Contribution of Chronic Conditions to Aggregate Changes in Old-Age Functioning

Vicki A. Freedman, PhD, and Linda G. Martin, PhD

ABSTRACT

Objectives. This study explored the role of various chronic conditions in explaining recent improvements in functioning among older Americans.

Methods. We used the Supplements on Aging to the 1984 and 1994 National Health Interview Surveys to examine changes among Americans 70 years and older in reports of chronic conditions and functional limitations. We decomposed functioning changes into condition-related components, controlling for demographic shifts.

Results. The percentage of older Americans with upper- and lower-body limitations declined from 5.1% and 34.2%, respectively, in 1984 to 4.3% and 28.5% in 1995, and the average number of lower body limitations decreased. During the same period, reports of 8 of 9 chronic conditions increased, but many of these conditions had less debilitating effects on functioning. Reductions in the debilitating effects of various chronic conditions—particularly arthritis—are important in explaining declines in limitations experienced by older Americans.

Conclusions. Earlier diagnosis and improved treatment and management of chronic conditions, rather than prevention, may be important contributing factors to improvements in upper- and lower-body functioning among older Americans. (*Am J Public Health.* 2000; 90:1755–1760)

The consequences of declines in mortality for geriatric health have been intensely debated for many years.[1] Gruenberg[2] and Kramer[3] suggested that postponement of death gives rise to more chronic disease and disability. Fries's[4] theory of the compression of morbidity purports the opposite—as morbidity onset is postponed and more adults reach the limit to human life, the morbid period is compressed. Manton[5] proposed a third perspective—dynamic equilibrium—in which declines in mortality yield increases in the prevalence of chronic disease for which the rate of progression is slowed.

These competing theories have implications not only for patterns of lifetime disability and disease[6] but also for trends in cross-sectional snapshots of older Americans. Gruenberg's theory portends pandemic increases in chronic disease and disability, whereas Fries suggested that aggregate declines will occur. In contrast, Manton's perspective suggests that declines in the severity of disease and consequent disability are possible even with increases in the prevalence of chronic disease.

Researchers have recently provided evidence consistent with the dynamic equilibrium perspective in France,[7] where increases in disease have been offset by decreases in their disabling effects. In the United States, several studies have shown substantial improvements during the 1980s and early 1990s in old-age disability and functioning,[8–11] although at least 1 study has shown mixed results.[12] Population-based studies have yielded a less consistent picture of chronic disease trends, with increases over time in some—musculoskeletal conditions, orthopedic impairments, diabetes—and decreases in others—heart disease, hypertension, arthritis—for more recent cohorts of elderly.[13–15] Other studies[16–21] have shown these conditions to be among the most debilitating.

Despite our evolving understanding of trends in population health, the role of chronic conditions in recent trends in old-age functioning in the United States remains unclear. Thus far, efforts to explain improvements have focused on changes in the demographic and socioeconomic composition of the population,[8,22] highlighting increases in education as a potentially important factor.[22] Consequently, the relative contributions of changes in prevalence and in disabling effects of disease are unknown. Changes in the former—through either postponement of onset or primary prevention efforts—may have led to improvements in old-age functioning. Alternatively, earlier detection or improvements in disease treatment and management—through pharmacological advances, more widespread medical procedures (e.g., hip replacements, cataract surgery), and changes in health-related behaviors of older Americans—may have attenuated the disease–functioning link over time. A clearer understanding of these relative contributions not only would provide insight into the continuing theoretical debate on implications of mortality declines but also would facilitate anticipation of future patterns of old-age functioning and planning for related medical and social services.

In this article, we examine changes over the past decade in linkages between chronic disease and functioning of older Americans, while controlling for demographic shifts. We focus on functional limitations—the inability without help or aids to carry out physical tasks such as grasping, lifting, and stooping—rather than more common measures of disability (e.g., difficulty bathing or doing laundry) because limitation measures are less sensitive to changes

Vicki A. Freedman is with the Polisher Research Institute, Philadelphia Geriatric Center, Jenkintown, Pa. Linda G. Martin is with the Population Council, New York, NY.

Requests for reprints should be sent to Vicki A. Freedman, PhD, Senior Research Scientist, Polisher Research Institute, Philadelphia Geriatric Center, The Pavilion, Suite 427, 261 Old York Rd, PO Box 728, Jenkintown, PA 19046-7128 (e-mail: vfreedman@pgc.org).

This article was accepted February 24, 2000.

Note. The conclusions in this article are those of the authors alone.

in expectations about roles or living environments.[23–25] We assess the relative importance of changes in prevalence and in the limiting effects of specific chronic conditions as explanations for aggregate changes in functioning.

Methods

Data

We used data from the Supplements on Aging to the 1984 and 1994 National Health Interview Survey (NHIS). The NHIS is the principal source of information on the health of the civilian noninstitutionalized population of the United States. The Supplement on Aging was designed to obtain detailed in-person information on the health and functioning of a large, representative sample of older Americans. The Supplement on Aging II was designed to replicate the Supplement on Aging.[26]

The Supplement on Aging was administered with the 1984 NHIS to approximately 16 000 individuals 55 years and older living in the community, 7527 of whom were 70 years or older. The Supplement on Aging II obtained data approximately 7 to 17 months after the 1994 NHIS for 9245 community-dwelling individuals 70 years and older at follow-up. Response rates were 93.2% and 87.4% for the Supplement on Aging and Supplement on Aging II, respectively. When respondents were unable to answer, a proxy (most often a spouse or child) was interviewed; 8.6% and 11.4% of the interviews were completed with proxies in the Supplement on Aging and Supplement on Aging II, respectively.

Sampling weights for the Supplement on Aging and Supplement on Aging II adjusted for the complex sample designs and for nonresponse. To make the Supplement on Aging and Supplement on Aging II comparable, we adjusted the weights for the Supplement on Aging II to account for potential biases introduced by the time lag between administration of the 1994 NHIS and the Supplement on Aging II.[27] The resulting weighted estimates yield comparisons of health for the community-dwelling 70 and older population between 1984 and 1995.

Others[10] have shown that the proportion of older Americans living in institutions declined over this period, implying that frail persons now may be more likely to live in the community. Omitting the institutionalized from our analysis could bias estimates of aggregate changes toward *understating* improvements in functioning and *overstating* increases in chronic disease.

Measures

The Supplement on Aging and Supplement on Aging II included identical questions on functional limitations adapted from Nagi's original scale.[23] We first validated for both years that, as shown previously for the Supplement on Aging,[16] these items map into upper- and lower-body limitations. We then formed 2 scales reflecting the inability to carry out 0 to 3 upper and 0 to 5 lower-body tasks by oneself and without using aids. Upper-body tasks include reaching up over one's head, reaching out, and using one's fingers to grasp or handle. Lower-body tasks include walking for a quarter mile; walking up 10 steps without resting; standing for about 2 hours; stooping, crouching, or kneeling; and lifting or carrying a 25-pound object. Both scales had relatively good internal consistency (α=0.68 for upper, α=0.88 for lower).

The Supplement on Aging and Supplement on Aging II also asked respondents about their experiences with several chronic diseases and injuries: broken hip, hypertension, stroke, cancer, osteoporosis, diabetes, heart disease, arthritis, and obesity. Although far from exhaustive, these conditions are among the most frequently cited as associated with functional limitations.[16–21] The most salient omission for our purposes is dementia, for which both prevalence and debilitating effects may have declined.[14,28] Respondents were not asked to identify specific conditions responsible for functioning deficits; instead, we assumed for each year that all mentioned conditions contributed.

For 6 of the 9 conditions, respondents were asked identical questions in both years: had they ever had a broken hip, hypertension, a stroke, cancer, or osteoporosis and what were their current height and weight measurements (from which we calculated obesity, defined as body mass index > 30). For 3 conditions, wording was changed. For arthritis and diabetes, the Supplement on Aging asked whether the respondent had these conditions in the last 12 months; the Supplement on Aging II asked whether the respondent ever had these conditions and, for diabetes, whether the respondent still had it. For heart disease, the Supplement on Aging asked separate questions about ever having coronary heart disease, angina pectoris, myocardial infarction, or any other heart attack, but the Supplement on Aging II asked about ever having "heart disease including coronary heart disease, angina pectoris, myocardial infarction, or any other heart attack." Analyses of the 1984 and 1994 NHIS (data not shown) suggested that for diabetes, a change from a 12-month reference period to still having the condition did not affect trends. However, wording changes for arthritis and heart disease yielded relatively higher estimates of these conditions in 1995 than would have been the case had the questions not been changed. As a result, the effect on lower-body functioning of changes in the presence of heart disease and arthritis and changes in the effect of heart disease are somewhat overstated. Such sensitivities do not change our conclusions about the role of chronic diseases as a group.

TABLE 1—Prevalence of Upper- and Lower-Body Limitations in Population 70 Years and Older: 1984 and 1995

	1984	1995	*P* for Difference
Upper body tasks			
No. of tasks unable to be carried out			.078
0	94.9%	95.7%	
1	4.1%	3.3%	
2	0.5%	0.4%	
3	0.4%	0.6%	
Average no.	0.065	0.058	.326
Sample size, no.	7422	9142	
Lower body tasks			
No. of tasks unable to be carried out			.000
0	65.8%	71.5%	
1	12.0%	9.9%	
2	6.1%	4.6%	
3	4.1%	3.8%	
4	5.1%	3.8%	
5	6.9%	6.4%	
Average no.	0.913	0.776	.000
Sample size, no.	6961	8056	

Note. Data are from the Supplements on Aging to the 1984 and 1994 National Health Interview Survey.

Sample

For our assessment of changes in the prevalence of demographic factors and chronic conditions, we used the full samples for 1984 and 1995. Because of nonresponse to functioning items, sample sizes were re-

TABLE 2—Presence of Chronic Disease in Population 70 Years and Older: 1984 and 1995

	1984 (n = 7527), %	1995 (n = 9245), %	*P* for Difference
Osteoporosis			.000
Yes	3.7	8.8	
No	94.8	88.5	
Missing	1.6	2.7	
Broken hip			.000
Yes	4.5	4.8	
No	95.0	93.8	
Missing	0.5	1.4	
Hypertension			.000
Yes	45.1	44.1	
No	53.9	53.9	
Missing	1.0	1.9	
Stroke			.000
Yes	7.5	9.3	
No	91.5	89.0	
Missing	1.0	1.7	
Cancer			.000
Yes	12.2	19.2	
No	87.0	79.3	
Missing	0.9	1.5	
Diabetes			.000
Yes	9.9	10.6	
No	89.2	87.1	
Missing	0.9	2.2	
Heart disease			.000
Yes	16.3	21.4	
No	83.1	76.7	
Missing	0.6	1.9	
Arthritis			.000
Yes	54.0	57.0	
No	44.3	40.6	
Missing	1.7	2.4	
Obesity			.000
Yes	10.4	11.9	
No	87.9	82.5	
Missing	1.7	5.6	

duced to 7422 in 1984 and 9142 in 1995 for the analysis of upper-body limitations and to 6961 in 1984 and 8056 in 1995 for the analysis of lower-body limitations. Our calculations indicate that this reduction did not affect conclusions about aggregate changes in functioning. Furthermore, the relation between chronic conditions and functioning would be affected only if nonrespondents differed substantially on dimensions other than those included in our models.

Statistical Analysis

We assessed changes in the prevalence of functional limitations, chronic conditions, and demographic factors with χ^2 tests for independence. We estimated the effects of chronic diseases on functioning with ordinary least squares regression models stratified by year, with the outcome the number of upper- (lower-) body limitations. We tested for changes over time in the effects of conditions with nonstratified models in which year was interacted with all variables. We also investigated specifications that explicitly accommodate skewed distributions (i.e., tobit regressions), but results were essentially identical.

All regression models included the 9 chronic conditions, age (in 5-year groups), sex, race (White, Black, other), Hispanic origin or not, marital status (married, separated/divorced, widowed, never married), completed education (less than high school, high school, greater than high school), region of residence (South, Northeast, North Central, and West), and dummy variables to control for missing information and to indicate a proxy respondent. Our specification assumed no comorbidity effects (i.e., conditions operate independently); exploratory analyses suggest that this assumption is reasonable.

We decomposed changes in mean upper- and lower-body functioning into 18 disease-related components. Kitagawa[29] showed that the contribution of a change in the prevalence of a given condition—for example, ever having cancer—to aggregate changes in functioning is obtained by multiplying the proportion ever having cancer (denoted X_{year}) differenced over the 2 years by the effect of ever having cancer (denoted β_{year}) averaged over the 2 years:

$$(X_{95} - X_{84})\ \frac{\beta_{95} + \beta_{84}}{2}.$$

The contribution of a change in the limiting effect of cancer is obtained by multiplying the difference in cancer's effect over time by the average proportion ever having cancer:

$$(\beta_{95} - \beta_{84})\ \frac{X_{95} + X_{84}}{2}.$$

Summing these 2 components yields the total contribution of a given factor.

We calculated all statistical tests and confidence intervals based on adjusted standard errors (produced by SUDAAN [Research Triangle Institute, Research Triangle Park, NC]) that account for the Supplement on Aging and Supplement on Aging II sample designs.

Results

The percentage of older Americans with upper- and lower-body limitations declined from 1984 to 1995 (see Table 1). The average number of upper-body limitations declined by 11%—on average, 1% per year—but this change was not statistically significant. Improvements were much larger and statistically significant for lower-body functions, averaging 1.4% annually.

During the same period, reports of the presence of many disabling chronic diseases increased (Table 2). Older Americans were increasingly likely to report having osteoporosis, a broken hip, a stroke, cancer, diabetes, heart disease, and arthritis and to be classified as obese. Only reports of ever having hypertension declined. These increases were not simply the result of demographic shifts. In 1995, for example, older Americans were older, more racially and ethnically diverse, and better educated than in 1984 (see Table 3). Additional analyses (results not shown) suggest that if such demographic factors had remained unchanged, statistically significant increases still would have occurred for all conditions except ever having a broken hip and hypertension.

In both years, nearly all of the chronic conditions were associated with having more limitations (see Table 4). For both upper- and lower-body limitations, ever having a broken hip and ever having a stroke were especially strong predictors. More important, when controlling for demographic shifts, we found that several chronic diseases had a less debilitating effect on functioning in 1995. For upper-body limitations, osteoporosis, heart disease, and arthritis were significantly less debilitating in 1995; only cancer was significantly more limiting. For lower-body limitations, osteoporosis and arthritis became significantly less debilitating over time.

TABLE 3—Demographic Characteristics of Population 70 Years and Older: 1984 and 1995

	1984 (n = 7527), %	1995 (n = 9245), %	*P* for Difference
Sex			.081
Female	61.3	60.0	
Male	38.7	40.0	
Age group, y			.000
70–74	41.5	38.1	
75–79	30.7	29.9	
80–84	16.9	18.7	
85–89	8.0	9.0	
≥90	2.9	4.3	
Race			.012
White	90.5	90.0	
Black	8.4	7.7	
Other	1.1	2.3	
Hispanic origin			.000
Yes	2.8	4.2	
No	96.8	94.6	
Missing	0.3	1.2	
Marital status			.000
Married	48.1	49.4	
Separated or divorced	4.6	5.4	
Widowed	42.4	39.7	
Never married	4.6	4.1	
Marital status missing	0.3	1.4	
Completed education			.000
<High school	56.1	39.4	
High school graduate	24.9	33.3	
>High school	17.5	25.1	
Education missing	1.6	2.2	
Region			.861
Northeast	22.9	22.5	
North Central	25.5	25.1	
South	33.8	33.0	
West	17.8	19.4	
Respondent type			.000
Self	90.0	86.2	
Proxy	8.6	11.6	
Proxy status missing	1.4	2.2	

Which conditions were most important in explaining improvements in functioning? For upper-body limitations, increases in osteoporosis, stroke, heart disease, arthritis, obesity, and the limiting effects of cancer significantly *increased* the average number of limitations (Table 5). These unfavorable contributions were offset by significant declines in the limiting effects of osteoporosis, heart disease, and arthritis. For other conditions (e.g., stroke, obesity), changes in the limiting effects were not statistically significant but were of sufficient size to offset increases in their presence, yielding total contributions that were not statistically significant. Thus, only 2 conditions made significant total contributions to changes in upper-body limitations: arthritis in a beneficial direction and cancer in an unfavorable one.

For lower-body functioning, increases in osteoporosis, stroke, cancer, heart disease, arthritis, and obesity significantly increased the average number of limitations, whereas declines in the limiting effects of osteoporosis and arthritis contributed significantly to improvements. Only 2 conditions made significant total contributions to changes in lower-body limitations: arthritis in a favorable direction and obesity in a detrimental one.

When the conditions are considered as a group (last row of Table 5), upper- and lower-body limitations show similar patterns. Statistically significant contributions due to increases in the presence of this group of conditions were offset, entirely for changes in upper-body limitations and in part for lower-body limitations, by declines in the limiting effects of those conditions. Consequently, the net effect on functioning for this group of conditions was not significantly different from zero.

Discussion

Despite increases in reports of chronic conditions, the percentage of older Americans with upper- and lower-body limitations declined from 1984 to 1995. Several major diseases—arthritis, most prominently—appear to have become less debilitating over time. Al-

TABLE 4—Regression Coefficients for the Effects of Chronic Conditions on Mean Number of Upper- and Lower-Body Limitations in Population 70 Years and Older: 1984 and 1995[a]

	Upper-Body Limitations			Lower-Body Limitations		
	1984 (n = 7422)	1995 (n = 9142)	Difference ± 1.96 SE	1984 (n = 6961)	1995 (n = 8056)	Difference ± 1.96 SE
Osteoporosis	0.081**	0.005	–0.076 ± 0.071**	0.614**	0.391**	–0.222 ± 0.257*
Broken hip	0.097**	0.077**	–0.020 ± 0.086	0.946**	0.953**	0.007 ± 0.327
Hypertension	0.010	–0.004	–0.014 ± 0.020	0.116**	0.096**	–0.020 ± 0.094
Stroke	0.120**	0.103**	–0.017 ± 0.071	0.880**	0.856**	–0.024 ± 0.218
Cancer	–0.003	0.023**	0.027 ± 0.029*	0.108**	0.132**	0.024 ± 0.131
Diabetes	0.014	0.047**	0.033 ± 0.043	0.366**	0.435**	0.069 ± 0.178
Heart disease	0.056**	0.025**	–0.031 ± 0.029**	0.506**	0.436**	–0.071 ± 0.139
Arthritis	0.035**	0.017**	–0.018 ± 0.020*	0.449**	0.337**	–0.111 ± 0.086**
Obesity	0.022**	0.022*	0.001 ± 0.031	0.343**	0.444**	0.100 ± 0.161
R^2	0.07	0.07		0.28	0.27	
F (*df*)	7.3 (39)**	5.0 (39)**		81.4 (39)**	45.8 (39)**	

[a]Models also control for sex, age, race, Hispanic origin, education, marital status, region of the country, missing information for chronic conditions, and the use of a proxy respondent.
*.05 < *P* < .10; **$P < .05$;

TABLE 5—Contribution of Chronic Conditions to Change in Mean Number of Upper- and Lower-Body Limitations in Population 70 Years and Older: 1984–1995[a]

Condition	Upper-Body Limitations (n = 16 564) Contribution of			Lower-Body Limitations (n = 15 017) Contribution of		
	Change in Presence	Change in Limiting Effect	Total Contribution	Change in Presence	Change in Limiting Effect	Total Contribution
Osteoporosis	0.002 ± 0.002**	–0.005 ± 0.004**	–0.003 ± 0.005	0.025 ± 0.007**	–0.014 ± 0.016*	0.012 ± 0.017
Broken hip	0.000 ± 0.001	–0.001 ± 0.004	–0.001 ± 0.004	0.002 ± 0.006	0.000 ± 0.015	0.002 ± 0.016
Hypertension	0.000 ± 0.000	–0.006 ± 0.009	–0.006 ± 0.009	–0.001 ± 0.002	–0.009 ± 0.042	–0.010 ± 0.042
Stroke	0.002 ± 0.001**	–0.001 ± 0.006	0.001 ± 0.006	0.013 ± 0.008**	–0.002 ± 0.018	0.011 ± 0.020
Cancer	0.001 ± 0.001	0.004 ± 0.005*	0.005 ± 0.005**	0.008 ± 0.004**	0.004 ± 0.020	0.012 ± 0.021
Diabetes	0.000 ± 0.000	0.003 ± 0.004	0.004 ± 0.004	0.002 ± 0.004	0.007 ± 0.018	0.010 ± 0.019
Heart disease	0.002 ± 0.001**	–0.006 ± 0.006**	–0.004 ± 0.006	0.023 ± 0.007**	–0.013 ± 0.026	0.010 ± 0.027
Arthritis	0.001 ± 0.000**	–0.010 ± 0.011*	–0.009 ± 0.011*	0.009 ± 0.006**	–0.061 ± 0.047**	–0.052 ± 0.048**
Obesity	0.000 ± 0.000**	0.000 ± 0.003	0.000 ± 0.004	0.004 ± 0.004**	0.011 ± 0.018	0.015 ± 0.018*
All conditions	0.008 ± 0.003**	–0.022 ± 0.019**	–0.013 ± 0.019	0.085 ± 0.017**	–0.076 ± 0.081*	0.008 ± 0.083

[a]Contribution (± 1.96 SE) controlling for sex, age, race, Hispanic origin, education, marital status, region of the country, missing information for chronic conditions, and the use of a proxy respondent.
*.05 < *P* < .10; **P* < .05.

though our analysis used only 2 time points, limiting our ability to draw conclusions about trends, our findings are consistent with a growing body of evidence showing recent improvements in old-age functioning.[8–11,22] Furthermore, many of the increases we report in disease prevalence are consistent with recent epidemiologic evidence drawing on multiple years of data. Studies vary with respect to time period, measures of disease, and target populations; however, they document recent age-adjusted increases in the incidence of heart attack,[30] stroke,[31] and several forms of cancer[32–35] and in the prevalence of diabetes[36] and obesity[37] for older Americans. Better detection may be responsible in part for increases in the incidence of stroke,[31] some forms of cancer,[32–34] heart disease,[38] and osteoporosis; in other cases, increases do not appear to be an artifact of diagnostic changes.

Our study does not permit us to pinpoint why some diseases appear to have been less debilitating in 1995 than they were in 1984, but for some conditions, improved diagnostic capabilities likely have allowed earlier detection of less severe cases. Such is probably the case for osteoporosis, for which we found large increases in prevalence and improvements in functioning. Progress in disease management, in part due to changes in treatment, also may be contributing. For example, for arthritis, disease-modifying antirheumatic drugs,[39,40] increased accessibility of nonsteroidal anti-inflammatory drugs, and, for women, estrogen replacement therapy[41] may be associated with fewer debilitating effects. Moreover, changes in behavioral risk factors such as diet, exercise, and smoking, which have been linked to the expression of disease as disability in other studies,[6,42,43] also may play a role. Further research is clearly needed to evaluate the relative contributions of these potential explanations to improvements in old-age functioning.

Irrespective of whether disease is being identified earlier or treated and managed more successfully, our study suggests that much of the improvement in old-age functioning is not a result of the primary prevention of chronic disease. Such a finding has important implications for planning future medical and social services. Others have argued that continued declines in disability could help keep the Medicare trust fund in balance well into the future.[44] Such a conclusion is based on the assumption that lower rates of old-age disability imply less underlying chronic disease. If the patterns that we find persist, however, we might expect to find more, not less, treated disease. Our study suggests that projections of medical care costs that take into account both chronic disease and functioning trends are warranted.

Finally, this study provides additional evidence that those who predicted major increases in disability as mortality declined were overly pessimistic. Because of difficulties in sorting out improvements in detection from real increases in disease prevalence, this work cannot provide definitive support for either the compression of morbidity or the dynamic equilibrium perspectives, although the evidence appears to be more consistent with the latter. Regardless of which perspective ultimately prevails, the overarching conclusion of improved old-age functioning suggests that cautious optimism is in order as the United States prepares for an even larger older population in the future. □

Contributors

V. A. Freedman and L. G. Martin jointly conceived of and designed the study, interpreted the data, and wrote the paper. V. A. Freedman analyzed the data with input from L. G. Martin.

Acknowledgments

This work, much of which was conducted at RAND, was supported by National Institute on Aging grant R03-AG15596.

The authors thank Dr Hakan Aykan for his valuable assistance in preparing the data and weights for this analysis. The data were provided by the National Center for Health Statistics.

References

1. Agree EM, Freedman VA. The implications of population aging for geriatric health. In: Gallo JJ, ed. *Clinical Aspects of Aging.* 5th ed. Baltimore, Md: Williams & Wilkins; 1999:659–669.
2. Gruenberg EM. The failures of success. *Milbank Memorial Fund Q Health Soc.* 1977;55:3–24.
3. Kramer M. The increasing prevalence of mental disorders: a pandemic threat. *Psychiatr Q.* 1983; 55(2–3):115–143.
4. Fries JF. Aging, natural death and the compression of morbidity. *N Engl J Med.* 1980;303: 130–135.
5. Manton KG. Changing concepts of morbidity and mortality in the elderly population. *Milbank Memorial Fund Q Health Soc.* 1982;60:183–244.
6. Vita AJ, Terry RB, Hubert HB, Fries JF. Aging, health risks, and cumulative disability. *N Engl J Med.* 1998;338:1035–1041.
7. Robine JM, Mormiche P, Sermet C. Examination of the causes and mechanisms of the increase in disability-free life expectancy. *J Aging Health.* 1998;10:171–191.
8. Freedman VA, Martin LG. Understanding trends in functioning among older Americans. *Am J Public Health.* 1998;88:1457–1462.
9. Manton KG, Corder L, Stallard E. Estimates of change in chronic disability and institutional incidence and prevalence rates in the US elderly population from the 1982, 1984, and 1989 National Long Term Care Survey. *J Gerontol.* 1993; 48:S153–S166.

10. Manton KG, Corder L, Stallard E. Chronic disability trends in elderly United States populations: 1982–1994. *Proc Natl Acad Sci U S A.* 1997;94:2593–2598.
11. Waidmann TA, Manton KG. *International Evidence on Disability Trends Among the Elderly.* Washington, DC: US Dept of Health and Human Services, Office of Assistant Secretary for Planning and Evaluation, Office of Disability, Aging and Long Term Care Policy; 1998.
12. Crimmins EM, Saito Y, Reynolds SL. Further evidence on recent trends in the prevalence and incidence of disability among older Americans from two sources: the LSOA and the NHIS. *J Gerontol.* 1997;52B:S59–S71.
13. Allaire SH, LaValley MP, Evans SR, et al. Evidence for decline in disability and improved health among persons aged 55 to 70 years: the Framingham Heart Study. *Am J Public Health.* 1999;89:1678–1683.
14. Manton KG, Stallard E, Corder L. Changes in morbidity and chronic disability in the US elderly population: evidence from the 1982, 1984, and 1989 National Long Term Care Surveys. *J Gerontol.* 1995;50B:S194–S204.
15. Reynolds SL, Crimmins EM, Yasuhiko S. Cohort differences in disability and disease presence. *Gerontologist.* 1998;38:578–590.
16. Johnson RJ, Wolinsky FD. The structure of health status among older adults: disease, disability, functional limitation, and perceived health. *J Health Soc Behav.* 1993;34:105–121.
17. Boult C, Kane RL, Louis TA, Boult L, McCaffrey D. Chronic conditions that lead to functional limitation in the elderly. *J Gerontol.* 1994;49: M28–M36.
18. Crimmins EM, Saito Y. Getting better and getting worse: transitions in functional status among older Americans. *J Aging Health.* 1993;5:3–36.
19. Ferrucci L, Guralnik JM, Pahor M, Corti MC, Havlik RJ. Hospital diagnoses, Medicare charges, and nursing home admissions in the year when older persons become severely disabled. *JAMA.* 1997;277:728–734.
20. Lawrence RH, Jette AM. Disentangling the disablement process. *J Gerontol.* 1996;51B: S173–S182.
21. Verbrugge LM, Lepkowski JM, Imanaka Y. Comorbidity and its impact on disability. *Milbank Memorial Fund Q.* 1989;67(3–4):450–484.
22. Freedman VA, Martin LG. The role of education in explaining and forecasting trends in functional limitations among older Americans. *Demography.* 1999;36:461–473.
23. Nagi SZ. Some conceptual issues in disability and rehabilitation. In: Sussman MB, ed. *Sociology and Rehabilitation.* Washington, DC: American Sociological Association; 1965:100–113.
24. Nagi SZ. Disability concepts revisited: implications for prevention. In: Pope AM, Tarlov AR, eds. *Disability in America: Toward a National Agenda for Prevention.* Washington, DC: National Academy Press; 1991:309–327.
25. Verbrugge LM, Jette AM. The disablement process. *Soc Sci Med.* 1994;38:1–14.
26. Data File Documentation, National Health Interview Survey Second Supplement on Aging, 1994. Hyattsville, Md: National Center for Health Statistics; 1998.
27. Aykan H, Freedman VA, Martin LG. Re-weighting the Second Supplement on Aging for trend analyses. Santa Monica, Calif: RAND; 1999. Labor and Population Program Working Paper Series, No. DRU-2066-NIA.
28. Manton KG, Stallard E, Corder L. The dynamics of dimensions of age-related disability 1982 to 1995 in the US elderly population. *J Gerontol.* 1998;53A:B59–B70.
29. Kitagawa EM. Components of a difference between two rates. *J Am Stat Assoc.* 1955;50: 1168–1194.
30. Rosamond WD, Chambless LE, Folsom AR, et al. Trends in the incidence of myocardial infarction and in mortality due to coronary heart disease, 1987–1994. *N Engl J Med.* 1998;339: 861–867.
31. May DS, Kittner SJ. Use of Medicare claims data to estimate national trends in stroke incidence, 1985–1991. *Stroke.* 1994;25:2343–2347.
32. Chu KC, Tarone RE, Kessler LG, et al. Recent trends in US breast cancer incidence, survival, and mortality rates. *J Natl Cancer Inst.* 1996;6: 1571–1579.
33. Newcomer LM, Stanford JL, Blumenstein BA, Brawer MK. Temporal trends in rates of prostate cancer: declining incidence of advanced stage disease. *J Urol.* 1997;158:1427–1430.
34. Chow WH, Devesa SS, Blot WJ. Colon cancer incidence: recent trends in the United States. *Cancer Causes Control.* 1991;2:419–425.
35. Holford TR, Zheng T, Mayne ST, McKay LA. Time trends of non-Hodgkin's lymphoma: are they real? What do they mean? *Cancer Res.* 1992; 52:5443S–5446S.
36. Centers for Disease Control and Prevention. Trends in the prevalence and incidence of self-reported diabetes mellitus, 1980–1994. *MMWR Morb Mortal Wkly Rep.* 1997;46:1014–1018.
37. Galuska DA, Serdula M, Pamuk E. Trends in overweight among US adults from 1987 to 1993: a multistate telephone survey. *Am J Public Health.* 1996;86:1729–1735.
38. Haan MN, Selby JV, Rice DP, et al. Trends in cardiovascular disease incidence and survival in the elderly. *Ann Epidemiol.* 1996;6:348–356.
39. Fries JF, Williams CA, Morfeld D, Singh G, Sibley J. Reduction in long-term disability in patients with rheumatoid arthritis by disease-modifying antirheumatic drug-based treatment strategies. *Arthritis Rheum.* 1996;39:616–622.
40. Ward MM, Fries JF. Trends in antirheumatic medication use among patients with rheumatoid arthritis, 1981–1996. *J Rheumatol.* 1998;25: 408–416.
41. Zhang Y, McAlindon TE, Hannan MT, et al. Estrogen replacement therapy and worsening of radiographic knee osteoarthritis: the Framingham Study. *Arthritis Rheum.* 1998;41: 1867–1873.
42. van Baar ME, Dekker J, Oostendorp RA, et al. The effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: a randomized clinical trial. *J Rheumatol.* 1998;25: 2432–2439.
43. Fiatarone MA, O'Neill EF, Ryan ND, et al. Exercise training and nutritional supplementation for physical frailty in very elderly people. *N Engl J Med.* 1994;330:1769–1775.
44. Singer BH, Manton KG. The effects of health changes on projections of health service needs for the elderly population of the United States. *Proc Natl Acad Sci U S A.* 1998;95: 15618–15622.