THE COMPRESSION OF MORBIDITY: PROGRESS AND POTENTIAL

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Abstract

The future health of our increasingly senior population depends upon the inter-relationship between two critical dates; first, the onset time of first major disease, infirmity or disability and, second, the time of death. Policy initiatives need to be directed at compressing the average period between these dates. Present data indicate that this goal of compression of morbidity currently is being achieved in some areas and can be made to occur more broadly. For example, life expectancy increases in the United States have begun to slow, with further increases becoming ever more difficult to achieve as the genetically determined life span begins to be approached. Some major chronic diseases are now occurring later in life. The factors which influence development of disability are beginning to be understood. Intergenerational comparisons demonstrate improved health at specific ages. Randomized controlled trials of preventive measures document the difficulty in decreasing total mortality, while at the some time demonstrating the ability to decrease morbidity, to improve health and to reduce costs, even in senior populations. Rectangularization of the morbidity curve has been documented for higher socioeconomic class subpopulations. These observations have major implications for health policy and mandate policy initiatives directed at prevention of disability and infirmity.

The future health of our increasingly senior populations depends upon future trends in two critical dates, the onset of time of first major disease, infirmity, or disability, and the time of death. Most lifetime morbidity is concentrated between these dates. Policy initiatives need to be directed at compressing the average period between these dates; the goal of compression of morbidity.

Consider these three possible scenarios with regard to future trends in infirmity (morbidity) and mortality (Figure 1).

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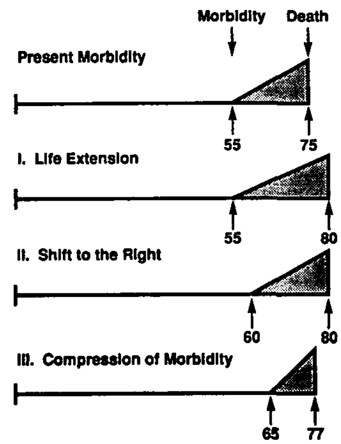
Figure 1

Senarios for Future Morbidity and Longivity



A. *Infirmity begins at the same average age* (for example 55 years) but *life expectancy increases by five years* (for example from 75 to 80). Under this scenario the increased longevity has added only infirm years to life; the so-called "failure of success."

B. *The average age of infirmity and life expectancy both increase by the same amount*, disability from 55 to 60 years, and mortality from 75 to 80. Under this scenario there are the same number of infirm years per person in the future.

C. *The average age at infirmity increases by more than life expectancy*, for example by 10 years from 55 to 65 while life expectancy increases by only two years, from 75 to 77 years. With this scenario, termed the "compression of morbidity"[1-3], the average period of disability is compressed between an increasing age at disability and a relatively constant age at death. There are fewer numbers of infirm years under this scenario.

Under which scenario is the United States presently operating? The preponderance of evidence presently suggests, for the most part, the second scenario. Further, data suggest that the first (and worst) scenario was an appropriate model for the first three quarters of this century, as acute diseases were replaced by chronic ones. What could be? In important areas, the data demonstrate that compression of morbidity is occurring today, and data indicate that the phenomenon of the third scenario can be made to increase in the future by appropriate policy initiatives. For rational policy decisions, it is crucial to understand the complex inter-relationships between infirmity and mortality. What is happening to each? What could happen?

Note that the point of first morbidity is a matter of definition, and will vary from study to study. In our work, we have often used the age at which disability index scores become non-zero. In studies of specific diseases, disease points may be appropriate, for example the first symptom of osteoarthritis, of atherosclerosis or of emphysema. Others may select a particular disability threshold or the first time that a respondent reports poor health. The compression of morbidity model is a broad and flexible one. It is important to recognize that the concept is not restricted to terminal events but is directed at the quality of life in senior years, and that it is the dynamic relationship between changes in markers of infirmity and death that determine active life expectancy and total morbidity.

What could cause the average age of first chronic infirmity to rise? First, reduction in risk factors for chronic illness so that chronic disease occurs later in life or not at all. Second, decrease in cumulative occupational trauma resulting from the shift to employment in the service industries. Third, attention to prevention of the risk factors (such as lack of fitness) which accelerate the senescent (loss of organ reserve) manifestations of human aging.

Why might our past trends of regular increases in longevity change? As life expectancy has increased, the factors of senescence, which genetically determine the optimal life span, begin to exert more control over future advances. It becomes ever more difficult to improve life expectancy. This paper will review some of the lines of evidence which bear upon present and future trends in the two most important markers of national health, the average age at first infirmity and the average age at death.

Infirmity

Data on trends in infirmity at specific ages are inadequate. I know of no worker in the field who believes that presently available data allow conclusions to be made with certainty. Indeed, that is one of the lessons to be emphasized: we must have better data if we are to make wise decisions in the future. Nevertheless, data are getting better and there already are a number of lines of evidence which document improvement in health at a given age.

Atherosclerosis, the most common chronic disease, in the United Sates, began to decline over 15 years ago.[4] The decline, in age-adjusted terms, is now over 40 per cent.[1] Myocardial infarction, the largest component of atherosclerotic mortality, has declined similarly.[5] The age-adjusted mortality rates have fallen far more rapidly than the crude rates, indicating a movement of atherosclerotic mortality into later ages. The average age at first heart attack has been shown in a number of studies to have increased, most probably by about 10 years, over a period when life expectancy increased by less than two years.[1,6,7,8,9]

Lung cancer mortality rates have now begun to decline in United States men, reflecting national changes in smoking habits, after a lag.[10] With incidence and mortality separated only by a year in this disease and with survival rates after diagnosis holding constant over the period, it can confidently be stated that these tumors are not only fewer, they are occurring later in life. Indeed, the risk factor models for the major solid cancers *require* that decreased exposure to carcinogens delays or prevents the onset of malignant change.

Atherosclerosis and lung cancer in men combine to make up 51 per cent of total mortality in the United States[11], hence effects in just these two disease categories have large consequences. While data are less available, similar arguments of the effects of risk factor reduction should apply to chronic obstructive pulmonary disease, diabetes, colorectal cancer, skin cancer, cirrhosis of the liver, and other conditions. It is theoretically possible, by preventive efforts, to cause such conditions to occur later in life. Neither data nor theory currently permit such an optimistic view for certain other conditions, notably Alzheimer's Disease.[12]

The scientist's ultimate source of hard data comes from prospective, large, long-term, randomized controlled clinical trials. Such trials of primary prevention of heart disease, whether taken singly or in aggregate, unequivocally document that effects of the study intervention upon morbidity (such as non-fatal heart attacks and strokes, angina pectoris, congestive heart failure, and intermittent claudication) are far greater than effects of the same interventions upon mortality. Effects on morbidity are typically on the order of 20 to 25 per cent, effects on total mortality so far have not been measurable, and are at best, modest (Table 1).[13-16]

Table 1 Major Randomized Trials of Primary Prevention

	Number of Men	Duration	Deaths Int	Deaths Cont	Deaths Diff/(%)	Coronary Deaths Int	Coronary Deaths Cont	Coronary Deaths Diff/(%)	Morbid Events Int	Morbid Events Cont	Morbid Events Diff/(%)	Morbidity/ Mortality
MRFIT[1]	12,866	7 yrs	265	260	−5(−2)	115	124	9(7)	1,366	1,628	262(16.1)***	262/−5
LRC[2]	3,806	7 yrs	68	71	3(4)	44	32	12(27)	906	1,112	206(18.5)***	206/3
Physicians[3]	22,071	5 yrs	217	227	10(4)	10	28	18(36)**	239	305	66(22)**	66/10
Helsinki[4]	4,081	5 yrs	45	42	−3(−7)	14	19	5(26)	45	71	26(37*	26/−3

Note: Int = intervention group, Cont = control group, Diff = difference, * = p<.05, ** = p<.01, *** = p<.001

1. Morbid events angina pectoris, intermittent claudication, congestive heart failure, peripheral vascular disease, stroke, accelerated hypertension, left ventricular hypertrophy, impaired renal function, total non-fatal coronary events.
2. Morbid events definite or suspect non-fatal coronary, positive exercise test, angina, coronary bypass surgery, congestive heart failure, inoperative myocardial infarction, resuscitated coronary collapse, TIA, brain infarct, intermittent claudication.
3. Morbid events non-fatal coronary, non-fatal stroke.
4. Morbid events non-fatal coronary.

Recent work from our group in assessing development of osteoarthritis and musculoskeletal disability is likewise encouraging.[17,18] Active individuals with few risk factors for disability (such as obesity or sedentary life style) maintain their physical function far longer, and with a negligible decline for age, when compared to less active individuals. Of interest, those engaged in strenuous or hazardous jobs are at substantially greater risk for premature musculoskeletal morbidity than those in other occupations. Our work clearly identifies risk factors for osteoarthritis and musculoskeletal disability.

Importantly for policy decisions, the presence of risk factors for disease strongly predicts future medical service and hospitalization use.[19] Our own studies confirm these effects in a retiree population of 1,558 individuals. Direct and indirect medical costs are strongly and adversely affected by adverse health habits such as cigarette smoking ($842 per year), alcohol excess ($384), seat belt use ($166), and lack of exercise ($259)

Table 2

Health Habits and Medical Costs
One-Year Predictions in 1,558 Bank of America Retirees
Preliminary Multiple Regression Results

	Hospital Days $750	Doctor Visits $65	Sick Days $54	Estimated Cost
Cigarette Smoking One pack a day versus none	.63	.36	6.4	$842
Alcohol > 2 drinks a day versus ≥2	.37	.31	1.6	$384
Seat belt use 50% use versus 100% use	.035	.005	2.6	$166
Exercise 100-minute a week increase	.05	.08	4.0	$259

Morbidity trends over the years have most frequently been estimated in the United States by noting the per cent of respondents reporting fair or poor health, and there has been little change in this percentage until the 1980s when health improvement, most marked in the over-65 population, began to be demonstrated. Unfortunately, with improving health standards the frame of reference changes for what constitutes fair or poor health, rendering these estimates unpersuasive. To avoid this bias and to control for genetic and socioeconomic factors, we recently asked some 739 individuals ranging from 55 to 80 years of age to compare their present health status with that of their parent of the same sex at a time when that parent was their same age, and to explain any differences. Respondents estimated their health as a full-grade higher than that of their parent at the same age and attributed most of the improvement to lifestyle differences, including exercise, diet and others. Specific improvements noted ranged from increased physical stamina to differences in dental status (Table 3). Over a generation, these data suggest marked improvement in health status at any given age.

Table 3

Inter-generational Health
739 Subjects

I. Subject's health versus parent (same sex) health at same age (mean 60 years)

Much Better	Somewhat Better	Same	Somewhat Worse	Much Worse	(Parent Died)
34%	24%	15%	3%	1%	(23%)

II. Child's health (same sex) versus subject's health (same sex) health at same age (mean 38 years).

Much Better	Somewhat Better	Same	Somewhat Worse	Much Worse	(Child Died)	(No Child)
7%	14%	39%	14%	2%	(1%)	(24%)

Mortality

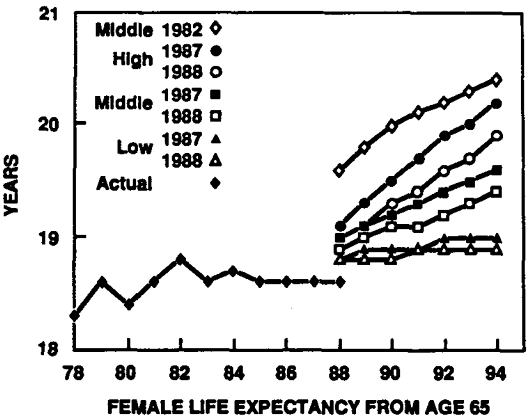
Randomized-controlled trials of preventive interventions, such as blood pressure control, smoking cessation and cholesterol reduction have failed, when applied to our contemporary society, to demonstrate the life expectancy increases which would have been predicted from the Framingham data of 30 years ago.[13-16] Overall, effects on total mortality in every such study have been negligible (Table 1). The obvious explanation is that with the greatly increased longevity of the present, further gains in longevity have become more difficult to achieve. We now can change the cause of death more readily than the occurrence of death. The biological limits of the genetically determined life span begin to limit benefits in terms of additional longevity, while leaving feasible future gains in terms of morbidity. The ultimate average life expectancy limits are currently best estimated at about 85 years. Our recent estimates by linear regression equations of past longevity trends, using current data and a variety of assumptions (Table 4), are consistent with earlier estimates. Similar estimates using Japanese data yield closely similar results.[1]

Table 4 Linear Regression Estimates of Maximum Average Life Expectancy

	Males		Females		All	
	Data through 1976	Data through 1986	Data through 1976	Data through 1986	Data through 1976	Data through 1986
From 1900 Mean age	79.2	79.8	83.0	84.2	81.1	82.0
From 1950 Mean age	81.1	83.0	91.7	90.6	86.4	86.8
Last 10 years Mean age	84.4	83.8	92.4	85.9	88.4	84.9
Last 20 years Mean age	83.5	84.2	94.6	89.1	89.1	86.7

If the forces of senescence actually are beginning to limit gains in life expectancy, we would expect to see this phenomenon occur first in women, who live an average of 7 years longer from birth in the United States and 4 years longer from age 65 than do men. Data from the 1980s clearly demonstrate this phenomenon. Life expectancy for females after age 65 rose rapidly in the 1970s, increasing by 1 to 3 months each year. Over the past decade this trend has changed dramatically (Figure 2). The present value of 18.6 years for female life expectancy after age 65 was first achieved in 1979 and has been constant over the past 9 years.[11,20,21]

Figure 2
Social Security Projections and Actual Values 1978–1994



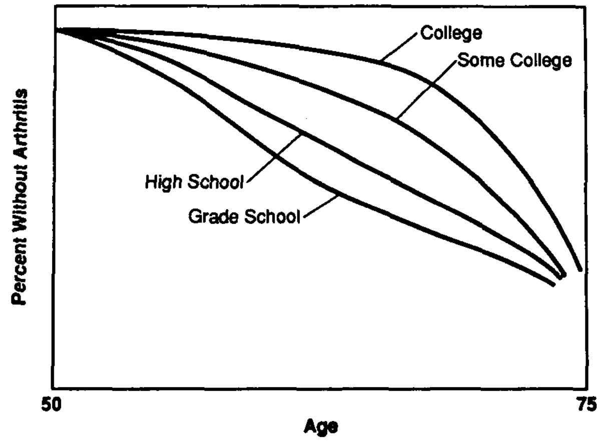
Sources: Statistical Bulletin, Metropolitan Life Vol. 68 pp. 18-23, 1988.
Statistical Bulletin, Metropolitan Life Vol. 69 pp. 26-32, 1989.
Social Security Area Population Projections, 1987; Actuarial Study No. 99, SSA Pub. No. 11-115 46, Actuarial Study No. 102, 1988, Pub. 11-11549, Actuarial Study No. 87. SSA Pub. No. 11-11534, 1982.

Some Forecasting Issues

One way to estimate future health would be to ask the consequences of extending the results of the large randomized-controlled trials of primary prevention (Table 1) to the entire population. This approach to estimation predicts a large reduction in the morbidity from chronic illness and a very small increase in overall longevity. A policy of prevention thus would be cost-effective in both human and economic terms.

A second way of visualizing the future is to ask what the consequences would be if the entire population achieved the health status currently enjoyed by the most favored members of society. Very strong links between socioeconomic status (categorized by education level or by income) with health status have been repeatedly reported. Recent work by our group and others has examined these differences by year of age, using data from the National Health and Nutrition Survey, the Health Interview Survey and other data sets, employing endpoints such as dependency, level of disability or presence of arthritis diagnosed by a physician. Persons in the highest socioeconomic strata have slower increases in disability at every year of age through age 70, after which time they begin to develop accelerating rates of disability and the curves representing the different socioeconomic classes rapidly converge. These observations, summarized graphically in Figure 3, document rectangularization of the morbidity curve (compression of morbidity) in certain favored subpopulations and suggest that a major future challenge will be to extend these benefits to less advantaged groups.

Figure 3
Chronic Arthritis, Age, and Highest Grade Level



A third major test of the potential for morbidity compression is documentation of the ability to improve health in the senior years by effecting changes in health risk behaviors. Health promotion programs directed at seniors were neglected until recently, upon the general belief that changes in health habits late in life were difficult to achieve and, in any event, would be "too little and too late". However, since the magnitude of health expenditures in the senior population is so much greater than at younger ages and the proximity of the intervention and the events to be prevented are so much closer, we and others began to argue that health preservation programs might be even more effective in seniors than in younger individuals. A recent study by our group illustrates and documents this contention. Approximately 6,000 Bank of America retirees[22] were randomized into three groups, one to receive a low-cost but well designed health promotion program, the second to receive survey questionnaires only, and the third to be followed unobtrusively only by measurement of medical claims data. Health habit changes of approximately 10 to 20 per cent over one year were achieved in the experimental group relative to controls (Table 5). Self-reported health status improved by a similar amount. Estimated medical costs and claims data showed cost reductions of over 20 per cent in the experimental group compared with either or both control groups. The dollar savings achieved of $300 per subject per year were 6 or more times greater than the cost of the program. This particular senior health promotion program is currently by several hundred thousand individuals in the United States.

Table 5

The Bank of America Retiree Study Changes Over 12 Months (per cent)

	Experimental Group	Questionnaire Only Group	Claims Data Only
Exercise	–2	–12	
Cigarettes	–21	–9	
Fat intake	–23	–11	
Computed health risk	–4	+1	
Self-reported health	0	+10	
Sick days	–4	+8	
Doctor visits	–7	–3	
Hospital days	–27	+18	
Computed costs	–22	+12	
Computed costs ($)	–132	+18	
Claims costs ($)	–74	+340	+180

Summary

At present, adding years to life expectancy has conveyed additional years of disability for some and additional years of healthy life for others. Now it is becoming increasing difficult to add additional years of life to present levels, whether these years are to be good years or bad years. The effects of preventive programs in improving health status, decreasing medical utilization requirements and decreasing health care costs are substantial and are increasingly well-documented. It is perhaps utopian, but certainly practically possible, to direct social policies toward "demand reduction"— toward reducing the need for medical services rather than relying upon payment caps or rationing of services in an attempt to control costs.

The predominant health burden of the United States has shifted from acute diseases to chronic ones, and is now in transition from these same chronic diseases toward problems of senescence. The national health burden is now overwhelmingly concentrated in the senior years, and in problems of chronic disease and senescent frailty. It is important to treat and to palliate chronic diseases, and to continue and accelerate research into how best to accomplish this. But even more importantly, we must develop policies directed at prevention, at health preservation. Success in achieving an increasingly healthy senior population requires that the age at first permanent disability be raised as rapidly, or more rapidly, than life expectancy. This can only be achieved by interventions which *precede* the development of disability and thus *must* involve preventive efforts. Preventive programs and services, whether to preserve health or to prevent disease, have not been systematically implemented and this neglect has been a costly one in both human and economic terms.

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