagnating or even increasing mortality in the United States and Britain.[6,7] During the Second World War, deaths from coronary disease declined in Norway and other German-occupied countries as fats and calories were drastically cut in the diet. Then, in 1945, pre-war levels returned both in diet and coronary deaths.[8] It also appears that the blockage of Confederate cotton exports at the start of the US civil war and the subsequent work stoppage improved both adult and infant health in the textile districts of England. Adults were no longer exposed to exhausting work and fumes in the factories, and infants could be breastfed by their mothers, who no longer gave them the Godfried's cordial, a 'baby syrup' made with opiates.[9] Though opiate syrups sold as medicines have been considered a major contributor to deaths of children <3 years old in 19th century England,[10] the health hazards of the early industrialization period have been generally attributed to overcrowding and lack of sanitary conditions in cities, as well as working conditions that packed workers (including children), animals, fumes, and water in mines and factories for working days of 12 and even more hours.[7,11,12] These examples of health declines during periods of prosperity and health improvements during periods of economic hardship show how the relationship between affluence and health is not a univocal one.[13] Two recent major pandemics—nicotine addiction and obesity—are unequivocally associated with increased purchasing power of multitudes who consume marketed commodities that are harmful to health.

Most researchers studying the secular decline of mortality would accept 'some kind' of link between demographic transition—in which death rates drop because of the decline in infectious disease mortality—and various factors associated with social and economic advancement in the past two centuries, including increasing levels of education; the abolition of slavery; significant reductions in discrimination by gender, ethnic, or religious issues; rising availability of material resources; urbanization; and improvement in physical infrastructure. But there is no consensus on which particular aspect is the major cause of the mortality decline.[14–21] Early in the 20th century, the secular drop in mortality was attributed to advances in

medical technology, improvements in the standard of life or in urban sanitation, and, even, to changes in the virulence of germs. But Dubos questioned these ideas[8,22] and McKeown[17,18] decisively broke the consensus,[21] claiming that better nutrition and the associated increase in levels of immune resistance were the basic determinants of mortality decline. Subsequently, Szreter[19] argued for the importance of sanitation and public health policies in mortality reductions, while Caldwell[20] emphasized the diffusion of health technology innovations brought about by the education of women.

Using information from a variety of sources, Preston[23,24] concluded that only about 20% of the massive international improvements in mortality between the 1930s and the 1960s could be attributed to improved standards of living measured in terms of income per capita, an estimate that, to my knowledge, has not been seriously challenged. Even Amartya Sen[25] has suggested that the rate of decline of mortality in Britain between 1900 and 1970 reveals an inverse relationship with economic growth, with decades of high economic growth associated with low increases in life expectancy. Data from low-income countries show that the proportional decline in child mortality between 1980 and 1995 was not correlated with GDP growth,[13,26] and in Central America child death rates have declined by a median annual rate of 5.3% since 1980, despite little improvement in incomes, in contrast to a much slower decline during the preceding 20 years, when incomes rose strongly.[27] Thus, there is quite a bit of evidence to show that secular trends in mortality are not driven by economic growth.

Of course, throughout the 20th century, rare exceptions apart, in every country the gross domestic product (and GDP per capita) has increased and age-adjusted mortality has dropped. Therefore, regressing a time series of mortality rates on GDP or GDP per capita easily 'establishes' an inverse relationship, with increasing levels of GDP or GDP per capita 'strongly generating' lower mortality, as shown in Figure 1 of Brenner's commentary.[28] However, since there are trends in both variables—or, in other words, they are non-stationary series—it is not possible to establish any causal connection.[29]

Brenner[28] claims that my paper[30] presents 'simple correlations' and lacks 'the standard econometric tests including those for residual autocorrelation and unit roots.'. On the contrary, I present both correlation and regression models, the results of the ADF test for unit roots appear in the first paragraph of the results, autocorrelation is considered in the discussion, and Durbin–Watson values gauging residual autocorrelation are also reported. Let the reader judge.

Brenner also argues that 'economic expansions cannot really be related to mortality increases over the 20th century because, during both expansion and recession years, age-adjusted

Institute of Labor and Industrial Relations and School of Social Work, University of Michigan, 1111 East Catherine Street, Ann Arbor, MI 48109-2054, USA. E-mail: jatapia@umich.edu
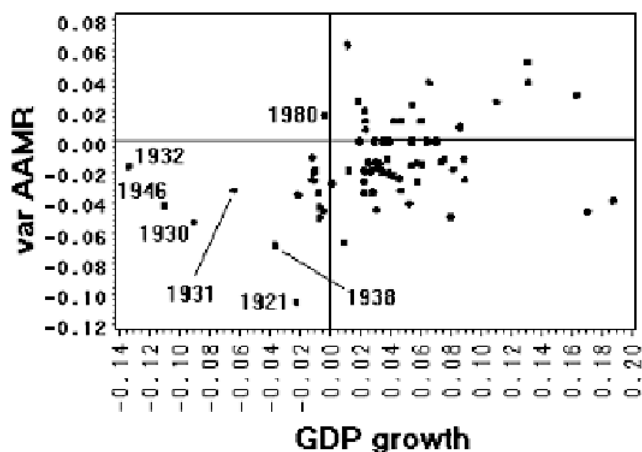
Figure 1 Scatter plot of age-adjusted mortality vs real GDP, both in rate of change, USA, 1920–96 ($r = 0.36$; $P < 0.001$). Note that in just one out of the 77 observations (1980) mortality increased during years in which GDP decreased (upper left quadrant)

Table 1 The 77 years from 1920 to 1997 classified according to the annual change of age-adjusted mortality in the United States

Mortality	Number of years	Mean annual mortality change (%)	Mean real GDP growth (%)
Decreased	48	−3.0	2.3
Constant	12	0.0	4.8
Increased	17	+2.5	6.2

mortality rates have, on average, fallen [...]. If economic growth literally caused mortality to rise, then age-adjusted mortality rates would have shown a trend of increase over the 20th century rather than a rapid and massive decline.' Here again Brenner appears to have misread my paper. In the model $\tilde{a} = -0.022 + 0.274 \cdot g$, which I estimated (see ref. 30, Table 2) for the years 1971–96, when GDP growth $g = 0$, the annual rate of change in age-adjusted mortality is $\tilde{a} = -0.022 = -2.2\%$. Therefore, my model predicts that even in a zero-growth economy, mortality will decrease 2.2% per year, although death rates will tend to decrease significantly more when GDP growth is small or even negative, and mortality may even increase, reversing its long-term decline, when GDP growth is very large. That is exactly what has happened during the past century in the United States (Table 1; Figure 1).

Figure 2 in Brenner's commentary[28] shows an adjusted $R^2 = 0.061$ for the relationship between the rates of change of GDP per capita and adjusted mortality. Though Brenner says that the relationship is 'very weak', his adjusted R^2 (the adjustment is useless for a simple correlation model) corresponds to a Pearson correlation $r = 0.25$ (i.e. $\sqrt{0.061}$). I have replicated Brenner's Figure 2 using GDP growth and the rate of change in adjusted mortality. The two figures (figure 2 from Brenner[28] and Figure 1 here) are remarkably similar. The two correlations, 0.25 and 0.36, are not very different, although Brenner's refers to 1900–99 and growth of GDP per capita, and mine to 1920–97 and growth of GDP. Both $r = 0.25$ with $n = 100$, and $r = 0.36$ with $n = 77$ are statistically significant ($P < 0.05$) against the null $r = 0$. This implies a positive relationship very difficult to explain by chance alone between the rate of expansion of the

economy and the rate of change in mortality (since population year-to-year change is very small, capitation of GDP growth changes little). Therefore, the statistical evidence presented by Brenner is in favour of a significant short-term positive relationship between economic growth and mortality change, as documented in my paper.

Though reluctantly, Brenner recognizes that in the short term there is a harmful effect of economic growth on mortality: 'in the very short term—i.e. within the first few months of that decade—rapid economic growth is associated with increased mortality, probably due to the initial stresses of adaptation to new technology in combination with greater work volume, speed and duration'. This may well be part of the explanation for fatalities at working ages during business upturns (why only the first few months?), but it does not help explain the increase in mortality associated with economic expansions observed in infants,[31] children, and even in the elderly—see Table 3 in my paper[30]— age-specific effects that Brenner does not even mention.

Brenner presents some analyses to dispute my results. Unfortunately, he provides few details on the specifics of his models, which make his results impossible to evaluate. I have already mentioned[32] the conflicting claims of Brenner's past publications about the lag to be considered in the mortality response to the economy. This time Brenner[28] proposes— without any rationale for it—distributed lags of up to 11 years in models in which mortality is cointegrated with GDP, unemployment, and the interaction of both.

Cointegration is an econometric technique used to prove that two variables that wander extensively, i.e. two non-stationary time series, do not drift too far apart.[33–35] Cointegration tests are applied to variables that economic theory suggests are 'linked' or 'in equilibrium' in the long run—for instance, prices and wages, or inventories and sales. To my knowledge, cointegration and its parent technique, vector autoregression, have never been used in epidemiology and only rarely in demography.[36] Brenner does not elaborate on this technique or its appropriateness for this question. As before, Brenner does not make explicit the assumptions of his models. Neither does he present the technical details clearly.

Based on the limited information available, it appears that Brenner's Model 2 in levels (see ref. 28, Table 1) is as follows:

$$\ln M_t = \alpha + \rho \cdot \ln M_{t-1} + \partial_1 \cdot D_{1918} + \partial_2 \cdot D_{1945}$$

$$+ \sum_{i=0}^{11} \beta_i \ln Y_{t-i} \cdot \ln U_{t-i} + \sum_{i=0}^{11} \gamma_i \ln U_{t-i} + \sum_{i=0}^{11} \eta_i \ln Y_{t-i} + \varepsilon_t$$

where M_t is age-adjusted mortality at year t, $\rho \cdot \ln M_{t-1}$ is the autorregressive term, D_{1918} and D_{1945} are dummies for 1918 and 1945, Y_t is GDP per capita at year t, U_t is unemployment at year t, and ε_t is the error term. Since each of the three summations implies 12 lags from 0 to 11, we have 40 explanatory variables for 100 observations of the dependent variable. That is a ratio of 2.5 observations per explanatory variable in the model, when ratios of at least 20–40 observations per variable have been recommended in basic statistical texts.[37] Further-more, since unemployment and the fluctuations of GDP per capita are strongly correlated, their inclusion as interacting terms in the regressions poses important colinearity issues.

Brenner[28] says he is using Shiller's procedure for estimating distributed lags, but he does not report the degree of smoothness
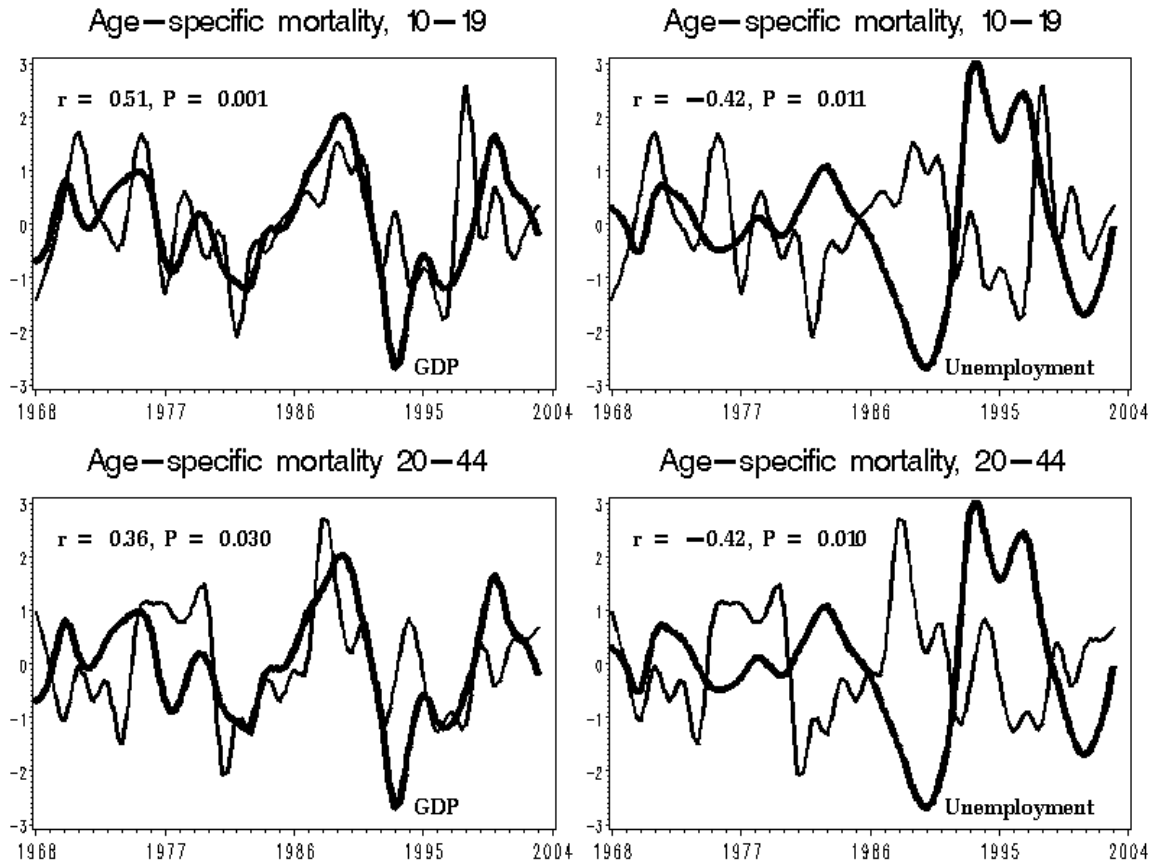
Figure 2 Age-specific mortality for ages 10–19 and 20–44 plotted vs real GDP and the unemployment rate, Sweden, 1968–2003. Mortality follows the path of real GDP and mirrors that of unemployment. The four variables are detrended with the Hodrick–Prescott filter (smoothing parameter = 100) and then normalized. All variables computed from Statistics Sweden data

priors that he uses, or if he is using endpoint priors. He reports only the sums of the coefficient estimates for the lags 0–11, which makes it impossible to ascertain which, if any, of these lags are significant. Furthermore, though econometricians have often emphasized that tests of cointegration are not standard and the usual levels for t-tests and other significance tests are not applicable,[35,38,39] Brenner provides only P-values without reporting standard errors or values for t or χ^2. His reported Durbin–Watson statistics are worthless, because there are autoregressive terms in the models.[34] In summary, as statistical evidence supporting the claim that economic growth is the main determinant of long-term mortality decline in the United States, Brenner's cointegration models have to be taken, as Mark Twain would say, with a few tons of salt.

An easy way to explore whether economic conditions have a lagged effect on mortality decline is to regress the change in age-adjusted mortality on lagged values of GDP growth, estimating β_k for different values of k and p in the equation $\tilde{m}_t = \alpha + \sum_{i=k}^{p} \beta_i g_{t-i}$, where $\tilde{m}_t$ is the annual rate of mortality change at year t, and g_{t-i} is GDP growth at year $t - i$. Since $\tilde{m}_t$ and g are both stationary series, spurious regression is not a problem. The impact of GDP growth on mortality (Table 2) disappears as soon as we go 1 or 2 years back. Similar results are obtained using unemployment or the rate of change of unemployment.

Table 2 Regression estimates of β_k in the equation $\tilde{m}_t = \alpha + \sum_{i=k}^{p} \beta_i g_{t-i}$ (see text)

	A	B	C	D	E
k	0	1	2	0	0
p	0	1	2	1	10
β_0	0.19**			0.24***	0.18*
β_1		−0.03		−0.14	−0.06
β_2			−0.05		−0.09
β_3					0.05
β_4					−0.02
β_5					−0.03
β_6					−0.06
β_7					−0.10
β_8					−0.08
β_9					0.06
β_{10}					−0.01
d	2.25	2.31	2.42	2.38	2.18
R^2	0.13	0.00	0.01	0.19	0.22

$*P < 0.05; **P < 0.01; ***P < 0.001.$

Equations estimated with United States data for the years 1920–96; d is the Durbin–Watson statistic.

If mortality is higher among the unemployed, how can it drop during recessions?

Catalano and Bellows[40] emphasize that epidemiologists should not infer from statistical findings presented in this debate that the loss of jobs makes people healthier. Of course I agree; drawing conclusions about the relationship between individual unemployment and individual health from data showing that mortality declines during recessions[30,41–53] would be an example of the ecologic fallacy. But the individual-level relationship is not what my paper is about. Moreover, even though there is a relationship between economic indicators and mortality at the aggregate population level, I do not suggest that epidemiologists (or anyone else) advocate unemployment or recessions. Richard Wilkinson[54] found that civilian mortality in Britain dropped at a quicker pace during 1914–18 and 1939–45, but I have not seen anyone suggest that he might be advocating world wars to reduce mortality.

What puzzles Catalano and Bellows[40] is the apparent incompatibility between the findings of ecological studies—mortality increases, or decreases less, during expansions; and decreases or decreases more during recessions—and the findings of studies on individuals, which show that death rates are higher in the unemployed than in the employed. As emphasized by others in this debate,[55,56] the two types of findings are not incompatible. The key issue is to ascertain how mortality of the non-unemployed (i.e. the large majority of society, composed of the employed and persons not in the labour market) and mortality of the unemployed change in response to fluctuations in the economy. Suppose, as suggested by some investigations,[57–60] that mortality in the unemployed is higher than in the non-unemployed during both recessions and expansions, say 6 and 10, respectively, during recessions and expansions in the unemployed, and 4 and 5, respectively, during recessions and expansions in the non-unemployed, so that the mortality differential between unemployed and non-unemployed is reduced in recessions. If the unemployed are 3% of the population in expansions and 7% in recessions, total mortality (a weighted average) will be $0.97 \cdot 5 + 0.03 \cdot 10 = 5.15$ during expansions, and $0.93 \cdot 4 + 0.07 \cdot 6 = 4.14$ during recessions. Mortality during recessions will be lower even though mortality at the individual level is always higher in the unemployed than in the employed.

Though Catalano and Bellows[40] do not provide any specific criticism of the statistical methods I have used, they refer vaguely to the 'external validity of econometric estimates based on annualized indicators' of the economy, and they state that my aggregate analysis suggests a spatial ecological fallacy and a temporal ecological fallacy. They seem to be unaware that panel studies on smaller aggregates such as US states,[31,47] German *Länder*,[52] and Spanish provinces[53] have provided similar results.

East/West mortality and the impact of the welfare state on the fluctuations of death rates

McKee and Suhrcke[61] discover similarities between the evolution of mortality in Russia and Ukraine during the 1990s and my results for the United States. Though their analyses are insightful and point to important issues and analogies, I would be cautious in comparing the United States 'business cycles' with the rapid economic changes undergone in the 1990s by Russia and Ukraine, two countries which suddenly became market economies after seven decades of authoritarian central planning. The abrupt collapse of the political and economic institutions of the Soviet block countries, where governments crumbled, legal systems disappeared, and accepted social values were transformed into their opposites from one week to the next and demographic indicators wildly jumped in the early 1990s,[62] is not analogous to a 'business fluctuation' like those periodically recurring in consolidated market economies. Moreover, the Russian situation with prolonged increases in mortality in the first half of the 1990s and death rates still escalating after 1997[63] is quite different from that of the United States during the 20th century, during which age-adjusted mortality did not increase for more than 2 years in a row.

The outsized and historically unprecedented increases in death rates in the countries of the ex-Soviet Union and Eastern Europe in the 1990s[64] contrast with reports from the Third World countries where nothing similar seems to have happened in recent decades of structural adjustment and economic hardship—except in Africa, where death rates escalated in countries like Zimbabwe because of AIDS. Studies from the Third World have consistently shown that 'economic crises and structural adjustment typically have not led to an increase in mortality',[65] though some suggest that mortality decline slowed in these countries during the recessionary 1980s. The short-term mortality responses to recessions in the second half of the 20th century in nine Latin American countries were found to be erratic, contrary to expectations, and not statistically significant.[66] Several researchers[67–69] have been surprised by positive associations between GDP growth and crude, infant, or adult mortality during the late 20th century in Argentina, Chile, and Brazil.

While McKee and Suhrcke[61] believe that the welfare state policies may counter the impact of economic fluctuations on death rates, Edwards[70] affirms that there 'may be considerable cross-country variation in such policies already, without any clear differences in procyclical mortality'. McKee and Suhrcke present some preliminary data suggesting that there are no procyclical oscillations of mortality in Britain and Sweden, two countries with a strong welfare state. However, the extent to which the welfare state may actually buffer the effects of economic fluctuations is still unresolved. Procyclical oscillations of mortality have been reported in other welfare state countries such as Germany,[55] and the OECD countries as a whole.[71] In Finland, during the early 1990s the unemployment rate reached 18.4%, but 'contrary to expectations, the development of life expectancy and mortality was more favourable during the recession than during economic prosperity'.[72] Conflicting results from Sweden have been reported. Male mortality was found increasing in recessions during the years 1980–96, with female deaths irresponsive to the economy,[73] but other authors[74] found a procyclical oscillation of liver cirrhosis and cardiovascular disease deaths in the Swedish working-age population during the years 1963–83. Crude death rates during the period 1950–97[5] and age-specific death rates for the years 1968–2003 (Figure 2), provide preliminary evidence of a significant increase in deaths

during the expansions of the Swedish economy in recent decades.

On theoretical perspectives, countercyclical policies, and human myopia

Though I agree with those who reject the attribution of a money value to human life in cost-benefit analysis (CBA),[75,76] I believe Edwards[70] has contributed insightful comments to this debate. According to Edwards, the observation that mortality tends to rise in expansions and drop in recessions 'turns both neoclassical and traditional Keynesian perspectives on their head'. That thought may help explain why this basic demographic regularity of the market economy, apparently discovered by Dorothy Thomas in the 1920s,[41,42] has been repeatedly ignored, and generates surprise and strong opposition—this debate is an example—every time it is rediscovered or restated. When facts go against theory, just ignore the facts.

Economists have usually agreed that 'utilities of different persons can be added together to form a total social utility'.[77] Since, in measuring national income 'money is the measuring rod used to give some approximate figure to the underlying "satisfactions" or "benefits" or "psychic income" that comes from goods',[77] the expectation is that rising incomes would necessarily have to be associated with increasing welfare. But empirical data suggest that in the long run, rising income per capita does not result in increases of average levels of subjective well being,[78,79] and, in the short term, rising income during booms associates with slowdowns or even reversals of the secular drop in mortality (a major negative index of welfare). Things seem to be much more complex than what is usually assumed in welfare economics or CBA, but this is not the place to pursue these conundrums.

Lord Keynes' idea of the necessity of economic interventions was based on what he saw as a persistent proclivity of the market economy to stagnate. But as far back as the 1960s, one of the fathers of today's economics, Paul Samuelson,[80] argued that the alleged proclivity to stagnations, i.e. the 'business cycle', was something of the past. Today the core of Keynesian theory is accepted by a minority of economists and rejected by all important financial institutions. With unemployment reaching two-digit levels in many OECD countries in recent decades, mainstream economists had to update their business cycle theories, but today's academic establishment in economics increasingly considers it 'bad manners' to talk about recessions, upturns, and swings of the economy, relegating these topics to textbook footnotes.[81] Moreover, as Edwards[70] has said, in the world of economics, government interventions are often considered ineffective at best and causes of both inflation and unemployment at worst.

The claim that regulations and policies to protect public health or favour those in greater need will create unemployment and misery is quite common. Edwards[70] seems to follow this pathway when he says that if stress and poor health 'are simply by-products of heated economic activity, that is a real conundrum for the policy'. Economic stagnation 'is a high price to pay for anything'. With this rationale, business interests and the majority of economists have opposed almost every social policy, since the beginning of the industrial revolution, including the 8 h working day, minimum-wage laws and regulations protecting workers, public health, or the environment. Perhaps because disease control has often required strong governmental regulations, public health professionals are much less appreciative than economists of the virtues of *laissez faire* and free markets.[12,82] At any rate, it would be naive to expect a common position among public health professionals on economic and public policies, when among social scientists in general and economists in particular there is a plurality of positions on them. Policies 'to stimulate the economy' may be of many different kinds,[83–85] for instance, governments can spend on wars, monuments, space exploration, highways, education or health care, providing unemployment compensation, and many other possible options. In order to 'facilitate business' and 'raise the ship for everybody,' businesses lobby for and usually get profitability-enhancing measures including tax cuts, changes in labour laws, and cutbacks or elimination of occupational, environmental, or public health regulations. The observation that mortality tends to increase during booms is a strong reason to oppose those types of measures, often passed under the rationale that 'it is for the economy'. Furthermore, health policies to prevent harmful effects of economic expansions on health may yield strong economic and health benefits for the society *in the long run*—related for instance to global warming.[86–88] *Pace* Lord Keynes, our children or grandchildren may still be alive at that time.

In the United States, overtime is mandatory and state legislatures have resisted attempts to make it voluntary after a certain cap, in spite of the increasing evidence of the impact of overtime and long hours on risk of injury or illness.[89–92] It was probably with some cynicism that Paul Samuelson[93] said that, in recent years, 'America's labour force surprised us with a new flexibility and a new tolerance for accepting *mediocre* jobs' (Samuelson's italics). In 2003, an Expert Meeting of the International Labour Organization, convened to develop a code of practice on violence and stress in jobs at service industries, was unable to address the stress issue because of opposition from the experts representing the employers.[94] In almost every country, there is ample room for policies to prevent the harmful effects of economic booms on health.

It is true that, as Edwards[70] says, 'political support for procyclical taxes on alcohol, tobacco, and hamburgers' will be difficult. Indeed, public health professionals have long known that political support for public health policies is always hard to muster.[95] But, I disagree with Edwards that 'procyclical mortality may be an unfortunate side-effect of some fundamental human myopia'. I rather believe that we must overcome and advance beyond what Albert Einstein[96] called 'the predatory phase of human development'.

Nicholas Georgeșçu-Roegen is sometimes considered to be one of the most important economists of the past century.[97,98] He was one of the most lucid critics of the idea that economic growth is the panacea for social ills, many years before global warming surfaced as a major issue, and before the emergence of increasingly serious concerns about historical levels of species extinction, and the other environmental consequences of human activities in the depletion of major renewable or non-renewable resources such as fresh water, soils, fisheries, and oil. There was much foresight in Georgeșçu-Roegen's call not to maximize

utility for present generations, but to minimize regrets for future ones. He was also far-sighted in noting that the control of mineral resources demanded for growth had always moved nations to wage war.[99] For Georgesçu-Roegen, 'growthmania' was an intellectual disease of many economists and technocrats, but what this debate has shown is that this disease has also disseminated among public health professionals. This is not surprising, since, as forcefully argued by Richard Easterlin, in our economic system ever-growing abundance is always matched by ever-growing material aspirations, so that we get richer, yes, but we are neither happier nor the governors of the system in which we live.[78,79] As sorcerer's apprentices, we are in fact governed by that system, which has set us on a course of senseless economic growth *ad infinitum*. But, is it not a major goal of science to make human beings more able to choose their own destiny?[100]

Acknowledgements

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