Aging, Cumulative Disability, and the Compression of Morbidity

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In the largely successful preventive approach to reduction in the prevalence of cardiovascular disease, three classic stages of investigation were employed. First, the hypothesis was raised that diet and cholesterol levels were a cause of heart disease. Second, multiple longitudinal observational studies, led by the Framingham group, documented a strong association between these health risks and heart disease mortality. Finally, randomized controlled trials of cholesterol-lowering drugs established proof of a causal relationship. This paper will follow the evidence for a similar sequence of concept, epidemiologic study, and clinical trials in developing approaches to improving the health of senior populations.

The daunting problems of aging populations in the developed nations emerged over the first 70 years of the past century. Over a historically brief time, an age in which acute infectious diseases dominated morbidity and mortality patterns gave way to an era in which chronic diseases, led by cancer, heart disease, and stroke on the mortality side and by arthritis and Alzheimer disease on the morbidity side, came to dominate the illness burden of developed nations. In the late 1960s yet another era began, in which there were declines in incidence for some of the most important of chronic illnesses, in particular cardiovascular disease and stroke. Given the declines in both acute and chronic diseases, the illness burden increasingly began to be determined by the frailty of seniors, the frailty adding to and complicating the problems of chronic illness. The concept of progressive frailty with age has within it the concept of natural death, when declining organ reserve function results in an organism barely able to survive even a minor perturbation.

Acute diseases characterized by premature death with little morbidity first gave way to chronic problems of much longer duration and much greater

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cumulative disability. Scientific advances such as antibiotics, insulin, and many others enabled people to live longer, to develop chronic illness, and thus to experience greater cumulative lifetime disability. This paradoxical problem was termed by Gruening the Failure of Success since rapid increases in life expectancy from birth (from 47 years at the turn of the 20th century to 76 years later in the century) were accompanied by an increase in the absolute amount of morbidity in the typical life and an increased fraction of that life spent in other than perfect health. Resulting demographic projections suggested a very gloomy health future for developed nations, with predictions of astronomical nursing home needs and a decline in the national quality of life.

**Compression of Morbidity**

The hypothesis of the Compression of Morbidity was presented initially in 1980. In 1980 it was widely recognized that the bulk of the national illness burden occurred toward the end of life, perhaps between the ages of approximately 55, where disability levels began to be above zero for the typical person, and the age of 76 when the median person died. Over the 20 years prior to 1980 there had been, on average, steadily increasing morbidity, during the period of chronic disease ascendency.

The Compression of Morbidity hypothesis suggested that the national illness burden could be substantially reduced if the average age at which chronic illness or frailty began could be moved later in life, approaching more closely the average age at death, and compressing morbidity between two points now closer together. Figure 1 diagrams morbidity compression and contrasts it with the increasing misery predicted by the Failure of Success notion. A proper metric to assess progress toward this goal would be computation of cumulative lifetime morbidity (or cumulative lifetime disability), represented schematically on the figure by the shaded areas. If lifetime morbidity (disability) could be decreased, then positive effects might be expected for the health of seniors, for age-specific disability levels and for the costs of medical care.

The Compression of Morbidity hypothesis presented a vision of a long and vigorous lifetime ending after a relatively short terminal decline, and a vision of a society of healthier and more productive seniors. Was this ideal realistic? Initially, the Compression of Morbidity hypothesis did not fit the dominant medical paradigm, which implicitly considered the relationship of age and morbidity to be a fixed one, whereas death could be indefinitely postponed, or even "cured." After all, life expectancy from birth was rising rapidly and well-documented to be rising rapidly while there were no comparable data on changes in age-specific morbidity rates. Moreover, postponing the onset of morbidity clearly implied primary prevention and a role for behavioral as well as physical interventions, contrary to the curative expectations of the technological imperative. To suggest that health improvement also might occur if people took better care of themselves was to sound dangerously naïve or, worse, anti-science.

Two assumptions underlay the Compression of Morbidity hypothesis. The first is that the life span is ultimately fixed and finite, with an average age at which natural death occurs even in the absence of disease or trauma, beyond which age life expectancy may not be further prolonged and against which morbidity might be compressed. This is a useful but not a necessary assumption.

The second assumption is that the age at first chronic disability or initial chronic morbidity may be postponed substantially. This is a necessary assumption. The important concept is the dynamic relationship over time between the age of onset of...