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# Trends in Disability-Free Life Expectancy in the United States, 1970–90

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ARE AMERICANS LIVING longer healthy lives as well as longer lives? This article readdresses this question adding information for the 1980 to 1990 decade to already existing estimates for 1970 and 1980 to produce trends in disability-free life expectancy for a 20-year period in the United States. In recent years, people have begun to question the value of increasing life expectancy without increasing the length of healthy life. Research has shown that increases in total expected years of life are not necessarily accompanied by increases in the expected years of, or proportion of, disability-free life (Crimmins, Hayward, and Saito 1994; Crimmins, Saito, and Ingegneri 1989). Here we examine active or disability-free life expectancy at three dates for males and females in the United States to determine how total life expectancy and active life expectancy, the latter defined as disability-free life expectancy, have changed and how the changes vary for men and women over the two decades.

## Background

Emphasis on increasing quality as well as quantity of life has led to renewed interest in the estimation of active life expectancy among both policymakers and members of the research community. Active life expectancy offers a summary measure of the effects of differences and changes in health and mortality on the expected years of active and inactive life where active life can be defined according to a variety of states of health and functioning that represent life of a specified quality.

An indication of the perceived usefulness for policymakers of the concept of active life expectancy is the fact that in the United States “years of active life” are now included among national health goals for the year 2000

(Office of Disease Prevention and Health Promotion 1991). A conceptual approach similar to active life expectancy also has been employed by the World Bank in estimating the social costs of a variety of diseases in the poorer countries of the world in its Global Burden of Disease project (World Bank 1993).

Testimony to the interest of researchers in the concept of active life expectancy is provided by the large number of articles published over the last ten years containing estimates of active life expectancy for numerous countries and discussions of alternative computational strategies for obtaining these estimates (Bebbington 1988, 1991; Crimmins, Hayward, and Saito 1994; Laditka and Wolf 1997; Robine et al. 1986; Katz et al. 1983, 1985; Mathers 1991; Manton and Stallard 1990, 1991; Robine and Ritchie 1991; Rogers, Rogers, and Branch 1989; Rogers, Rogers, and Belanger 1990; Rogers, Rogers, and Belanger 1989).

Estimates of active life expectancy have been made for the US population for a number of dates using a variety of definitions (US Department of Health, Education, and Welfare 1969; Sullivan 1966, 1971a, 1971b; McKinlay and McKinlay 1979; McKinlay, McKinlay, and Beaglehold 1989; Colvez 1980; Colvez and Blanchet 1981, 1983; Erickson, Wilson, and Shannon 1995). Crimmins, Saito, and Ingegneri (1989) have made estimates for change over the 1970–80 decade. Estimates for multiple dates are also available for Great Britain (Bebbington 1988), Canada (Wilkins and Adams 1983), Australia (Mathers 1991), Netherlands (Perenboom, Boshuizen, and van de Water 1993), Sweden (National Board of Health and Welfare 1994), and France (Robine and Mormiche 1994). A meta-analysis of empirical results reflecting international experience through the early 1980s by Robine, Bucquet, and Ritchie (1991) has concluded that regardless of what time period, country, or measure is used, active life has not increased relative to total life when inactive life includes moderate or light disability. When inactive life is limited to severe disability, disability-free life expectancy has increased along with, and relative to, total life expectancy. These generalizations accurately characterize findings about change in active life expectancy in the United States between 1970 and 1980 (Crimmins, Saito, and Ingegneri 1989).

There is, however, reason to reinvestigate the trend in disability-free life expectancy for the United States in more recent years. There are indications of changing trends in the United States in mortality and disability, the basic components of disability-free life expectancy. For instance, mortality declines during the 1980s have occurred at a slower pace than during the previous 15 years. Also, recent research has reported declines in the prevalence of certain types of disability and of some diseases for older Americans for the latter half of the 1980s (Manton, Corder, and Stallard 1993; Manton, Stallard, and Corder 1995; Crimmins and Ingegneri 1993; Crimmins, Saito, and Reynolds 1997; Waidmann, Bound, and Schoenbaum

1995; Ycas 1987). In addition, increases in disability-free life expectancy have been noted in other countries. Between 1981 and 1991, France experienced remarkable increases in years of active life that exceeded increases in total life expectancy (Robine and Mormiche 1994).

Estimates of active life expectancy by sex have been made by a number of researchers. After reviewing a large number of studies, Robine, Mathers, and Brouard (1993) conclude that most find that both total life expectancy and disability-free life expectancy are longer for females than for males but that the proportion of disability-free years is lower for females. In 1970 and 1980, the disability-free life expectancy for females in the United States exceeded that of males, but the proportion of life without disability was only slightly lower among females (Crimmins, Saito, and Ingegneri 1989). Since 1980, however, the relative size of the mortality decline by sex has changed, with the pace of decline becoming relatively faster for males. This could result in differential trends in the relative length of active life expectancy by sex.

## Data and methods

In this study we define active life expectancy as disability-free life expectancy—years of life when an individual's health does not affect ability to perform the normal activities of life including both major and secondary activities. Major activities are going to school for children, and working, keeping house, or "something else" for adults. Secondary activities are the other things that people do. This is the definition of long-term disability used by the US National Center for Health Statistics as the basis for data collection in the National Health Interview Survey (NHIS), the primary data source for estimates of the disabled population. The NHIS is an annual survey of approximately 100,000 persons that is used to monitor the country's health and health care utilization. It has been ongoing since 1957. Our definition of inactivity or disability includes a range from moderate to severe disability, and the inactive population consists of two parts: those institutionalized for physical or mental health problems and those living in the community with an activity-limiting disability.

### The institutionalized population

Estimates of the proportion of the population institutionalized for mental or physical conditions by age and sex for 1970 and 1980 were computed using published material from the US Bureau of the Census and procedures described in Crimmins, Saito, and Ingegneri (1989). Estimates for 1990 were made from a combination of published and unpublished data supplied by the Bureau of the Census according to the method described in Appendix A.

**TABLE 1** Percent of the population institutionalized by sex and five-year age groups: United States 1970, 1980, and 1990

| Age group | Males |        |        | Females |        |        |
|-----------|-------|--------|--------|---------|--------|--------|
|           | 1970  | 1980   | 1990   | 1970    | 1980   | 1990   |
| 0-4       | 0.03  | 0.02*  | 0.02   | 0.03    | 0.01*  | 0.02*  |
| 5-9       | 0.14  | 0.06*  | 0.02*  | 0.10    | 0.04*  | 0.01*  |
| 10-14     | 0.30  | 0.18*  | 0.07*  | 0.18    | 0.11*  | 0.07*  |
| 15-19     | 0.40  | 0.32*  | 0.25*  | 0.28    | 0.20*  | 0.17*  |
| 20-24     | 0.45  | 0.35*  | 0.21*  | 0.24    | 0.18*  | 0.15*  |
| 25-29     | 0.44  | 0.38*  | 0.28*  | 0.25    | 0.21*  | 0.17*  |
| 30-34     | 0.45  | 0.37*  | 0.35*  | 0.27    | 0.20*  | 0.20   |
| 35-39     | 0.49  | 0.36*  | 0.32*  | 0.32    | 0.23*  | 0.17*  |
| 40-44     | 0.57  | 0.39*  | 0.32*  | 0.36    | 0.25*  | 0.19*  |
| 45-49     | 0.67  | 0.45*  | 0.34*  | 0.45    | 0.32*  | 0.24*  |
| 50-54     | 0.78  | 0.56*  | 0.41*  | 0.55    | 0.40*  | 0.31*  |
| 55-59     | 0.98  | 0.72*  | 0.57*  | 0.74    | 0.55*  | 0.42*  |
| 60-64     | 1.26  | 0.92*  | 0.82*  | 0.97    | 0.79*  | 0.67*  |
| 65-69     | 1.69  | 1.39*  | 1.21*  | 1.57    | 1.32*  | 1.12*  |
| 70-74     | 2.44  | 2.20*  | 2.01*  | 2.84    | 2.61*  | 2.24*  |
| 75-79     | 4.13  | 3.89*  | 3.64*  | 5.87    | 5.63*  | 4.88*  |
| 80-84     | 7.46  | 7.33   | 7.23   | 11.87   | 12.01  | 11.15* |
| 85+       | 12.89 | 16.09* | 17.27* | 20.76   | 26.25* | 28.22* |

\*Statistically significant difference at the 0.05 level between this percent and the percent ten years earlier.  
SOURCES: See text and Appendix A.

Across the 20-year period there has been a trend toward deinstitutionalization of the population at most ages (see Table 1). Between 1970 and 1980, the percent institutionalized declined at all ages below 80, remained unchanged in the 80-84 age group, and increased at age 85 and above. Between 1980 and 1990, the percent institutionalized continued to decline below age 80 and to rise above age 85. This pattern of age change is similar to the change in the nursing home population reported by Taeuber (1993).

### The noninstitutionalized disabled population

The noninstitutionalized disabled population is estimated from the National Health Interview Survey (NHIS) for the three years including and surrounding each of the census years. Three years of data are used to ensure stable age-sex-specific estimates.

An earlier publication (Crimmins, Saito, and Ingegneri 1989) provides extensive detail on our method of estimating the disabled population from the NHIS for 1970 and 1980. Here, we discuss the estimates for 1990. Because of changes in the wording of survey questions after 1981, the unad-

justed data for 1989–91 are not directly comparable to those for earlier years for some age groups. These changes especially affect the comparability of data for children and older persons (Chyba and Washington 1990). To provide comparable estimates of disability, we adjusted the data for some age groups for 1989, 1990, and 1991 to account for questionnaire changes, using information on the annual percentages of persons limited because of health for each group for each year from 1970 through 1991 and regression techniques. The aim of the adjustment was to shift the level of the estimate to reflect the effect of the questionnaire wording change while retaining any differences due to time trend. We performed an analysis of the trend for each age-sex group in the 1970 to 1991 period and in the subperiods 1970–81 and 1982–91 to determine the appropriate adjustment procedure for each age group. The adjustment procedures differed across age groups according to whether there were time trends across or within the periods before and after the questionnaire changes. The adjustment procedure and the questionnaire changes are described in Appendix B.

Disability change between 1980 and 1990 is very different from that between 1970 and 1980. Between 1970 and 1980, there was a small but significant increase in the level of disability in most age-sex groups below age 75 among the noninstitutionalized population (see Table 2). On the other hand, between 1980 and 1990 only two age-sex groups experienced a statistically significant increase in reported disability: males aged 10–14 and females 15–19. There was little change between 1980 and 1990 in the prevalence of disability in most age groups between age 20 and the early retirement years. Only men in their 30s experienced statistically significant declines in disability. However, there was some significant decline in disability among persons in the early retirement ages during the 1980s. Persons of both sexes in the early retirement age groups (60–69) experienced a decrease in the level of disability. Women 55–59 also experienced lower levels of limitation in 1990 than in 1980.

These findings are not surprising in light of other reports in the literature. For instance, a rise in disability as measured by activity limitation has been reported among young people during the 1960s and 1970s by Newacheck, Budetti, and Halfon (1986). Crimmins, Reynolds, and Saito (1995) report an improvement in ability to work among those in their 60s. Waidmann, Bound, and Schoenbaum (1995) report a decrease in the prevalence of some diseases among those above age 44. On the other hand, the findings appear to differ somewhat from those of Manton, Corder, and Stallard (1993) and Crimmins, Saito, and Reynolds (1997), who report decreases in disability among the older population. In both of the latter two cases, however, only more severe disability is included in contrast to this analysis. Crimmins (1996) has discussed in detail why different definitions of disability may result in different conclusions about trends and differences in disability.

**TABLE 2** Percent of the noninstitutionalized population with limitation of activity by sex and five-year age groups: United States 1970, 1980, 1990

| Age group | Males |        |        | Females |        |        |
|-----------|-------|--------|--------|---------|--------|--------|
|           | 1970  | 1980   | 1990   | 1970    | 1980   | 1990   |
| 0-4       | 1.84  | 2.19   | 2.69   | 1.40    | 1.96*  | 1.90   |
| 5-9       | 3.22  | 4.62*  | 4.22   | 2.22    | 3.08*  | 3.08   |
| 10-14     | 3.71  | 5.51*  | 7.25*  | 2.66    | 3.91*  | 3.61   |
| 15-19     | 5.91  | 5.80   | 5.64   | 3.96    | 5.12*  | 6.38*  |
| 20-24     | 9.56  | 6.75*  | 6.64   | 4.74    | 5.48*  | 5.93   |
| 25-29     | 7.80  | 8.52   | 7.26*  | 6.10    | 6.54   | 7.21   |
| 30-34     | 7.60  | 10.39* | 8.62*  | 7.12    | 8.82*  | 8.42   |
| 35-39     | 8.89  | 12.07* | 10.99  | 9.09    | 11.17* | 10.86  |
| 40-44     | 10.85 | 12.45* | 13.13  | 11.00   | 13.66* | 13.82  |
| 45-49     | 15.75 | 17.09  | 16.73  | 13.37   | 17.03* | 16.84  |
| 50-54     | 18.40 | 20.88* | 20.87  | 16.60   | 19.86* | 20.84  |
| 55-59     | 23.44 | 28.09* | 25.78* | 21.25   | 24.63* | 23.78  |
| 60-64     | 31.15 | 36.07* | 32.88* | 24.57   | 30.80* | 26.17* |
| 65-69     | 37.84 | 43.68* | 39.39* | 30.00   | 36.20* | 30.56* |
| 70-74     | 44.92 | 49.10* | 47.08  | 36.57   | 39.54* | 38.31  |
| 75-79     | 51.35 | 51.23  | 53.22  | 45.52   | 46.85  | 45.52  |
| 80-84     | 61.40 | 58.22  | 58.54  | 52.85   | 52.07  | 54.24  |
| 85+       | 65.00 | 65.33  | 62.79  | 68.22   | 64.77  | 64.41  |

\*Statistically significant difference at the 0.05 level between this percent and the percent ten years earlier.  
SOURCES: See text and Appendix B.

## Mortality rates

Decennial life tables of the United States for 1970 and 1980 and the 1990 annual life table are the basis of the mortality estimates used in constructing active life expectancy at the three dates. As noted earlier, the pace of mortality decline slowed considerably during the 1980s. Between 1970 and 1980 each sex gained three years of life expectancy at birth. The gains in life expectancy between 1980 and 1990 were much smaller, particularly for females. The increase in life expectancy at birth between 1980 and 1990 was only 1.7 years for males and 1.2 years for females. At age 65 males gained 1.2 years in the earlier decade and 0.9 years in the most recent decade. Female life expectancy at age 65 increased by 1.6 years between 1970 and 1980 and by 0.5 years between 1980 and 1990. For males the later increase was 75 percent the size of that for the previous decade. For females, the increase was only a third of that for the previous decade. Thus, the reduction in the rate of mortality decline was greater for females than males.

## Methodology

In this analysis we estimate disability-free life expectancy using prevalence life tables. The prevalence method gives an estimate of the expected years of life with and without disability, assuming current levels of disability prevalence and current mortality rates.

Using the prevalence method, we estimate active and inactive life by dividing the years lived in each age range of the life table population ( ${}_5L_x$ ) into institutionalized, disabled in the community, and free of disability in the community, using the observed prevalences of these states. These figures are then used to compute the life table value of the total remaining years of life ( $T_x$ ) and the corresponding life expectancy in each state for each age. Total life expectancy at any age is the sum of life expectancy in the three states. Reported figures consider both institutional and community life with a disability as inactive life expectancy. Further explanation of this method is provided in Crimmins, Saito, and Ingegneri (1989). Following Mathers (1991) we estimate age-specific survival without disability ( $l_x$ ).

Prevalence-based estimates of active life expectancy differ from traditional life tables and multistate approaches to active life expectancy in that they are based on a combination of incidence and prevalence data, that is, mortality incidence and disability prevalence. All estimates of active life expectancy that span the entire age range, including those for multiple dates, have been made using prevalence methods because available data allow only this approach (Crimmins and Hayward 1997).

There has been much discussion of the relative merits of the incidence and prevalence methods of estimating active life expectancy. Numerical results based on a prevalence method may differ from those based on an incidence method, and each method has its strengths and weaknesses (Crimmins, Saito, and Hayward 1993; Rogers, Rogers, and Belanger 1990; Mathers and Robine 1993). Using simulation exercises, Mathers and Robine (1993) have shown that prevalence and incidence methods of computing active life expectancy result in very similar conclusions except under unusual circumstances of very rapid change.

## Results

Total life expectancy, life expectancy free of disability, and disabled life in the community and in institutions are shown for men and women at three dates and three ages in Table 3. At birth, life expectancy free of disability increased for males over the whole time period and for females between 1980 and 1990. Between 1980 and 1990, over 90 percent of the increase in life expectancy at birth was in disability-free years for both sexes. For males there was a small increase in expected years at birth with disability



**TABLE 3** Expectation of life (in years) spent in various states of health, at birth, at age 65, and at age 85, by sex: United States 1970, 1980, and 1990

| Expectation of life          | Males |      |      |         |         | Females |      |      |         |         |
|------------------------------|-------|------|------|---------|---------|---------|------|------|---------|---------|
|                              | 1970  | 1980 | 1990 | Change  |         | 1970    | 1980 | 1990 | Change  |         |
|                              |       |      |      | 1970-80 | 1980-90 |         |      |      | 1970-80 | 1980-90 |
| <b>At birth</b>              |       |      |      |         |         |         |      |      |         |         |
| Total                        | 67.0  | 70.1 | 71.8 | 3.1     | 1.7     | 74.6    | 77.6 | 78.8 | 3.0     | 1.2     |
| Free of disability           | 56.5  | 57.2 | 58.8 | 0.7     | 1.6     | 62.7    | 62.8 | 63.9 | 0.1     | 1.1     |
| With disability in community | 10.0  | 12.2 | 12.4 | 2.2     | 0.2     | 10.9    | 13.4 | 13.4 | 2.5     | 0.0     |
| Institutionalized            | 0.6   | 0.6  | 0.7  | 0.0     | 0.1     | 1.1     | 1.4  | 1.4  | 0.3     | 0.0     |
| <b>At age 65</b>             |       |      |      |         |         |         |      |      |         |         |
| Total                        | 13.0  | 14.2 | 15.1 | 1.2     | 0.9     | 16.8    | 18.4 | 18.9 | 1.6     | 0.5     |
| Free of disability           | 6.6   | 6.8  | 7.4  | 0.2     | 0.6     | 9.1     | 9.3  | 9.8  | 0.2     | 0.5     |
| With disability in community | 5.8   | 6.8  | 7.0  | 1.0     | 0.2     | 6.6     | 7.6  | 7.5  | 1.0     | -0.1    |
| Institutionalized            | 0.5   | 0.6  | 0.6  | 0.1     | 0.0     | 1.1     | 1.5  | 1.5  | 0.4     | 0.0     |
| <b>At age 85</b>             |       |      |      |         |         |         |      |      |         |         |
| Total                        | 4.7   | 5.1  | 5.2  | 0.4     | 0.1     | 5.6     | 6.4  | 6.4  | 0.8     | 0.0     |
| Free of disability           | 1.4   | 1.5  | 1.6  | 0.1     | 0.1     | 1.4     | 1.7  | 1.6  | 0.3     | -0.1    |
| With disability in community | 2.7   | 2.8  | 2.7  | 0.1     | -0.1    | 3.0     | 3.0  | 3.0  | 0.0     | 0.0     |
| Institutionalized            | 0.6   | 0.8  | 0.9  | 0.2     | 0.1     | 1.2     | 1.7  | 1.8  | 0.5     | 0.1     |

NOTE: Sum of life expectancy in states sometimes does not add to total expectation of life because of rounding.

in the community, but there was no change in the value for females. There was little change in expected years in an institution for either sex. The 1980s contrast with the experience of the 1970s in that most of the increase in life expectancy during the 1970s was concentrated in expected years with a disability.

At age 65 similar generalizations can be made about change in the most recent decade. Most of the increase in life expectancy is in disability-free years—all of the increase in the case of females; there is no increase in the expected years of institutionalization; and there is some increase in the expected years disabled in the community among males but a small decrease for females. The above generalizations about change in the earlier decade also hold for this age group; that is, most of the increase in life expectancy in the 1970s was concentrated in disabled years.

The 1980s were a time of virtually no change in any of these measures for the population 85 years of age and over. Years of total life ex-

pected, expected years of disabled life in the community, and years expected in an institution all stayed virtually constant. This decade of no change followed a decade in which increased years of life had been concentrated in one of the disabled states.

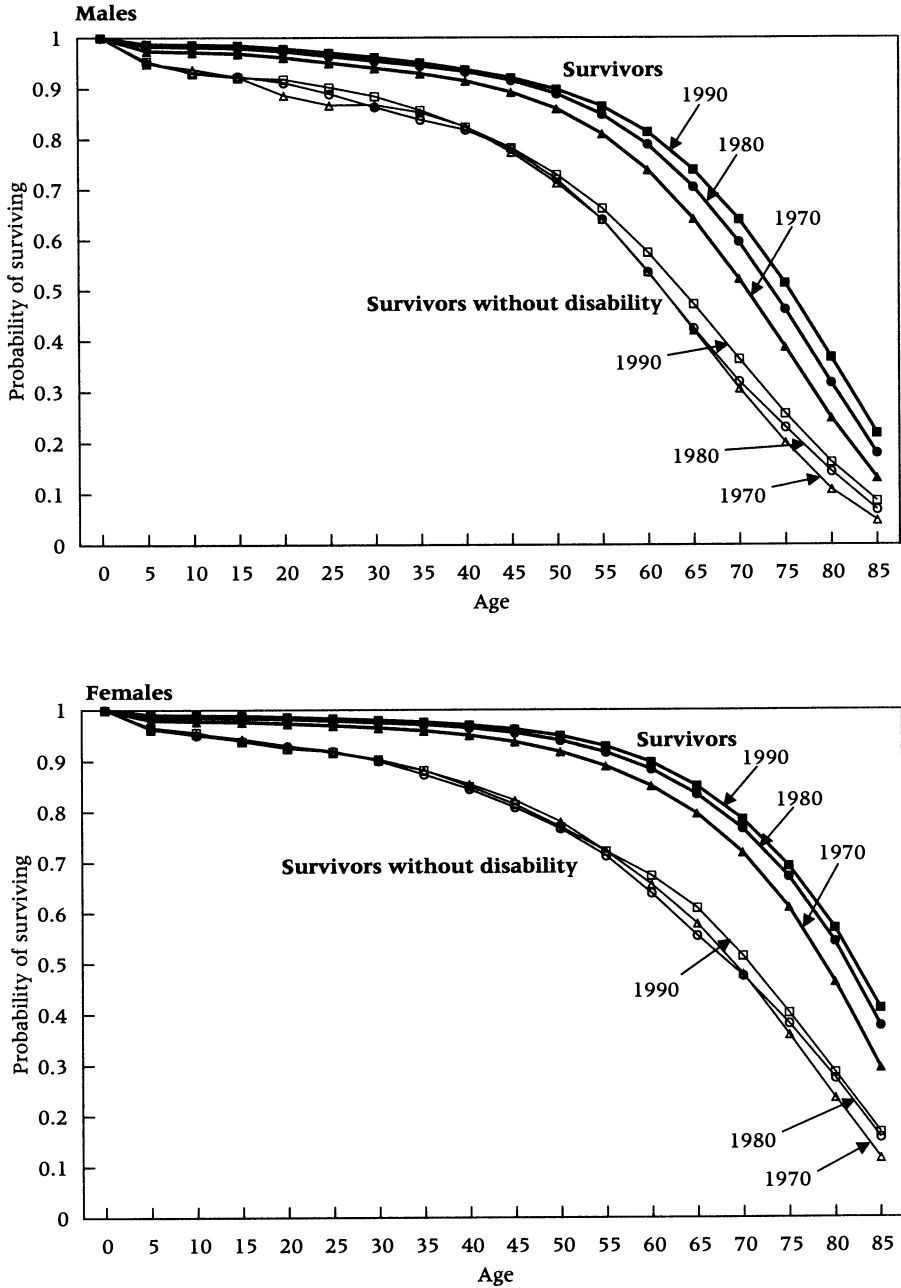
As expected, female total life expectancy and life expectancy in each state exceed male values at all dates. The only exception to this generalization is that expected years free of disability at age 85 are the same for both sexes at two of the dates. This means that at the oldest ages men and women differ only in the length of disabled life, not in the length of nondisabled life.

The life table probabilities of surviving from birth to each age and the probabilities of surviving without disability for 1970, 1980, and 1990 are shown in Figure 1. Note the wider differences in the survival curves between 1980 and 1970 than between 1990 and 1980. Fries (1980) originally hypothesized that with the compression of morbidity, the survival curve should become relatively fixed as a maximum life span is approached and, at the same time, the survival-without-disability curve should move closer to the total survival curve, indicating a reduction in the relative length of time with morbidity. Examination of the curves for survival from disability and overall survival for three dates shows that the mortality survival curve continues to move outward, indicating increased probabilities of survival from birth to each age; but only in the most recent decade has the survival-without-disability curve begun to move outward, and, as shown earlier, this is only true for the late middle ages and early older ages.

An increase in the proportion of disability-free life has been suggested as an indication of the compression of morbidity. Examination of this indicator shows little compression over the most recent decade even though there was an increase in the expected length of life without disability (see Table 4). However, there is some indication of a compression of morbidity in the most recent decade for those in the older ages. For males at ages 65 and 85, and for females at age 65, the proportion of expected life that is disability-free increased slightly between 1980 and 1990. While the change is slight, the direction of change is opposite to that observed in the preceding decade, which, by this measure, was a decade of increasing morbidity.

At birth, the proportional distribution by various states of health of the expected total length of life is virtually identical for men and women in 1990. At the older ages this is not the case. The proportion of expected life free from disability at age 65 is higher for women than for men but this is reversed by age 85. This reversal may be due to more selective survival among men at the oldest ages. A marked difference by sex in the expected proportion of life spent institutionalized also appears at the oldest ages. A 65-year-old woman can expect to spend 8 percent of her remaining life in an institution; for a man the expected proportion is only half as large.

**FIGURE 1** Life table probabilities of surviving from birth to each age and probabilities of surviving without disability, by sex: United States 1970, 1980, 1990



**TABLE 4** Percent of expected life in various states of health, at birth, at age 65, and at age 85, by sex: United States 1970, 1980, and 1990

| Expectation of life          | Males |       |       | Females |       |       |
|------------------------------|-------|-------|-------|---------|-------|-------|
|                              | 1970  | 1980  | 1990  | 1970    | 1980  | 1990  |
| <b>At birth</b>              |       |       |       |         |       |       |
| Total                        | 100.0 | 100.0 | 100.0 | 100.0   | 100.0 | 100.0 |
| Free of disability           | 84.2  | 81.6  | 81.8  | 84.0    | 80.9  | 81.1  |
| With disability in community | 14.9  | 17.4  | 17.3  | 14.6    | 17.3  | 17.0  |
| Institutionalized            | 0.9   | 0.9   | 0.9   | 1.5     | 1.8   | 1.8   |
| <b>At age 65</b>             |       |       |       |         |       |       |
| Total                        | 100.0 | 100.0 | 100.0 | 100.0   | 100.0 | 100.0 |
| Free of disability           | 51.2  | 47.8  | 49.1  | 54.2    | 50.5  | 52.0  |
| With disability in community | 45.0  | 48.0  | 46.6  | 39.2    | 41.5  | 39.9  |
| Institutionalized            | 3.8   | 4.2   | 4.3   | 6.6     | 8.0   | 8.1   |
| <b>At age 85</b>             |       |       |       |         |       |       |
| Total                        | 100.0 | 100.0 | 100.0 | 100.0   | 100.0 | 100.0 |
| Free of disability           | 30.4  | 29.0  | 30.8  | 25.2    | 26.0  | 25.5  |
| With disability in community | 56.7  | 55.0  | 51.9  | 54.0    | 47.6  | 46.2  |
| Institutionalized            | 12.9  | 16.0  | 17.3  | 20.8    | 26.3  | 28.2  |

NOTE: Life expectancy in states sometimes does not add to 100 percent because of rounding.

## Conclusion

This analysis provides evidence for the United States that in the 1980s increases in life expectancy were concentrated in years spent without disability. This stands in remarkable contrast to the preceding decade when almost all of the increase in life expectancy was in disabled years. While this outcome is true for both males and females, the increases in both life expectancy and in life expectancy free of disability for males have been much larger than those for females.

The primary reason for the increase in disability-free life expectancy is a decrease in the proportion of the community-dwelling population who are disabled among those in their late 50s and their 60s. While the institutionalized population at most ages continued to decline, this trend had very little effect on the expected overall length of disabled life. The age groups for which disability declined were comprised primarily of those who reached adulthood before World War II in 1980 and after World War II in 1990. Cohort experiences in education, the labor force, and socioeconomic circumstances are one potential explanation for the improved disability sta-

tus from 1980 to 1990. In addition, medical advances may be reducing the likelihood that diseases progress to disabling conditions. The improvement between 1980 and 1990 may be concentrated among those in their late 50s and 60s because these groups have had significantly different life-time experiences that affect the onset of disability.

Even though the expected length of disability-free life has increased over the 1980–90 decade, there has been very little increase in the proportion of life without disability. Using this measure as an indicator of the compression of morbidity, there has been a slight compression during the recent decade at the older ages. Given the expansion of morbidity during the 1970s, even a small compression is an improvement over prior change. Returning to our original question, we answer that Americans are living longer healthy lives in 1990 than in 1980 both absolutely and, at some ages, proportionately.

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## Appendix A

### Estimating the proportion of the population institutionalized because of a mental or physical condition in 1990

Data from the 1990 census of the US population are used to estimate the age-specific proportion of the population institutionalized for mental and physical disabilities. Estimates were made because sufficient detail on the type of institution was not published, nor could it be computed from the public-use census tapes.

Data to make estimates were drawn from the following published and unpublished tables:

—Table 13. Single years of age by sex, race, and Hispanic origin: 1990 (US Bureau of the Census 1992)

—Table 35. Persons in group quarters by type of group quarters, sex, race, and Hispanic origin: 1990 (US Bureau of the Census 1992)

—Group quarters by selected age groups: 1990 (Dialog Information Services 1992)

—Special Tabulation for Department of Health and Human Services, Health Care Financing Administration, STP 16. Institutionalized population in group quarters by type of group quarters, age, and sex (US Bureau of the Census 1994).

The number of persons institutionalized for mental and physical disabilities by five-year age groups was calculated by adding the number of persons in:

- Mental (psychiatric) hospitals (from Special Tabulation)
- Homes for the aged (from Special Tabulation)
- Other institutional group quarters excluding correctional institutions and juvenile institutions (from Special Tabulation and Table 35)
- Homes for the mentally ill, mentally retarded, and physically handicapped (from Group quarters by selected age groups: 1990).

The number of persons in mental hospitals and homes for the aged is tabulated by sex and five-year age groups. As tabulated, the number of persons in other institutional group quarters includes persons in juvenile institutions and hospitals or wards for drug/alcohol abuse. To estimate the number of those institutionalized only for health reasons, we subtracted the total number of males and females in juvenile institutions from each five-year age group under 20 for both sexes. Because it is not available for 1990, we assumed the distribution of those in juvenile institutions by age and sex to be the same as in 1980. The number of persons in hospitals or wards for drug/alcohol abuse could not be subtracted from the total in other institutional group quarters because no information was available regarding the age distribution of persons in such hospitals. However, those in hospitals or wards for drug/alcohol abuse comprise only about one-third of one percent of males in all group quarters and less than one-quarter of one percent of females in all group quarters.

The number of persons by age and sex in group homes for the mentally ill, mentally retarded, and physically handicapped was not available from the Bureau of the Census. Table 35, cited above, presents this information for males and females. The table titled Group quarters by selected age groups: 1990 presents this information by three age groups: 0–17, 18–34, 35 and older. This broad age distribution was assumed to vary insignificantly by sex. For each sex, the total number of persons in homes for the mentally ill, mentally retarded, and physically handicapped was distributed across approximations of three age groupings—0–19, 20–34, 35 and older—based on the observed distribution for the total population. Within these age groupings, the number of persons in homes for the mentally ill, mentally retarded, and physically handicapped was distributed by five-year age groups according to the age distribution of other persons in institutions for mental and physical disabilities.

## Appendix B

### Estimating the proportion disabled among the community-dwelling population

Through 1981, long-term disability in the National Health Interview Survey was indicated by responses to a series of questions that begin by categorizing people according to their usual activity during the past 12 months. Usual activities included working, keeping house, being retired, going to school, or something else. Children less than age 6 were assumed to have play as a usual activity. People were then asked whether, because of health, they were able to do their usual activity at all, or whether they were limited in the “kind or amount” of this activity. People who were retired were asked about ability to work. Finally, if no limitation in major activity was reported, people were asked whether they were limited in “any way” because of health. In our analysis any limitation in activity is regarded as a disability and a part of inactive life.

Beginning in 1982, the questions on activity limitation were slightly revised for older persons and school-age children. These revisions, while they make sense

in light of what we know about age-specific usual activities, make analysis over time difficult. People 70 years of age and older (actually age 69 and older in 1982) were asked about ability to perform "personal care and routine needs" rather than the normal activities of housekeeping or working that were referenced at other ages and in earlier years for older persons. Questions about ability to attend school were asked for those aged 5 through 17, whereas previously these questions had been asked for those 6 through 16. In addition, the question was changed to include special school classes as well as special schools in defining limitation of activity. Finally, up to 1982, men were not assigned to housekeeping as a major activity, but thereafter men could be classified as housekeepers; however, only 1.5 percent of men above age 30 were so classified in 1983.

To provide estimates of disability comparable to those for earlier years, we adjusted the data for 1989, 1990, and 1991 for these changes using regression techniques and information on the annual percentages of persons limited because of health for each group for each year from 1970 through 1991. Because the change in the questionnaire affected only some age groups, the adjustment procedure affects only a portion of the population. In their evaluation of the effect of questionnaire changes, Chyba and Washington observe noticeable differences between 1981 and 1983 in the percent with an activity limitation both among children and older persons, differences that are consistent with the questionnaire changes (1990: 163). Following their analysis we developed procedures for adjusting the percent limited because of health for those aged 5-9, 10-14, 15-19, and 65 and older for both sexes. In addition, because of the potential effect of the change in the use of housekeeping as a major activity for males, we considered the possible effect of this on males who might at one time have reported their activity as retired. We tested for such an effect for males 45 years of age and older. Also, because of change in the use of retirement as a category of usual activity, we also adjusted the data for women aged 60-64.

We estimated the shift in the value of the percent limited because of health caused by the change in the questionnaire for each age-sex group. Our approach varies depending upon the trends for the periods before and after the questionnaire switch. First, we determined the time trends in the two periods, 1970-81 and 1982-91 (1983-91 for those 65-69 years of age). We assumed that if there was no trend in the proportion limited because of health between 1982 and 1991, the effect of the change in the questionnaire should be reflected in the difference in means between the two time periods. Then we subtracted a coefficient for the dummy variable representing this shift from the computed proportion limited because of health for 1989-91. We did this for those aged 5-9 and those aged 70 and older of both sexes, for males 15-19, 45-49, and 50-54, and for females 10-14.

Where there is a time trend, this was taken into account. For instance, for males aged 10-14 the trend in the proportion limited because of health increases over the whole period, with a jump in 1982. We included time as an independent variable in a regression analysis to remove the effect of the trend, and we estimated the effect of the shift with a dummy variable representing the period of questionnaire change (1982-91). This effect we then used to estimate the value for 1989-91.

On the other hand, for females 15–19 there is no trend in the first period but an increase in the proportion limited because of health in the second period. The difference between the mean value of the percent not limited because of health in the first period and the estimated value for 1981 is the adjustment factor.

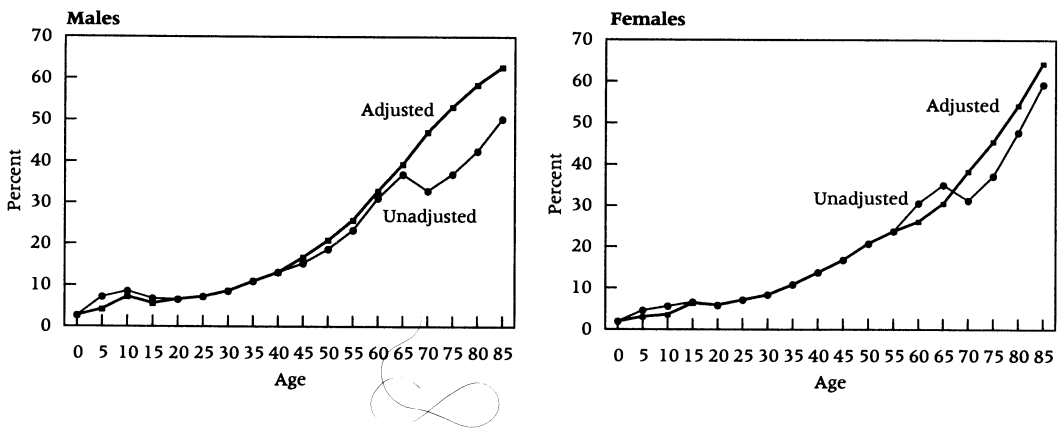
For age groups 60–64 and 65–69 for both sexes and 55–59 for males, the time trends observed in the two time periods are in opposite directions: increases in limitation because of health during the 1970s and decreases during the 1980s. To adjust for questionnaire changes, we computed two estimated values for 1981 using time trend regression coefficients for equations based on 1970–81 and 1982–91. The difference between the two values for 1981 is regarded as the effect of the questionnaire change and is used to adjust the observed 1989–91 value.

Adjustments were made for 12 five-year age groups for males and nine five-year age groups for females. For males, this included the three five-year age groups between 5 and 19, and the nine five-year age groups for age 45 and older; for females, this included the three five-year age groups between 5 and 19, and the six age groups above age 60. The adjusted percent limited because of health for each age group and the original percent limited because of health are shown in Appendix Figure 1.

As is obvious from the figures, the adjustment increases the estimated percent disabled at the older ages by compensating for the change in the definition of disability at these ages. At the younger ages the adjustment lowers the figures somewhat in order to compensate for the change in the definition of what constitutes a disability among the school-age population. For men from ages 45 to 69, the adjustment raises only slightly the estimated percent with disability; for women in their 60s, the estimated figures lower the percent slightly.

To test the sensitivity of our conclusions to the adjustment procedure, we also calculated disability-free life expectancy without any adjustments for the age groups below age 70. The estimates of disability-free life expectancy at birth and at age 65 are shown in Appendix Table 1. For males, the adjustments for ages less

**APPENDIX FIGURE 1 Percent limited in activity because of impairment of health, by sex: United States, 1990, adjusted and unadjusted**





**APPENDIX TABLE 1** Estimates of disability-free life expectancy (in years) in 1990 made with and without adjustments to the basic data for the population less than age 70

| Age       | Males    |            | Females  |            |
|-----------|----------|------------|----------|------------|
|           | Adjusted | Unadjusted | Adjusted | Unadjusted |
| At birth  | 58.8     | 58.9       | 63.9     | 63.4       |
| At age 65 | 7.4      | 7.5        | 9.8      | 9.6        |

than 70 make almost no difference in the estimates. For females, the adjustments make a greater difference. At birth, the size of the increase in female disability-free life expectancy would only be about half as large as with adjustments. The increase for women at age 65 without adjustment would be 60 percent of that with adjustment.

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