Epidemiological, Demographic, and Social Correlates of Disability among the Elderly

KENNETH G. MANTON

Duke University

IN ANALYZING "DISABILITY" OR "FUNCTIONAL impairment" among subgroups of the population of the United States, the elderly and oldest-old populations require special attention both because they represent the largest numbers of disabled persons and, perhaps more critically, they are the population groups for which defining disability and functional impairment is most difficult. This is because, until relatively recently, both popular concepts and the scientific literature tended to regard functional loss as a necessary and nearly universal correlate of the aging process.

More recent research on aging has challenged the inevitability of the linkage of severe functional loss and impairment with age. A number of new studies have shown that the age rate of decline of physiological parameters and function with age found in prior studies was, in part, a product of design flaws in many of those studies (e.g., Lakatta 1985). Specifically, in many of the older studies "representative" samples of elderly were selected. Since the prevalence of chronic disease, both manifest and latent, tends to increase with age, a large part of the functional loss with age found in older studies reflected the effects of an increasing prevalence of chronic disease on function, not the "natural concomitants" of aging itself.

Many newer studies are specifically designed to unconfound the effects of chronic disease and aging by carefully screening for the presence of both latent and manifest disease (e.g., Lakatta 1985).

The Milbank Quarterly, Vol. 67, Suppl. 2, Pt. 1, 1989
© 1989 Milbank Memorial Fund

These studies show that many physiological functions can be preserved to greater ages than previously thought. Other studies have shown that there is great individual variation in the trajectory of functional loss with age which depends upon the type of chronic disease affecting the individual. These studies of the so-called "terminal drop" show that the rate of physical and cognitive functional decline before death at advanced ages is often quite rapid, producing in some groups of elderly individuals very short periods of impairment (e.g., Manton, Siegler and Woodbury 1986). In addition, other studies have shown that many mechanisms emerge at latter ages that compensate for specific types of functional loss, and that there is a much greater potential for rehabilitation and regaining function at advanced ages than previously supposed (World Health Organization 1982). In sum, the current scientific evidence suggests that though there is certainly a strong correlation of functional loss with age, function can (by appropriate early preventive actions) be preserved to more advanced ages and at higher levels than was previously believed, that individuals show considerable variability in the rate at which functional losses occur, and that rehabilitative interventions can help improve functional status at later ages for many individuals. The benefits of efforts to control the disability associated with aging will not be restricted to the elderly population. The most efficient interventions involve prevention of disability, by intervening in the early stages of the chronic disease processes producing the greatest proportion of disability in middle, and even early adult, years. This will reduce the prevalence of disability during the late adult working years and perhaps, by prolonging work ability, reduce some of the pressure for early retirement. It should also be recognized that handicapped and disabled persons now often survive to more advanced ages (e.g., advances in the longevity of spinal-cord-injured veterans due to better antibiotic therapies for urinary tract and other infections) and are at risk of additional disability resulting from age-related processes. Thus, such handicapped, disabled younger persons may have special needs to reduce the risk and forestall the emergence of additional age-related disability.

This evidence suggests that the past acceptance of "natural" age-related loss of function and disability among the elderly has been counterproductive—a type of self-fulfilling prophecy—and that a more active approach should be adopted in attempting to preserve function at later ages. This approach must be reflected in changes both in the medical and institutional response to disability and chronic disease among the elderly *and* in the self-concepts accepted by many elderly themselves.

The evidence also suggests the need for more active research into lifestyle and other risk factors of functional loss (e.g., Manton 1989). Specifically, much of the past epidemiological investigation of chronic-disease risk factors has focused upon the identification and control of risk factors for acute lethal conditions—especially those affecting middle-aged males. Because of this research, medical science has been successful in identifying risk factors (e.g., blood pressure, serum cholesterol, smoking, obesity, exercise) for lethal conditions like coronary heart disease, stroke, and cancer. In addition to identifying the risk factors for these diseases, considerable progress has occurred in the development of medical and pharmacological technologies to control those factors. For example, there are now five types of antihypertensive agents (i.e., diuretics, beta blockers, ACE inhibitors, calcium channel blockers, serotonin antagonists) which can be used singly, or in combination, for different types of hypertension. By targeting specific features of the disease mechanisms, these different classes of drugs can result in greater degrees of risk factor control with less adverse side effects (Julius 1988; Williams 1988).

More recently, the potential efficacy of treatment, control, and prevention of these acute disease processes and their risk factors at advanced ages has been demonstrated. For example, while early analyses of the effects of controlling the standard heart-disease risk factors suggested little benefit at advanced ages (e.g., Kannel and Gordon 1980), recent studies which controlled for the general rise of mortality with age show that many of these factors continue to be as important (or more so) at advanced ages. Studies of a large group of persons with relatively healthy lifestyles show significantly higher life expectancy *at* age 65 (Lew and Garfinkel 1984). Even after adjusting for other risk factors like smoking, parental longevity, and blood pressure, the benefits of physical activity have been demonstrated in significantly enhanced life expectancy up to at least age 80 (Paffenbarger et al. 1986). These recent epidemiological findings have caused the revision of clinical principles about treating persons at more ad-

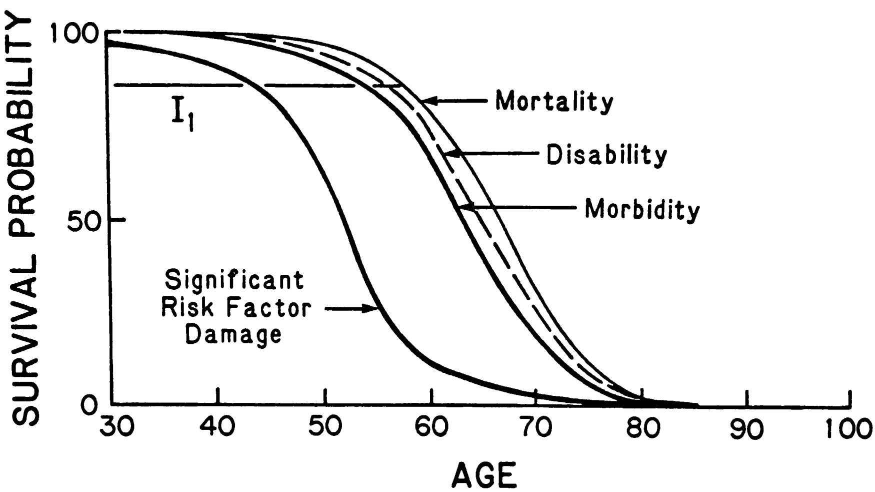

FIG. 1. Survival Curve for Person (I_1) Dying of a Rapidly Lethal Disease
Source: Manton 1989, figure 2.

vanced ages and led to the development, for example, by the National Institute on Aging, of multicenter randomized controlled intervention trials for isolated systolic hypertension.

Because of their characteristic natural history, acute, lethal conditions, however, do not generate the largest amount of disability in the elderly population. This is illustrated (figure 1) in a modified life-table model (World Health Organization 1984) of the age relation of chronic disease to disability and mortality.

In figure 1 four lines are presented. The outermost line, labelled "Mortality," represents the decline with age of the probability of living to age *x*. The line labelled "Morbidity" represents the probability of surviving to age *x* free of the manifestation of a major chronic disease. Note that the figure begins at age 30, suggesting that the development of morbidity (and subsequently disability) involves a lengthy process that may begin much earlier in life. Interestingly, this suggests that age 65, the age frequently used to define the elderly population, is unlikely to have special significance for the onset and progression of these diseases. In the figure, age 30, where risk starts to increase more rapidly, and age 80, by which time many deaths have occurred, represent age ranges that may be typically more significant in terms of health and functional changes for those types of diseases. The area under morbidity curve represents "healthy" life expectancy. The intermediate line labelled "Disability" represents the probability of surviving to age *x* free of serious disability. The area under this curve represents "active" life expectancy (e.g., Wilkins and Adams 1983; Katz et al. 1983). The line labelled "significant risk factor damage" represents the age by which risk factor exposure relevant to these types of acute lethal processes (e.g., smoking, circulatory degeneration due to improper nutrition, or hypertension) has begun to generate latent physiological changes that will eventually lead to the manifestation of morbidity.

In one sense "morbidity" can be viewed as beginning with the accumulation of exposure to the types of risk factors which can affect multiple acute, lethal (as well as possibly chronic degenerative) disease processes. For example, cigarette consumption increases both the risks of lung cancer and of more slowly developing processes like osteoporosis. The inclusion of the risk factor exposure curve is intended to emphasize the lengthy natural history of even rapidly lethal disease processes and the fact that "prevention" may need to begin at relatively early ages. It is also intended to suggest that there is a latent phase of accumulated physiological damage during which intervention may be successful in reversing some of the damage. Once "morbidity" for the acute, lethal diseases becomes manifest, additional pathological processes are initiated that may be more difficult to reverse than the latent processes (e.g., it is easier to reverse the left ventricular hypertrophy associated with hypertension than the damage to the myocardium associated with the ischemic circulatory events associated with a heart attack).

Figure 1 is modified from the original model (World Health Organization, 1984) to reflect better the typical impact of acute lethal diseases on healthy and active life expectancy among the elderly. Thus, the areas between the morbidity, disability, and mortality curves have been compressed to represent the shorter survival time after an acute lethal condition is manifest. Furthermore, the model is drawn to reflect such conditions (e.g., heart attack, cancer) affecting mainly persons in late middle age and in the so-called "young-old" population (Manton, Siegler and Woodbury 1986). In contrast, in figure 2 a different set of survival curves represent the morbidity, disability, and mortality patterns typically associated with the chronic degenerative conditions (e.g., osteoarthritis, chronic obstructive pulmonary disease,

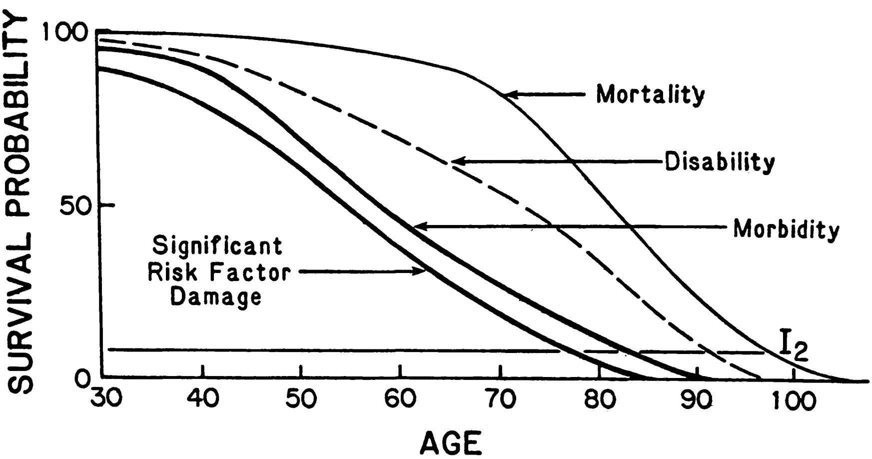

FIG. 2. Survival Curve for Person (I_2) Dying of Degenerative Disease
Source: Manton 1989, figure 2.

rheumatoid arthritis, osteoporosis, diabetes, Alzheimer's disease) which produce much of the duration-weighted impact of disability in the elderly population. Indeed, though we tend to associate these processes with the elderly because of age increases in prevalence, a number of these disease processes (e.g., rheumatoid arthritis, diabetes, and chronic obstructive pulmonary disease) have significant impact in the late middle ages (e.g., 50 years of age and older) and thus also may have a significant impact on the adult working population.

The natural history of this type of disease process is quite different in that impairments of physical functioning become manifest long before the "catastrophic" failure of the individual due to disease (or its sequelae). Consequently, the figure shows that persons affected with such slowly developing conditions tend to live longer and spend a greater proportion of the life span in a disabled state. It should be noted that, while such diseases are manifest for much longer periods, they too eventually cause catastrophic organ system failure (i.e., death). For example, poor nutrition, high alcohol consumption, and smoking may cause a woman to have very low bone density premenopausally. As a consequence, postmenopausally, she may rapidly manifest the initial signs of osteoporosis. Typically, the progression of osteoporosis will be lengthy and continue until the skeleton becomes so unstable that there is high risk of serious fracture (e.g., hip fracture). Such catastrophic acute consequences of osteoporosis can lead to extended bedrest, debilitation, heightened risk of infection, and other co-morbidities all of which, in the context of poor physiological homeostatic forces at advanced ages, can trigger rapid physiological decline leading to death.

One factor differentiating the acute lethal and chronic degenerative disease processes are the different organ systems and physiological functions they most affect. Many of the chronic conditions producing much age-related disability affect the musculo-skeletal, immunological, and neurological systems. Many acute conditions affect the coronary or pulmonary systems or are produced by neoplastic processes. The situation for a given individual is often more complex than represented by either model with multiple, interacting chronic diseases often present. Furthermore, certain chronic degenerative diseases, like diabetes, may heighten the risk of loss of physical function *and* of acute lethal disease.

Though the prevention of disability through early intervention in the underlying chronic disease processes is a preferable strategy in many regards, the potential for rehabilitation among the elderly should not be minimized. A number of studies have shown that physical activity may improve physical functioning for even very elderly persons. Transition tables presented later in this article suggest considerable potential for regaining function over a two-year period. Other studies have shown that some persons manifesting severe cognitive impairment in institutions suffered deficits because of social isolation and could be rehabilitated. The potential for rehabilitation will be linked to the type of disease process or condition producing the disability, e.g., much function may be regained after successful rehabilitation from a severe fracture. Even in those cases where the disease processes is not currently treatable (e.g., Alzheimer's disease), however, appropriate management and social support may slow the loss of function associated with the disease by maximizing environmental input and social support (Besdine 1988).

While we have been successful in identifying and controlling the risk factors associated with many acute, lethal conditions (figure 1), medical science to date has been less successful in identifying and managing the risk factors for chronic degenerative conditions which most affect *active* life expectancy. For example, in Canada (Wilkins and Adams 1983) where, of approximately six years of life expectancy

1. Medical/Epidemiological Model
   Etiology → Pathology → Manifestation
2. Extension of Medical Model for Disease Consequences
   Disease → Impairment → Disability → Handicap
   where

   Impairments are "concerned with abnormalities of body structure and appearance and with organ or system function, resulting from any cause; in principle, impairments represent disturbances at the organ level."

   Disabilities are "reflecting the consequences of impairments in terms of functional performance and activity by the individual; disabilities thus represent disturbances at the level of the person."

   Handicaps are "concerned with the disadvantages experienced by the individual as a result of impairments and disabilities; handicaps thus reflect interaction with and adaptation to the individual's surroundings."

FIG. 3. A Comparison of the Logic of the Medical/Epidemiological Model of Disease and the Extension of the Model for Assessing Disease Consequences
Source: World Health Organization 1980, 14.

gained at age 65 between 1950 and 1978, 80 percent (about 4.7 years) was in an impaired state. This situation may change because of new research on the possible causes of Alzheimer's disease, rheumatoid arthritis, and other chronic degenerative processes (e.g., Manton 1989).

In addition to problems in defining biomedical dimensions of disability among the elderly, there are problems in defining their social and behavioral consequences. This has led to the World Health Organization (1980) classification system in figure 3.

In figure 3 a conceptual distinction is made between impairments, disabilities, and handicaps. Impairments refer to the loss of specific physical functions. Disabilities refer to the incapacity to perform basic self-care functions. Handicaps refer to the restrictions that impairments and disability place on the performance of basic social roles and on interaction with one's environment. Services and care might be directed at any level of the impairment process, i.e., to compensate for impairments, disabilities, or handicaps. It is also clear that, for the elderly, the same level of impairment might produce different levels of disability and handicap because of different social expectations about the functional capacity of the elderly (e.g., expectations about the ability of the elderly to fulfill labor-force roles). In the following discussion we focus upon the medical determinants of disability and not upon social and work-role adaptations that may be made exogenous to the individual. We utilize the term disability to refer to loss of self-care capacity and focus our analysis on the physical dimensions of the process though definitional problems reemerge in later sections where we discuss service needs of the disabled elderly.

In the remainder of this paper we will explore the quantitative implications of these concepts for the United States elderly population—both now and in the future. To do this we will examine the current and future patterns of disability projected for the United States elderly population, using data from several national surveys. We then explore how those disability patterns are affected by altering the risks of diseases reported as causing chronic disability. Finally, we examine the implication of those changes for the service requirements of the disabled elderly population by reviewing estimates of need for long-term care (LTC) services in the United States elderly population.

Projections of Disability in the Elderly Population

In this section projections are presented of the growth of the disabled and institutionalized elderly population based on data from two recent national surveys. The characteristics of the community-based chronically disabled elderly population are derived from the 1984 National Long Term Care Survey (NLTCS). This survey was designed to describe the characteristics of community-dwelling, elderly (aged 65 and over) persons with "chronic" disability, i.e., persons who reported an activity of daily living (ADL) or instrumental activity of daily living (IADL) that had lasted, or was expected to last, at least 90 days. The 1984 sample was, in part, derived from the 1982 NLTCS where the sample was identified by screening a large sample of Medicare-eligible persons (35,789) aged 65 and over for chronic disability. This identified 6,393 disabled persons in 1982. The 1984 sample included approximately 6,000 community dwelling and 1,700 institutionalized persons and represented both newly disabled persons identified from further screening as well as survivors of the disabled and institutionalized samples identified for the 1982 survey (Manton and Soldo 1985). An important feature of the NLTCS sample is its age stratification with over-samples of (about 2,000) persons aged 85 and over drawn from the Medicare-eligible population. This age group has both a high prevalence and levels of disability and thus is critical for studying disability among the elderly. The NLTCS is one of the few national surveys to over-sample this group to improve the precision of the estimates of its characteristics.

The characteristics of the institutionalized population are derived from the 1985 National Nursing Home Survey (NNHS). This survey collected detailed information on a large sample of discharges over a preceding 12-month period and a large sample of current residents. The current resident sample was used to calculate the rates employed in this study.

The rates estimated from the 1984 NLTCS and 1985 NNHS were used to project the future growth of the community-based disabled and institutionalized elderly populations using a static component model. Rates of disability, specific to sex, age, marital status, and disability level are derived from the 1985 NNHS. These rates are applied to projections of the growth of the United States elderly population (specific to age, sex, and marital status) produced by the U.S. Social Security Administration (1987) (SSA) actuaries for 1987 to project the future growth of the disabled and institutionalized elderly populations. The SSA population projections are adjusted to represent the United States resident population. These projections update and extend projections reported earlier (Manton and Liu 1984) based on the 1982 NLTCS, the 1977 NNHS, and the SSA projections of the Social Security entitlement population for 1982. They differ from those earlier projections by having higher IADL impairment rates, though the overall impaired population size is similar due to lower projected rates of population growth in the new SSA series.

The basic quantities projected are the number of elderly persons in specific age, sex, marital status, disability, and institutional states for the years 1985, 2000, 2020, and 2060. These dates reflect critical points in the growth of the United States elderly population where large birth cohorts pass certain critical ages, i.e., 65 and 85. The post-World War II "baby-boom" cohorts, for example, will largely have passed age 65 by 2020 and age 85 by 2060.

In the projections, disability intensity is coded into five levels: (1) no chronic disability; (2) at least one IADL disability but *no* disability in ADL; (3) 1 or 2 ADL disabilities; (4) 3 to 4 ADL disabilities; and (5) 5 to 6 ADL disabilities. Disability here is defined to be the inability to perform a specific function because of health or age, whether that person (a) does not perform the activity at all, (b) can only perform it with the help of another person, (c) can only perform it with the help of special equipment, or (d) can only perform it if a person is *available* to give aid (but may not actually deliver aid).

We selected five levels of disability intensity because they have different implications for health and social service needs. Many proposals regarding federal reimbursement of LTC services have been based on the number of ADL impairments. For example, the Pepper bill introduced in 1988 used 2 of 5 ADL impairments as the criterion for receiving extended home health care benefits under Medicare. Persons with 5 to 6 ADLs are highly impaired and likely require nursing services in addition to aid care.

The projected populations at these five disability levels and for the institutionalized population are presented in table 1 using SSA projections (adjusted for United States residence) based upon the medium variant assumptions about the rate of decline of mortality rates.

In table 1 the total number of community-based disabled elderly with any level of chronic disability in 1985 was estimated to be 5.465 million, with 4.359 million aged 65 84 to 1.1 million aged 85 and over. The estimate of 5.465 million persons is based upon the survey criterion of a condition being chronic (i.e., lasting or expected to last 90 days or more at the time the Medicare-eligible population is screened for disability) and the sets of ADL and IADL used to define disability. Other definitions of disability could be used to give somewhat different estimates and, because the estimates are based on survey data, they are subject to sampling variability. Alternate definitions of disability in 1984 would not alter the projected rates of growth of the disabled population (only the absolute level) and would probably not significantly affect the conclusions. In particular, persons with significant disability (e.g., with 3 or more ADL impairments) would almost certainly emerge as impaired under any reasonable classification.

In addition, the institutional population, which tends to have very high levels of impairment, is projected. Indeed, recent changes in

TABLE 1

Projections of the Community-based Disabled, Institutionalized, and Nondisabled Elderly Population, 1985–2060, by Three Age Groups and Disability Levels (numbers in thousands)

			Community-based disabled[2]					
Year	Total[1]	Nondisabled	IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total	Institutionalized[3]
				Aged 65–85				
1985	25,829	20,752	1,684	1,419	655	601	4,359	718
2000	30,609	24,377	2,057	1,733	797	751	5,338	894
2020	46,011	37,289	2,929	2,414	1,130	1,066	7,539	1,183
2060	55,214	43,943	3,725	3,100	1,434	1,379	9,638	1,633
				Aged 85+				
1985	2,707	1,008	282	407	181	236	1,106	593
2000	4,462	1,666	465	668	299	393	1,826	970
2020	6,357	2,401	663	947	425	558	2,593	1,363
2060	13,809	5,340	1,434	2,035	915	1,202	5,585	2,884
				Aged 65+				
1985	28,536	21,761	1,965	1,826	836	837	5,465	1,310
2000	35,071	26,045	2,522	2,401	1,096	1,144	7,163	1,863
2020	52,368	39,690	3,592	3,360	1,555	1,624	10,131	2,547
2060	69,023	49,283	5,160	5,135	2,348	2,581	15,223	4,517

Sources: U.S. Social Security Administration 1987[1]; 1984 National Long-term Care Survey[2]; 1985 National Nursing Home Survey.[3]
Totals may reflect rounding error.

Medicare reimbursement for acute-care hospitalization seem likely to increase the medical acuity and functional impairment of institutionalized persons. The number of institutionalized persons aged 65 and over increased from 1.1 million in 1977 to 1.3 million in 1985 (National Center for Health Statistics 1989, Table 17, p. 23). Of the 1.3 million, 718,000 were aged 65 to 84, and 593,000 were aged 85 and older. Thus, the institutional population is proportionately much older than the community-based disabled elderly population. Though there is a significant increase in the risk of institutionalization with age, more persons with 3 or more ADL impairments are estimated to be resident in the community in 1985 (1.67 million) than in institutions (1.31 million).

Assuming constant age, sex and marital status specific disability rates, the size of the elderly chronically disabled and institutionalized populations is projected to increase considerably due to the aging of the United States population and greater life expectancy at advanced ages. The total number of chronically disabled persons grows by 31 percent to 7.16 million persons by the year 2000. The growth of the most severely disabled persons (i.e., those with 5 to 6 ADL impairments) to the year 2000 is even faster: 36.7 percent. The growth of the institutionalized population was faster yet: 42.2 percent. These growth rates may be contrasted with the growth of the nondisabled population of only 19.7 percent.

The rapid increase of the disabled and institutional population is projected to continue to the year 2060, when the WWII "baby boom" cohorts will have passed age 85. The institutionalized population is projected to grow 245 percent, the total disabled population 179 percent, the community-based population with 5 to 6 ADL impairments 208 percent, while the nondisabled elderly population is projected to grow only 126 percent. As a consequence, the ratio of the nondisabled elderly population to the disabled elderly population (including those institutionalized) decreases from 3.2 to 1 in 1985 to 2.5 to 1 in 2060. Thus, there will be relatively fewer nondisabled elderly to provide informal care to an increasing disabled elderly population. For example, the likelihood that elderly spouses, siblings, or young-old children will be nondisabled and available to provide care-giver services to the disabled elderly will decrease. The relative numbers of younger persons available to take care of the disabled elderly population will decline even faster, suggesting that the relative

TABLE 2
Projections of the Community-based Disabled Elderly Population by Disability Level, and the Institutionalized Population, 1985–2060, Stratified by Age and Sex (numbers in thousands)

Year	Community-based disabled[1] IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total	Institutionalized[2]
			Males			
			Aged 65–85			
1985	611	446	226	257	1,539	221
2000	770	569	283	327	1,949	295
2020	1,180	844	435	487	2,935	427
2060	1,522	1,125	531	637	3,304	644
			Aged 85+			
1985	87	106	48	63	304	112
2000	142	166	78	106	492	167
2020	213	248	116	159	736	249
2060	500	587	273	372	1,732	596
			Aged 65+			
1985	698	551	274	320	1,844	332
2000	912	735	361	433	2,441	463
2020	1,381	1,092	551	647	3,670	676
2060	2,021	1,712	833	1,009	5,576	1,240

			Females			
			Aged 65–84			
1985	1,073	973	428	344	2,819	497
2000	1,287	1,164	513	425	3,389	598
2020	1,761	1,570	695	579	4,604	757
2060	2,204	1,975	873	743	5,793	989
			Aged 85+			
1985	195	302	133	172	802	481
2000	323	502	222	286	1,333	802
2020	450	699	309	399	1,857	1,114
2060	934	1,448	642	829	3,853	2,287
			Aged 65+			
1985	1,267	1,275	562	517	3,621	978
2000	1,610	1,666	735	711	4,722	1,401
2020	2,211	2,269	1,004	977	6,561	1,871
2060	3,138	3,423	1,515	1,572	9,647	3,277

Sources: 1984 National Long-term Care Survey[1]; 1985 National Nursing Home Survey.[2]
Totals may reflect rounding error.

availability of informal care resources is likely to decline significantly in the future.

These demographic dynamics not only cause the total number of disabled elderly and institutionalized persons to increase but also have significant effects on the demographic composition of the disabled populations as different age and sex groups with very different levels of disability are projected to grow at different rates. For example, as described above the most rapidly growing component of the community-based disabled elderly population are those with 5 to 6 ADL limitations, i.e., those with the most severe disability levels (an increase of 208 percent). Those with only IADL impairments, in contrast, increase least rapidly (163 percent). The institutionalized population is projected to grow most rapidly (245 percent).

The reason for these differences is the rapid growth of the oldest-old population with their higher risks of disability and institutionalization. While the community-dwelling disabled elderly population aged 65 to 84 grew 121 percent, those aged 85 and older are projected to increase fivefold. For persons aged 85 and older with 5 to 6 ADL impairments there is a 409 percent increase compared to a 129 percent increase for persons aged 65 to 84 with this level of disability. The growth of the institutional population aged 65 to 84 was 127 percent, while for those aged 85 and over the growth is 386 percent. Thus, in addition to the rapid growth of the disabled elderly population, the more highly disabled components of that population are growing more rapidly, causing the disabled elderly population, on average, to become more disabled.

The projected rate of growth of the disabled population varies strongly by sex as well as age because of large sex differences in the rate of improvement in mortality among males and females. This is illustrated in table 2. We see that the rate of increase of disabled persons in the community is higher for males aged 85 and over than for females (470 percent vs. 380 percent). This is due to males' lower initial life expectancy levels in 1985 so that, as mortality declines up to age 85, it declines more rapidly for males. Despite the more rapid increases in the size of the older male population in the community, the female groups remain absolutely larger at all ages and disability levels. Consequently, the problem of disability among the elderly remains one disproportionately of women.

These projections are subject to several sources of uncertainty, including uncertainty about the rate of future mortality improvement and uncertainty about the future pattern of institutional versus home health care. In table 3 we illustrate how much these two sources of uncertainty affect the projections. An additional source of uncertainty, the possibility of changes in the underlying health status of the population (i.e., the change in the age-specific relation of the curves in figures 1 and 2), is explored in the next section.

In table 3 we present, for the total elderly population and for different age groups, (a) the upper and lower bounds to the growth of the institutional and community-based disabled elderly population based on the high and low mortality assumptions made in the SSA projection series (i.e., where mortality rates are assumed to decline one-half as fast and twice as fast as the middle projection series used in tables 1 and 2), and (b) the change in the community-based disabled population resulting from a 50 percent reduction in the growth rate of institutionalization (i.e., a reduction from a growth rate of the institutionalized population from the 2.1 percent per annum observed from 1977 to 1985 to 1.05 percent per annum).

The extreme mortality assumptions, though having large absolute effects, do not significantly alter the basic conclusions about the magnitude of the growth of the disabled and institutionalized elderly populations. By 2060 there is a 45.8 percent difference in the size of the projected disabled and institutionalized populations aged 85 and older based upon the high (12 million) and low (6.5 million) mortality assumptions—the group most sensitive to mortality assumptions. For the disabled and institutionalized populations aged 65 to 84 in 2060 the difference due to the extreme mortality assumptions is only 2.04 percent.

Even under the lowest assumed mortality rate decline, the total disabled community-based elderly population increases 153 percent by 2060—as compared to 230 percent under the fastest mortality declines. This produces a 31 percent difference in the projected size of the total disabled population in 2060. For persons aged 85 and over the mortality assumptions have an even larger impact. The growth of the disabled population aged 85 and over is 628 percent under the optimistic mortality assumptions and 284 percent under the pessimistic mortality assumptions. Even though the growth rates of various age, sex, and disability level specific populations vary significantly, in all cases there is significant growth of the disabled population.

TABLE 3

Projections of the Community-based Disabled Population by Disability Level, the Institutionalized, and Nondisabled Elderly Populations, 1985–2060, Assuming Upper and Lower Bounds on Population Growth Rates, and 50 Percent Reduction in Institutionalization Rates (numbers in thousands)

Year	Total[1]	Nondisabled	Community-based disabled[2]					Institutionalized[3]
			IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total	
				Upper bounds				
				Aged 65–84				
1985	25,829	20,752	1,684	1,419	655	601	4,359	718
2000	31,036	24,732	2,083	1,753	807	767	5,410	894
2020	47,852	38,891	3,021	2,483	1,166	1,131	7,802	1,159
2060	57,516	45,958	3,864	3,170	1,481	1,509	10,023	1,535
				Aged 85+				
1985	2,707	1,008	282	407	181	236	1,106	593
2000	4,796	1,803	500	716	321	422	1,958	1,035
2020	7,727	2,988	803	1,136	513	677	3,128	1,611
2060	20,284	8,281	2,085	2,896	1,319	1,748	8,049	3,954
				Aged 65+				
1985	28,536	21,761	1,965	1,826	836	837	5,465	1,310
2000	35,832	26,535	2,583	2,468	1,128	1,189	7,368	1,929
2020	55,579	41,879	3,824	3,619	1,679	1,808	10,930	2,770
2060	77,800	54,239	5,949	6,066	2,800	3,258	18,072	5,489

				Lower bounds				
				Aged 65–84				
1985	25,829	20,752	1,684	1,419	655	601	4,359	718
2000	30,128	23,983	2,026	1,709	785	734	5,254	891
2020	44,513	35,988	2,855	2,355	1,101	1,012	7,323	1,202
2060	54,409	43,087	3,714	3,108	1,428	1,303	9,552	1,770
				Aged 85+				
1985	2,707	1,008	282	407	181	236	1,106	593
2000	4,119	1,550	430	619	277	363	1,688	901
2020	5,265	1,952	551	792	354	463	2,160	1,153
2060	10,387	3,886	1,085	1,559	695	907	4,247	2,254
				Aged 65+				
1985	28,536	21,761	1,965	1,826	836	837	5,465	1,310
2000	34,247	25,512	2,457	2,328	1,062	1,097	6,943	1,792
2020	49,778	37,939	3,406	3,147	1,455	1,475	9,483	2,356
2060	64,796	46,974	4,799	4,667	2,123	2,210	13,799	4,023

TABLE 3
(continued)

Year	Total[1]	Nondisabled	Community-based disabled[2]: IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total	Institutionalized[3]
			50% reduction in institutionalization rates					
				Aged 65–84				
1985	25,829	20,752	1,684	1,419	655	601	4,359	718
2000	30,609	24,378	2,066	1,763	850	817	5,496	735
2020	46,011	37,289	2,948	2,473	1,232	1,191	7,844	878
2060	55,214	43,943	3,762	3,215	1,633	1,624	10,234	1,037
				Aged 85+				
1985	2,707	1,008	282	407	181	236	1,106	593
2000	4,462	1,666	476	701	357	464	1,998	798
2020	6,357	2,401	684	1,015	543	703	2,945	1,011
2060	13,809	5,341	1,498	2,238	1,267	1,635	6,637	1,831
				Aged 65+				
1985	28,563	21,761	1,965	1,826	836	837	5,465	1,310
2000	35,071	26,044	2,542	2,464	1,207	1,280	7,494	1,533
2020	52,368	39,690	3,632	3,487	1,775	1,895	10,789	1,889
2060	69,023	49,284	5,259	5,453	2,900	3,260	16,871	2,886

Sources: U.S. Social Security Administration 1987[1]; 1984 National Long-term Care Survey[2]; 1985 National Nursing Home Survey.[3]
Totals may reflect rounding error.

Furthermore, since most of our discussion is based upon the intermediate (series II) mortality assumptions, the differences between the projection we evaluate, and those produced under the extreme assumptions, is one-half of the range of potential variability.

Though having a large effect on the size of the institutional population (by 2060, a 36.5 percent decline from 4.52 million [Table 1] to 2.87 million persons), an assumed 50 percent reduction in the current per annum rate of increase of the institutionalized population, with those persons being transferred to the community population according to the distribution of disability reported in the 1985 NNHS, has a relatively small impact on the rate of increase of the total community-based disabled population. This is because of the much smaller size of the institutionalized population. Though the "transferred" population is relatively small (a total of 1.65 million persons versus the 19.7 million persons projected to be disabled or institutionalized by 2060 [table 1]) it is concentrated at advanced ages (e.g., an 18.8 percent increase in the number of disabled persons over the age of 85) and the highest disability levels (among those aged 85 and over with 5 to 6 ADL limitations, the projected increase is 36 percent). Thus, the promotion of a policy of "deinstitutionalization" of the elderly disabled population could lead to a sharply increased need for home health and other community-based services unless the deinstitutionalization policies are targeted to the least disabled persons in institutions.

Though the projections described above represent the increase of the disabled elderly in terms of demographic variables alone, even that limited set of variables has important implications for the level and types of care required by the disabled population (Manton and Soldo 1985). For example, persons with IADL dependencies only will tend to require primarily nonmedical services needs which may often be met by improved housing, the provision of equipment, and other nonmedical care-giver services. In contrast, persons with 5 to 6 ADL impairments are largely bed-bound and have high levels of need for formal (trained) care-giver, nursing, and medical services. Likewise, differences in those rates for males and females are indications of major differences in the availability of informal care services, with males typically having more care available from spouses whereas females are at higher risk of not having adequate social resources to keep them out of institutions (Manton and Soldo 1989).

The Effect of Changes in Health on the Future Increase of the Disabled Elderly Population

One aspect of the growth of the disabled elderly population that has not received adequate attention in health policy and health service research is the potential impact of fundamental changes in health and functioning at later ages—and strategies by which such changes might be achieved. There has been considerable qualitative debate over whether increases in life expectancy at later ages have been achieved by improving health and function—or achieved simply by delaying the age at death (e.g., Gruenberg 1977; Fries 1980; Feldman 1983). Certain evidence suggests that acute lethal processes (typified by the health processes represented in figure 1) may be modified somewhat independently of the chronic degenerative processes (see figure 2). Other evidence suggests that (a) the improvement of life expectancy to date has been achieved primarily by intervention in the acute lethal processes—thus tending to increase the duration of the life span spent in a disabled state (e.g., Wilkins and Adams 1983; Nihon University, 1982; Robine et al. 1989) and (b) that we do not currently know many of the risk factors that must be modified to alter the risk of chronic degenerative processes.

This does not mean that controlling risk factors for acute lethal processes has *no* affect on the chronic degenerative processes. Reducing obesity at advanced ages and eliminating smoking may both reduce the risk of the more slowly progressing degenerative processes of osteoarthritis and osteoporosis and reduce the risk of acute lethal diseases like lung cancer and heart disease. Controlling hypertension reduces the risk of both lethal strokes and strokes that can produce significant long-term disability as well as dementia due to multiple cerebrovascular infarcts. Few population risk-factor intervention programs to date however, have been explicitly targeted at reducing disability. Consequently, most programs have more efficiently reduced *mortality* than *disability* rates. By targeting prevention programs specifically at the diseases generating the greatest amount of disability, the relative rate of improvement of active to total life expectancy could be increased.

To explore the potential impact of prevention programs targeted to reduce the rate of growth of the disabled elderly population we simulated two types of interventions in population morbidity and disability processes. In table 4 the disabled elderly population was projected under the assumption that disability rates could be reduced as rapidly as mortality rates. Such projections represent the assumption that an intervention program would affect the *general* health and functional status of the elderly population and, instead of reducing the incidence of any single disease, delay the age at onset of multiple disease processes. Such general improvements in health have been argued by Brody (1984) to have been responsible for recent increases in life expectancy at advanced ages. Cause-specific mortality changes provide some evidence for this in that the mean age at death from most major acute, lethal, and chronic diseases has increased significantly (Manton 1985). There is also evidence to suggest that early differences in lifestyle and health factors between birth cohorts may produce persistent differences in health and functioning when those cohorts reach advanced age (e.g., Manton and Myers 1987).

In this projection scenario, disability declines 13 percent in 2000, 20 percent in 2020, and 30 percent in 2060 from the middle variant (table 1). Furthermore, a comparison of the two columns representing the percentage of persons disabled show significant reductions, suggesting the dual benefit of increasing the number of *nondisabled* elderly to help provide informal care. Thus, if we were to target the reduction of disability among the elderly as a major federal health policy—and if we were as successful as we are projected to be in reducing mortality—we could both significantly reduce the disability impact of population aging and increase the pool of functionally able elderly care givers, though the community-based disabled elderly population would still nearly double.

The above projections were based on two assumptions: first, that the progress in reducing mortality could be produced by actions to reduce disability independently of changes in mortality; second, that with the requisite research and policy actions we could achieve the same degree of progress in reducing disability at advanced ages that can be achieved in reducing mortality at advanced ages. In order to determine how realistic such assumptions might be we consider two further pieces of evidence.

The first type of evidence represents the two-year transition rates between disability levels among the elderly *after* those rates have been adjusted for mortality. These are presented in table 5 separately for males and females for persons aged 65 to 74 and persons aged 85

TABLE 4
Projected Numbers of the Community-based Disabled Elderly by Disability Level and the Institutionalized Populations, by Three Age Groups, Assuming Disability Rates Reduce as Rapidly as Mortality Rates; and Percentage of the Elderly Population Disabled and/or Institutionalized, Assuming Reduced Disability Rates and No Change in Disability Rates, 1985–2060 (numbers in thousands)

		Community-based disabled[2]					
Year	Total[1]	IADL limitations	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total	Institutionalized[3]
				Age 65–84			
1985	25,829	1,684	1,419	655	601	4,359	718
2000	30,609	1,777	1,492	687	650	4,606	756
2020	46,011	2,289	1,881	881	833	5,885	902
2060	55,214	2,480	2,055	951	919	6,406	1,054
				Age 85 +			
1985	2,707	282	407	181	236	1,106	593
2000	4,462	415	596	267	350	1,628	821
2020	6,357	567	810	363	477	2,217	1,093
2060	13,809	1,083	1,539	690	906	4,217	1,975
				Age 65 +			
1985	28,536	1,965	1,826	836	837	5,465	1,310
2000	35,071	2,192	2,089	954	1,000	6,234	1,578
2020	52,368	2,856	2,691	1,245	1,310	8,102	1,995
2060	69,023	3,563	3,594	1,641	1,825	10,623	3,030

			Age 65–84			
1985	16.9	2.8	19.7	16.9	2.8	19.7
2000	15.0	2.5	17.5	17.4	2.9	20.4
2020	12.8	2.0	14.8	16.4	2.6	19.0
2060	11.6	1.9	13.5	17.5	3.0	20.4
			Age 85+			
1985	40.9	21.9	62.8	40.9	21.9	62.8
2000	36.5	18.4	54.9	40.9	21.7	62.7
2020	34.9	17.2	52.1	40.8	21.4	62.2
2060	30.5	14.3	44.8	40.4	20.9	61.3
			Age 65+			
1985	19.2	4.6	23.7	19.2	4.6	23.7
2000	17.8	4.5	22.3	20.4	5.3	25.7
2020	15.5	3.8	19.3	19.3	4.9	24.2
2060	15.4	4.4	19.8	22.1	6.5	28.6

Sources: U.S. Social Security Administration 1987[1]; 1984 National Long-term Care Survey[2]; 1985 National Nursing Home Survey[3].
Totals may reflect rounding error.

TABLE 5

Transitional Probabilities (%) of 1982 versus 1984 Disability Status, Adjusted for Mortality, and Rates Used for Mortality Adjustments, for Males and Females by Two Age Groups

	Not disabled		IADL limitation		1–2 ADL limitations		3–4 ADL limitations		5–6 ADL limitations		Institutional		Rates used for mortality adjustments	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Not disabled														
65–74	91.82	92.23	2.70	3.68	1.51	2.21	0.78	0.80	0.60	0.57	0.68	0.52	8.24	3.79
85+	66.15	57.57	9.07	8.97	11.88	13.52	4.26	2.95	2.78	4.41	5.86	12.58	26.27	19.25
IADL limitation														
65–74	17.52	14.21	58.26	49.44	14.97	22.22	1.14	6.20	5.84	3.08	2.28	4.48	16.54	8.19
85+	2.13	0.74	50.17	36.09	23.13	34.96	9.99	6.51	6.07	7.86	8.53	13.85	33.41	19.31
1–2 ADL limitations														
65–74	4.32	9.02	20.12	22.79	39.38	45.56	20.47	12.35	9.01	5.48	6.71	4.83	20.67	12.61
85+	0.00	0.85	9.70	11.18	30.74	41.09	16.16	20.39	20.32	10.87	23.10	15.63	32.13	21.18
3–4 ADL limitations														
65–74	6.46	3.23	7.59	6.84	27.74	31.33	30.89	32.09	23.97	19.27	3.39	7.24	28.29	11.88
85+	0.00	0.00	3.49	2.98	10.46	10.44	23.30	28.61	38.35	34.62	24.41	23.33	47.90	24.78

5–6 ADL limitations														
65–74	1.94	1.55	9.53	12.41	15.21	13.49	15.61	14.60	49.17	46.95	8.77	10.99	35.12	30.40
85+	0.00	0.00	0.00	1.98	9.22	11.29	18.45	11.62	58.49	49.28	13.84	25.83	53.60	44.49
Institutional as of 4-1-82														
65–74	2.59	2.81	1.29	0.80	3.90	1.40	1.29	3.00	2.59	1.63	88.32	90.38	35.08	23.71
85+	0.00	0.00	0.00	0.91	0.00	0.00	0.00	1.51	0.00	1.20	100.00	96.40	62.46	44.97
'82 detail noncompleters														
65–74	11.90	12.65	17.20	25.30	11.90	28.69	24.19	16.61	11.47	12.65	23.34	4.01	61.10	30.91
85+	0.00	0.00	19.98	4.02	19.98	7.36	0.00	12.09	0.00	16.11	60.01	59.76	72.22	42.02
Institutional (after 4-1-82)														
65–74	12.71	9.06	6.35	9.65	0.00	8.46	12.71	4.82	4.73	0.00	63.52	67.98	38.85	35.95
85+	0.00	2.39	0.00	0.00	10.00	0.00	10.00	0.00	0.00	4.79	80.00	92.84	60.00	43.85

Sources: 1982 & 1984 National Long-term Care Survey.
Includes those not disabled on screener or detailed interview.

and over. The intermediate age group (75 to 84) has been omitted for parsimony and because the disability rates increase regularly with age.

At all levels of disability there is a significant probability of regaining function. For example, at ages 65 to 74, men and women with 5 to 6 ADL impairments, *and* who survive two years, have similar changes of long-term (two-year) functional improvement (42 percent). For survivors aged 85 and older the probability of improving functional level is less—though it is still significant (about 25 percent for females and 27.7 percent for males). Much of the similarity in these transitions is produced by the adjustment for mortality level which varies considerably by age and sex (e.g., in the columns with the mortality rates used for adjustment the two-year mortality probability for females aged 65 to 74 who are not disabled is 3.8 percent versus 30.4 percent for females of the same age with 5 to 6 ADL limitations). Without the mortality adjustment, persons with 5 to 6 ADL impairments have a 22.2 percent chance of reducing the disability level over a two-year interval. With adjustment for survival (37.2 percent of those with 5 to 6 ADL limitations die in two years), this increases to nearly 35.3 percent. These improvements occur even without a systematic national program for the prevention of disability and rehabilitation among the elderly—and with social norms that currently accept increasing disability with age.

While the incidence of disability, unadjusted for mortality, is similar for males and females (Manton 1988), females at all disability levels (and for all ages) have higher survival rates than males (e.g., two-year mortality for males aged 85 and older with 1 to 2 ADL limitations is 32.1 percent, 21.2 percent for females [table 5]). Thus, though disability occurs at similar rates, females tend to live longer with disability. This is probably because females haver higher risks of a number of chronic degenerative conditions like osteoporosis, diabetes, and rheumatoid arthritis. Therefore, targeting these chronic degenerative diseases for prevention is likely to have a greater effect on females—the group with the highest levels of disability *and* fewer social and economic resources to cope with that disability.

To describe the potential quantitative effects of such programs we conducted an alternate set of projections. We examined the conditions that the elderly reported as most important in causing their disability in the 1984 NLTCS specific to age, sex, marital status, and disability level. Then, both for 1985 and for future years, we estimated the total effect, separately for males and females, of selected conditions on disability. To illustrate the different impact of acute and chronic conditions, projections were generated for four conditions—two acute lethal conditions (cancer, ischemic heart disease) and two chronic degenerative conditions (dementia, and arthritis and other skeletal problems). The results are presented in table 6.

Far more disability is attributed to arthritis and skeletal problems and dementia, with the effects increasing with time as the population ages. The total number of cases of disability attributed to cancer and ischemic heart disease by 2060 is almost 600,000—compared to a total community-based disabled elderly population of a little over 15 million. In contrast, the total number of persons with disability attributed to dementia is 1.6 million. About 5.2 million persons report arthritis and skeletal problems as causing disability. Together, the two conditions are reported as helping cause approximately one-half of the total disability—with a proportionately greater effect on females. While the effect of cancer and heart disease is relatively greater for males than females, the absolute size of the effect is still smaller than for the chronic conditions.

This suggests that, if effective strategies could be found to eliminate or significantly modify the degenerative processes of arthritis and dementia, a significant proportion of the projected increase in the disabled elderly population could be prevented. The improvement would not necessarily be as large as projected in table 6 because a person may have multiple disabling conditions (though presumably we are eliminating the most important cause). Furthermore, because persons typically survive with these diseases for lengthy periods of time, the reduction of the risks of these diseases would have a significant effect on the amount of time the individual could expect to spend free of disability. This is significant for the design of health service systems and national health policy because the length of time that a person has a disability could have a significant impact on his exhaustion of economic resources (e.g., a lengthy institutionalization could produce the "Medicaid spend-down" phenomenon—for either the disabled person or a noninstitutionalized spouse) and on the capacity of informal care givers to maintain the person in the community.

The strategies and technologies developed to eliminate or control

TABLE 6
Projections of the Community-based Disabled Elderly Population, 1985–2060, by Sex, Age Group, and Disability Level, for Four Conditions Reported Most Important in Causing Disability (numbers are in thousands)

	Males					Females				
Year	IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total	IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total
A. *Cancer*										
					Aged 65–84					
1985	14	7	11	4	35	14	13	11	13	52
2000	17	8	13	5	44	15	16	14	18	62
2020	27	13	20	7	66	23	22	19	24	89
2060	32	18	25	9	84	26	15	23	32	109
					Aged 85+					
1985	—	4	4	4	12	1	2	2	3	7
2000	2	7	6	8	21	2	3	3	5	12
2020	2	11	9	12	31	2	4	4	7	16
2060	4	25	21	27	73	5	8	7	14	34
					Aged 65+					
1985	14	11	14	8	48	15	15	13	16	59
2000	17	16	19	12	65	17	18	16	22	74
2020	27	24	29	19	98	26	26	22	31	105
2060	32	43	46	35	157	31	36	31	46	143

B. *Ischemic heart disease*										
					Aged 65–84					
1985	30	8	5	9	50	28	19	4	2	53
2000	36	9	6	11	63	32	23	5	3	64
2020	55	15	9	16	95	42	31	6	4	83
2060	67	18	13	20	118	52	41	9	6	107
					Aged 85+					
1985	1	1	1	3	6	1	3	2	1	7
2000	1	1	1	5	9	1	6	2	2	12
2020	2	2	2	8	14	2	8	3	3	16
2060	5	4	5	17	32	4	16	7	7	33
					Aged 65+					
1985	31	9	6	11	56	28	22	5	4	60
2000	38	11	8	16	72	33	29	7	6	75
2020	57	16	11	24	108	43	39	10	7	99
2060	72	23	19	37	151	56	57	16	13	140
C. *Dementia*										
					Aged 65–84					
1985	35	14	8	10	67	83	48	12	26	169
2000	47	19	1	13	91	102	60	14	32	208
2020	67	25	15	19	126	126	74	18	40	258
2060	96	39	22	27	185	169	102	23	53	347
					Aged 85+					
1985	14	18	6	13	52	43	50	28	44	166
2000	24	28	9	20	81	72	84	48	73	276
2020	36	42	14	30	121	100	117	66	102	384
2060	84	120	32	72	287	206	240	135	211	792
					Aged 65+					
1985	50	32	14	23	119	126	98	40	70	335
2000	71	47	20	33	172	172	144	62	105	484
2020	103	67	29	48	247	226	190	83	142	642
2060	180	139	54	99	472	376	342	158	263	1,139

TABLE 6
(continued)

Year	Males					Females				
	IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total	IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total
D. *Arthritis & other skeletal diseases*										
					Aged 65–84					
1985	139	180	85	43	447	395	446	187	110	1,139
2000	175	227	95	74	561	470	529	227	139	1,365
2020	267	344	161	83	856	654	725	304	187	1,870
2060	344	459	207	107	1,111	806	899	387	246	2,338
					Aged 85 +					
1985	25	39	14	8	86	51	135	51	37	256
2000	43	62	22	15	142	84	194	84	62	425
2020	64	92	33	23	212	118	271	117	87	592
2060	150	217	79	52	497	234	565	242	180	1,230
					Aged 65 +					
1985	165	219	97	52	533	446	563	238	148	1,394
2000	218	289	127	69	703	554	723	311	201	1,789
2020	332	436	194	106	1,068	772	995	421	274	2,462
2060	494	670	284	159	1,607	1,049	1,463	630	426	3,568

Source: 1984 National Long-term Care Survey.

these diseases might be based upon a generically different logic than are disease prevention programs at younger ages, e.g., instead of eliminating the disease one might consider how to delay the age at onset of significant impairment. Thus, for chronic degenerative diseases secondary and tertiary prevention strategies along with rehabilitation are likely to play greater roles. Interestingly, the prevalence of impairment from a number of these degenerative diseases, because their risk increases rapidly with age, could be significantly reduced by even relatively modest increases in their age at manifestation. Brody (1984) has postulated that a five-year delay in the age at onset of dementia could reduce its prevalence by 50 percent—assuming that there was no concomitant increase in life expectancy. In such scenarios the way in which disease incidence relates to mortality changes is important. Some alternatives are considered in figure 4.

In figure 4 there are two panels. The first describes the change in the risk of a chronic, degenerative disease with age (for the discussion we are assuming that from the onset of the disease the time to death is unchanged). The second describes the age distribution of cases that would be generated by each of the age-specific risk functions in the first panel. In panel 2, in addition, there is an "age at death" distribution. A shift of the distribution of cases to the right (i.e., to more advanced ages) would result in a greater number of cases *not* being manifest due to a lower age at death than age at disease onset for more persons (assuming that changes in morbidity are not strongly associated with the total force of mortality). Thus, in panel 1 the two curves labelled "delay" represent the effect of a five-year shift in the risk function described by Brody. This corresponds to the two, identically shaped distributions of cases in panel 2 showing that the shift of the distribution to later ages would result in a similar, but later, distribution of the age at onset of the condition—except that more persons would die before manifesting the disease because the average mortality risks are higher for the second curve.

In the second scenario, labelled "disease modification" the physiological mechanism of the disease is modified in a way that its dependence on age is altered so that the shape of the age-specific disease hazard function is altered, i.e., it is made flatter. This produces a much different distribution of age at onset of the disease in panel 2 with even more cases being prevented from being manifest.

Of course, to be effective both types of interventions assume that

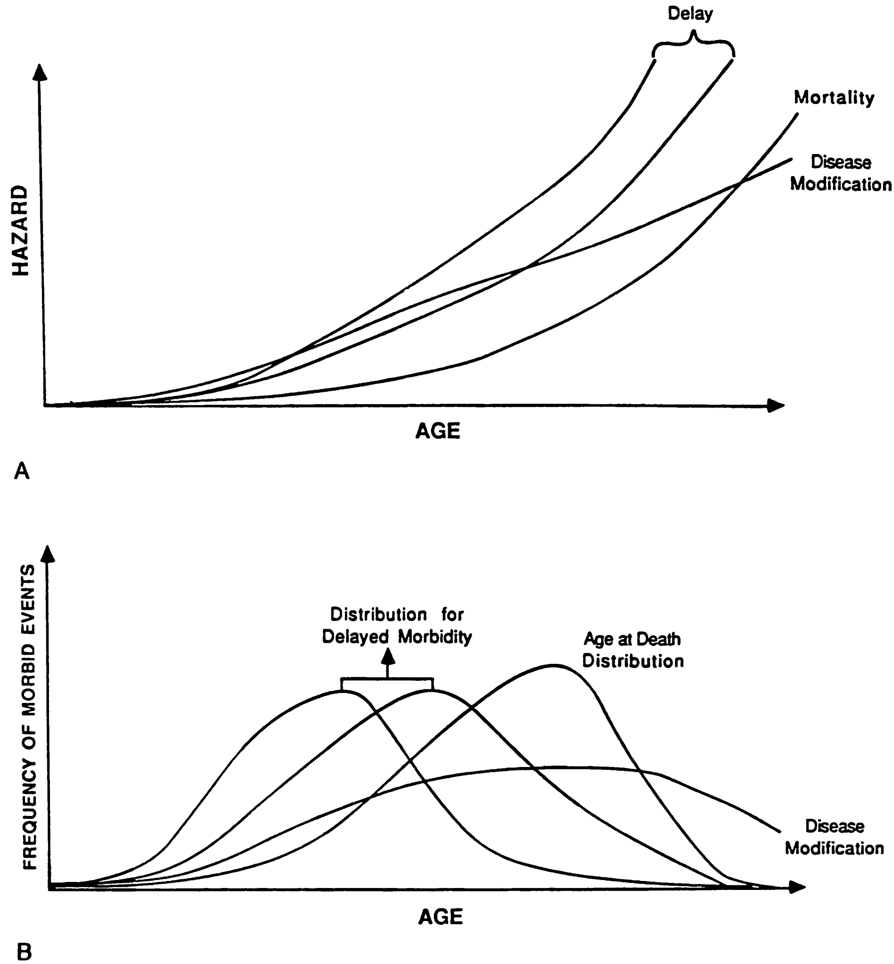

FIG. 4. (A). Change in the Age-specific Hazards of Disease (B). Distribution of Morbid Events Associated with Specific Hazard Functions

the correlation between the age at onset of the condition and the distribution of the ages at death is small. If the correlation is positive and a large delay in the average age at onset of the disease is associated with an upward shift in the distribution of the age at death there may be little gain in active life expectancy.

To design interventions to achieve increases in active life expectancy we must (a) understand the disease mechanism, its progression, and natural history, (b) identify risk factors affecting different stages of disease, and (c) develop intervention strategies and technologies to control effectively those risk factor inputs.

Significant scientific evidence on several of the most disabling chronic degenerative diseases now suggests that significant interventions may be developed in the near future. For example, in the case of osteoporosis discussed earlier, prevention programs would involve different pre- and postmenopausal strategies. Premenopausally one wishes to promote behaviors that maximize bone density at menopause. Risk factors decreasing bone density are smoking, alcohol consumption, extreme exercise (and consequential low body weight leading to low estrogen production), while moderate exercise, good nutrition, and adequate calcium intake are protective. Postmenopausally, calcium supplementation, exercise, adequate vitamin D supplementation, and possibly exogenous estrogen can retard the loss of bone density. Exactly how those interventions would alter the distribution of the age at onset is currently unclear. For example, by maximizing bone density at menopause one might shift the incidence curve to the right while by taking exogenous estrogen the disease process might be altered so that the shape of the incidence curve might be modified. Many of the details of the natural history of these disease processes are currently unknown and are necessary to understand the precise effects of a given intervention on the distribution of disability in the elderly population. Additionally, it is unclear to what extent such interventions in osteoporosis would affect life expectancy—especially at extreme ages where hip fracture and other major skeletal failures caused by advanced osteoporosis are responsible for a significant number of deaths (Manton 1986a). Resolution of this problem requires ancillary data and biological insight into the disease processes to model the biological dependency of both multiple disease risks and multiple causes of death.

Such detailed knowledge of the basic disease mechanisms is beginning to emerge from some chronic diseases. For example, our knowledge of the genetic, viral, and immunological basis of rheumatoid arthritis is improving. Consequently, for the first time, rheumatologists are discussing medical therapies that are truly disease *modifying* (e.g., long-term, low-dose methotrexate, gold salts, cyclosporine). Considerable research is being initiated on the determinants of Alzheimer's disease and possible medical interventions being identified for clinical evaluation (e.g., nerve growth factors). Research on Alzheimer's disease is at a very early stage. The absolute numbers of cases (and their duration weighted impact) that could be affected by effective therapy for such diseases, however, is so large that even if only a small proportion of the total effect is realized, such efforts may be cost effective.

Service Patterns among the Disabled Elderly

In prior sections the future magnitude of the problem of disability among the elderly was illustrated as well as how much of that problem might be resolved by further research on disease mechanisms, the development of disease-modifyiung therapies and effective prevention and rehabilitation strategies. Our conclusion, based upon an assessment of the recent rate of scientific progress, was that a significant proportion of the degenerative processes responsible for much of the disability at later ages might be subject to significant control or modification within 10 to 20 years by appropriately targeted biomedical and public health efforts. This is well within the time horizon of our projections. Even under the most optimistic scenarios, however, a significant increase in the size of the disabled elderly population is likely to occur. This seems particularly likely for the very elderly who have a high prevalence of multiple chronic conditions so that elimination of one condition still leaves individuals with other conditions to cause impairment and/or disability—though possibly at lower levels.

In this section, we estimate not simply the number of disabled elderly but the need (met and unmet) of certain types of services. The determination of need for services is complex because, in addition to ascertaining intrinsic levels of disability, one must evaluate the efficacy of different strategies for responding to those disabilities. For example, needs could remain unfulfilled if one did not have *either* appropriate equipment or personal care to respond to specific types of functional impairment. In some cases equipment may be substituted for personal care. The perceived adequacy of the available level of services is itself a function of (a) the efficacy of current techniques in resolving the impairment, and (b) current social values and governmental policy regarding the commitment to meet different needs (e.g., we might be more likely to provide home health services publicly than to provide alternate housing services). Furthermore, there is a broad range of daily actions that are affected by functional disability so that one current need might induce others. Thus, adequate medical care might be unavailable because of impairments in outside mobility. Impairments in outside mobility could result because of housing deficiencies (e.g., multistory housing without elevators) or characteristics of residential location (e.g., crowded metropolitan areas).

The first dimension of need examined is that for personal care and equipment to deal with each of 6 ADL disabilities. This is detailed in table 7.

For each of the first 4 ADL disabilities, the proportion of community-resident elderly persons with at least 1 ADL disability, who report lack of either equipment or personal care, is less than 2.5 percent. Both bathing or toileting limitations are more prevalent (9.1 percent and 27.9 percent). The 976,000 persons with chronic ADL impairments who report unmet needs with toileting represent the difficulty in defining need. Much of the need arises because persons report "wetting" or "soiling" themselves on a regular basis. Current technology to respond to these problems (e.g., using diapers) may not prevent this. Hence, even if the best current technology were employed, the need may remain. Of course, it could be argued that innovative surgical or other interventions could eliminate the problem so that the resolution of the problem may require research rather than increases in existing services.

Though 35 percent of the community chronically disabled elderly report needing help for ADL functions, most needs results from 2 ADL impairments at low levels in the Katz hierarchy (Katz and Akpom 1976). This is not surprising since persons who cannot satisfactorily perform a function like eating are probably quickly institutionalized. The level of unmet need is also strongly correlated with disability level. The prevalence of unmet need doubles (25.2 to 52.7 percent) from 1 to 2 to 5 to 6 ADL impairments. It also varies strongly by age (not reported here) with the oldest-old having the highest level of unmet need.

A second dimension of need is for equipment. Some persons report having no need for specific equipment (e.g., handrails) and, among those reporting a need, some may have the equipment. Table 8 presents the numbers of persons who have special equipment versus those who do *not* but who report that having the equipment would make them more comfortable or aid them.

We see that there are about 96,000 persons reporting needing doors

TABLE 7

Number and Percentage of Community-based Disabled Elderly Population with ADL Limitation Unmet Needs, by Disability Level and Type of ADL Unmet Need, and Number of Elderly with Selected IADL Limitation (numbers in thousands)

Disability level	Total disabled persons	Number of persons reporting ADL unmet needs	ADL limitation unmet need					
			Eating	Getting up	Getting around	Dressing	Bathing	Toileting
1–2 limitations	1,826	459 (25.2)	7 (0.4)	10 (0.6)	8 (0.4)	17 (0.9)	130 (7.1)	358 (19.6)
3–4 ADL limitations	836	312 (37.3)	6 (0.7)	11 (1.3)	8 (1.0)	26 (3.1)	107 (12.8)	238 (28.5)
5–6 ADL limitations	837	441 (52.7)	36 (4.3)	64 (7.7)	53 (6.3)	38 (4.5)	81 (9.7)	379 (45.3)
Total	3,499	1,212 (34.6)	49 (1.4)	85 (2.4)	69 (2.0)	81 (2.3)	318 (9.1)	976 (27.9)

Source: 1984 National Long-term Care Survey.
Numbers in parentheses are percentage of persons at disability level with specific unmet need.
Totals may not sum due to rounding error.

TABLE 8
Number of Community-based Disabled Elderly Persons Who Have Special Equipment ("Have") and Those Who Report They Need but Do Not Have Special Equipment ("Need"), by Disability Level and Type of Equipment
(numbers in thousands)

Disability level	Status	Type of equipment: Pushbar doors	Handrails	Ramps	Elevators	Extra-wide doors	Raised toilet
IADL limitation	Have	20.1	212.5	29.6	61.0	59.6	28.9
	need	12.9	261.4	24.2	43.2	12.8	57.3
1–2 ADL limitations	Have	33.8	535.9	74.1	96.7	114.0	90.6
	need	16.1	301.2	45.6	75.8	26.3	135.5
3–4 ADL limitations	Have	16.1	287.8	52.6	66.7	68.1	128.9
	need	30.6	156.8	50.3	35.1	27.7	83.2
5–6 ADL limitations	Have	7.0	249.2	90.6	34.5	50.1	130.6
	need	36.6	183.2	69.1	44.2	69.2	128.8
Total	Have	77.0	1,285.4	246.9	258.9	291.8	379.0
	need	96.2	902.6	189.2	198.3	136.0	404.8

Source: 1984 National Long-term Care Survey.

TABLE 9
Projected Number of Physicians, Nurses, and Home Health Workers Required to maintain Current Levels of Service for the Elderly Population

	1985	2000	2020	2040
1. Physicians	110,000	137,830	206,030	267,760
2. Nurses	390,000	488,740	730,650	949,333
3. Home health workers				
(a) Aides	198,900	249,258	372,640	484,059
(b) Nurses	22,100	27,695	41,404	53,797

Source: Manton 1986b, table 11.

with pushbars in contrast to 77,000 who report having them. About 1.3 million persons report living in a built environment with handrails while a little more than 903,000 persons say handrails would be useful but they do not have them. Among persons with 5 to 6 ADL limitations, about 250,000 persons report having handrails and about 183,000 do not. About 380,000 persons report having raised toilets and 405,000 report needing but not having them. Thus, there is a considerable *reported* need for special equipment in the built environment to help compensate for a number of impairments.

An additional dimension of need involves acute and LTC health services. This need, current and future, can be presented by (a) the demand for medical and auxiliary health professional manpower, and (b) the demand for informal care. In table 9 we examine projections of the numbers of three classes of health care workers required to meet future demand for institutional and home health services (Manton 1986b).

The number of physicians required to continue current levels of services for the elderly population increases nearly 150 percent— far more than the increase of the total United States population. There are similar increases in projected demand for nurses and home health workers. Thus, there will have to be a more rapid increase in the requirements for medical manpower than expected on the basis of population growth. Furthermore, because much of this growth occurs in meeting the needs of an elderly, disabled population there is need for specialized geriatric training of these health professionals.

In table 10 we present the number of care givers required, and number of days spent by care givers to maintain current levels of informal care.

The number of care givers increases much more rapidly than the general growth of the United States population. This means that to maintain current levels the intensity of care giving will have to increase on a per capita basis and probably implies that, in the future, more of this care will have to be provided by paid care givers.

Summary

The magnitude and quality of the problem of disability for the United States elderly population was analyzed in a series of projections. An analysis of the impact of disability on this population is more difficult than for other disabled groups because previously, in both the popular and scientific literature, there was the assumption that the prevalence and severity of disability was a natural consequence of the aging process. Such a perspective has implications not only for initiatives to improve the health and functional states of the elderly population but also for the perception of the level of disability, the handicaps associated with it, and the types of services that are appropriately provided.

This image of the natural emergence of frailty with age is now challenged by a number of studies. The extreme heterogeneity of functional status in even the oldest-old (those aged 85 and over) population is evidence that functional impairment among the elderly is not a natural consequence of aging and must be evaluated on an individual basis.

There is also increasing evidence that the physiological processes generating impairment are subject to intervention and, in some cases, may even be partly reversed and function regained. Recent research has begun to identify the risk factors for such processes and to explicate the mechanisms of these processes so that more effective interventions can be developed.

Whatever interventions may be introduced, the demographic aging of the population will cause large increases in the number of disabled elderly. This is a national problem whose magnitude will depend upon the degree to which the broadly defined needs of this population

TABLE 10
Number of Care Givers and Care-giver Days for the Community-based Disabled Elderly Population, 1985–2060, by Three Age Groups and Disability Level (numbers in thousands)

Year	Care givers					Care-giver days				
	IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total	IADL limitation	1–2 ADL limitations	3–4 ADL limitations	5–6 ADL limitations	Total
					Aged 65–84					
1985	2,711	2,682	1,485	1,641	8,520	7,889	8,470	5,132	7,029	28,519
2000	3,303	3,286	1,804	2,049	10,442	9,703	10,498	6,242	8,791	35,232
2020	4,650	4,511	2,527	2,880	14,568	13,904	14,518	8,891	12,377	49,690
2060	5,940	5,856	3,220	3,745	18,761	17,764	18,903	11,237	16,102	64,005
					Aged 85+					
1985	521	951	454	703	2,629	1,575	2,857	1,627	3,096	9,155
2000	859	1,557	750	1,168	4,334	2,610	1,657	2,695	5,137	15,100
2020	1,219	2,210	1,066	1,663	6,158	3,737	6,629	3,837	7,317	21,520
2060	2,626	4,756	2,301	3,594	13,278	8,167	14,371	8,310	15,833	46,681
					Aged 65+					
1985	3,232	3,633	1,939	2,344	11,148	9,463	11,327	6,759	10,125	37,374
2000	4,162	4,844	2,553	3,218	14,776	12,313	15,155	8,937	13,927	50,331
2020	5,869	6,720	3,594	4,543	20,726	17,641	21,147	12,728	19,695	71,211
2060	8,567	10,612	5,520	7,339	32,039	25,931	323,274	19,547	31,934	110,686

Source: 1984 National Long-term Care Survey.
Totals may not sum due to rounding error.

are or are not met. We considered needs on a number of levels. In terms of basic self-care only bathing and toileting are reported as currently "unmet" to a considerable degree. The most serious deficiencies on a relative basis were for physical equipment and changes in the built environment.

All of these factors contribute to a general assessment of changes in the size, structure, and needs of the disabled elderly population. It is clear that no single response will suffice given the magnitude of the problems. Thus, a multidimensional approach involving the private sector and state and federal programs, and their coordination, will be needed to develop adequate responses to the problem. Given the dimensions of the problem, however, it is likely that no response will be satisfactory unless fundamental changes in the sociocultural perception of the functioning of elderly people, and the provision of family and other social resources to maintaining that functioning, are developed.

One aspect of the problem that is of particular concern has been the relative paucity of nationally representative data to monitor the growth of the problem, to characterize the dimensions of the problem, and to monitor the efficacy of different interventions. Only recently has nationally representative logitudinal data appropriate for this task become available. The existing temporal series of such national data in the United States, however, are not yet lengthy enough either to identify major cohort differences or accurately assess whether active or healthy life expectancy has increased or decreased as life expectancy at later ages increases. This is a serious hindrance to the development of effective policies to meet the problems of a rapidly aging population.

References

Besdine, R. W. 1988. Dementia and Delirium. In *Geriatric Medicine,* ed. J.W. Rowe and J.W. Besdine, 375–401. Boston: Little, Brown.

Brody, J.A. 1984. The Best of Times/The Worst of Times: Aging and Dependency in the 21st Century. *Ethical Dimensions of Geriatric Care Value Conflicts for the 21st Century,* ed. S.F. Spicker, In S.R. Ingman, and I.R. Lawson, 3–22. Dordrecht, Holland: D. Reidel.

Feldman, J.J. 1983. Work Ability of the Aged under Conditions of

Improving Mortality. *Milbank Memorial Fund Quarterly/Health and Society* 61:430–44.

Fries, J.F. 1980. Aging, Natural Death, and the Compression of Morbidity. *New England Journal of Medicine* 303:130–35.

Gruenberg, E.M. 1977. The Failures of Success. *Milbank Memorial Fund Quarterly/Health and Society* 55:3–24.

Julius, S. 1988. The Therapeutic Dilemma of Hypertension in the Elderly. *Drugs* 36 (Suppl. 1):7–17.

Kannel, W.B., and T. Gordon. 1980. Cardiovascular Risk Factors in the Aged: The Framingham Study. In *Epidemiology of Aging* ed. S.G. Haynes, and M. Feinleib, 65–90. U.S. Department of Health and Human Services Pub. No. 80–969. Washington.

Katz, S., L.G. Branch, M.H. Branson, J.A. Papsidero, J.C. Beck, and D.S. Greer. 1983. Active Life Expectancy. *New England Journal of Medicine* 309:1218–23.

Katz, S., and C.A. Akpom. 1976. A Measure of Primary Sociobiological Functions. *International Journal of Health Services* 6:493–508.

Lakatta, E.G. 1985. Health, Disease, and Cardiovascular Aging. In *America's Aging: Health in an Older Society*, Institute of Medicine, National Research Council, National Academy of Sciences, 73–104. Washington: National Academy Press.

Lew, E.A., and L. Garfinkel. 1984. Mortality at Ages 65 and Over in a Middle-Class Population. *Transactions of the Society of Actuaries* 36:257–95.

Manton, K.G. 1985. Future Patterns of Chronic Disease Incidence, Disability, and Mortality among the Elderly. *New York State Journal of Medicine* 85(11):623–33.

———. 1986a. Cause-specific Mortality Patterns among the Oldest Old: Multiple Cause of Death Trends 1968–1980. *Journal of Gerontology* 41(2):282–89.

———. 1986b. Preliminary Report on Ways of Adjusting Public and Private Reimbursement Mechanisms for Promoting the Training of Geriatric Manpower. Paper presented at The National Institute on Aging, Bethesda, Dec. 11–12.

———. 1988. A Longitudinal Study of Functional Change and Mortality in the U.S. *Journal of Gerontology* 43:153–61.

———. 1989. Life Style Risk Factors. *Annals of the American Academy of Political and Social Science* 503:72–87.

Manton, K.G., and K. Liu. 1984. The Future Growth of the Long-term Care Population: Projections Based on the 1977 National Nursing Home Survey and the 1982 Long-term Care Survey.

Paper presented at the Third National Leadership Conference on Long-term Care Issues: The Future World of Long-term Care, Hillhaven Foundation, Washington, March 7–9.

Manton, K.G., and G.C. Myers. 1987. Recent Trends in Multiple-cause Mortality, 1968 to 1982: Age and Cohort Components. *Population Research and Policy Review* 6:161–76.

Manton, K.G., I.C. Siegler, and M.A. Woodbury. 1986. Patterns of Intellectual Development in Later Life. *Journal of Gerontology* 41:486–99.

Manton, K.G., and B.J. Soldo. 1985. Dynamics of Health Changes in the Oldest Old: New Perspectives and Evidence. *Milbank Memorial Fund Quarterly/Health and Society* 63:206–85.

National Center for Health Statistics. 1989. The National Nursing Home Survey: 1985 Summary for the United States. *Vital and Health Statistics,* series 13, no. 97. DHHS pub. No. (PHS) 89-1758. Washington.

Nihon University. 1982. *Population Aging in Japan: Problems and Policy Issues in the 21st Century.* Paper presented at the International Conference on an Aging Society: Strategies for 21st Century Japan, Nihon University, Nov. 24–27. Tokyo: Nihon University Population Research Institute.

Paffenbarger, R.S., R.T. Hyde, A.L. Wing, and C.C. Hsieh. 1986. Physical Activity, All-cause Mortality, and Longevity of College Alumni. *New England Journal of Medicine* 314:605–13.

Robine, J.M., M. Labbe, M.S. Serouss, and A. Colvez. 1989. The Upper-Normandy Longitudinal Survey on Disability in the Aged, 1978–1985. *Revue d'Epidemiologie et de Santé Publique* 37(1):37–48.

U.S. Social Security Administration. 1987. *Social Security Area Population Projections: 1987.* Actuarial Study no. 99, SSA pub. No. 11-11546. Washington.

Wilkins R., and O. Adams. 1983. *Healthfulness of Life.* Montreal: Institute for Research on Public Policy.

Williams, G.H. 1988. Drug Therapy. Coverting-enzyme Inhibitors in the Treatment of Hypertension. *New England Journal of Medicine* 319:1517–25.

World Health Organization. 1980. *International Classification of Impairments, Disabilities, and Handicaps: A Manual of Classification Relating to the Consequences of Disease.* Geneva.

———. 1982. *Epidemiological Studies on Social and Medical Conditions of the Elderly: Report on a Survey.* EURO Reports and Studies no. 62. Copenhagen.

———. 1984. *The Use of Epidemiology in the Study of the Elderly: Report of a WHO Scientific Group on the Epidemiology of Aging*. Technical Report Series no. 706. Geneva.

Acknowledgments: This paper was prepared for the Milbank Memorial Fund Roundtable on Disability Policy, Harriman, N.Y., September 23–24, 1988. Research reported herein was supported by ASPE grant no. 87ASPE 185A, HCFA cooperative agreement nos. 18-C-98641 and 17-C-99009, and NIA grant nos. AG07198 and AG07469. Figures 1 and 2 are reprinted from *Annals* 503 by permission of Sage Publications, Inc.

Address correspondence to: Kenneth G. Manton, Ph.D., Research Professor, Demographic Studies, Center for Demographic Studies, Duke University, 2117 Campus Drive, Durham, NC 27706.