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HEALTHY PEOPLE 2000 Statistical Notes

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Years of Healthy Life

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Introduction

Increasing the span of healthy life for Americans is one of the three broad goals of *Healthy People 2000*[1] (1). The years of healthy life measure has been selected for monitoring progress toward this goal. The sources and methods used for calculating years of healthy life are described in this issue of *Statistical Notes*. Estimated years of healthy life measures for 1990 for the total U.S. population and for selected subgroups are presented and discussed.

Historically, health has been measured primarily in terms of mortality—infant mortality, life expectancy, age-specific and disease-specific death rates—and morbidity—disability days and prevalence of chronic conditions. On the one hand, measures of mortality may understate the public health importance of conditions that result in proportionately more morbidity and disability. On the other hand, commonly used morbidity measures tend to focus on physical function

and thus may underestimate social and mental dysfunction as well as satisfaction with health. In addition, these traditional indicators do not provide summary information on a population's health status.

A single measure that incorporates health-related quality of life and life expectancy gives a more comprehensive picture of the population's health. Such a summary number would help in monitoring the Nation's health, identifying health priorities, evaluating the effectiveness of interventions, and comparing the effectiveness of different interventions. Several approaches to the development of a comprehensive measure have been taken, including Disability Free Life Years (2,3), Healthy Life Expectancy (4,5), and Disability Adjusted Life Years (6). The years of healthy life (YHL) concept, however, has emerged as one of the more commonly used health status measures that include both mortality and morbidity. Years of healthy life can be sensitive to changes in health among the well and the ill.

Definition of years of healthy life

Health and well-being can be defined and measured in many ways. For example, symptoms usually involve

the assessment of physical and psychological sensations, such as pain and feelings of anxiety, which are not directly observable. Physical functioning may be measured in terms of being confined to bed, couch, or chair due to health reasons, or in terms of health-related limitations in mobility. Social functioning may be measured in terms of an individual's limitation in performing one's usual social role, whether it is work, housework, or school. Health perceptions are assessed in terms of subjective evaluations of health and satisfaction with health. Social opportunity includes resilience and coping and can be measured in terms of social impact due to health. When symptoms and subjective complaints; mental, physical, and social functioning; general health perceptions; and social opportunity are combined to describe health, the resulting multidimensional concept is generally referred to as health-related quality of life (7).

Combining measures of different concepts of health into a single number requires a conceptual model that considers health as a continuum ranging from perfect health to death (or worse). Between these two points are a number of discrete health states. These states are defined in terms of one or more concepts of health-related quality of life. For example, when health is defined as excellent, very good, good, fair, or poor perceived health, then each state corresponds to one of these five possible responses. When the definition of health-related quality of life is expanded to include two concepts (for example, perceived health and activity limitation) then each health state is indicated by two dimensions. For example, a person may be in excellent health and have no activity limitations or a person may be in good health but unable to perform his or her major activity, such as going to work or school.

To convert this conceptual model into an operational definition of health-related quality of life, death is assigned a value of 0.0 and optimal health is assigned a value of 1.0. Health states falling between these two points are assigned numbers that represent the values that either society as a whole or individuals place on being in each health state. Various methods from economic and psychometric theories have been used to determine the values for different health states (7,8).

Of the many measures of health-related quality of life that are available, three are based on the continuum model of health and are suitable for monitoring the health of the general population. The EuroQOL defines health in terms of mobility, self-care, main activity, pain, mood, and social relationships (9). The HUI-I defines health in terms of physical, role, and social and emotional function as well as health problems (10). The Quality of Well-Being Scale defines health in terms of mobility, physical activity, social activity, and symptoms and problems (11,12).

The health states and values from these, as well as other similarly constructed measures, can be used to numerically summarize the health of an individual or group of individuals. These summary scores can be interpreted as representing the overall level of functioning for either an individual or a group of individuals for a specified time period. For example, a health state that has a value of 0.75 represents 75 percent of full function over the time interval, such as 1 year.

Measures of years of healthy life are obtained when the values representing states along the health continuum are used to modify duration of life. In practice, the years of healthy life measure uses a life expectancy model in which standard life table data are adjusted by the health-related quality of life of a population.

A measure of years of healthy life for *Healthy People 2000*

The questions needed to produce data for calculating years of healthy life from any of the existing methods, however, have not been adopted for regular use in national surveys, such as the National Health Interview Survey. Although analogues of these measures can be created using national data (13–15), these data have not been available annually. As a result, neither existing measures nor retrospective analysis can be used for annual monitoring of progress toward the overall goal in *Healthy People 2000*.

It has been necessary, therefore, to develop a measure of healthy life using data that were collected in 1990 and will be available for each year until 2000. The requirement for annual measurement of years of healthy life logically leads to the use of the National Health Interview Survey as the major source of data. In the National Health Interview Survey, information is collected in an ongoing national sample of approximately 50,000 households (16). The sample represents the resident civilian noninstitutionalized population of the United States living at the time of the interview. The sample does not include persons residing in nursing homes or other institutionalized settings, members of the armed forces, or U.S. nationals living abroad. Information on the size of these nonhousehold populations is available from the 1990 U.S. Census and can be used to supplement data from the National Health Interview Survey to produce years of healthy life estimates for the entire U.S. population.

Topics included in the first part of the National Health Interview Survey, frequently referred to as the "core" questionnaire, remain the same from year to year. The rest of the National Health Interview Survey consists of special supplements that change yearly. Therefore, only data from the core questionnaire could

be used to produce annual estimates of health-related quality of life. Among the health characteristics measured by the National Health Interview Survey core are the incidence of acute conditions, the prevalence of chronic conditions, limitation of activity due to chronic conditions, restriction in activity due to impairment or health problems, perceived health status, and utilization of health care services.

Some data from the National Health Interview Survey core have limitations that preclude their inclusion in the development of a healthy life measure for measuring years of healthy life. For example, although the utilization of health services is sometimes used as a proxy measure of health status, the interpretation of health status from changes in utilization can be difficult. Increased health services utilization may represent increased access to health care services for persons with relatively low health status or may reflect a relatively high health status due to better medical care. Therefore, measures of utilization were excluded from consideration in the development of the new comprehensive measure. Information on conditions was also excluded because comprehensive information on acute and chronic conditions is not collected on all persons in the National Health Interview Survey.

Consequently, activity limitation and perceived health were selected to generate a measure of healthy life for use in calculating years of healthy life during the 1990's. Data for both concepts are collected in the core questionnaire of the National Health Interview Survey for all survey respondents and are direct, rather than indirect, measures of health status. The National Health Interview Survey core questionnaire for both topics has remained the same each year beginning in the early 1980's; trend data are available from 1984. The redesign of the National Health Interview Survey that is planned for 1996 will include questions about activity limitation and perceived health so that comparable data will be available through this decade.

The *Healthy People 2000* years of healthy life measure provides a meaningful summary of health-related quality of life given the need for annual, available data. This measure of years of healthy life will be used to track the objectives in *Healthy People 2000* throughout the decade.

Development of the *Healthy People 2000* years of healthy life measure

The following sections describe the procedures for using data from the National Health Interview Survey to assign values to health states as measured by activity limitation and perceived health. These health-related quality-of-life data are then combined with mortality data to produce estimates of years of healthy life.

Health-related quality of life

Two types of information from the National Health Interview Survey, activity limitation and perceived health, are used to form an operational definition of health-related quality of life. Activity limitation captures a person's ability to perform the social role that is usually associated with his or her particular age group, for example, working, keeping house, or going to school (3). For the *Healthy People 2000* measure of health-related quality of life, each person is classified into one of the following six categories based on age and ability to perform a major activity:

- not limited: not limited in any way
- limited-other: not limited in major activity, but limited in other activities
- limited-major: limited in major activity
- unable-major: unable to perform major activity
- limited in IADL: unable to perform instrumental activities of daily living (IADL) without the help of other persons
- limited in ADL: unable to perform self-care activities of daily living (ADL) without the help of other persons.

The National Health Interview Survey questions used to classify persons into one of these six categories of activity limitation according to age group are shown in table I in the Technical notes. Precise definitions for each category are given in table II in the Technical notes. Persons who could be classified into two or more categories are assigned to the category representing the most dysfunction. For example, persons who report having limitations in performing all IADL's and need help with ADL's are assigned to the "Limited in activities of daily living" category, the more severe limitation.

Each National Health Interview Survey respondent is asked the following question about perceived health status: "Would you say your health in general is excellent, very good, good, fair, or poor?" The response to the question on perceived health status is used to form a matrix with the six categories of activity limitation. This matrix yields an operational definition of health-related quality of life consisting of 30 possible health states, ranging from the optimal level of not limited in activity and in excellent health to the lowest health state of needing help to perform self-care activities of daily living and being in poor health. The estimated number and percent of persons in each of these health states (based on the National Health Interview Survey) are shown in tables 1 and 2. In 1990, over 202 million persons, or almost 83 percent of the noninstitutionalized population, had no role limitation and were perceived to be in excellent, very good, or good health. Approximately 1 percent of the

Table 1. Number of persons in the civilian noninstitutionalized U.S. population, by health state defined in terms of activity limitation and perceived health status: National Health Interview Survey, 1990

Activity limitation	Perceived health status				
	Excellent	Very good	Good	Fair	Poor
	Number in thousands				
Not limited	93,362	64,336	44,538	8,127	853
Limited-other	1,558	2,709	4,316	3,087	1,023
Limited-major	1,131	1,823	3,075	1,828	529
Unable-major	261	455	1,308	1,525	1,283
Limited in IADL[1]	237	470	1,242	1,586	1,451
Limited in ADL[2].	80	206	555	692	1,203

[1]IADL is instrumental activities of daily living.
[2]ADL is activities of daily living.

Source: National Health Interview Survey, Centers for Disease Control and Prevention, National Center for Health Statistics.

Table 2. Percent of persons in the civilian noninstitutionalized U.S. population, by health state defined in terms of activity limitation and perceived health status: National Health Interview Survey, 1990

Activity limitation	Perceived health status				
	Excellent	Very good	Good	Fair	Poor
Not limited	38.1	26.3	18.2	3.3	0.3
Limited-other	0.6	1.1	1.8	1.3	0.4
Limited-major	0.5	0.7	1.3	0.7	0.2
Unable-major	0.1	0.2	0.5	0.6	0.5
Limited in IADL[1]	0.1	0.2	0.5	0.6	0.6
Limited in ADL[2].	<0.1	0.1	0.2	0.3	0.5

[1]IADL is instrumental activities of daily living.
[2]ADL is activities of daily living.

Source: National Health Interview Survey, Centers for Disease Control and Prevention, National Center for Health Statistics.

population was in the lowest three health states, that is, limited in ADL and in good, fair, or poor health.

According to the 1990 Census, approximately 5 million Americans either were living in institutions—including correctional facilities, nursing homes, long-term stay hospitals, and residential care facilities—or were serving in the armed forces. Because health status data were unavailable for these persons, they were assigned to health states based on existing information and assumptions about their activity limitations and perceived health.

Using the work of Colsher and colleagues (17), the approximately 1,115,000 prisoners in correctional facilities in 1990 were considered limited in major activity and in very good health. The approximately 1,772,000 nursing home residents who were identified in the 1990 Census were assumed to be limited in activities of daily living and in fair health.

The more than 342,000 persons who were in long-term stay hospitals[2] in 1990 were considered to be limited in IADL and in good health. According to the 1990 Census, approximately 104,000 persons less than 30 years of age were in residential care facilities. These persons were assumed to be limited in other activities, but not in their major activity, and in good health.

The military population of 1.7 million persons in 1990 comprises a basically healthy group, that is, one that is considered to be in excellent health and with no limitations in usual activity. The combined institutional and noninstitutional populations for each of the health-state groups discussed above are used in the subsequent calculations to estimate years of healthy life for the total population in 1990.

Valuing health states of health-related quality of life

Values were assigned to each of the 30 cells in the matrix defined by perceived health and role limitation using multiattribute utility scaling (18). The method

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[2]Long-term stay hospitals include facilities for treatment of drug and alcohol abuse and care for chronically ill, mentally ill, and handicapped persons.

Table 3. Values for health states defined in terms of activity limitation and perceived health status

Activity limitation	Perceived health status				
	Excellent	Very good	Good	Fair	Poor
Not limited	1.00	0.92	0.84	0.63	0.47
Limited-other	0.87	0.79	0.72	0.52	0.38
Limited-major	0.81	0.74	0.67	0.48	0.34
Unable-major	0.68	0.62	0.55	0.38	0.25
Limited in IADL[1]	0.57	0.51	0.45	0.29	0.17
Limited in ADL[2]	0.47	0.41	0.36	0.21	0.10

[1]IADL is instrumental activities of daily living.

[2]ADL is activities of daily living.

Source: National Health Interview Survey, Centers for Disease Control and Prevention, National Center for Health Statistics.

and assumptions for arriving at the values are described in the Technical notes. Values range from 1.00 for persons who have no role limitation and are in excellent health to 0.10 for persons who are limited in ADL and are in poor health (table 3). According to these values, if a person lives 1 year in excellent health and has no limitation in activity, then he or she has 1 full year of healthy life. Other health states result in less than a full year of healthy life. For example, a health state that is defined as being limited in major activity and in good health represents a person having 67 percent of full function for the year.

Estimating health-related quality of life

It is possible to estimate an individual's health-related quality of life by using the health states defined by activity limitation and perceived health along with the values for these weights (table 3). To estimate health-related quality of life for a population, one needs the number of persons in and the score for each health state and the ages of the persons in the population.[3] Health status information on institutionalized and noninstitutionalized persons is combined to estimate health-related quality of life for the total U.S. population (table 4). This table shows the total number of persons, or person-years, and the quality-adjusted person-years for each population by 5-year age groups. Since the health states, in terms of perceived health and activity limitation, have been assumed for each institutionalized population, all

persons within each of these populations are considered to be in the same health state. For example, the total number of prisoners within each age group (column 4) was adjusted by 0.74, the value that is associated with being limited in major activity and having very good perceived health status from table 3. The adjusted figures are shown in column 5. Similar adjustments were made to the other institutionalized groups; the values used to adjust these groups are under the headings for columns 5, 7, 9, 11, and 12 in table 4.

Summing across the total and adjusted populations gives the total person-years for the United States (institutionalized and noninstitutionalized populations combined). These sums are shown in columns 13 and 14. Column 15 (Q) is generated by dividing the number of quality-adjusted person-years (column 14) by the total population (column 13). One way Q can be understood is as the average health-related quality-of-life score for each age group in the U.S. population. For example, persons 45–50 years of age had an average health-related quality of life that is 86 percent of full health. Persons 65–70 years of age, however, had an average score of about three-fourths of full health.

Combining health-related quality of life with mortality

Following the method for adjusting life expectancy using national health status data that was first implemented by Sullivan (3), calculation of years of healthy life starts with two sets of data—an abridged life table and age-specific estimates of health-related quality of life of the U.S. population. An abridged life table for a given population and year assumes that a hypothetical cohort is subject throughout its lifetime to the age-specific death rates observed for the actual population for that year. Procedures used to calculate abridged life tables for the United States are discussed in NCHS's annual vital statistics volumes (19).

Table 5 shows how life table and health-related quality-of-life data are combined to compute years of

[3]A simple estimate of the health-related quality of life for any population can be obtained by summing the products of the number of people in the population who are in each health state by the values placed on each state, and dividing by the total number of people in the population. For the information given in tables 1 and 2, the mean health-related quality of life of the civilian, noninstitutionalized population of the U.S. in 1990 was 0.87. Since this method of estimation does not take into account the age distribution of the population, it should be used only when a quick approximation of health-related quality of life is needed. Also, since institutionalized persons are omitted, this crude calculation will tend to overestimate health-related quality of life.

Table 4. Computation of health-related quality of life for the noninstitutionalized and institutionalized populations by age: United States, 1990

Age (1)	Noninstitutionalized population Total (2)	Quality-adjusted (from NHIS) (3)	Prisoners Total (4)	Quality-adjusted (4) • 0.74 (5)	Nursing homes Total (6)	Quality-adjusted (6) • 0.21 (7)	Long-term hospitals[1] Total (8)	Quality-adjusted (8) • 0.45 (9)	Residential care facilities Total (10)	Quality-adjusted (10) • 0.72 (11)	Military (factor= 1.0) (12)	Total institution-alized and non-institutionalized population (13)	Quality-adjusted institutionalized and noninstitution-alized population (14)	Average health-related quality of life of persons in the age interval (15)
0–5 years	18,884,512	17,693,335	. . .	. . .	. . .	. . .	3,842	1,729	1,073	773	. . .	18,889,427	17,695,836	0.94
5–10 years.	18,197,667	16,964,570	. . .	. . .	. . .	. . .	4,176	1,879	4,412	3,177	. . .	18,206,255	16,969,626	0.93
10–15 years. . . .	17,135,917	15,915,043	. . .	. . .	. . .	. . .	12,286	5,529	28,092	20,226	. . .	17,176,295	15,940,798	0.93
15–20 years	17,008,240	15,710,202	71,203	52,690	1,242	261	22,271	10,022	65,114	46,882	168,175	17,336,245	15,988,232	0.92
20–25 years	17,727,533	16,173,028	226,692	167,752	2,989	628	21,581	9,711	3,813	2,745	533,402	18,516,010	16,887,267	0.91
25–30 years	20,711,913	18,835,597	263,361	194,887	5,801	1,218	31,624	14,231	1,696	1,221	378,834	21,393,229	19,425,988	0.91
30–35 years	21,874,900	19,808,259	222,051	164,318	9,330	1,959	37,918	17,063	. . .	. . .	265,084	22,409,283	20,256,683	0.90
35–40 years	19,576,251	17,440,677	149,181	110,394	12,008	2,522	35,218	15,848	. . .	. . .	192,198	19,964,856	17,761,639	0.89
40–45 years	17,628,775	15,460,578	86,180	63,773	15,295	3,212	27,902	12,556	. . .	. . .	113,249	17,871,401	15,653,368	0.88
45–50 years	13,792,992	11,838,938	44,055	32,601	17,912	3,762	20,563	9,253	. . .	. . .	39,183	13,914,705	11,923,737	0.86
50–55 years	11,445,897	9,531,829	23,684	17,526	22,991	4,828	16,037	7,217	. . .	. . .	12,662	11,521,271	9,574,062	0.83
55–60 years	10,608,077	8,568,261	13,241	9,798	34,740	7,295	15,155	6,820	. . .	. . .	4,978	10,676,191	8,597,152	0.81
60–65 years	10,588,415	8,167,694	7,828	5,793	58,961	12,382	16,438	7,397	. . .	. . .	951	10,672,593	8,194,217	0.77
65–70 years	10,033,938	7,699,708	3,949	2,922	95,108	19,973	17,581	7,911	. . .	. . .	115	10,150,691	7,730,629	0.76
70–75 years	8,005,851	6,038,646	1,689	1,250	149,568	31,409	16,212	7,295	. . .	. . .	65	8,173,385	6,078,666	0.74
75–80 years	5,703,158	4,097,405	843	624	245,972	51,654	14,746	6,636	. . .	. . .	32	5,964,751	4,156,351	0.70
80–85 years	3,613,260	2,428,926	498	369	361,330	75,879	12,749	5,737	. . .	. . .	. . .	3,987,837	2,510,911	0.63
85 years and over	2,308,119	1,395,807	656	485	738,785	155,145	16,376	7,369	. . .	. . .	. . .	3,063,936	1,558,806	0.51

[1]Includes long-term stay hospitalizations, including treatment for drug and alcohol abuse, care for the chronically ill, mentally retarded, and handicapped persons.

Source: 1990, Decennial Census, U.S. Bureau of the Census, 1990 National Health Interview Survey (NHIS), National Center for Health Statistics, Centers for Disease Control and Prevention.

Table 5. Calculation of years of healthy life: Total U.S. population, 1990

Age interval Period of life between two exact ages stated in years x to x+n (1)	Number living at beginning of age interval of 100,000 born alive (l_x) (2)	Stationary population in the age interval ($_nL_x$) (3)	Average health-related quality of life of persons in the age interval (Q_x) (4)	Quality-adjusted stationary population		Years of healthy life remaining (7)	Life years remaining (8)
				In the age interval ($Q_x \cdot _nL_x$) (5)	In this and all subsequent age intervals (T_x') (6)		
0–5 years	100,000	495,073	0.94	465,369	6,403,748	64.0	75.4
5–10 years.	98,890	494,150	0.93	459,560	5,938,379	60.1	75.1
10–15 years.	98,780	493,654	0.93	459,098	5,478,819	55.5	71.2
15–20 years.	98,653	492,290	0.92	452,907	5,019,721	50.9	66.3
20–25 years.	98,223	489,794	0.91	445,713	4,566,814	46.5	61.3
25–30 years.	97,684	486,901	0.91	443,080	4,121,101	42.2	56.6
30–35 years.	97,077	483,571	0.90	435,214	3,678,021	37.9	51.9
35–40 years.	96,334	479,425	0.89	426,688	3,242,807	33.7	47.2
40–45 years.	95,382	474,117	0.88	417,223	2,816,119	29.5	42.6
45–50 years.	94,179	466,820	0.86	401,465	2,398,896	25.5	38.0
50–55 years.	92,420	455,809	0.83	378,321	1,997,431	21.6	33.4
55–60 years.	89,735	439,012	0.81	355,600	1,619,110	18.0	29.0
60–65 years.	85,634	413,879	0.77	318,687	1,263,510	14.8	24.8
65–70 years.	79,590	378,369	0.76	287,560	944,823	11.9	20.8
70–75 years.	71,404	330,846	0.74	244,826	657,263	9.2	17.2
75–80 years.	60,557	270,129	0.70	189,090	412,437	6.8	13.9
80–85 years.	47,168	197,857	0.63	124,650	223,347	4.7	10.9
85 years and over	31,892	193,523	0.51	98,697	98,697	3.1	8.3

healthy life. The first three columns of table 5 are from the abridged 1990 life table (20). Column 1 contains the 5-year age intervals; column 2 details the number of persons who are alive at the beginning of the age interval (l_x); and column 3 contains the stationary population, which is also the number of person-years in each age interval ($_nL_x$). The average health-related quality-of-life scores (Q) for each age interval, column 4, are taken from table 4, column 15. These average scores are multiplied by the number of person-years in each age interval, $_nL_x$ (column 3), to obtain the quality-adjusted person-years lived in each age interval, column 5. These adjusted person-years are then summed from the bottom to the top of the table to obtain the cumulative number of quality-adjusted person-years, which also can be thought of as the adjusted stationary population in each age interval as well as in all subsequent intervals, T_x' (column 6). Dividing the cumulative quality-adjusted person-years, T_x', by the number of persons alive at the beginning of the interval, l_x (column 2), results in the number of years of healthy life remaining at the beginning of the age interval (column 7). For example, for persons 45–50 years of age, the number of adjusted person-years in this and subsequent intervals is 2,398,896. Dividing this by the number of persons alive at the beginning of the age interval (94,179), results in 25.5 years of healthy life remaining at age 45. Average life years remaining, column 8, have been added from the abridged life tables for comparison (16). For persons 45–50 years of age in 1990 life

expectancy was 38.0 years with 25.5 years of healthy life. That is, persons in this age group can expect to experience an average of 67.1 percent of optimal functioning.

The method illustrated in table 5 can be used for calculating years of healthy life for any population for which both a life table and health-related quality-of-life scores are available for the same age intervals. It is important to note that both the mortality data and the health-related quality-of-life data represent cross-sectional data for a given year. When summarized in a life table format, they represent the experience of a hypothetical cohort born in a given year subject throughout life to the age-specific death and health-related quality-of-life values observed in that same year. They do not represent the experience of any actual population over the lifetime of all its members.

The next section presents years of healthy life data for white, black, and Hispanic persons and discusses various issues in the interpretation of these estimates.

Years of healthy life for 1990

In 1990, the life expectancy at birth for the total population was 75.4 years and the corresponding number of years of healthy life was 64.0 years. This means that people born in 1990 can expect to experience an average of 85 percent of full function over their lifetimes, assuming that the mortality and

health situations observed in 1990 are maintained throughout their lifetimes. The corresponding expected average of 15 percent dysfunction over the population's lifetime represents illnesses, both acute and chronic, that occur throughout a lifetime as measured by activity limitation and perceived health. For persons 65 years old, life expectancy was 20.8 years and the corresponding number of years of healthy life was 11.9. That is, of the expected years of life remaining, the population can expect to have an average of 57.2 percent of full function.

Although this calculation is shown for the total U.S. population, the same method can be applied for calculating years of healthy life for various sociodemographic groups—people classified by race, ethnicity, or gender. The same method can also be used for estimating years of healthy life for State or local populations.

Race and ethnic differences

Figure 1 presents years of healthy life and total life years (life expectancy at birth) by race and Hispanic origin. In 1990, black persons had a life expectancy at birth of 69.1 years with 56.0 years of healthy life. The difference between life expectancy and years of healthy life for black persons is 13.1 years, which indicates black persons had an average of 81 percent of full function, namely no activity limitation and in excellent perceived health, over their life span.

Based on preliminary data, Hispanic persons had a life expectancy at birth of 79.1 years with 64.7 years of healthy life, which indicates that Hispanic persons

have about the same average health-related quality of life (82 percent) over their lifetime. In contrast, white persons have a life expectancy of 76.1 and 65.0 years of healthy life, which indicates that over their lifetime white persons average 85 percent of full function.

The difference in years of healthy life for the black population compared with the white population is due to both the higher mortality and higher morbidity experiences of the black population. The life expectancy at birth for black persons is lower than that for white persons, 69.1 compared with 76.1 years. At the same time, the greater disparity between total years of life and healthy years of life for black persons than for white persons, 13.1 compared with 11.1 years, indicates that health-related quality of life is also lower for black people than for white people.

Life expectancy at birth for the Hispanic population is higher than that for the white and total populations. It is important to note, however, that data for this population are preliminary and do not include New York, Oklahoma, Louisiana, Connecticut, and New Hampshire. The U.S. Puerto Rican population tends to have higher death rates than other Hispanic subgroups. Because 45 percent of the U.S. Puerto Rican population resides in New York, omission of New York's Hispanic data may result in an underestimate of the number of deaths for Hispanics. The lower mortality experience for Hispanic persons, reflected by the higher life expectancy, may also result, in part, from misclassification of Hispanic origin on the death certificate (21).

Persons with disabilities

A unique feature of the *Healthy People 2000* years of healthy life measure of health-related quality of life is that it incorporates perceived health status. Thus, the health status of people with disabilities, who might score low on role limitation, can be compensated by their perception of their own health. Over 800,000 noninstitutionalized civilians have disabilities that limit their performance of activities of daily living, but consider themselves to be in good to excellent health. For example, the health of persons with spinal cord injuries who use wheelchairs to get around in the community and who also play basketball may be more accurately represented by a set of health states that includes perceived health. Thus, for the many persons with disabilities who feel they are healthier than their physical limitations may suggest, a health-related quality-of-life measure that includes perceived health will be more representative of their overall health-related quality of life than a measure that is based on activity limitation alone. It should be noted, however, that relatively few people who are extremely
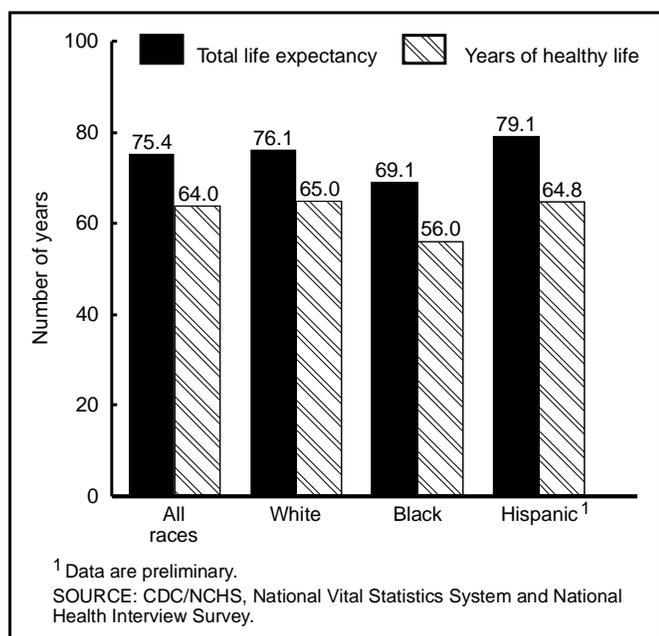
Figure 1. Total life expectancy and years of healthy life by race and Hispanic origin: United States, 1990

limited in role function report themselves in excellent or very good health (table 1).

Relationships between activity limitation, perceived health, and selected health promotion and disease prevention initiatives are complex. For example, reducing the proportion of persons with asthma who experience activity limitation to no more than 10 percent (*Healthy People 2000* objective 17.4) will increase years of healthy life only if the more rigorous case management does not also result in persons with asthma having lower perceived health. (Persons with asthma might lower their rating of perceived health if the intervention suggested that they were less healthy than they thought prior to beginning the treatment.) Additional use of both the health-related quality-of-life measure and years of healthy life will result in a better understanding of these relationships.

Estimating years of healthy life for States

Although the examples shown in this report are based on national data, the same methods can be used with State and local data. One major step toward making data on health-related quality of life available at the State level is the development of the "activity limitations" module for the Behavioral Risk Factor Surveillance System.[4] This was called "Module—Activity Limitations" in the 1993 and 1994 questionnaire. It will be referred to as the "Years of Healthy Life module" beginning in 1995. The Behavioral Risk Factor Surveillance System module was designed to collect information comparable to that collected by the National Health Interview Survey. Data on perceived health status are collected in the "core" section of this survey. These Behavioral Risk Factor Surveillance System data can be combined with the values shown in table 4 to develop estimates of health-related quality of life that are comparable to those that are based on data from the National Health Interview Survey.

Staff at the National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention (CDC), are developing an algorithm for transforming the information collected by the Years of Healthy Life module into the format shown in table 1. CDC plans to produce State-specific years of healthy life estimates using the 1990 Census data to estimate the size of the institutionalized population within each State. These estimates, which will be comparable to the U.S. figures, will be part of the routine report that CDC provides to each State that administers the Years of Healthy Life module of the Behavioral Risk Factor Surveillance System.

Thus, State-level estimates of years of healthy life can be compared with national estimates and with those for other States to determine relative progress in reaching the year 2000 targets. Caution should be exercised in making comparisons between State and national estimates of years of healthy life, however, because methodological differences in the collection of health-related quality-of-life data may result in slightly different estimates.

Future research

The NCHS is committed to further studying how activity limitation and perceived health interrelate to reflect the American people's view of a healthy life. Among the topics currently on the research agenda are (a) the relationship between activity limitation and perceived health, how this relationship changes over time and differs by socioeconomic characteristics of the population; (b) the definition of and data sources for institutionalized populations, especially in intercensal years; (c) the robustness of the *Healthy People 2000* years of healthy life measure to changes in assumptions used in the current calculations (for example, the value assigned to the lowest health state); and (d) the effect of small sample sizes, for example, those representing selected minority populations, on the *Healthy People 2000* measure. A better understanding of the *Healthy People 2000* measure of years of healthy life will indicate how responsive the health care system, reflected by its interventions, is in producing healthy citizens and communities.

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[4]The BRFSS is a State-based telephone survey sponsored by CDC. The survey includes questions on a variety of health topics, such as smoking, cholesterol screening, and exercise.

Technical notes

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The measure of years of healthy life used to monitor progress in increasing the span of healthy life for all Americans by the year 2000, that is, the *Healthy People 2000* Years of Healthy Life (HP2000 YHL) is based on two concepts of health-related quality of life: perceived health status and activity limitation. The operational definition of perceived health status is a result of the question asked in the National Health Interview Survey (NHIS). Each sample person is classified into one of five categories (excellent, very good, good, fair, and poor) based on his or her response to the question "Would you say your health in general is excellent, very good, good, fair, or poor?" For the 1990 estimates, both self-respondent and proxy data have been used.

Activity limitation is defined using questions about a person's ability to perform his or her usual social role (table I). Definitions of each of the six levels of activity limitation, given in table II, are based on the NHIS. For the 1990 estimates, self and proxy data have both been used. Although the definition of this concept is based primarily on limitation of activity used by the NHIS, activity limitation differs slightly from the standard NHIS definition. The major difference is that role limitations are defined for persons 65 years of age and older in developing the measure, rather than 70 years and older as is done for limitation of activity in the standard NHIS definition.

In classifying persons into one of the six levels of activity limitation, it has sometimes been necessary to make assumptions about their health status. For example, persons with unknown activity limitation were considered to be unlimited in their function. This assumption records some persons as healthier than they actually might be. Upward bias in activity limitation also can occur because of questionnaire design. For example, information about ability to perform self-care activities was not asked of persons 0–4 years of age. Inability to perform a major activity is the most severe functional limitation to which these persons can be assigned. Thus, children less than 5 years of age cannot be assigned to the lowest level of functioning. If the number of respondents in these two categories is

Table I. Questions used to identify persons with activity limitations, by age group and usual activity: National Health Interview Survey (NHIS)

Age group and activity	Activity limitation and NHIS questions
Under 5 years Ordinary play	Unable to perform major activity 10a. Is __ able to take part AT ALL in the usual kinds of play activities done by most children __ age? Limited in performing major activity 10b. Is __ limited in the kind OR amount of play activities __ can do because of any impairment or health problem?
5–17 years Attending school	Unable to perform major activity 11a. Does any impairment or health problem NOW keep __ from attending school? Limited in performing major activity 11b. Does __ attend a special school or special classes because of any impairment or health problem? 11c. Does __ need to attend a special school or special classes because of any impairment or health problem? 11d. Is __ limited in school attendance because of health?
18–64 years Working or keeping house[a]	Unable to perform major activity 2a. Does any impairment or health problem NOW keep __ from working at a job or business? 3a. Does any impairment or health problem NOW keep __ from doing any housework at all? Limited in performing major activity 2b. Is __ limited in the kind OR amount of work __ can do because of any impairment or health problem? 3b. Is __ limited in the kind OR amount of housework __ can do because of any impairment or health problem?
65 years and older[b] Independent living	Limited in activities of daily living 14a. Because of any impairment or health problem, does __ need the help of other persons with __ personal care needs, such as eating, bathing, dressing, or getting around this home? Limited in instrumental activities of daily living (IADL) 14b. Because of any impairment or health problem, does __ need the help of other persons in handling __ routine needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes?
All ages	Limited in other activities 6a. (12a) Is __ limited in ANY WAY in any activities because of an impairment or health problem?

[a]Working or keeping house depends on what the respondent says that he or she was doing in the last 12 months.
[b]These questions are also asked of persons 5–64 years if reported unable or limited in major activity.
Source: National Health Interview Survey, Centers for Disease Control and Prevention, National Center for Health Statistics.

Table II. Definitions of activity limitation using National Health Interview Survey items

Not limited
- Not limited (includes unknowns) regardless of age; this category includes unknown role regardless of a person's age.

Limited in other activities
- Limited in other activities regardless of age, or
- Limitation in activity and 65–69 years of age but able to perform activities of daily living (ADLs) and able to perform instrumental activities of daily living (IADLs).

Limited in major activity
- 64 years of age and younger — limited in amount or kind of major activity.
- 65 years and older — major activity is considered to be ADL and IADL activities; therefore people in this age group cannot fall in this category.

Unable to perform major activity
- 64 years of age and younger — Unable to perform major activity.
- 65 years and older — major activity is considered to be ADL and IADL activities; therefore people in this age group cannot fall in this category.

Instrumental activities of daily living (IADL)
- 0–17 years of age — not applicable. Proxy respondents were used to obtain this information about children; unable to perform their major activity is the most severe functional limitation to which they can be assigned.
- 18–64 years of age — unable to perform routine needs without the help of other persons and unable to perform or limited in major activity.
- 65 years of age and older — unable to perform routine needs without the help of other persons.

Activities of daily living (ADL)
- 0–4 years of age — not applicable. Proxy respondents were used to obtain this information about children; unable to perform their major activity is the most severe functional limitation to which they can be assigned.
- 5–64 years of age — unable to perform personal care needs without the help of other persons and unable to perform or limited in major activity.
- 65 years of age and older — unable to perform personal care needs without the help of other persons.

NOTE: Persons are placed in only one activity limitation category. When a person can be classified in more than one activity, he or she is assigned to the limitation with the lowest score.

large, then the assumptions about unknown role and this feature of the questionnaire can increase the population's level of health. This bias may be offset by a questionnaire feature for persons in the 65 years and older category. The major activities for these persons are considered to be instrumental and self-care activities of daily living. Thus, these persons cannot be assigned to either of the two categories that reflect limitation in major activity. This questionnaire design feature may make the population seem less healthy than it actually is.

The two concepts of health status—activity limitation and perceived health status—jointly define 30 unique living health states, as shown in table III. The table also shows a 31st health state—dead. The task is to assign scores or weights to these 31 cells. By definition, and following the normal convention in health status scoring, the best health state (11) is assigned a score of 1.00 and the dead state is assigned a score of 0.00. The assignment of other scores is relative to these two "anchor" scores.

The structure of multiattribute utility theory (18) was used to determine a scoring formula for the health states. In adhering to the terminology used in multiattribute utility scaling, activity limitation and perceived health are referred to as "attributes" in this report. In this structure, each attribute has single attribute scores on a scale where the best level on the attribute has a score of 1.00 and the worst level has a score of 0.00. These are combined by a multiplicative model, shown in the footnote to table III, to determine the score for joint states. The multiplicative model does not restrict the final function. Rather, this model is a general case and includes the additive model as a special case. Thus, the resulting function will be either multiplicative or additive, depending on the data. The advantage of the multiplicative model is that it can accommodate synergies and interdependencies between the attributes. Past empirical work suggests that such synergies are often important (22,23).

Other methods for assigning the values, such as the evaluation of holistic health states, require that data be collected explicitly for this purpose. The time frame available for developing the *Healthy People 2000* years of healthy life measure did not allow for special data collection.

The first step in developing the scores was to quantify the distance between different levels for each of the attributes. There are a variety of different psychometric techniques that could be used for assigning these distances, depending on what is being measured. To measure the variance common to both activity limitation and perceived health status, they were treated as measures of the same dimension of the health domain. Therefore, correspondence analysis was an appropriate technique for determining intervals between the levels of function that fall within the two ends of the response categories—between "excellent" and "poor" for perceived health and between "not limited" and "limited in ADL" for activity limitation. Correspondence analysis determines the set of scale values associated with the levels for each attribute, maximizing the correlation between the attributes based on the joint frequency distribution of the population of interest (24,25).

Correspondence analyses were calculated separately for several different 5-year age groups and for several different years of NHIS data. These analyses demonstrated that to maximize the correlation between activity limitation and perceived health, the distance between "limited, major" and "unable, major" had to be made comparably large as did the difference between "good" and "fair." If the criterion had been something else, the relative size of the intervals would

Table III. Derivation of values for the *Healthy People 2000* years of healthy life measure

Activity limitation	Single attribute score	Perceived health status					Dead
		Excellent y_1 1.00	Very good y_2 0.85	Good y_3 0.70	Fair y_4 0.30	Poor y_5 0.00	
Not limited	x_1 1.00	1.00					
Limited-other	x_2 0.75						
Limited-major	x_3 0.65			S_{33}			
Unable-major	x_4 0.40						
Limited in IADL	x_5 0.20						
Limited in ADL	x_6 0.00	0.47				a=0.10	
Dead							0.00

Multiplicative model:

The values are found by calculating a matrix, M_{ij}, based on the following formula:

$M_{ij} = k_1 x_i + k_2 y_i + (1 - k_1 - k_2) x_i y_j$
where x_i refers to one of six levels of role limitation and
y_j refers to one of five levels of perceived health.
$k_1 = k_2 = (S_{61} - a)/(S_{11} - a)$

This matrix, M_{ij}, is converted to the values for the health states using the following formula.

$S_{ij} = a + (1–a) M_{ij}$

Assumptions:

$S_{11} = 1.00$
$S_{65} = 0.10 = a$
$k_1 = k_2$

The scaling constants are calculated as follows:

$k_1 = (0.47 - a)/(1.00 - a)$
When $a = 0.10$, then
$k_1 = k_2 = 0.41$
$(1 - k_1 - k_2) = 0.18$

Sample calculation for Health State $x_3 y_3$:

The value for persons who are limited in their major activity and report themselves in good health, that is, $y_3 = 0.70$ and $x_3 = 0.65$, is obtained as follows:

$M_{33} = 0.41(.70) + 0.41(.65) + 0.18 (0.455) = 0.64$
$S_{33} = 0.10 + 0.90(0.64) = 0.67$

have to be quite different. Although there were differences between age groups in the optimal patterning of interval size, the set of intervals adopted fits nearly all the age groups. The assigned single attribute scores for activity limitation were 1.00, 0.75, 0.65, 0.40, 0.20, and 0.00, and for perceived health status were 1.00, 0.85, 0.70, 0.30, and 0.00.

These single attribute scores were used to develop values for each of the 30 cells in the matrix using the general multiplicative model. See table III for the formulas. The most functional state, having no activity limitations and having an excellent perceived health status, is assigned a value of 1.00. This is shown in the upper left cell, or corner, of the matrix. The value of the most dysfunctional living health state in this matrix, which is limited in activities of daily living and in poor health, has been assigned a value of 0.10. This is shown in the lower right corner of the matrix and is represented by *a* in the formula for S_{ij}.

One other corner value is needed to complete the calculations. To obtain a score for the health state that is defined as limited in activities of daily living but in excellent perceived health (the lower left corner cell), the Health Utilities Index Mark I (26) was used. One of the four attributes in the Health Utilities Index Mark I (HUI-I), Role Function, is conceptually similar to activity limitation as it is used in the *Healthy People 2000* measure of years of healthy life. The two HUI-I health states that are similar to activity limitations as defined in the National Health Interview Survey are shown in table IV. The lowest level in the HUI-I Role Function attribute, R5, is defined as "needing help to eat, dress, bathe, or go to the toilet; and not being able to play, attend school, or work." The next higher level, R4, has the same dependence in activities of daily living, but allows for performance of one's usual role with some limitation in performing one's usual role. The health state defined as being limited in activities of daily living but in excellent health was assumed to

Table IV. Derivation of the value for the health state defined as limited in activities of daily living and in excellent health

	Health utilities index	
Level	Role function definition	Value
R4	Needing help to eat, dress, bathe, or go to the toilet; and having some limitations when playing, going to school, working, or in other activities.	0.75
R5	Needing help to eat, dress, bathe, or go to the toilet; and not being able to play, attend school, or work.	0.50

Calculating formula:

$$HUI = 1.42 (P_i R_j S_k H_l) - 0.42$$

where

P_i represents the value associated with Physical Function

R_j represents the value associated with Role Function

S_k represents the value associated with Socio-Emotional Function

H_l represents the value associated with Health Problems

Source: Drummond MF, Stoddart GL, Torrance GW. *Methods for the Economic Evaluation of Health Care Programmes.* Oxford: Oxford University Press, 1987, pp. 121–24.

The health state defined as limited in activities of daily living and being in excellent health, $x_6 y_1$, is assumed to lie half way between levels R4 and R5 of the Health Utility Index. Assuming no other dysfunction, that is, $P_i = S_k = H_l = 1$, then the value of this state as measured by the HUI is 0.47 as shown in the calculation below.

$$x_6 y_1 = 1/2(1.42 \cdot 0.75 - 0.42) + 1/2(1.42 \cdot 0.50 - 0.42) = 0.47$$

have a value that was half way between levels R4 and R5 of the HUI-I. With these assumptions, the value of 0.47 was obtained for the lower left corner cell (see the calculations in table IV).

Values in the corner cells allow for the calculation of the constants, k_1 and k_2, in the equation for M_{ij} (table III). For simplicity, k_1 and k_2 are assumed to be equal, that is, the two attributes of activity limitation and perceived health status are given equal weight. More specifically, it is assumed that it is equally bad to be at the lowest level of either attribute while at the highest level of the other. With values for three of the four corner health states and the stated assumptions, values in the rest of the matrix can be computed using the formula for M_{ij} and S_{ij} (table III). Using these assumptions and formula, values obtained for S_{ij} are given in table 3.

Although there is no exact classification system against which to validate these scores, selected research studies allow comparison. For example, Stewart et al. (27) have found that ratings of excellent, very good, and good health have scores that are closer together than do ratings of fair and poor health. The results of the correspondence analysis of data from the National Health Interview Survey agree with this finding of nonlinearity within the perceived health status scale. More research, however, is needed on the validity of the methods and resulting scores for estimating *Healthy People 2000* years of healthy life.

NCHS is conducting sensitivity analyses to test the effect of various assumptions on the health-related quality-of-life score as well as on the calculated years of healthy life. For example, sensitivity analyses have been done to assess the impact of choosing 0.1 as the value assigned to the lowest health state—limited in activities of daily living and in poor health. Changing the lowest value from 0.1 to 0.2 raises the estimate of years of healthy life for the total population by about 0.3 years. Lowering the value to 0.05 reduces years of healthy life by 0.2 years. Although the level of years of healthy life is affected by the value assigned to the lowest health state, the value has no systematic effect on the amount of change in years of healthy life that is observed over time. Other analyses will be conducted to investigate the robustness of this measure to various assumptions used in its construction and to gain a better understanding of how to interpret changes over time.

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