Health, Wealth and Wisdom—Living Long, Living Well: An Actuary Muses on Longevity

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Abstract

Living well has been the holy grail of philosophers for millennia. Living long as an ideal, though, has more recent provenance. With the greatest historic advances in human longevity having taken place in the 20th century, alarms are now sounding that the expense implications of these two goals will be ignored by successful societies throughout the world at their economic peril.

The United States leads all other industrialized nations in the share of economic output devoted to what, for want of a better description, is labeled health care. In 2007, approximately $2.25 trillion—one-sixth of America's GDP, and more than the entire economy of all other countries save Japan and Germany—was spent on this endeavor. By one account, over 90 percent of it was spent on trying to get people well and less than 10 percent on keeping them healthy in the first place. At the margin, additional health care expenditure appears to have limited effects on aggregate measures of longevity.

A worldview reveals high statistical correlations of physical wellness to wealth and, to some extent, to education. These same relationships also hold within the United States. Better educated and higher income segments of society are healthier—hardly a surprise—and live longer. Though far less likely to smoke, they are only marginally more successful in maintaining healthy weight. Geography also turns out to be important. Certain areas in the United States have average life expectancies 8 to 10 years greater than others. However, as one researcher points out, it is not so much physical environment, rather social and cultural differences that define habits such as diet and exercise. His study specifically attributes these mortality differences to smoking, obesity, alcohol use and related diseases of the heart and lungs—diabetes, cirrhosis of the liver and cancer, which are among the leading causes of death.

Other researchers, looking to genetics as an explanation for why some people live much longer than others, point to the tendency of long-lived people to cluster in families.

The author attempts to weave together these biological and environmental explanations into the mathematical approaches developed over the past two centuries so as to, in the words of

two earlier authors from the actuarial profession, reground the relationship of actuarial science with cellular biology and gerontology. Also examined is the extent to which increasing wealth and higher standards of education and health contribute to happiness.

The paper concludes with the author's views on the implications of not reining in runaway costs—of substituting legalized entitlements to "care" in place of people taking personal responsibility for their health—and with his personal approach to aging and wellness.

1. Introduction and Background

1.1 Living Well

Enabling people to live well was Aristotle's ideal of the purpose of the city.[1] Today we might broadly interpret his "city" as civic society in general. He continued with some ambivalent remarks about living together, and one may question just how successfully, two and one-third millennia after he tendered his advice, we have managed to do either. The living together component of Aristotle's wisdom—the getting-along-with-each-other bit—may better be left to philosophers, psychologists and diplomats. Rather, this inquiry focuses on the more clearly inferable and quantifiable wellness part of his equation with added emphasis for this symposium on living long.

At the 90th chapter of his book, the Psalmist proclaims the days of our years to be threescore and ten, and if by reason of strength fourscore years, yet, he adds, is their success toil and sorrow, for it—presumably he is referring to life—is soon cut off and we fly away.

Conflating wisdom from these two often irreconcilable fonts of Western Civilization, ancient Athens and the Bible, can lead to complications. Nevertheless, for the theme underlying this inquiry it does not seem unreasonable to suggest that present day societies pass both tests if they manage to get a majority of their citizens beyond the threescore mark while still enabling them to live well until the time comes for them to fly. This paper focuses on the consequences of individuals and of entire societies pursuing these twin—sometimes conflicting—objectives.

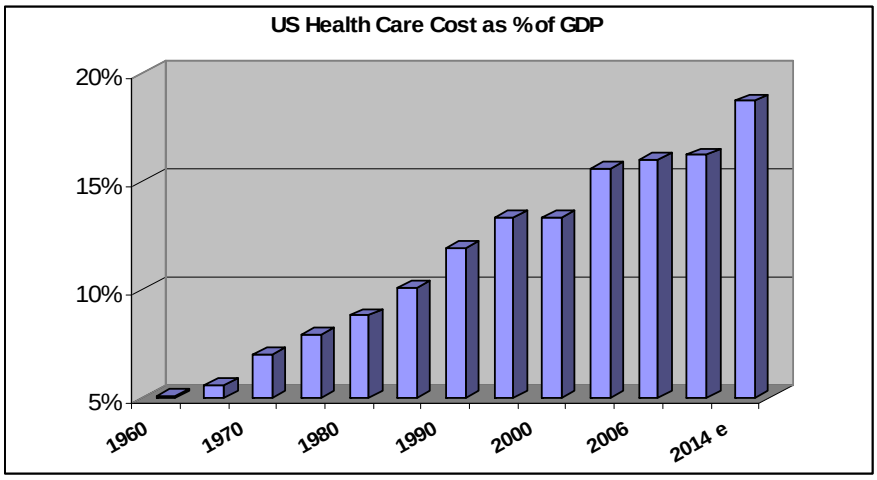
1.2 The Costs

It was one score and three years ago that this author's editorial on the cure for health care was published.[2] That piece, dashed off with little or no research to back up its assertions, was in response to Anna Rappaport's analysis of what, at the time, was perceived to be an emerging crisis.[3] This author made the added mistake of inserting some political observations. But he has already alluded to politics and diplomacy not being his strong suit, so the main thrust of this presentation will be the actuarial, biological and economic aspects of the debate.

That earlier article, “The Cure for Health Care,” was written in 1985. Medicare and Medicaid costs were beginning to sound alarm bells, consuming as they were ever higher portions of the federal budget. Total health care expenditures in the United States including these two federal programs were then some $420 billion, in 1985 numbers a little over 10 percent of GDP. The author opined that, if the trends of those times were to continue, the percentage could exceed 12 percent by 1990; five years later, the actual number was 11.9 percent. Now, another 17 years beyond that, health care for 2007 is expected to come in at around $2.25 trillion, about 16 percent of an American economy of $14 trillion. Actuaries at the Centers for Medicare and Medicaid Services estimate that this share could approach 19 percent by the middle of the next decade.[4] For the past 20 years, the cost of medical care in the United States has increased at an average rate of 5 percent annually, more than 60 percent above the 3.1 percent annual average for all goods and services that go into the Consumer Price Index. And, much like water going over Niagara Falls, this trend seems to have little in the way to stop it.

What are the consequences of not stopping it, or, at a minimum, not slowing it down? Some see them as dire. If spending is allowed to continue growing at this pace, then, by the middle of this century—about the same time that some economists predict the U.S. economy will be eclipsed by China’s—Medicare, Medicaid and Social Security could exceed 100 percent of the projected Federal budget.[5] In the opinion of the Comptroller General, the most serious threat to the very survival of the nation is not someone holed up in a mountain cave on the Afghan-Pakistan border, but our own fiscal irresponsibility.[6]

CHART 1



Source: www.nchc.org/facts/2007%20updates/cost.pdf

1.3 The Goal of this Paper

In challenging the extent to which this largest single component of the U.S. economy—what is referred to as health care—makes a commensurate contribution to the objective of our living well and longer, to say nothing of living together, this paper introduces a global perspective to these sometimes elusive quests even if, as some see, the cost portends our fiscal doom. And in deference to the professional tenets of the body sponsoring this symposium, the paper attempts to substitute facts for appearances, demonstrations to corroborate the author's earlier impressions. It revisits what was proposed in 1985 as a cure, with added perspectives borne of more thorough appreciation for the interplay of genetic and behavioral factors. The author concludes with a few observations on perspectives in approaching life, liberty and the pursuit of happiness.

Gratuitously, the author throws in some personal insights into coping with these issues after his own three score and 10 years, with its attendant toils and pains, and before he flies away.

Perhaps more relevant to today than Aristotle or the Psalmist, neither of whom took into account the potentially ruinous financial implications of their opinions on life, sorrowful, good or long, is the ditty attributed to Benjamin Franklin, that early to bed, early to rise, makes a man healthy and wealthy and wise. This paper offers incidental evidence that, among other things, it

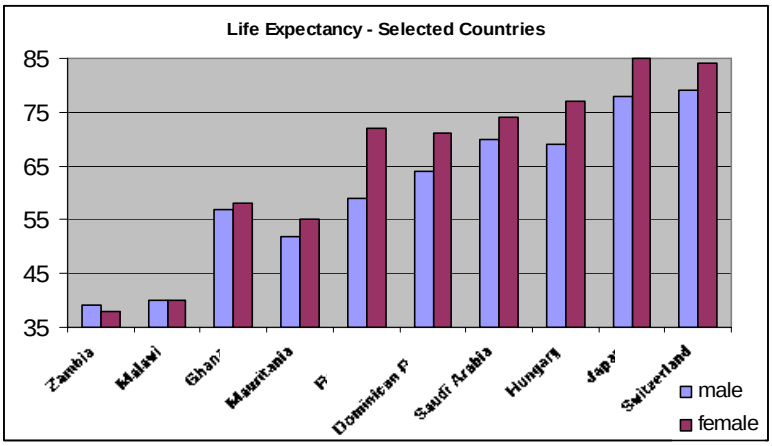
makes a woman even healthier, a condition not unrelated, perhaps, to her having become arguably wiser and even wealthier.

2. Living Long—A Worldview

For this symposium, the particular relevance of these enormous expenditures on health care is the extent to which they are helping us to live better and longer, two quantifiable criteria often used today in judging whether a society has achieved success.

Chart 2 shows a sample of life expectancies at birth from the World Bank's 2007 Development Report,[7] from the poorest of the poor (places like Malawi and Zambia, where people are living on less than $3 a day) to the richest of the rich (Norway, Switzerland, Japan and the United States, for example), countries where the average citizen enjoys 50 to 100 times the income of the least fortunate of the earth's people.

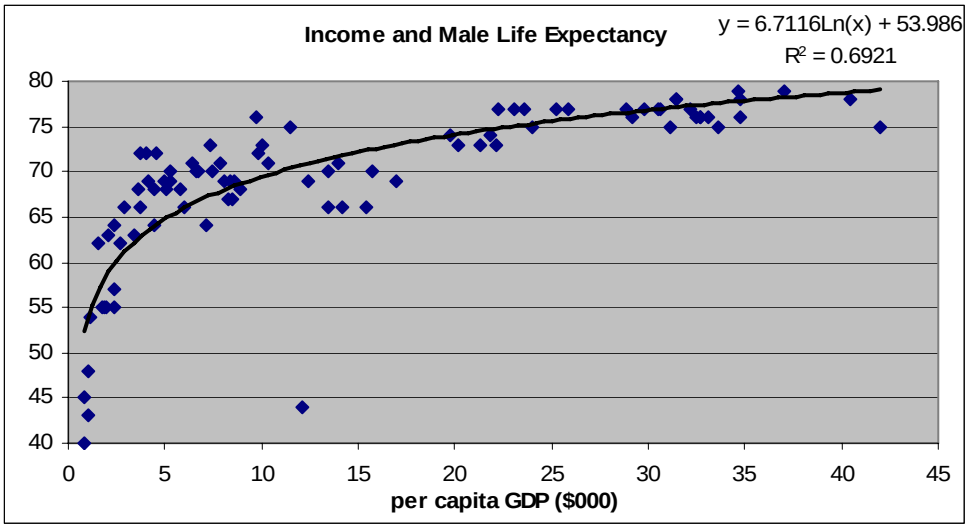
CHART 2



Source: World Development Report, "Development and the Next Generation", The World Bank, 2007, data from Table 1

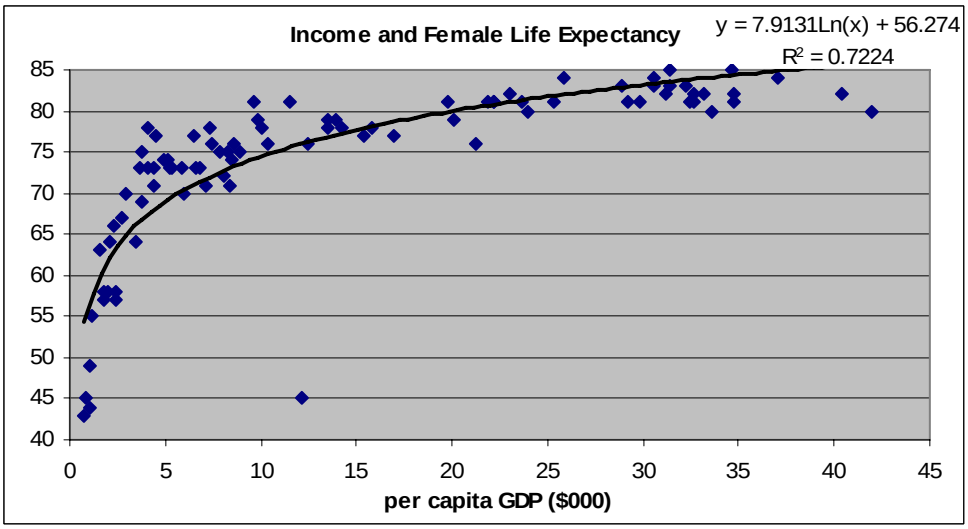
In the two charts that follow, the entries are for all 88 countries shown in the World Bank's Report, plotted against per capita GDP.

CHART 3a



Source for Charts 3a and 3b: World Development Report, *ibid.*,

CHART 3b

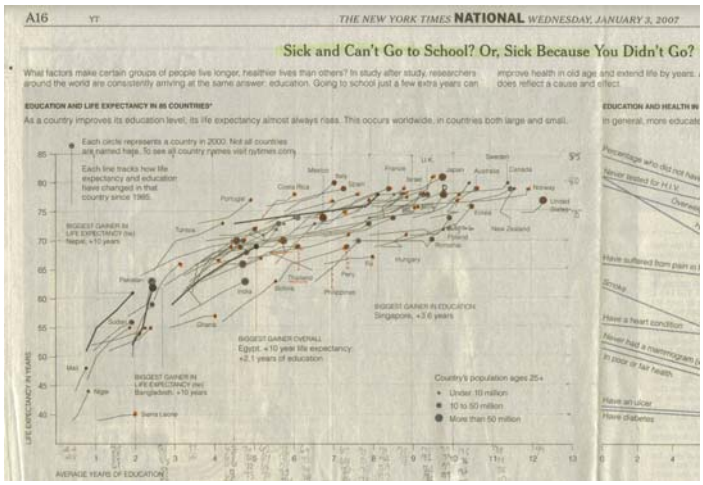


A valid question then, as suggested by these relationships, is the extent to which living better—and, more specifically in the context of this symposium, living longer—is largely a function of economics.

Not only do females outlive males—by five years on average across all 88 countries—but the divergence from the trend line that can be explained by differences in income (what statisticians refer to as "R-squared," the regression mean square) while at a fairly high 69.2 percent for males, is an even higher 72.2 percent for females.

3. Education, Income and Longevity

Early last year, the *New York Times* ran this article, "Sick and Can't Go to School? Or Sick Because You Didn't Go?" [8]



This is one of those classic socio-economic conundrums that can arise when attempting to relate outcomes to attributed variables in non-controlled studies. The *NYT* chart shows patterns similar to those based on the World Bank's data. Not surprisingly, some of the same group of poor countries—Gambia, Mali and Sierra Leone—appear at the bottom of the longevity scale in the *Times*' analysis by education as in the World Bank's by income; similarly, Norway, Japan, Switzerland and Canada show up at the top end by both measures.

The numbers are difficult to refute. Japanese, Norwegian and Swiss babies, to cite examples at the upper extremes, have life expectancies more than twice as long as those born in Sierra Leone, Zambia and Malawi. And if the objective is to live well, it is left to the reader as to the "city"—the civic society—where one would choose to achieve it. Zambia, Malawi, Mali, Sierra Leone, for example? Or Japan, Norway, Switzerland?

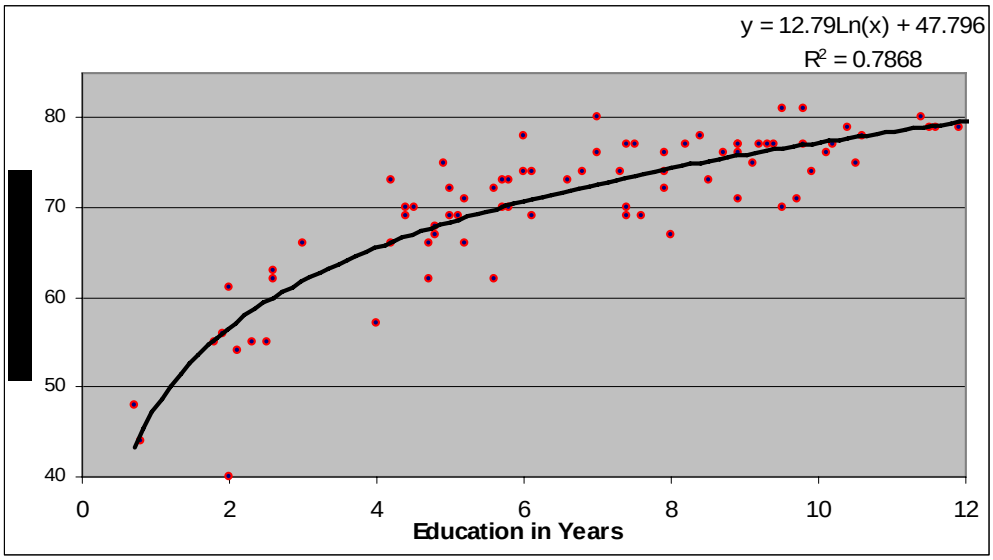
But does higher income alone translate to improved longevity? In the 1960s, U.S. health care expenditure was, as shown in Chart 1, just 5 percent of GDP. This percentage was not far out of line from that of other developed industrial economies. However, the almost 16 percent expended last year—some $7,500 on average for every man, woman and child in the United States—exceeded by a good margin the next highest in the developed world, Switzerland's 11.6 percent of around $6,000 per capita, and was more than double Japan's mere 8 percent, or $ 3,300 per capita.

3.1 Education, Income and Life Expectancy by the Numbers

Following are plots of life expectancy against education and average income, respectively, as the independent variables:

CHART 4a

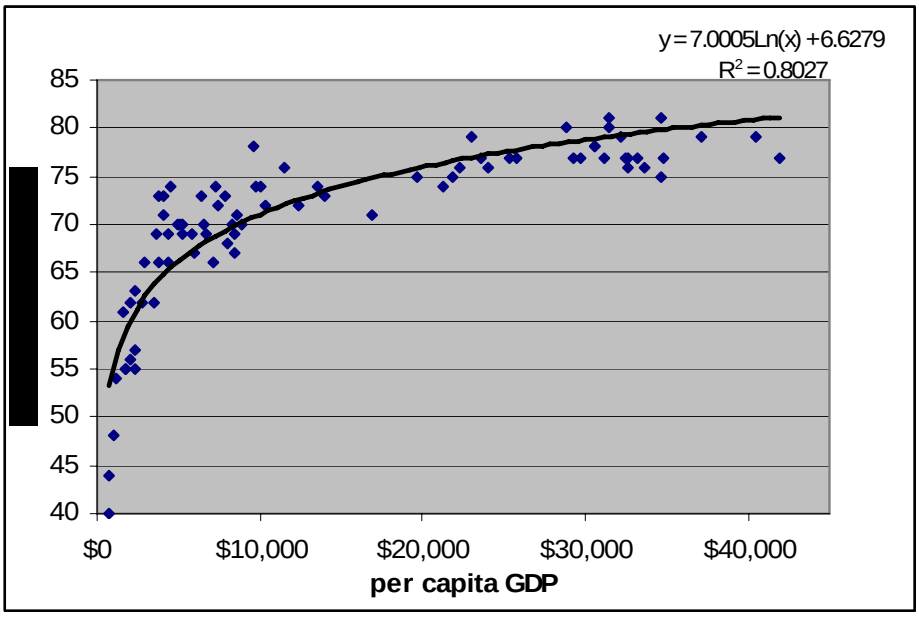
Education and Life Expectancy



Sources for Charts 4a, 4b and 5: Education—*New York Times*, January 3, 2007, *ibid*.
Life expectancy and per capita GDP: Development Report 2007, The World Bank, Washington, DC, 2007, Table 1.

CHART 4b

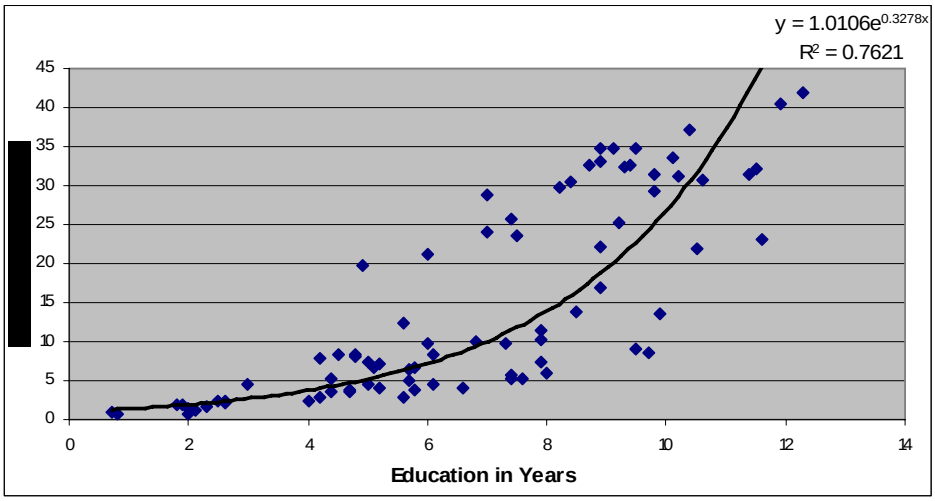
Income and Life Expectancy



There appears more than ample evidence that Franklin got at least two—probably all three—parts of his maxim right. Health, as measured by longevity, does correlate highly to wisdom, and even more so to wealth. Also, not surprisingly, as the following chart shows, wealth correlates almost as highly to wisdom:

CHART 5

Income and Education



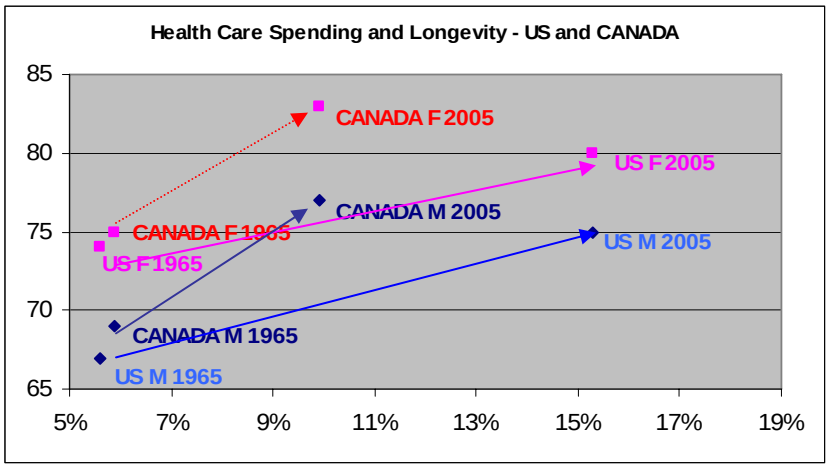
A detailed analysis of variance of life expectancy expressed as a function of both years of schooling and the logarithm of per capita GDP for 80 countries for which consistent data are available is shown in Appendix 1.

If some of the countries cited are considered not good bases for comparison to the United States, then perhaps Canada is a more acceptable model. Historical trends of health care costs relative to those of our closest neighbor, socio-economically as well as geographically, leave one to wonder about the effectiveness at the margin of all those extra hundreds of billions of dollars the United States spends.

Chart 6 shows improvements in life expectancy for the United States and Canada measured against their share of GDP spent on health care. In 1965, each country devoted about the same percentage of its economy to health care; in fact, at 5.9 percent, Canada was then slightly ahead of the United States' 5.6 percent. But by 2005, while Canada's health costs had reached 9.9 percent of its GDP, the United States topped the rest of the world at 15.3 percent.[9] And for each additional percentage point of GDP spent over the past 40 years, about 10 months were added to life expectancy for American males and eight months for females. Our neighbors to the north, with education levels almost identical to ours and per capita GDP slightly lower, achieved equal improvements for males over this same period and even greater gains in female longevity, but at only 40 percent of the U.S. increase in per capita cost.

It is tempting to conclude that, besides education and income, other variables must be at work to account for the United States not reaping rewards from its health care expenditures in the form of commensurate improvements in longevity. The next sections focus on two major obstacles to health that at the extreme reaches of age appear to be less significant issues—namely, smoking and obesity. However, in terms of their costs in medical care and mortality, which are well quantified across the principal range of adult ages, and in the case of obesity alarmingly so at the youngest ages, these two controllable risks still stand out as serious impediments to a healthy society.

CHART 6



Sources: United States—2006 Report of the Social Security and Medicare Boards of Trustees; Canada: Statistics Canada, 2005.

Before proceeding, however, it is perhaps pertinent to also acknowledge the data presented by Kestenbaum and Ferguson at the 2005 symposium in this series, which suggest that the low mortality of centenarians in the United States relative to that in other developed countries may be attributable to the high quality of care afforded under Medicare to this extremely old cohort.[10] So, if one can make it to the century mark, the chances of survival beyond that and the odds of receiving good medical care appear relatively benign!

4. Smoking and Health—A Retrospective

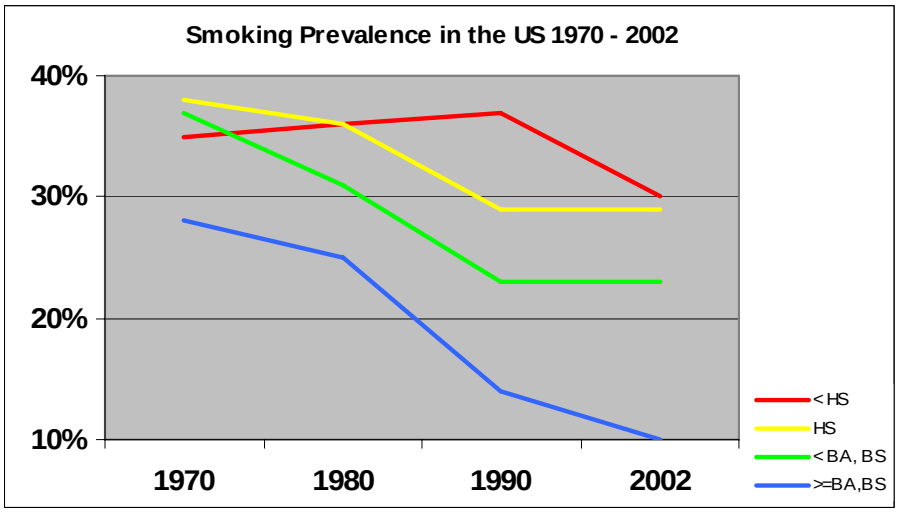
4.1 Some Personal Background

The author's professional interest in relating lifestyle to longevity dates from 1964, when the U.S. Surgeon General issued the first *Report on Smoking and Health*. That same year, State Mutual Life Assurance Company, where the author was a student actuary, introduced cigarette smoking as a criterion in underwriting and pricing life insurance. In 1979, having studied 15 years of select mortality experience on insured lives whose only ostensible differentiation was smoking habits, the author, together with his colleague, Brian Hirst, published "Mortality Differences between Smokers and Non-Smokers."[11] That paper documented differences in mortality broadly paralleling the Surgeon General's in the overall population, but that were even more pronounced between two groups underwritten for life insurance according to their smoking habits and appearing otherwise healthy. In 1985, the author participated in a Society of Actuaries workshop at which other insurers' mortality data were presented, together with the first five years of State Mutual's ultimate experience. By then, the SOA had also developed life insurance valuation tables separated by smoker status, and the Surgeon General had published mortality ratios for smokers according to their average daily cigarette usage.[12], [13] This author proposed that, if the same mortality gradient by cigarette usage reported by the Surgeon General were to apply to the insured population then, compared to male lifetime non-smokers with a life expectancy at birth of 79, the heaviest smokers—those using two packs of cigarettes or more a day—could be taking as much as 13 years off their longevity.[14]

With the volumes of publicity stemming from the Surgeon General's Reports over the past four decades and related efforts of health organizations to discourage the habit, cigarette smoking has declined by more than a half among U.S. men (from above 50 percent in the early 1960s to below 25 percent in 2004) and by about one-third among women (from just below 30 percent, down to 20 percent). This trend has led to a major reduction in deaths from causes directly attributable to smoking, principally lung cancer, ischemic heart disease, cerebrovascular impairments and chronic obstructive pulmonary disease. [15] The decline, however, has been far from uniform. Chart 7—what might be viewed as the learning curve of non-smoking—shows

marked differences in the pattern of changes in prevalence between those with less than high school education and college graduates.

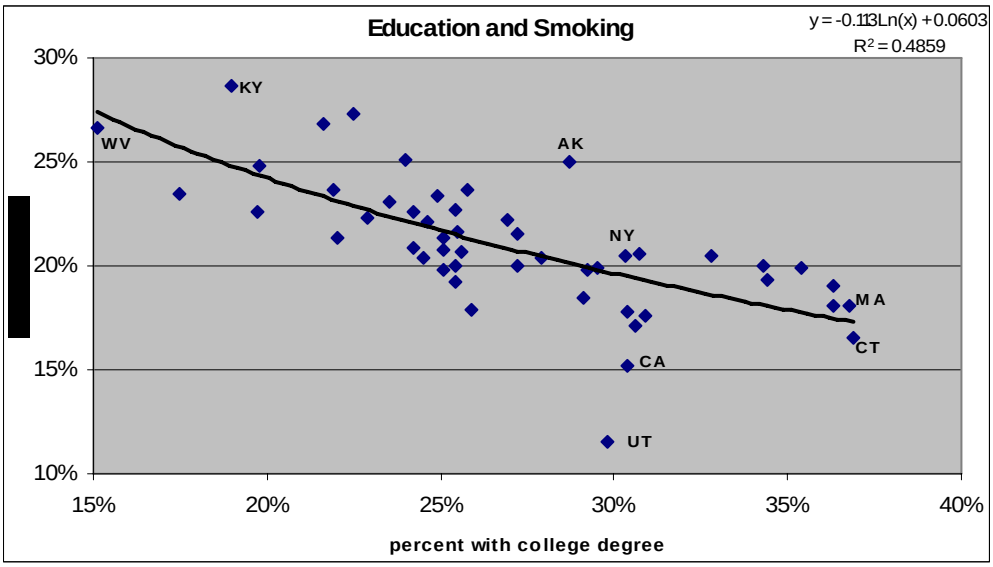
CHART 7



Source: "Health, United States, 2006," Office of the Surgeon General, Table 64

Chart 8 plots cigarette smoking on a state-by-state basis against the percentage of the population with undergraduate education or higher.[16] The R-squared value of 48.6 percent means that almost half the variation in smoking prevalence by state is explained by differences in education level.

CHART 8

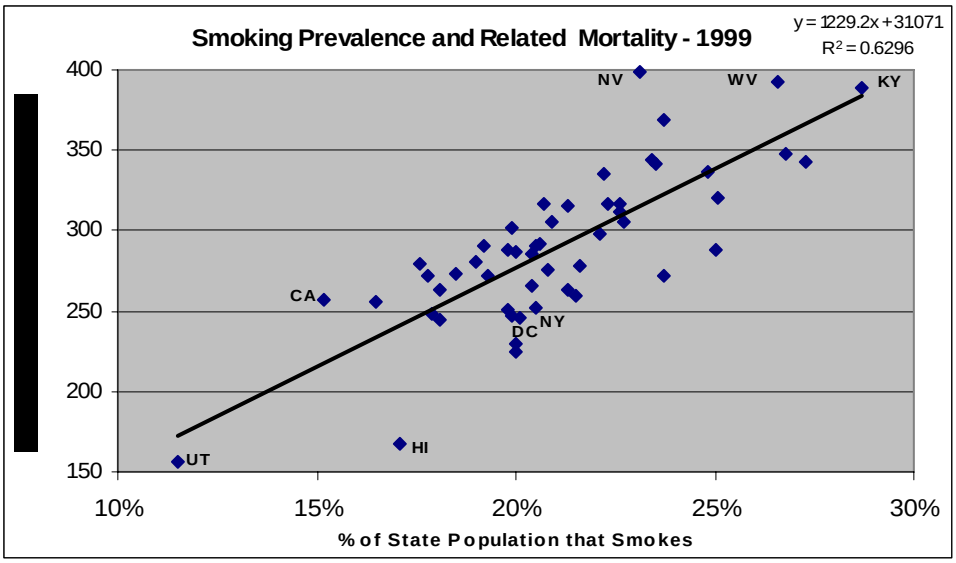


Sources: Education—U.S. Census Bureau, 1990 Census CPH-L-96 and Current Population Report, Table 218 www.census.gov/compendia/statab/tables/07s; Smoking—Centers for Disease Control: http://apps.nccd.cdc.gov/StateSystem/stateSystem.aspx?selectedTopic.

The Surgeon General put the total cost of smoking in 2000 at approximately $130 billion, of which $45 billion was direct care for the more than 400,000 dying each year from its health consequences, plus another $85 billion as the cost of lost productivity.[17] It is interesting to speculate just how much higher these numbers might have been had not the Surgeon General's original report been issued in 1964.

To complete the cycle of education, smoking and health, Chart 9 plots the Surgeon General's age-adjusted mortality attributable to smoking against the prevalence of cigarette smoking for each state.[18] It seems hardly surprising that 63 percent of the variation across states in mortality attributed to smoking should be explained by differences in smoking prevalence. Just how much of the related cost of that extra mortality is borne by the smokers themselves and the purveyors of tobacco products is not as readily discernible.

CHART 9



Sources: Cigarette Usage—Centers for Disease Control, same as for Chart 8; Smoking Attributed Mortality – Surgeon General's Report 2005, "The Health Consequences of Smoking," Table 7.6.

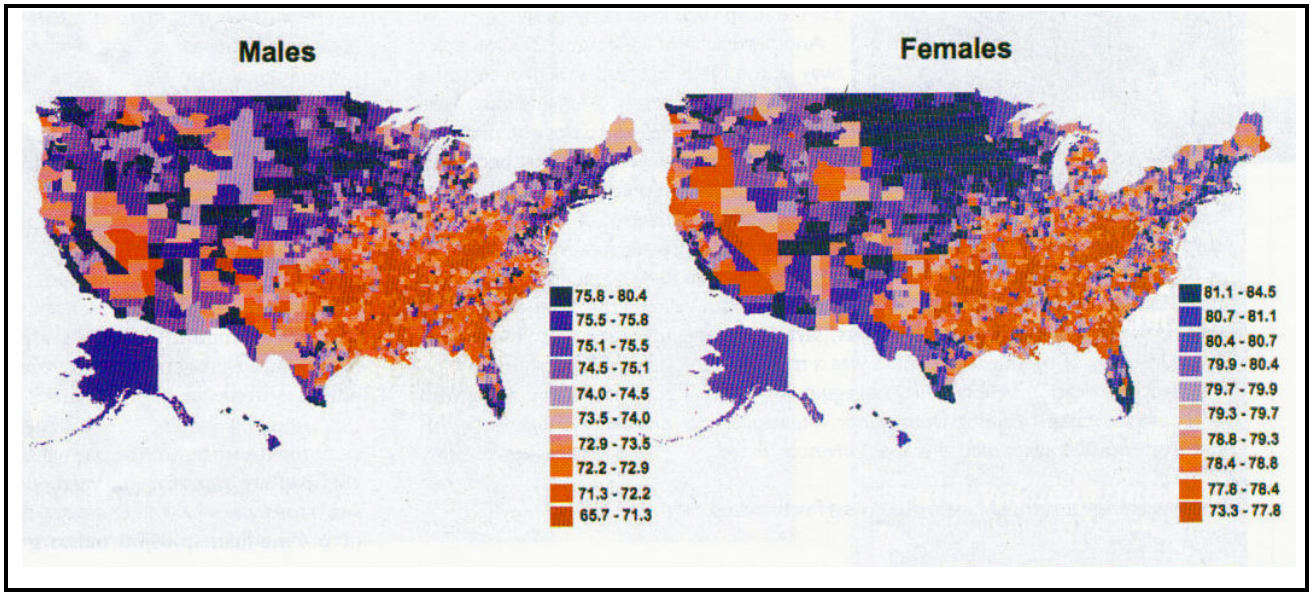
5. How Many Americas?

The *New York Times* article cited earlier indicated a strong relationship between a nation's education level and its longevity. This paper has presented evidence that the wealth of a nation may be an even stronger predictor of its people's health. And not only across countries, but also within the United States, there exists a gradient in longevity—one marker for health-related behavior—that appears to be a function of educational achievement. And while such differences within the United States are not nearly as sharp as among nations—a 6.4-year differential for females between the District of Columbia (76.1) and Hawaii (82.5), and 8.6 years for males (68.5 vs. 77.1),[19] it is, nevertheless, possible to extend the analysis of the previous section to relate these differentials in life expectancy on a state-by-state basis to levels of educational achievement and income. This analysis is detailed in Appendix 2.

One team of researchers at Harvard, directed by Christopher Murray of their Global Health Initiative, has made an even finer analysis, showing longevity differences by county to come up with these compelling maps: [20]

CHART 10

US Longevity Differences by County



Source: "Eight Americas," Ashley Pettus, *Harvard Magazine*, Vol. 109, No.3, January-February 2007, p. 9.

Measured in terms of life expectancy, the most healthful locations in the United States are Hawaii, the California coast, the Pacific Northwest, the Northern Plains, the Boston-Washington I-95 corridor and coastal Southern Florida. The poorest longevity is reported in a wide swath running through Appalachia to the Central South and the Southeast. Variations across the Harvard team's 10 longevity groupings are even greater than those referenced earlier in this paper. For females, the differential is 7 to 8 years between the most and least favorable counties, while the gap for males is 9 to10 years. Murray's report notes that low-income rural whites in Appalachia and the Mississippi valley have life expectancies at birth comparable to those of Mexico and Panama. If his maps are accurate, the situation is actually even worse. At around 68 to 70 years, life expectancy for males is closer to that in Peru or Algeria, while the 74 to 76 years for females compares more nearly to Paraguay and Malaysia. However, Murray omits the observation that

longevity of Americans in the most favorable counties—76-80 for men; 81-84 for women—is comparable to that of Norway and Sweden. He does emphasize though, that, while geography is important, it is not so much the physical environment, but rather social and cultural differences that define habits such as diet and exercise. His study specifically attributes the principal mortality differences across the team's groupings to smoking, obesity and alcohol use, and the related diseases of the heart and lungs, diabetes, cirrhosis of the liver and cancer. The second of these risks is the focus of the next segment of this paper.

6. Obesity: Is it Becoming the "New Smoking"?

The Surgeon General's Report "Health, United States 2006" classifies two-thirds of American adults as overweight, almost half of these as obese. [21] This leaves only one-third—28 percent of men and 36 percent of women—considered to be at healthy weight. The CDC's criterion for obesity is a Body Mass Index of 30 or above. In Chart 11, the area in red shows how heavy one has to be to meet this description. For a 5'10" man, tipping the scales above 210 lbs. is considered obese; for a 5'6" woman, the threshold is 185 lbs. The pink-shaded area—a BMI between 25 and 30—is the CDC's classification of overweight.

CHART 11

U.S. Centers for Disease Control's Obesity Standards

Weight in pounds

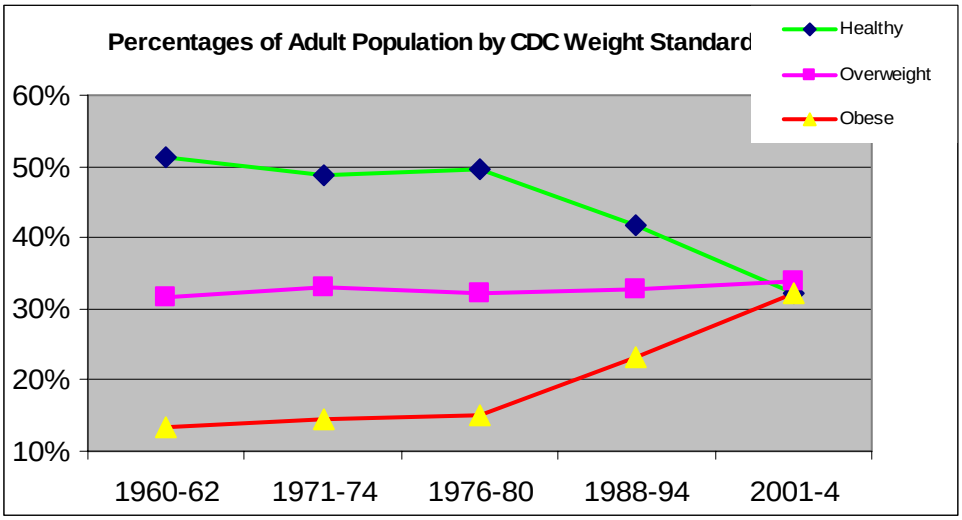
Height	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260
5'0"	23.4	25.4	27.3	29.3	**31.2**	**33.2**	**35.2**	**37.1**	**39.1**	**41.0**	**43.0**	**44.9**	**46.9**	**48.8**	**50.8**
5'1"	22.7	24.6	26.5	28.3	**30.2**	**32.1**	**34.0**	**35.9**	**37.8**	**39.7**	**41.6**	**43.5**	**45.3**	**47.2**	**49.1**
5'2"	21.9	23.8	25.6	27.4	29.3	**31.1**	**32.9**	**34.8**	**36.6**	**38.4**	**40.2**	**42.1**	**43.9**	**45.7**	**47.6**
5'3"	21.3	23.0	24.8	26.6	28.3	**30.1**	**31.9**	**33.7**	**35.4**	**37.2**	**39.0**	**40.7**	**42.5**	**44.3**	**46.1**
5'4"	20.6	22.3	24.0	25.7	27.5	29.2	**30.9**	**32.6**	**34.3**	**36.0**	**37.8**	**39.5**	**41.2**	**42.9**	**44.6**
5'5"	20.0	21.6	23.3	25.0	26.6	28.3	**30.0**	**31.6**	**33.3**	**34.9**	**36.6**	**38.3**	**39.9**	**41.6**	**43.3**
5'6"	19.4	21.0	22.6	24.2	25.8	27.4	29.1	**30.7**	**32.3**	**33.9**	**35.5**	**37.1**	**38.7**	**40.4**	**42.0**
5'7"	18.8	20.4	21.9	23.5	25.1	26.6	28.2	29.8	**31.3**	**32.9**	**34.5**	**36.0**	**37.6**	**39.2**	**40.7**
5'8"	18.2	19.8	21.3	22.8	24.3	25.8	27.4	28.9	**30.4**	**31.9**	**33.5**	**35.0**	**36.5**	**38.0**	**39.5**
5'9"	**17.7**	19.2	20.7	22.2	23.6	25.1	26.6	28.1	29.5	**31.0**	**32.5**	**34.0**	**35.4**	**36.9**	**38.4**
5'10"	**17.2**	18.7	20.1	21.5	23.0	24.4	25.8	27.3	28.7	**30.1**	**31.6**	**33.0**	**34.4**	**35.9**	**37.3**
5'11"	**16.7**	**18.1**	19.5	20.9	22.3	23.7	25.1	26.5	27.9	29.3	**30.7**	**32.1**	**33.5**	**34.9**	**36.3**
6'0"	**16.3**	**17.6**	19.0	20.3	21.7	23.1	24.4	25.8	27.1	28.5	29.8	**31.2**	**32.6**	**33.9**	**35.3**
6'1"	**15.8**	**17.2**	18.5	19.8	21.1	22.4	23.7	25.1	26.4	27.7	29.0	**30.3**	**31.7**	**33.0**	**34.3**
6'2"	**15.4**	**16.7**	18.0	19.3	20.5	21.8	23.1	24.4	25.7	27.0	28.2	29.5	**30.8**	**32.1**	**33.4**
6'3"	**15.0**	**16.2**	**17.5**	18.7	20.0	21.2	22.5	23.7	25.0	26.2	27.5	28.7	**30.0**	**31.2**	**32.5**
6'4"	**14.6**	**15.8**	**17.0**	18.3	19.5	20.7	21.9	23.1	24.3	25.6	26.8	28.0	29.2	**30.4**	**31.6**
6'5"	**14.2**	**15.4**	**16.6**	**17.8**	19.0	20.2	21.3	22.5	23.7	24.9	26.1	27.3	28.5	29.6	**30.8**
6'6"	**13.9**	**15.0**	**16.2**	**17.3**	18.5	19.6	20.8	22.0	23.1	24.3	25.4	26.6	27.7	28.9	**30.0**

Numbers shown are Body Mass Index = weight in kg. ÷ (height in m.)^2
or 703 x weight in pounds ÷ (height in inches)^2

- **Seriously underweight - BMI < 18**
- **Healthy underweight – BMI 18 - 20**
- **Ideal weight – BMI 20 - 23**
- **Slightly overweight - BMI 23 - 25**
- **Overweight – BMI > 25 - 30**
- **Obese – BMI > 30**

For that 5'10" man, anything above 175 lbs, and for the 5'6" woman, over 155 lbs is considered overweight. Particularly disturbing, as shown in the following chart, is the increase during the past 45 years in the population in the obese category—from a mere 13 percent in the early 1960s—to one in three today, a pattern roughly a mirror image of the time line for smoking.

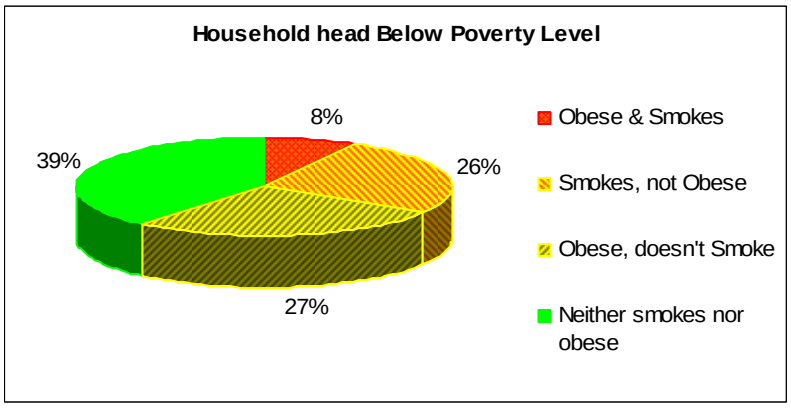
CHART 12
Putting on the Pounds: U.S. Weight Patterns 1960-2004

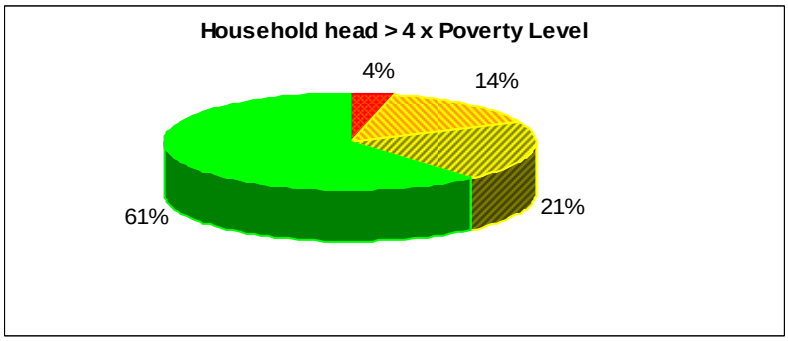


Source: "Health, United States, 2006," Office of the Surgeon General, Table 73.

Data on U.S. health care spending from the late 1990s attribute almost one dollar in 10 of total costs to overweight and obesity, with approximately half of that paid by Medicare and Medicaid. In 1998, according to the Surgeon General, overweight and obesity accounted for almost $100 billion of total health care spending[22];; extrapolated to 2007, this cost could be approaching $200 billion. But, unlike smoking with the numerous deterrents to the habit, not least of which are the huge spike in cigarette prices over the past 40 years and the virtual ostracization of smokers in many sectors of American culture, obesity is far more difficult to address. In the first place, being obese is not so neatly differentiated by socio-economic status as is smoking.

CHART 13
Smoking Prevalence and Obesity by Income Level





Percent of Total US adult population (2001) that:

smokes	is obese
23%	32%

Sources: Data by income level: www.axcessnew.com/modules/wfsection/article.php?articleid=3244; Total population: "Health, United States", *op.cit*, Table 73. Poverty level in 2006 defined as income below $20,000 for a family of four.

Movement up the socio-economic scale is associated with a dramatic reduction in smoking, data consistent with those shown earlier by educational level. Obesity, by contrast, is only fractionally less prevalent among the more affluent.

Secondly, except for the most morbidly obese conditions, the social stigma attached to being "a little on the chubby side" does not begin to compare to the near pariah status of nicotine addiction. To the contrary, in spite of the billions of dollars the public spends on diets, that segment of the fashion industry catering to so-called "queen size" for women especially appears dedicated, if anything, to the notion that "big is beautiful." Is this a culture that will readily yield

for the vague promise of a few extra years of life expectancy? Experience with the far deadlier habit of smoking suggests a major challenge ahead.

A third factor making this health risk more difficult to manage is that while the Surgeon General quantitatively links specific causes of death directly to smoking—lung cancer, ischemic heart disease, cerebrovascular and chronic obstructive pulmonary disease, mortality data for overweight and obese conditions are shown in the aggregate but are not readily available by cause. Much of the extra mortality from obesity is indirect; few, except the most morbidly obese, die from their excess weight alone. The causes are typically indirect, such as diabetes and heart conditions brought on by obesity, and cerebrovascular conditions resulting from extremely high cholesterol levels. And while the CDC does now keep track of medical expenditures attributable to overweight and obesity,[23] the associated excess mortality cannot be so precisely quantified with the same degree of statistical certainty. This situation is quite unlike that pertaining to the 400,000 or so deaths that the Surgeon General continues to attribute each year to smoking-related conditions. Being at least one-third less prevalent among the elderly than in the population as a whole, obesity provides only indirect markers. To paraphrase the conundrum posed by the *NYT* article: "Thin because you're old, or did you survive to old age because you're thin?"

CHART 14

Percentage of U.S. Adult Population Classified Obese (2001-2004)[24]

		Male	Female
All ages		30%	34%
Age	20-34	23%	29%
	35-44	34	33
	45-54	32	38
	55-64	36	39
	65-74	32	38
	>= 75	20	23

Source: "Health, United States, 2006," Office of the Surgeon General, Table 73.

The evidence thus far for not smoking and for staying thin is persuasive, though it is still viewed by some as largely statistical. The next section attempts to strengthen the causal relationship.

7. Genetics, Behavior and Mortality

So far, this paper has presented a number of studies to link elevated mortality and excess health care costs to two major lifestyle risks, smoking and obesity. But, as statisticians correctly point out, correlation is not causation. To forge a more rigorous scientific link between behavior, wellness and longevity, we turn initially to the work of two 19th century researchers, the mathematician-demographer Benjamin Gompertz and the actuary William Makeham.

Gompertz was the first to observe a mathematical law underlying mortality and make his findings widely published among the scientific community. In his 1825 paper to the British Royal Society, he noted from his study of mortality that "...the number of living at each successive year, from 92 up to 99, forms very nearly a geometrical progression, whose common ratio is ¾."[25] He examined the possibility ". . . that death may be the consequence of two generally co-existing causes; the one chance ... the other a deterioration, or an increased inability to withstand destruction." And although his mathematics took account of only the latter cause, Gompertz's pioneering work led to the law of mortality named after him, namely $\mu_x = B\,c^x$. In light of the crude computational devices available in his day, Gompertz's approach to estimating values for the constants **B** and **c** across what were fairly wide ranges of ages for the mortality tables existing at that time may be considered nothing short of ingenious. The next step in fitting mortality to a more inclusive form came in 1860, when Makeham introduced the constant **A** to account for the accident factor missing from Gompertz's law. In a paper to the British Institute of Actuaries, "On the Law of Mortality and the Construction of Annuity Tables," Makeham proposed $\mu_x = A + B\,c^x$.[26]

Twentieth century enhancements in computation enabled more complex variations of these formulas to be applied in graduating mortality rates across an ever wider range of the table. If only they were accurate over a sufficiently extensive range, a manageable number of such constants could completely quantify mortality. Our own actuarial colleagues, Professors Aaron Tenenbein

and the late Irwin Vanderhoof, in their 1980 paper, "New Mathematical Laws of Mortality,"[27] built on the pioneering work of Gompertz and Makeham to add immeasurably to our understanding of the link between the mathematics of mortality and biological explanations of aging and death.

Participants at the 2005 symposium in this series invoked Gompertz-type formulations and applications of extreme value theory to justify the statistical rationale for the underlying decline of vitality of living organisms. These explanations included not only theories by gerontologists of declining resistance to death at the human level, but one even addressed the more general biological approach for other life forms, specifically the postponement of aging achieved through genetic engineering of nematode worms.[28] However, as one team of researchers at the Universities of California and Washington and the California Pacific Medical Center Research Institute hastened to emphasize, generalizing results from nematode worms to humans may not be appropriate.[29] However, using studies based on fruit flies and mice, these researchers have presented evidence to quantify the genetic component of human longevity.

Also, as previously noted, papers at the 2005 Symposium documented statistical evidence of improvements in mortality at the higher range of human life span and, as a consequence, the growing population of centenarians.[30], [31], [32] These included analysis by Gallop and Macdonald of parallel trends in the United Kingdom, with reference to yet another mathematical formulation for μ_x used by a team from Odense University to fit data from historical life tables back to medieval times.[33] While such a rigorous quantification of mortality rates at the higher ages is not a focal point of this paper, it is difficult to address these issues of living a long life without some minimal acknowledgement of the underlying dynamics of extreme longevity.

For the purpose of graduating mortality across a broad range of ages, this paper breaks no new ground, but relies on the above referenced work of Gompertz and Makeham in the 19th century and Tenenbein and Vanderhoof in the 20th. This author employs a modified Makeham form in which $\mathbf{q_x/p_x}$, an approximation to the quantity $\boldsymbol{\mu_{x+½}/(1 - ½\, \mu_{x+½})}$, is expressed as $\mathbf{B\, c^{(x-k)} - h\,(x-k)}$, with a value for **h** in the order of magnitude 10^{-5} and **k** somewhere in the age range 25 to 30. The negative term in this expression, with the value **k** representing the age at which the

accident hazard peaks—typically in the late 20s for males—is somewhat analogous to the modification to the basic Gompertz formula that Makeham introduced in 1860 to quantify the non-biological accident hazard.

However, for the data presented in 2005 by Hustead, and also by Kestenbaum and Ferguson, this author has ignored the accident hazard in view of the extreme ages involved, and has graduated their crude values of q_x with a least-squares fit to Gompertz's formula. As Tenenbein and Vanderhoof and others point out, at extremely high ages mortality tends to delaminate from Gompertz's formula. The author was able, nevertheless, to closely approximate the crude q_x values using the least squares method, with excellent fit from ages 90 through 109. Details of these formulae and calculations appear in Appendix 3. The results are summarized as follows:

CHART 15

Gompertz Fit of Mortality at Extreme Ages

	q_x - male		e_x - male	
x	Hustead, Kestenbaum and Ferguson	Least-Squares Gompertz	H, K&F	Least-Squares Gompertz
90	0.189	0.197	3.26	3.20
95	0.274	0.272	2.21	2.25
100	0.375	0.363	1.49	1.55
105	0.472	0.465	1.07	1.04
	Male **B** = 0.000123		Male **c** = 1.0881	
	q_x - female		e_x - female	
90	0.140	0.144	4.13	4.10
95	0.223	0.221	2.72	2.74
100	0.332	0.322	1.72	1.78
105	0.438	0.444	1.14	1.10
	Female **B** = 0.0000151		Female **c** = 1.1092	

Across the 20-year range of ages, the graduated male $\mathbf{q_x}$ values are never less than 95 percent nor more than 108 percent of the crude rates, and graduated female values are within an

even tighter range; the graduated male values of $\mathbf{e_x}$ differ from the crude by at most seven one-hundredths of a year, while the graduated female values never differ from the crude by more than five-hundredths of a year. The author considers this degree of precision sufficient for the arguments made in the balance of the paper.

7.1 A Longevity Gene?

Perhaps of greater significance for this symposium are not so much mortality rates around 100, but rather the factors influencing the passages of survivors who reach such upper ranges. While biologists are not of one mind as to whether a single "longevity gene" exists as such, the researchers Browner et al. from the Universities of California and Washington present evidence for a set of alleles—a group of genes occupying a specific position on the human chromosome associated with more complex phenotypes, i.e., physical or biochemical characteristics. These gene groups have a role in regulating the repair of DNA, thereby increasing resistance to stresses of infection and injury, including retardation of the rate of age-related changes in the human cell that lead to its failure and eventual death.[34]

In actuarial parlance, human resistance to this process at the extreme reaches of age is associated as much with span of life, as distinguished from life expectancy. In his paper to the 2005 symposium, Edwin Hustead addressed the subject of the ultimate age at which $\mathbf{q_x}$ approaches unity.[35] He cited work by Jeune and Vaupel documenting the validity of the longest lived person in recent times, Jeanne Louise Calment of Arles, born in 1875 and dying there in 1997, 17 days short of 122½. Consistent with this author's recommendation of physical exercise, she rode her bicycle around town until she was 100 but, belying the indictment of smoking as a habit that puts distance between one's longevity and potential life span, Mme. Calment didn't give up her nicotine passion until she was 117.[36] For purposes of discussion in this paper, the span of human life at the beginning of the 21st century will be taken to agree with Hustead's limit of 120. The next several paragraphs examine the extent to which it is within the control of each of us to reach some individual numerical potential that may be the days of our years.

As part of their claim for a genetic component, Browner et al. also cite studies to show long-lived people clustering in families and, that in old age, children of centenarians are less

susceptible to diabetes and heart disease than are elders who did not have long-lived parents. This leads to their estimate that up to 25 percent of "variation in human lifespan is heritable."[37] In the context of the distinction above, they may have intended "variation in human longevity." The issue was also addressed at this symposium in 2005 by our actuarial colleague, Eric Stallard, who tracked individually almost 37,000 Medicare participants in the National Long-Term Care Survey across the period 1984-1999. Citing his earlier work with Vaupel and Manton, Stallard presents the concept of "frailty" as a fixed characteristic of each individual's relative susceptibility to death, and documents analysis indicating that about half the variability in individual frailty is genetic.[38]

Based upon the foregoing evidence, then, it may not be too unrealistic to consider each individual, at birth, as being genetically endowed with an individual life span. Exposures to accidental death—Makeham's **A**—and to environmental hazards, including not least of which are individual choices of lifestyle, constitute the factors that determine the time gap between expectancy and span. It might also be argued that for those exceedingly rare and unfortunate cases cited by Browner's team in which genetic mutations cause the human chromosome to become scrambled, as in the case of children born with Hutchinson-Gilford progeria (premature aging) syndrome, [39] the percentage of heritable lifespan is closer to 100 percent. For the vast majority of healthy lives, however, the Browner studies and the work by Stallard and his co-researchers, raise the interesting question as to the remaining 50 percent to 75 percent of variation in longevity, the principal focus of the balance of this paper.

7.2 Behavior

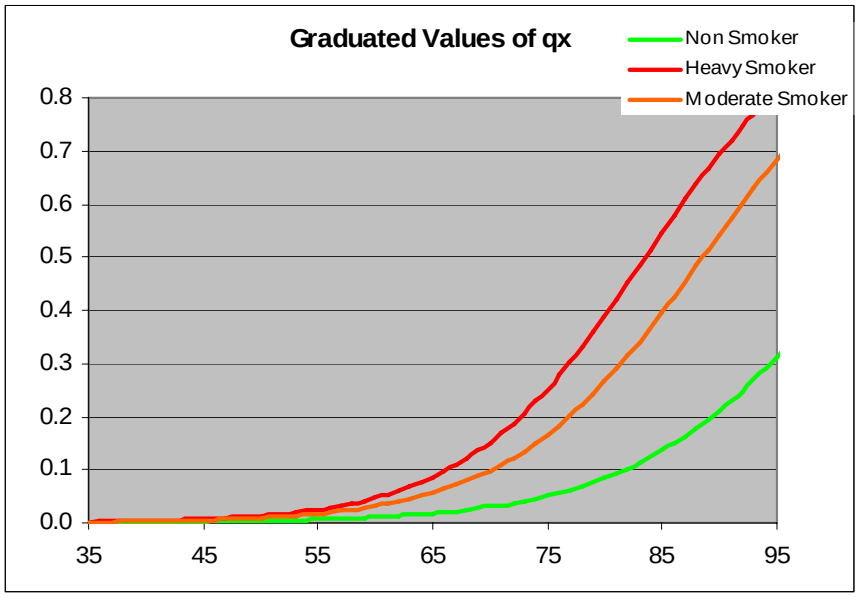
Picking up on the Browner thesis, it is interesting to speculate just how much longer beyond 122½ Jeanne Calment might have lived if she hadn't smoked. Studies have come to light, while not widely publicized, suggesting that a byproduct of nicotine may help prevent formation of amyloid beta proteins, neural plaques linked to Alzheimer's disease. The researchers hasten to add, though, that their findings are "test-tube based," and that smoking is not a good way of getting this drug into the body.[40] But Jeanne Calment was that unique individual among billions[41] who has to be regarded as a demographic exception in the extreme. For the vast

majority of us, bad health habits will likely shorten the days of whatever the years of our genetic heritage might otherwise be.

As discussed in Section 4, by the early 1980s the Society of Actuaries had developed life insurance valuation tables separated by smoker status, and the Surgeon General had published mortality ratios for smokers according to their average daily cigarette usage. From these data, this author reconstructed from the SOA basic tables, separate mortality for "moderate" and "heavy" smokers, based on the Surgeon General's classification of the use of 25-34 cigarettes a day—in 1975, the consumption of the average cigarette smoker—and 35 or more, respectively, and then fitted them from age 35 to the Modified Makeham form described above with values of **h** and **k** held constant. The resulting $\mathbf{q_x}$ values are compared in Chart 16 to those for non-smokers. The values of **B** and **c** resulting from an unweighted least-squares fit, and the graduated values of $\mathbf{e_{35}}$ are as follows:

	B	**c**	$\mathbf{e_{35}}$
Non-Smokers	0.000156	1.11230	42.3
"Moderate" Smokers	0.000283	1.12661	32.3
"Heavy" Smokers	0.000309	1.13564	29.2

CHART 16
Smoking and Mortality



The variation in these fitted values of **c** is quite modest—approximately 1 percent apart—whereas the ratio of **B** for the "moderate" smokers to that for the non-smokers is about 64 percent of the ratio of the respective values of $\mathbf{q_x}$, while the ratio for the "heavy" smokers is about 50 percent of the ratio of the $\mathbf{q_x}$ values.

In their explanation for the rationale underlying the values **B** and **c**, Tenenbein and Vanderhoof made a number of observations. They cited Brillinger from an earlier actuarial paper that treated the probability of death as the sum of probabilities of failure of the individual bodily systems essential to human life. [42] Biologists Mildvan and Strehler were also quoted by Tenenbein and Vanderhoof and again by Stallard to the effect that Gompertz formulations may be applied to specific diseases as well as to total mortality. Mildvan and Strehler further concluded that continuous exposure to radiation increases the value of **c**, while intermittent exposure increases **B** but not **c**.[43]

As noted throughout this paper, no behavioral health risk has been as well quantified in terms of its aggregate impact on mortality as has smoking, with related disease-specific costs now tracked by the Surgeon General on a state-by-state basis. Yet even with the documented contributions of such diseases to medical costs—for lung cancer, ischemic heart disease, cerebrovascular impairment and chronic obstructive pulmonary disease—the excess mortality associated with each disease is still a matter of conjecture. From the evidence presented, however, it does not seem too far a stretch to postulate that observed increases in fitted values of **B** are consistent, or at a minimum are not inconsistent, with the conclusions of Tenenbein and Vanderhoof although, as a reading of the discussions to their paper reveals, there is far from unanimity among biologists, demographers and actuaries on these specific points.

Nevertheless, this author suggests, if only to stimulate further discussion or, more to the point, further research, that the **B** factor in these Gompertz-type expressions—which in Tenenbein and Vandehoof and elsewhere is assigned values subject to considerable variation across a range from 10^{-6} to 10^{-3}—captures much of the behavioral risk.[44] Over many years of the habit, continuous exposure to cigarette smoke similarly could increase the value **B** by several multiples

and still lie within this range, but it appears to have only limited effect on **c**. Further, the relative invariance in **c**—it is almost always shown within the range 1.06 < **c** < 1.14—with the only limit placed by Gompertz and Makeham being that it necessarily exceed unity, suggests that it is more nearly a constant measuring the gradual aging of human cells.

This perspective is presented with the expectation that it will be seen as generally in line with the goals expressed by Tenenbein and Vanderhoof to re-establish the relationship of actuarial science to cellular biology and gerontology. It also leads this author to the useful mnemonic device of **A**, the accident factor—which Makeham may explicitly have intended—**B** the behavioral and **c** the genetic information for aging encoded into the human cell, though it seems quite improbable that Gompertz would have had those labels in mind in 1825.

Also, as noted earlier, it is unfortunate in a way that obesity, which after smoking is indicted as the next most serious controllable threat to health and is well quantified in terms of added health care costs, does not have as closely linked related costs in terms of mortality and reductions in longevity. Diabetes, especially the adult onset form, and high cholesterol levels are clinically associated with excess weight, and obesity is a major contributor to the high cost of health care, perhaps, as suggested, by as much as 10 percent of total cost. But people of normal weight can also contract diabetes and have high cholesterol levels, so that deaths related to these causes would be too crude a marker from which to estimate obesity's impact on the value of **B**. This said though, the more than doubling of the percentage of adults classified obese, from 15 percent in 1978 to 32 percent by 2003, should be causing as much concern in the office of the Surgeon General today as smoking did in the early 1960s.

Another lifestyle factor that may be less intuitively associated with health care costs and longevity is marital status. In serving as editor of the SOA's Report on Longevity in the "2005 Risks and Process of Retirement Survey," this author cited data from the U.S. Census,[45] the Social Security Administration, [46] the National Vital Statistics Report [47] and one paper published by the SOA,[48] demonstrating that married couples experience longevity more favorable than their single, widowed or divorced counterparts. In particular, central death rates for unmarried men at some ages are as much as three times those for their married counterparts, the resulting

longevity advantage being more pronounced than that for women, perhaps by four or more years for a man age 65.

CHART 17

Marriage and Longevity

Life Expectancy and Probabilities of Survival from age 65 in 2005 [49]

	Total	Married	Single, Widowed, Divorced
MALES			
e_{65}	**16.2**	**17.7**	**13.1**
Survival probability:			
to age 80	56%	62%	40%
to age 90	16%	22%	7%
FEMALES			
e_{65}	**19.2**	**21.5**	**17.8**
Survival probability:			
to age 80	68%	76%	62%
to age 90	28%	41%	23%

Sources: See footnote reference 49

Several explanations have been offered to account for the longevity advantage conferred by marriage, especially for men, many of which go to the socialization effect. Spouses tend to be solicitous of each other's health, and married men are more likely to follow regular patterns of eating, less likely to smoke or drink to excess, than their non-married counterparts. If this is correct, then some of the marital advantage may be a proxy for non-smoking and other positive health aspects. In the absence of a multivariate analysis taking each of these variables into account separately, something beyond the scope of this paper, marriage may best be thought of as one of the several covariables that correlate highly to other behavior conducive to good health.

8. Taking Charge of One's Chances

8.1 More Personal Background

Among the list of tips this author included in his 1985 editorial to cure the nation's emerging health care "crisis," was regular exercise, with the added observation that few of the millions of Americans who had participated in the running boom of the 1970s were still smoking. Also noted was the contrast between the $25 or $50 visits to the podiatrist or orthopedist they might be incurring from stress injuries (1985 prices!) and the cost of the more than 200,000 angioplastic coronary bypasses then being performed annually. The editorial went on to suggest that while it might be expected that the new devotion to exercise as a trend in taking personal responsibility for one's well-being would be encouraged by health care professionals, the reality was that more than 90 percent of all physicians' income was derived from trying to get sick people back to health, and less than 10 percent in keeping them well in the first place. This disparity has not lessened; if anything it is even more pronounced now than in 1985. For example, by 2004, the number of angioplastic procedures performed in the United States had risen to 1,285,000, with estimates as to the related hospital and surgical costs alone now amounting to more than $20 billion, or 1 percent of annual "health care" costs. [50]

Turning from the pontification mode, this author also pointed to the example set by members of our profession, with almost half the actuaries with whom he once associated engaging in some form of regular physical exercise, and about one in five a fairly serious runner. Just the year prior to the publication of "The Cure for Health Care," intrigued by the unusually high representation of actuaries in the sport, this author had launched *The Actuarial Marathoner*, a quarterly journal of endurance sport for the profession. Another actuarial runner, John Cook, had noted in a letter to *The Actuary*, December 1981, that in that year's running of the New York Marathon, 44 participants in a field of 15,816 had listed actuary as their occupation. This author calculated that with the profession in North America then numbering approximately 12,000 in a combined labor force for the United States and Canada of 120 million (0.01 of 1 percent), one might expect 1.6 runners in that year's New York Marathon to be actuaries, so that the 44 actual participants amounted to an overrepresentation of between 25 and 30 to 1.

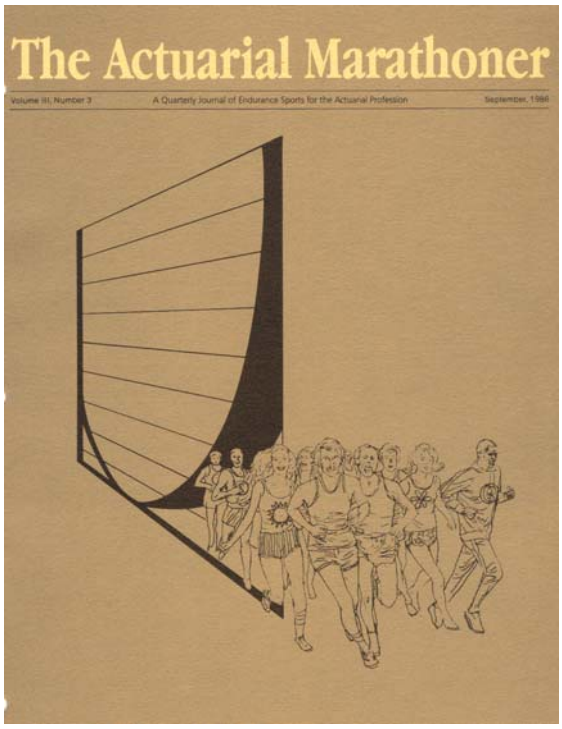
By its third year of publication, *The Actuarial Marathoner* had a directory of more than 220 actuaries from Canada, the United States, Mexico, the United Kingdom, Australia, South Africa and Norway who had completed at least one marathon. The fastest then in the directory, Carl J. Stevenson, FIA, FIAA, with an impressive 2 hour 25 minute personal best in the 1985 Melbourne Marathon, was also Australia's Masters (over 50) champion. The most prolific distance-running actuary was Gerry Wilson, FSA, MAAA, from Chicago, who by 1986 had completed 72 marathons, with a personal best of 3 hours 9 minutes. He later went on to surpass the 100 marathon mark. This overrepresentation of the profession in this sport appeared to be a worldwide phenomenon. Readers volunteered a number of suggestions for this situation:

1. In their years studying for the exams, actuaries had developed a pent-up desire to make up for all the lost time when they might otherwise have been out enjoying life with the rest of the world;

2. The mental discipline required to prepare for the exams—months of planning, singleness of purpose, time scheduling—and a decided tendency to masochism, were analogous to the mental and physical rigor of training for a marathon; and

3. Both events—taking the exams, and running marathons—were the culmination of months of solitary, disciplined training in which one had to demonstrate performance among a competitive field within a relatively short time frame, and where, on the appointed day, everything had to come together just right.

8.2 Beating Down the Odds?



For its cover, *The Actuarial Marathoner* sported a stylized mortality curve, the runners fancying an escape from its inexorable rise as they ran their lives' race.

Unfortunately, that publication became an unintended victim of the HIV/AIDS epidemic of the mid- to late-1980s, as the author's attention was diverted to researching and writing with his colleague, Walter Hoskins, the SOA report, "AIDS, HIV and Insurance."

In an attempt to quantify the effect of that explosive health crisis, and to offer guidance to the profession and the life and health insurance industry in managing it, little enough time was left to train for marathons, let alone to write about them.

Sobered by the intervening years marking his own inevitable decline, and a more realistic assessment of the evidence pointing to the difficulty of doing more than improving one's chances within the bounds of whatever genetic legacy one's grandparents bequeathed, this author now recognizes the fantasy of his earlier design.

One hopeful observation though, and one that the author contemplates frequently, is that beset by so much evidence from their studies of mortality, many actuaries do in fact take more than casual notice of the relationship between lifestyle and longevity. In the referenced 1985 editorial, the author opined that while our profession had, for the most part, passively recorded statistics on sickness and death, more actuaries were coming to view their tables not as mere numerical reflections of the *status quo*, rather an aggregation of contingencies over which they

might exert a positive influence. As John Cook and Jack Moorhead noted in their 1990 paper on the mortality of actuaries, as far back as 1898, Miles Dawson (a century ahead of his time?) had expressed his belief that actuaries themselves would enjoy more favorable longevity than average because they would learn from their own mortality studies.[51] Only last year, Philip Lehpamer, updating the earlier studies by Dawson, Cook and Moorhead, and others, and covering half-a-century of experience from 1955 through 2004, documented mortality of males who became SOA fellows before 1975 at approximately half that in the general population.[52]

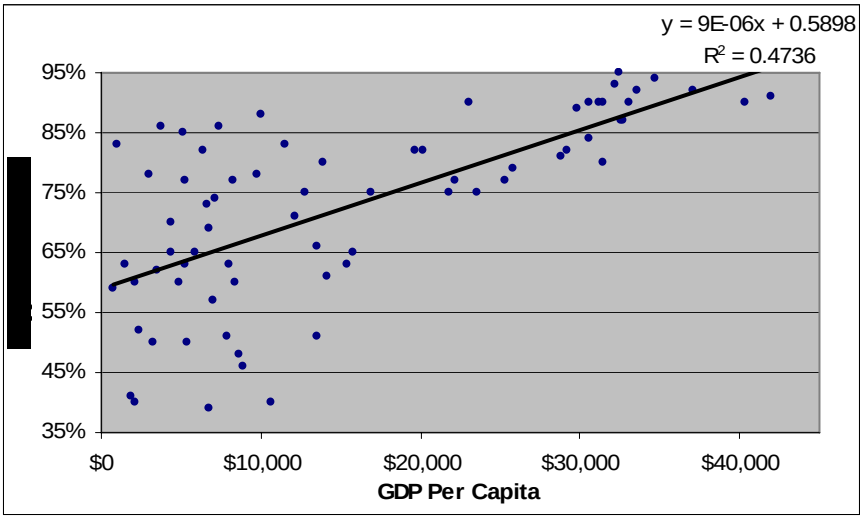
Several years ago, when the actuarial profession was in one of its reflective modes on the uniqueness of its contribution, yet another of our members, Fred Kilbourne, offered a succinct definition of the actuary's role as measuring, managing and communicating the present impact of contingent events. These observations, along with those of Tenenbein and Vanderhoof, are not inconsistent with what has been expressed in this paper. The fundamental difference, however, is that this author looks to the profession to assert more of an advocacy role, and to go the further step of communicating these relationships in such a way that we have a positive impact on the health and longevity of the individuals who eventually become the statistics in our tables. Colleagues in the casualty profession follow this approach in assessing risk for inanimate objects like boats, boilers and buildings. Should life, health and pension actuaries take less proactive a position with respect to the subjects of the contingent events that they study?

9. Health, Wealth, Wisdom—and Happiness!

Even as Benjamin Franklin pursued his wealthy, wise and, by the standards of his day, long life (he had already lived 70 of his 86 years when he met in June 1776 in his adopted Philadelphia with the other signers), Thomas Jefferson was putting the finishing touches on the Declaration of Independence. Striking "protection of property," Jefferson at the last moment substituted "pursuit of happiness" to the list of "unalienable rights" beyond life and liberty for which the signers committed to pledge their lives, fortunes and sacred honor. And just as the issue has been raised here as to whether unrealistic expectations for guarantees of health care are not potentially harmful to a nation's long-term financial well-being, so too it might be asked whether Jefferson's "unalienable right" to pursue happiness isn't being inferred as a right to happiness itself. For some decades now, researchers in the social sciences have been attempting to quantify

happiness, using such measures as the percentage of the population that admits to being ”quite happy” or ”very happy” with their lot in life. One such study by Richard Layard of the London School of Economics plots the resulting happiness quotient for 72 countries against their per capita income.[53]

CHART 18
Per Capita Income and ‘Happiness’



Source: Layard, Richard, “Happiness: Lessons from a New Science,” 2005, London, Penguin Press, p. 32. Statistical analysis is the author’s.

CHART 19
‘Happiness’ Quotients—Selected Countries

Average of Percentages of Population claiming to be ‘Happy’ and ‘Satisfied’ with Life

Unhappiest		Average		Happiest	
Zimbabwe	41	Poland	67	Netherlands	95
Moldova	40	Morocco	66	Ireland	94
Russia	40	Peru	65	Canada	93
Ukraine	39	Slovakia	65	Denmark	92
				Switzerland	92

Source: Layard, *ibid.*

This author has performed a series of multi-variate statistical analyses to demonstrate that such measures of happiness do correlate significantly to income, education and life expectancy. These results are detailed in Appendix 4.

10. Summary and Conclusions

This paper was written as a reprise of the author's 1985 perspective on health care expenditures and their relationship to wellness. An attempt has been made to give this issue some historical depth, and to broaden it from the serious fiscal challenge facing the United States to a more global outlook as the leading countries of the industrial world grapple with the politics and economics of the wellness of their populations, and, specifically within the context of the topic of this symposium, to relate these health issues to longevity and a broader sense of well-being. Many societies in the advanced industrial world, Japan and Western Europe especially, are aging faster than ours. Their approach to sharply increasing dependency ratios—the population beyond retirement age to the population working—may offer clues to the solution to our own dilemma.

As prescient as Ben Franklin was in offering his prescription for staying healthy, getting wealthy and becoming wise, it is not likely that even he could have foreseen a day when misguided approaches to health could threaten the nation's wealth, nor that his compatriot, Thomas Jefferson, could have anticipated that his last-minute inspiration on the right to pursue happiness, might one day be construed as a right to happiness itself. It would be misleading to label Jefferson an Aristotelian. On one occasion he slighted *The Politics* on the ground that while the ancient Athenians had ideas of the value of personal liberty, they lacked an understanding "of the structure of government best calculated to preserve it." [54] That said, though, in crafting the Declaration, he had once acknowledged that the authority it carried rested on such "elementary books of public right as Aristotle, Cicero [and] Locke . . ." [55]

The debate has clearly been joined. The fiscal threat to the nation—perhaps to most nations of the developed world—cannot be overenunciated. A runaway psychology of entitlement to health care, or to other ingredients for the "good life," if untempered by personal responsibility for wellness, will vitiate "nanny-state" governments dependent for their reelection on promises of health and happiness for all. They will increasingly find it impossible to deliver anything to anyone. It could be an ironic fulfillment of another of Franklin's adages that those who give up liberty to obtain temporary safety deserve neither.

But in invoking Franklin, and then Jefferson, the author has drifted dangerously close to the political abyss he vowed to avoid. So, rather than recite a long litany of statistics relating to health care and aging, and make suggestions for tinkering with an already unsustainable system, the paper has attempted to introduce a few ideas that, in the words of fellow professionals Aaron Tenenbein and the late Irwin Vanderhoof, "reground actuarial science in the sub-structure of biology and gerontology." [56] From this perspective, the author suggests that actuaries can offer unique insights to, and serve as advocacy models for the solution of the health care crisis. With the modifications noted throughout the paper, the author stands by his basic 10 steps to sound health:

Don't smoke.
Stay lean.
Eat and drink sensibly.
Exercise regularly.
Keep on learning.
Keep on earning, and spend less than you earn.
Sleep soundly.
Buckle up.
Manage stress.
Monitor your blood pressure and cholesterol, and get regular physical checkups.

To this list, the author now adds two factors not considered in his 1985 editorial: live in a healthy and wealthy and wise culture, and stay married. On this last point, as some wags (all male!) have observed, it may not guarantee a man living to 100, but it could seem that way!

These are clearly no guarantees. Save death—and perhaps taxes—there are no guarantees, and one of these will not be cheated. There seems little question that how well a society has developed economically does have a significant bearing on its aggregate measures of health and longevity. Also, to the extent it is quantifiable, the happiness a society's members have not only pursued but believe they have achieved, also depends in part on its economy. Yet even with all the scientific, medical and public health advances, there is probably a limit to the extent that any one of us, individually, can lengthen the days of his or her years. This is not to suggest that each of us

should not take full responsibility for our own health—we should, all the more so if we expect quality of life in our own old age and healthy economic life for the nation we bequeath to those who follow us.

For in the last analysis, it is becoming, for this author at least, less a question of how to add years to our life, rather how to best add life to our years.

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from 110 to 120 of no more than one in 50,000, although the variance attributable to such an estimate must be enormous. Compounding these highly speculative projections results in a probability of survival from birth to age 120 somewhere in the order of magnitude between 10^{-13} and 10^{-12}. A *New York Times* article several years ago suggested that since the dawn of the human race, perhaps as many as 50 billion people have ever populated the earth. If the survival probabilities suggested here are anywhere close to reality, it would take between 200 and 2,000 such populations to produce one Jeanne Calment.

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