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U.S. State Life Tables, 2019

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Abstract

Objectives—This report presents complete period life tables for each of the 50 states and the District of Columbia (D.C.) by sex based on age-specific death rates in 2019.

Methods—Data used to prepare the 2019 state-specific life tables include: 2019 final mortality statistics; July 1, 2019, population estimates based on the 2010 decennial census; and 2019 Medicare data for people aged 66–99. The methodology used to estimate the state-specific life tables is the same as that used to estimate the 2019 national life tables, with some modifications.

Results—Among the 50 states and D.C., Hawaii had the highest life expectancy at birth, 80.9 years in 2019, and Mississippi had the lowest, 74.4 years. Life expectancy at age 65 ranged from 17.5 years in Mississippi to 21.2 years in Hawaii. Life expectancy at birth was higher for females in all states and D.C. The difference in life expectancy between females and males ranged from 3.5 years in Utah to 6.4 years in Mississippi.

Keywords: state life expectancy • survival • death rates • National Vital Statistics System

Introduction

This report presents annual complete period life tables for each of the 50 states and the District of Columbia (D.C.) for 2019. Life tables were produced for the total, male, and female populations of each state and D.C. based on age-specific death rates for 2019. The methodology used to estimate the state-specific life tables is the same as that used to estimate the annual U.S. life tables (1), with some minor modifications described in the Technical Notes.

Life tables are of two types: the cohort (or generation) life table and the period (or current) life table. The cohort life table presents the mortality experience of a particular birth cohort—all people born in the year 1900, for example—from the moment of birth through consecutive ages in successive calendar years. Based on age-specific death rates observed through consecutive calendar years, the cohort life table reflects the mortality experience of an actual cohort from birth until no lives remain in the group. To prepare just a single complete cohort life table requires data over many years. Due to data unavailability or incompleteness (2), constructing cohort life tables based entirely on observed data for real cohorts is usually not feasible. For instance, a life table representation of the mortality experience of a cohort of people born in 1970 would require the use of data projection techniques to estimate deaths into the future (3,4).

The period life table, by contrast, presents what would happen to a hypothetical cohort if it experienced throughout its entire life the mortality conditions of a particular period. For example, a period life table for 2019 assumes a hypothetical cohort that is subject throughout its lifetime to the age-specific death rates prevailing for the actual population in 2019. The period life table could be characterized as producing a snapshot of current mortality experience and showing the long-range implications of a set of age-specific death rates that prevailed in a given year. In this report, the term "life table" refers only to the period life table, not to the cohort life table.

Life tables can be classified in two ways according to the length of the age interval in which data are presented. A complete life table contains data for every single year of age. An abridged life table typically contains data by 5- or 10-year age intervals. A complete life table can be combined into 5- or 10-year age groups. U.S. decennial life tables and, beginning in 1997, U.S. annual life tables are complete life tables. This report presents the results for 2019 for the series of annual complete period state-specific life tables.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics
National Vital Statistics System

NCHS reports can be downloaded from: https://www.cdc.gov/nchs/products/index.htm.

Data and Methods

The data used to prepare the U.S. state life tables for 2019 are state-specific final numbers of deaths for 2019; July 1, 2019, state-specific population estimates based on the 2010 decennial census; and state-specific death and population counts for Medicare beneficiaries aged 66–99 for 2019 from the Centers for Medicare & Medicaid Services. Data from the Medicare program are used to supplement vital statistics and census data for ages 66 and over.

The methodology used to estimate the 2019 complete life tables for the 50 states and D.C. presented in this report is the same as that used to estimate the annual U.S. national life tables, with some modifications. For some states, very small age-specific or zero numbers of deaths in childhood ages sometimes required the use of additional smoothing techniques not needed in constructing the national life tables. A modification to the estimation of death rates in the oldest ages was also necessary because of the lack of state-specific census population estimates for ages 85–100. The methodology with modifications used to construct the first set of annual U.S. state life tables is detailed in the Technical Notes.

Explanation of life table columns

Column 1. Age (between x and $x + 1$)—Shows the age interval between the two exact ages indicated. For instance, 20–21 means the 1-year interval between the 20th and 21st birthdays.

Column 2. Probability of dying (q_x)—Shows the probability of dying between ages x and $x + 1$. For example, for males who reach age 20 in Massachusetts, the probability of dying before reaching their 21st birthday is 0.000616 (Table MA–2). This column forms the basis of the life table; all subsequent columns are calculated from it.

Column 3. Number surviving (l_x)—Shows the number of people from the original hypothetical cohort of 100,000 live births who survive to the beginning of each age interval. The l_x values are computed from the q_x values, which are successively applied to the remainder of the original 100,000 people still alive at the beginning of each age interval. For example, out of 100,000 male babies born alive in Massachusetts in 2019, 99,215 will survive to their 21st birthday (Table MA–2).

Column 4. Number dying (d_x)—Shows the number dying in each successive age interval out of the original 100,000 live births. For example, out of 100,000 males born alive in Massachusetts in 2019, 61 will die between ages 20 and 21 (Table MA–2). Each figure in column 4 is the difference between two successive figures in column 3.

Column 5. Person-years lived (L_x)—Shows the number of person-years lived by the hypothetical life table cohort within an age interval x to $x + 1$. Each figure in column 5 represents the total time (in years) lived between two indicated birthdays by all those reaching the earlier birthday. Consequently, the figure 99,246 for males in the age interval 20–21 is the total number of years lived between the 20th and 21st birthdays by the 99,277 males in Massachusetts (column 3) who reached their 20th birthday out of 100,000 males born alive (Table MA–2).

Column 6. Total number of person-years lived (T_x)—Shows the total number of person-years that would be lived after the beginning of the age interval x to $x + 1$ by the hypothetical life table cohort. For example, the figure 5,803,110 is the total number of years lived after reaching age 20 by the 99,277 males reaching that age in Massachusetts (Table MA–2).

Column 7. Expectation of life (e_x)—At any given age, shows the average number of years remaining to be lived by those surviving to that age, based on a given set of age-specific rates of dying. It is calculated by dividing the total person-years that would be lived beyond age x by the number of people who survived to that age interval (T_x/l_x). Thus, the average remaining lifetime for males in Massachusetts who reach age 20 is 58.5 years (5,803,110 divided by 99,277) (Table MA–2).

Standard errors of the probability of dying and life expectancy

Although based on complete counts of death, the life table functions presented in this report are subject to error. As a result, standard errors of the two most important functions, the probability of dying and life expectancy, are also presented. The mortality data on which state life tables are based are not affected by sampling error because they are based on complete counts of deaths and, as a result, standard errors reflect only stochastic (random) variation. While measurement errors such as age misreporting on death certificates or census data are known to affect mortality estimates, they are not considered in calculating the standard errors of the life table functions. In most cases, standard errors for life expectancy at birth and the probability of dying are small due to large numbers of deaths. However, for some states with small populations, particularly at the youngest ages, the standard errors presented are relatively large.

Results

Complete life tables for the 50 states and D.C.

A set of complete period life tables for each state and D.C. is available online from "U.S. State Life Tables, 2019" at: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/70-18/. Table I lists table titles for each of these tables. Table numbering is based on the federal information processing standards, or FIPS, alphabetic code for the state combined with a table code. The table codes are 1 for the total population, 2 for males, 3 for females, and 4 for the standard errors of the probability of dying and life expectancy. For example, Table FL–2 refers to the complete period life table for males in Florida.

Life expectancy in the 50 states and D.C.

Table A shows life expectancy at birth for the total, male, and female populations for each state, D.C., and the United States. In 2019, among the 50 states and D.C., Hawaii ranked first for the total and female populations, with life expectancies at birth of 80.9 and 83.9 years, respectively. California ranked first for

Table A. Life expectancy at birth, rank, and standard error, by sex: Each state, District of Columbia, and United States, 2019

Area	Rank	Total	Standard error	Rank	Male	Standard error	Rank	Female	Standard error
Hawaii	1	80.9	0.119	5	78.0	0.172	1	83.9	0.158
California	2	80.9	0.022	1	78.4	0.032	2	83.3	0.028
New York	3	80.7	0.030	3	78.2	0.045	3	83.1	0.040
Minnesota	4	80.4	0.056	2	78.3	0.082	6	82.6	0.075
Massachusetts	5	80.4	0.050	6	77.9	0.074	5	82.8	0.065
Connecticut	6	80.3	0.073	9	77.7	0.107	4	82.8	0.094
New Jersey	7	80.1	0.046	10	77.6	0.067	7	82.5	0.060
Washington	8	80.0	0.048	7	77.9	0.070	10	82.1	0.064
Colorado	9	80.0	0.058	8	77.8	0.084	9	82.2	0.077
Vermont	10	79.8	0.172	13	77.2	0.259	8	82.3	0.223
Utah	11	79.7	0.078	4	78.0	0.114	17	81.5	0.105
Oregon	12	79.6	0.066	12	77.3	0.097	11	81.9	0.086
Idaho	13	79.5	0.101	11	77.5	0.147	20	81.5	0.137
Rhode Island	14	79.5	0.135	17	77.0	0.199	12	81.8	0.179
New Hampshire	15	79.4	0.116	15	77.1	0.171	14	81.6	0.154
Wisconsin	16	79.3	0.057	16	77.0	0.082	18	81.5	0.078
Nebraska	17	79.2	0.098	14	77.1	0.141	22	81.3	0.134
Virginia	18	79.1	0.047	18	76.8	0.069	23	81.3	0.063
Florida	19	79.0	0.032	22	76.3	0.047	13	81.8	0.042
Iowa	20	79.0	0.077	19	76.5	0.113	16	81.6	0.101
Illinois	21	79.0	0.039	20	76.4	0.058	19	81.5	0.052
United States	…	78.8	…	…	76.3	…	…	81.4	…
Arizona	22	78.8	0.054	25	76.1	0.080	15	81.6	0.071
North Dakota	23	78.8	0.166	21	76.3	0.235	21	81.5	0.227
Texas	24	78.6	0.026	24	76.1	0.038	25	81.0	0.035
Maryland	25	78.5	0.059	30	75.8	0.088	24	81.2	0.075
Montana	26	78.4	0.139	23	76.2	0.204	31	80.8	0.185
South Dakota	27	78.4	0.157	26	76.1	0.226	29	80.8	0.214
Pennsylvania	28	78.3	0.040	31	75.7	0.059	27	80.9	0.053
Maine	29	78.3	0.123	28	75.8	0.180	28	80.9	0.164
Kansas	30	78.2	0.082	27	75.9	0.119	34	80.4	0.111
Delaware	31	78.1	0.153	35	75.1	0.225	26	81.0	0.202
District of Columbia	32	78.0	0.186	37	74.9	0.276	30	80.8	0.244
Nevada	33	78.0	0.080	33	75.6	0.115	32	80.6	0.107
Michigan	34	78.0	0.045	32	75.6	0.066	35	80.3	0.060
Alaska	35	77.7	0.173	29	75.8	0.247	38	79.9	0.237
Wyoming	36	77.7	0.199	34	75.4	0.279	33	80.5	0.262
North Carolina	37	77.6	0.045	36	75.0	0.066	36	80.1	0.059
Georgia	38	77.4	0.044	38	74.9	0.065	39	79.9	0.059
Indiana	39	77.0	0.056	39	74.5	0.081	42	79.5	0.075
Missouri	40	76.9	0.059	41	74.1	0.087	40	79.8	0.078
New Mexico	41	76.9	0.109	42	73.9	0.159	37	80.1	0.143
Ohio	42	76.9	0.043	40	74.3	0.062	43	79.5	0.057
South Carolina	43	76.8	0.066	43	73.9	0.098	41	79.7	0.086
Louisiana	44	75.7	0.070	47	72.8	0.102	44	78.6	0.093
Oklahoma	45	75.7	0.073	44	73.2	0.106	47	78.3	0.099
Arkansas	46	75.7	0.085	45	73.0	0.122	46	78.4	0.114
Tennessee	47	75.6	0.057	48	72.8	0.082	45	78.5	0.075
Kentucky	48	75.5	0.068	46	72.9	0.097	49	78.0	0.091
Alabama	49	75.2	0.068	49	72.2	0.099	48	78.2	0.090
West Virginia	50	74.5	0.114	50	71.9	0.164	51	77.3	0.153
Mississippi	51	74.4	0.089	51	71.2	0.129	50	77.6	0.118

… Category not applicable.

NOTE: Life expectancies shown are rounded, but rankings are based on unrounded life expectancies.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

males, with a life expectancy of 78.4 years. Mississippi ranked 51st among the 50 states and D.C. for the total and male populations, with life expectancies at birth of 74.4 and 71.2 years, respectively. West Virginia ranked 51st among females, with a life expectancy at birth of 77.3 years. In comparison, life expectancy at birth for the entire United States was 78.8, 76.3, and 81.4 for the total, male, and female populations, respectively. Figure 1 presents a U.S. map with state-specific life expectancy at birth grouped into quartiles. It shows that states with the lowest life expectancy at birth are mostly Southern states, and states with the highest life expectancy at birth are predominantly Western and Northeastern states.

The difference in life expectancy between the sexes in the United States was 5.1 years in 2019, ranging from a high of 6.4 years in Mississippi to a low of 3.5 years in Utah (Figure 2). With a few exceptions, the states with the largest sex differences are those with lower life expectancy at birth, while the smallest sex differences are found mostly among states with higher life expectancy.

Table B shows life expectancy at age 65 for the total, male, and female populations for the 50 states, D.C., and United States. In 2019, Hawaii ranked first for the total, male, and female populations, with life expectancy at age 65 of 21.2, 19.4, and 22.9 years, respectively. Mississippi ranked 51st, with the lowest life expectancy among the 50 states and D.C. for the total and male populations, with life expectancy at age 65 of 17.5 and 15.8 years, respectively. For females, Kentucky ranked 51st, with a life expectancy at age 65 of 18.8 years. In comparison, life expectancy at age 65 for the entire United States was 19.6, 18.2, and 20.8 for the total, male, and female populations, respectively. Figure 3 shows that states with the lowest life expectancies at age 65 are mostly concentrated in the South, and those with the highest life expectancies are mostly in the West and Northeast.

From 2018 to 2019, life expectancy at birth declined for 14 states (Figure 4) (5). The declines ranged from 0.1 to 0.5 year. Life expectancy remained the same for 5 states and increased for 31 states and D.C. Increases ranged from 0.1 to 0.5 year. Overall, life expectancy in the United States increased by 0.1 year from 2018 to 2019.

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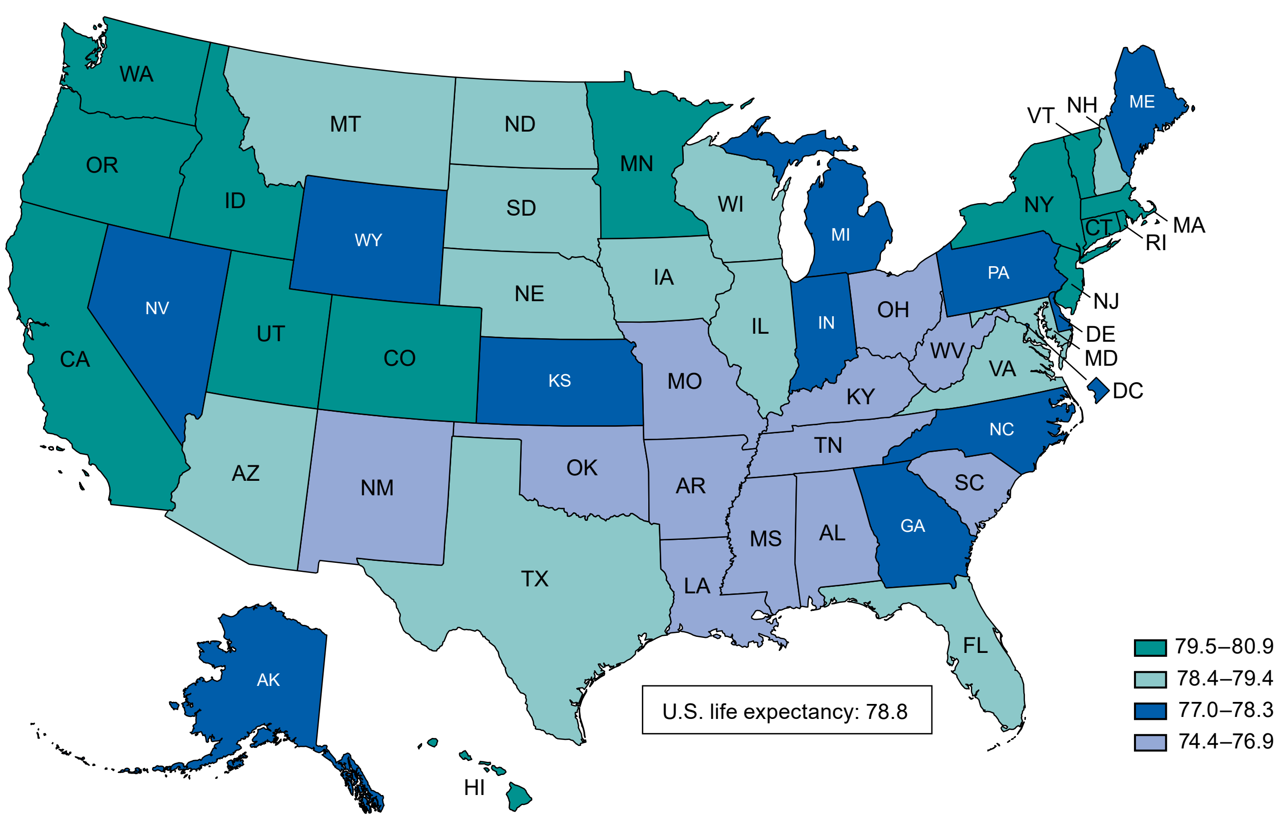
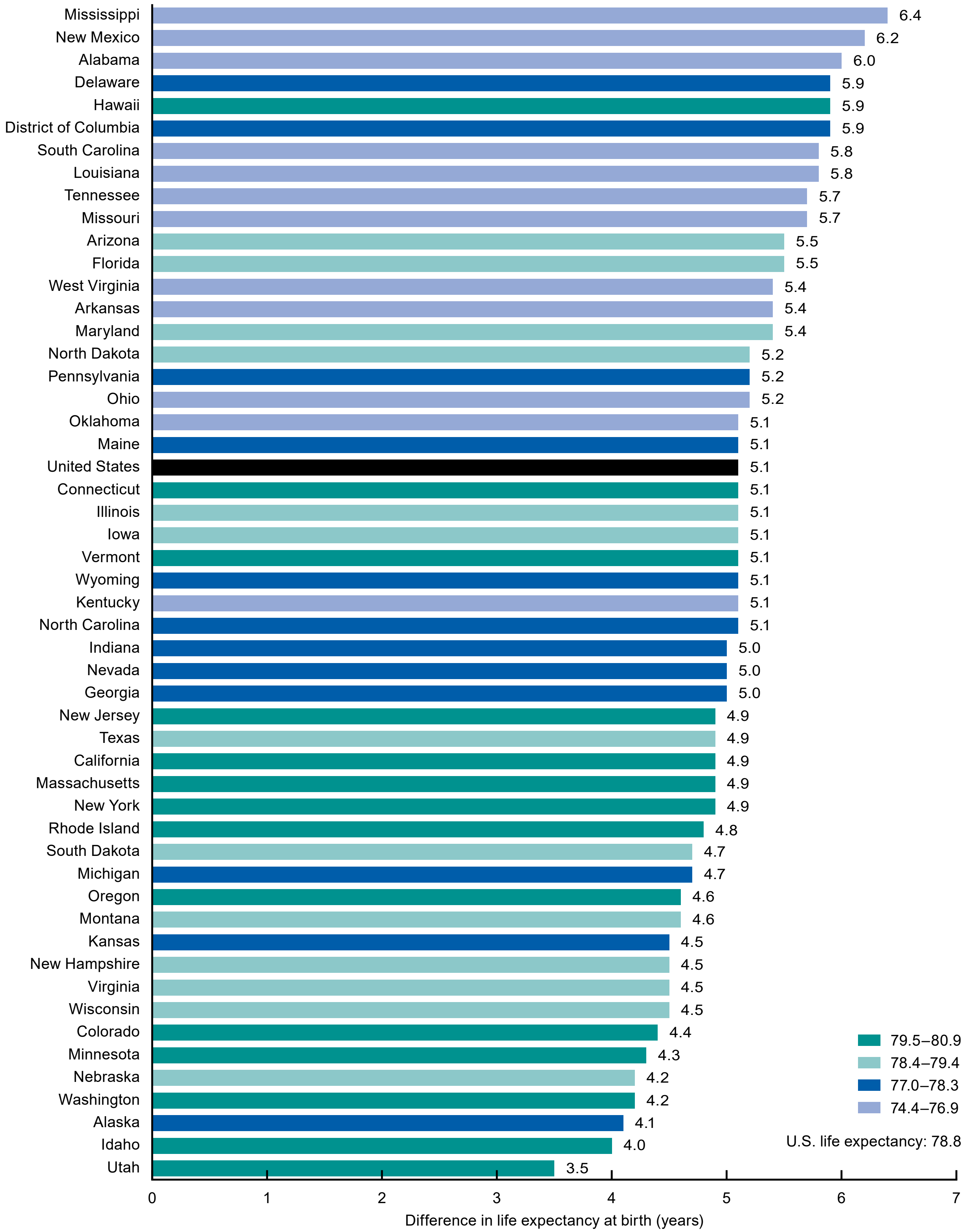
Figure 1. Life expectancy at birth: Each state, District of Columbia, and United States, 2019



SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure 2. Difference between male and female life expectancy at birth: Each state, District of Columbia, and United States, 2019



NOTE: The color key reflects the range of life expectancy at birth for both sexes for each area.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Table B. Life expectancy at age 65, rank, and standard error, by sex: Each state, District of Columbia, and United States, 2019

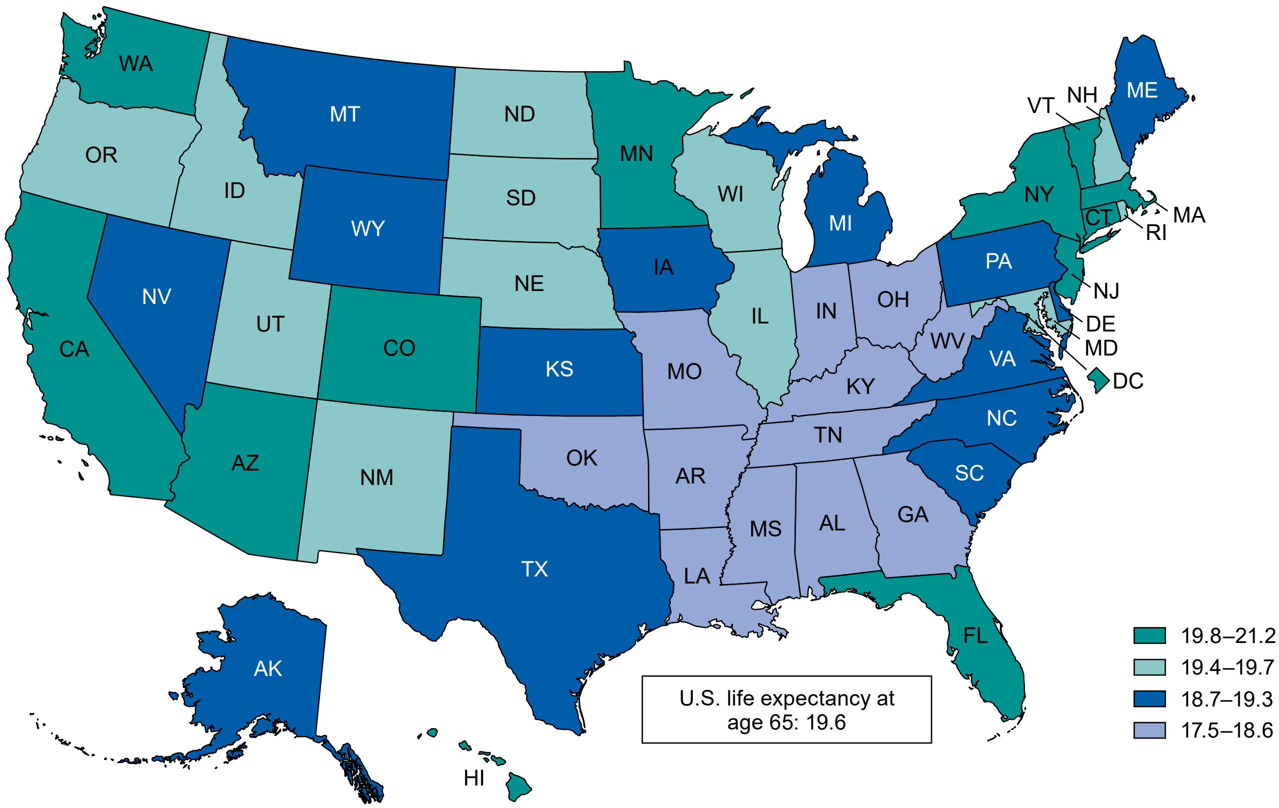
Area	Rank	Total	Standard error	Rank	Male	Standard error	Rank	Female	Standard error
Hawaii	1	21.2	0.065	1	19.4	0.090	1	22.9	0.089
California	2	20.5	0.013	2	19.1	0.019	2	21.8	0.018
New York	3	20.3	0.018	4	18.8	0.025	3	21.6	0.024
Connecticut	4	20.2	0.039	5	18.8	0.055	4	21.5	0.053
Colorado	5	20.1	0.031	3	19.0	0.045	11	21.1	0.043
Florida	6	20.1	0.016	10	18.6	0.023	5	21.4	0.022
Massachussetts	7	20.1	0.028	7	18.7	0.040	6	21.3	0.039
New Jersey	8	20.0	0.026	9	18.6	0.036	8	21.2	0.035
Minnesota	9	20.0	0.031	6	18.7	0.044	7	21.2	0.043
District of Columbia	10	19.9	0.115	20	18.3	0.171	9	21.1	0.152
Vermont	11	19.9	0.085	12	18.5	0.121	10	21.1	0.117
Arizona	12	19.8	0.028	13	18.5	0.041	12	21.0	0.038
Washington	13	19.8	0.027	11	18.5	0.039	15	20.9	0.037
Delaware	14	19.7	0.071	23	18.2	0.103	13	21.0	0.095
Oregon	15	19.6	0.035	14	18.5	0.050	19	20.7	0.048
New Mexico	16	19.6	0.051	19	18.3	0.074	16	20.8	0.068
United States	…	19.6	…	…	18.2	…	…	20.8	…
Utah	17	19.6	0.047	8	18.6	0.067	28	20.5	0.065
South Dakota	18	19.6	0.077	18	18.3	0.107	17	20.8	0.108
Rhode Island	19	19.6	0.071	21	18.2	0.101	20	20.7	0.097
New Hampshire	20	19.5	0.058	15	18.4	0.081	25	20.6	0.081
North Dakota	21	19.5	0.090	28	18.0	0.122	14	20.9	0.127
Idaho	22	19.5	0.055	17	18.3	0.077	27	20.5	0.076
Maryland	23	19.5	0.032	24	18.1	0.045	22	20.6	0.043
Wisconsin	24	19.5	0.030	25	18.1	0.041	18	20.7	0.042
Illinois	25	19.4	0.022	26	18.0	0.031	21	20.6	0.030
Nebraska	26	19.4	0.055	27	18.0	0.077	23	20.6	0.076
Virginia	27	19.3	0.026	29	18.0	0.038	26	20.5	0.036
Iowa	28	19.3	0.042	30	17.9	0.059	24	20.6	0.058
Montana	29	19.3	0.065	22	18.2	0.091	30	20.4	0.091
Pennsylvania	30	19.3	0.020	31	17.9	0.028	29	20.5	0.028
Alaska	31	19.2	0.090	16	18.4	0.127	35	20.1	0.126
Maine	32	19.1	0.056	32	17.8	0.080	32	20.3	0.077
Wyoming	33	19.1	0.091	33	17.8	0.124	31	20.4	0.130
Texas	34	19.0	0.016	35	17.7	0.022	33	20.2	0.021
Michigan	35	18.9	0.023	34	17.7	0.033	37	20.0	0.032
Kansas	36	18.9	0.045	36	17.6	0.062	34	20.1	0.062
South Carolina	37	18.8	0.032	37	17.4	0.047	38	20.0	0.043
North Carolina	38	18.8	0.023	38	17.4	0.033	39	19.9	0.031
Nevada	39	18.7	0.044	39	17.4	0.062	36	20.1	0.060
Missouri	40	18.6	0.030	40	17.2	0.043	40	19.8	0.042
Georgia	41	18.6	0.025	42	17.2	0.035	41	19.8	0.033
Ohio	42	18.5	0.022	41	17.2	0.030	42	19.7	0.030
Indiana	43	18.4	0.029	43	17.0	0.041	43	19.6	0.041
Louisiana	44	18.2	0.035	44	16.8	0.050	44	19.5	0.049
Tennessee	45	18.0	0.029	45	16.5	0.041	45	19.3	0.039
Arkansas	46	17.8	0.044	48	16.3	0.062	46	19.2	0.060
Oklahoma	47	17.8	0.039	46	16.5	0.055	49	18.9	0.054
Alabama	48	17.7	0.034	50	16.2	0.048	47	19.1	0.046
West Virginia	49	17.7	0.051	47	16.4	0.071	50	18.9	0.071
Kentucky	50	17.7	0.035	49	16.3	0.049	51	18.8	0.048
Mississippi	51	17.5	0.044	51	15.8	0.063	48	19.0	0.061

… Category not applicable.

NOTE: Life expectancies shown are rounded, but rankings are based on unrounded life expectancies.

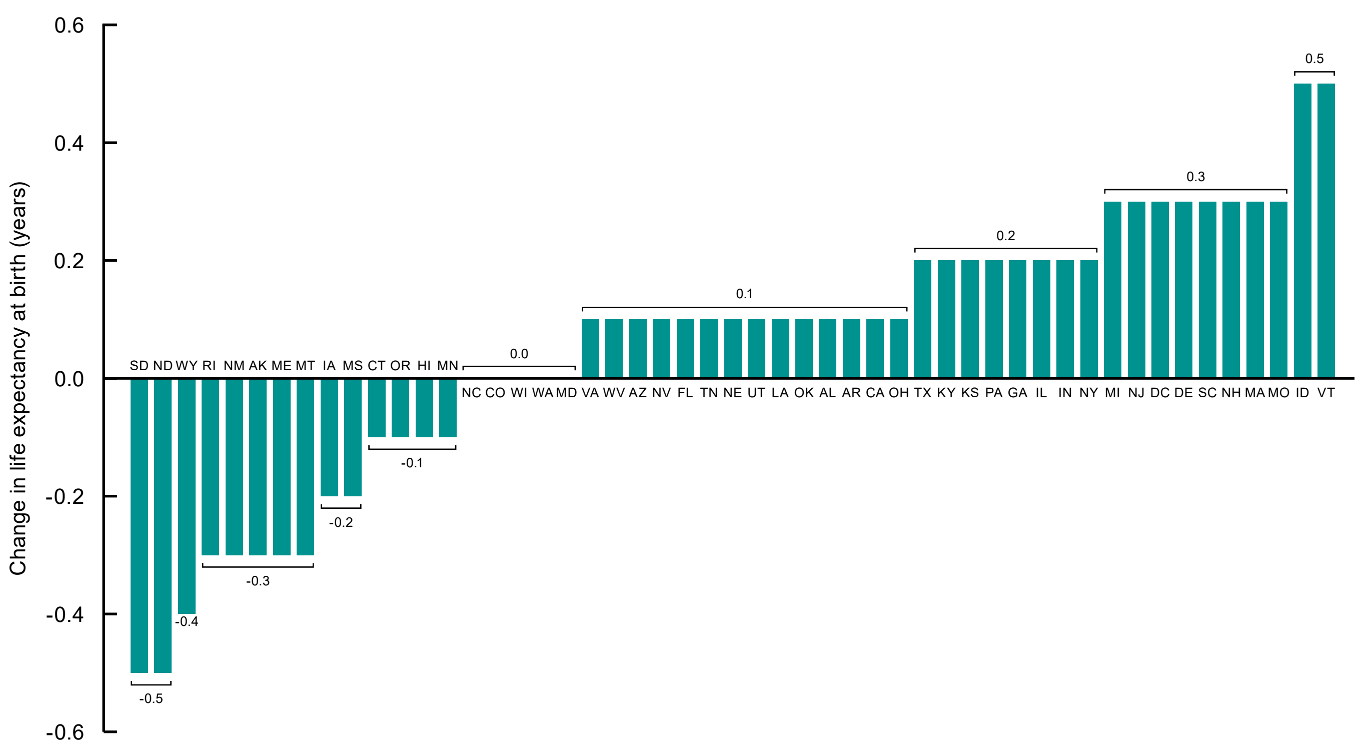
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure 3. Life expectancy at age 65: Each state, District of Columbia, and United States, 2019



SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure 4. Change in life expectancy at birth from 2018 to 2019: Each state and District of Columbia



SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

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Technical Notes

The methods used to estimate the 2019 complete life tables for the 50 states and the District of Columbia (D.C.) are the same as those used to estimate the U.S. annual life tables, with two modifications (1). First, for states with zero death counts at single ages 1–4 years, linear interpolation was used to replace those zero death counts. For a few states, linear interpolation was also used to replace zero and negative death counts resulting from the application of Beers' smoothing technique to very small death counts for ages 6–12 years. Second, a modification was made to the estimation of the age-specific death rates for ages 66–99. Because state age-specific census population estimates for ages 85–100 are not available, the age range needed to be modified where vital and Medicare death rates are blended and where Medicare data are used exclusively. Details of the methodology and modifications follow.

Data for calculating life table functions

The data used to prepare the U.S. state life tables (Table I) include state-specific final death counts from the National Vital Statistics System (NVSS), state-specific population estimates from the U.S. Census Bureau, and state-specific death and population counts for Medicare beneficiaries aged 66–99 from the Centers for Medicare & Medicaid Services (CMS).

Vital statistics data

Death counts used for computing the life tables presented in this report are state-specific final numbers of deaths for 2019 collected from death certificates filed in state vital statistics offices and reported to the National Center for Health Statistics (NCHS) as part of NVSS.

Census population data

The population data used to estimate the life tables shown in this report are state-specific postcensal population estimates based on the 2010 decennial census and are available from the Census Bureau website at: https://www2.census.gov/programs-surveys/popest/tables/2010-2019/state/asrh/sc-est2019-alldata6.csv.

Medicare data

Data from the Medicare program are used to supplement vital statistics and census data for ages 66–99 for the total population and by sex for each state and D.C.

Medicare data are considered more accurate than vital statistics and census data at the oldest ages because Medicare enrollees must have proof of age to enroll (6). However, the reliability of Medicare data beyond age 100 declines because of the small percentage of people who enrolled at the start of the Medicare program in 1965 for whom it was not possible to verify exact age (6).

Table I. Complete period life tables: 50 states and District of Columbia, 2019

Available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/70-18/

Table title
AK–1. Life table for total population: Alaska, 2019
AK–2. Life table for males: Alaska, 2019
AK–3. Life table for females: Alaska, 2019
AK–4. Standard errors of probability of dying and life expectancy: Alaska, 2019
AL–1. Life table for total population: Alabama, 2019
AL–2. Life table for males: Alabama, 2019
AL–3. Life table for females: Alabama, 2019
AL–4. Standard errors of probability of dying and life expectancy: Alabama, 2019
AR–1. Life table for total population: Arkansas, 2019
AR–2. Life table for males: Arkansas, 2019
AR–3. Life table for females: Arkansas, 2019
AR–4. Standard errors of probability of dying and life expectancy: Arkansas, 2019
AZ–1. Life table for total population: Arizona, 2019
AZ–2. Life table for males: Arizona, 2019
AZ–3. Life table for females: Arizona, 2019
AZ–4. Standard errors of probability of dying and life expectancy: Arizona, 2019
CA–1. Life table for total population: California, 2019
CA–2. Life table for males: California, 2019
CA–3. Life table for females: California, 2019
CA–4. Standard errors of probability of dying and life expectancy: California, 2019
CO–1. Life table for total population: Colorado, 2019
CO–2. Life table for males: Colorado, 2019
CO–3. Life table for females: Colorado, 2019
CO–4. Standard errors of probability of dying and life expectancy: Colorado, 2019
CT–1. Life table for total population: Connecticut, 2019
CT–2. Life table for males: Connecticut, 2019
CT–3. Life table for females: Connecticut, 2019
CT–4. Standard errors of probability of dying and life expectancy: Connecticut, 2019
DC–1. Life table for total population: District of Columbia, 2019
DC–2. Life table for males: District of Columbia, 2019
DC–3. Life table for females: District of Columbia, 2019
DC–4. Standard errors of probability of dying and life expectancy: District of Columbia, 2019
DE–1. Life table for total population: Delaware, 2019
DE–2. Life table for males: Delaware, 2019
DE–3. Life table for females: Delaware, 2019
DE–4. Standard errors of probability of dying and life expectancy: Delaware, 2019
FL–1. Life table for total population: Florida, 2019
FL–2. Life table for males: Florida, 2019
FL–3. Life table for females: Florida, 2019
FL–4. Standard errors of probability of dying and life expectancy: Florida, 2019
GA–1. Life table for total population: Georgia, 2019
GA–2. Life table for males: Georgia, 2019
GA–3. Life table for females: Georgia, 2019
GA–4. Standard errors of probability of dying and life expectancy: Georgia, 2019
HI–1. Life table for total population: Hawaii, 2019
HI–2. Life table for males: Hawaii, 2019
HI–3. Life table for females: Hawaii, 2019
HI–4. Standard errors of probability of dying and life expectancy: Hawaii, 2019
IA–1. Life table for total population: Iowa, 2019
IA–2. Life table for males: Iowa, 2019
IA–3. Life table for females: Iowa, 2019
IA–4. Standard errors of probability of dying and life expectancy: Iowa, 2019
ID–1. Life table for total population: Idaho, 2019
ID–2. Life table for males: Idaho, 2019
ID–3. Life table for females: Idaho, 2019

See footnote at end of table.

Table I. Complete period life tables: 50 states and District of Columbia, 2019—Con.

Available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/70-18/

Table title
ID–4. Standard errors of probability of dying and life expectancy: Idaho, 2019
IL–1. Life table for total population: Illinois, 2019
IL–2. Life table for males: Illinois, 2019
IL–3. Life table for females: Illinois, 2019
IL–4. Standard errors of probability of dying and life expectancy: Illinois, 2019
IN–1. Life table for total population: Indiana, 2019
IN–2. Life table for males: Indiana, 2019
IN–3. Life table for females: Indiana, 2019
IN–4. Standard errors of probability of dying and life expectancy: Indiana, 2019
KS–1. Life table for total population: Kansas, 2019
KS–2. Life table for males: Kansas, 2019
KS–3. Life table for females: Kansas, 2019
KS–4. Standard errors of probability of dying and life expectancy: Kansas, 2019
KY–1. Life table for total population: Kentucky, 2019
KY–2. Life table for males: Kentucky, 2019
KY–3. Life table for females: Kentucky, 2019
KY–4. Standard errors of probability of dying and life expectancy: Kentucky, 2019
LA–1. Life table for total population: Louisiana, 2019
LA–2. Life table for males: Louisiana, 2019
LA–3. Life table for females: Louisiana, 2019
LA–4. Standard errors of probability of dying and life expectancy: Louisiana, 2019
MA–1. Life table for total population: Massachusetts, 2019
MA–2. Life table for males: Massachusetts, 2019
MA–3. Life table for females: Massachusetts, 2019
MA–4. Standard errors of probability of dying and life expectancy: Massachusetts, 2019
MD–1. Life table for total population: Maryland, 2019
MD–2. Life table for males: Maryland, 2019
MD–3. Life table for females: Maryland, 2019
MD–4. Standard errors of probability of dying and life expectancy: Maryland, 2019
ME–1. Life table for total population: Maine, 2019
ME–2. Life table for males: Maine, 2019
ME–3. Life table for females: Maine, 2019
ME–4. Standard errors of probability of dying and life expectancy: Maine, 2019
MI–1. Life table for total population: Michigan, 2019
MI–2. Life table for males: Michigan, 2019
MI–3. Life table for females: Michigan, 2019
MI–4. Standard errors of probability of dying and life expectancy: Michigan, 2019
MN–1. Life table for total population: Minnesota, 2019
MN–2. Life table for males: Minnesota, 2019
MN–3. Life table for females: Minnesota, 2019
MN–4. Standard errors of probability of dying and life expectancy: Minnesota, 2019
MO–1. Life table for total population: Missouri, 2019
MO–2. Life table for males: Missouri, 2019
MO–3. Life table for females: Missouri, 2019
MO–4. Standard errors of probability of dying and life expectancy: Missouri, 2019
MS–1. Life table for total population: Mississippi, 2019
MS–2. Life table for males: Mississippi, 2019
MS–3. Life table for females: Mississippi, 2019
MS–4. Standard errors of probability of dying and life expectancy: Mississippi, 2019
MT–1. Life table for total population: Montana, 2019
MT–2. Life table for males: Montana, 2019
MT–3. Life table for females: Montana, 2019
MT–4. Standard errors of probability of dying and life expectancy: Montana, 2019
NC–1. Life table for total population: North Carolina, 2019
NC–2. Life table for males: North Carolina, 2019
NC–3. Life table for females: North Carolina, 2019
NC–4. Standard errors of probability of dying and life expectancy: North Carolina, 2019
ND–1. Life table for total population: North Dakota, 2019
ND–2. Life table for males: North Dakota, 2019
ND–3. Life table for females: North Dakota, 2019
ND–4. Standard errors of probability of dying and life expectancy: North Dakota, 2019
NE–1. Life table for total population: Nebraska, 2019
NE–2. Life table for males: Nebraska, 2019
NE–3. Life table for females: Nebraska, 2019
NE–4. Standard errors of probability of dying and life expectancy: Nebraska, 2019
NH–1. Life table for total population: New Hampshire, 2019
NH–2. Life table for males: New Hampshire, 2019
NH–3. Life table for females: New Hampshire, 2019
NH–4. Standard errors of probability of dying and life expectancy: New Hampshire, 2019
NJ–1. Life table for total population: New Jersey, 2019
NJ–2. Life table for males: New Jersey, 2019
NJ–3. Life table for females: New Jersey, 2019
NJ–4. Standard errors of probability of dying and life expectancy: New Jersey, 2019
NM–1. Life table for total population: New Mexico, 2019
NM–2. Life table for males: New Mexico, 2019
NM–3. Life table for females: New Mexico, 2019
NM–4. Standard errors of probability of dying and life expectancy: New Mexico, 2019
NV–1. Life table for total population: Nevada, 2019
NV–2. Life table for males: Nevada, 2019
NV–3. Life table for females: Nevada, 2019
NV–4. Standard errors of probability of dying and life expectancy: Nevada, 2019
NY–1. Life table for total population: New York, 2019
NY–2. Life table for males: New York, 2019
NY–3. Life table for females: New York, 2019
NY–4. Standard errors of probability of dying and life expectancy: New York, 2019
OH–1. Life table for total population: Ohio, 2019
OH–2. Life table for males: Ohio, 2019
OH–3. Life table for females: Ohio, 2019
OH–4. Standard errors of probability of dying and life expectancy: Ohio, 2019
OK–1. Life table for total population: Oklahoma, 2019
OK–2. Life table for males: Oklahoma, 2019
OK–3. Life table for females: Oklahoma, 2019
OK–4. Standard errors of probability of dying and life expectancy: Oklahoma, 2019
OR–1. Life table for total population: Oregon, 2019
OR–2. Life table for males: Oregon, 2019
OR–3. Life table for females: Oregon, 2019
OR–4. Standard errors of probability of dying and life expectancy: Oregon, 2019
PA–1. Life table for total population: Pennsylvania, 2019
PA–2. Life table for males: Pennsylvania, 2019
PA–3. Life table for females: Pennsylvania, 2019
PA–4. Standard errors of probability of dying and life expectancy: Pennsylvania, 2019
RI–1. Life table for total population: Rhode Island, 2019
RI–2. Life table for males: Rhode Island, 2019
RI–3. Life table for females: Rhode Island, 2019
RI–4. Standard errors of probability of dying and life expectancy: Rhode Island, 2019
SC–1. Life table for total population: South Carolina, 2019
SC–2. Life table for males: South Carolina, 2019

See footnote at end of table.

Table I. Complete period life tables: 50 states and District of Columbia, 2019—Con.

Available from: https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/70-18/

Table title
SC–3. Life table for females: South Carolina, 2019
SC–4. Standard errors of probability of dying and life expectancy: South Carolina, 2019
SD–1. Life table for total population: South Dakota, 2019
SD–2. Life table for males: South Dakota, 2019
SD–3. Life table for females: South Dakota, 2019
SD–4. Standard errors of probability of dying and life expectancy: South Dakota, 2019
TN–1. Life table for total population: Tennessee, 2019
TN–2. Life table for males: Tennessee, 2019
TN–3. Life table for females: Tennessee, 2019
TN–4. Standard errors of probability of dying and life expectancy: Tennessee, 2019
TX–1. Life table for total population: Texas, 2019
TX–2. Life table for males: Texas, 2019
TX–3. Life table for females: Texas, 2019
TX–4. Standard errors of probability of dying and life expectancy: Texas, 2019
UT–1. Life table for total population: Utah, 2019
UT–2. Life table for males: Utah, 2019
UT–3. Life table for females: Utah, 2019
UT–4. Standard errors of probability of dying and life expectancy: Utah, 2019
VA–1. Life table for total population: Virginia, 2019
VA–2. Life table for males: Virginia, 2019
VA–3. Life table for females: Virginia, 2019
VA–4. Standard errors of probability of dying and life expectancy: Virginia, 2019
VT–1. Life table for total population: Vermont, 2019
VT–2. Life table for males: Vermont, 2019
VT–3. Life table for females: Vermont, 2019
VT–4. Standard errors of probability of dying and life expectancy: Vermont, 2019
WA–1. Life table for total population: Washington, 2019
WA–2. Life table for males: Washington, 2019
WA–3. Life table for females: Washington, 2019
WA–4. Standard errors of probability of dying and life expectancy: Washington, 2019
WI–1. Life table for total population: Wisconsin, 2019
WI–2. Life table for males: Wisconsin, 2019
WI–3. Life table for females: Wisconsin, 2019
WI–4. Standard errors of probability of dying and life expectancy: Wisconsin, 2019
WV–1. Life table for total population: West Virginia, 2019
WV–2. Life table for males: West Virginia, 2019
WV–3. Life table for females: West Virginia, 2019
WV–4. Standard errors of probability of dying and life expectancy: West Virginia, 2019
WY–1. Life table for total population: Wyoming, 2019
WY–2. Life table for males: Wyoming, 2019
WY–3. Life table for females: Wyoming, 2019
WY–4. Standard errors of probability of dying and life expectancy: Wyoming, 2019

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

To estimate death rates for the state-specific Medicare populations in 2019, sex- and age-specific numbers of deaths and population counts were used for the population aged 66–99 in each state and D.C. from the 2019 Medicare file. The data file, created by CMS for the Social Security Administration, is shared with NCHS under a special agreement. The 2019 file contains state-specific 2019 midyear Medicare population counts (as of June 30, 2019) and calendar-year Medicare death counts (for January 1 through December 31, 2019). Age for both death and midyear population counts is calculated as age at last birthday.

Preliminary adjustment of data

Adjustments for unknown age

An adjustment is made to account for the small proportion of deaths each year for which age is not reported on the death certificate. The number of deaths in each age category is adjusted proportionally to account for those with not-stated age. An adjustment factor (F) is used to distribute deaths with nonstated ages. F is calculated for the total population and by sex for each state and D.C. as:

$$F = \frac{D}{D^a} \quad [1]$$

where D is the total number of deaths and D^a is the total number of deaths for which age is stated. F is then applied by multiplying it by the number of deaths in each age group.

Interpolation of P_x and D_x

Anomalies—both random and those associated with reporting age at death—can be problematic when using vital statistics and census data by single years of age to estimate the probability of death (2,7). Graduation techniques are often used to eliminate these anomalies and to derive a smooth curve by age. Beers' ordinary minimized fifth difference formula is used to obtain smoothed values of population counts (P_x) and death counts (D_x) from 5-year age groupings of ${}_nP_x$ from age 0–99 and ${}_nD_x$ from age 5–99, and where ${}_nD_x$ has first been adjusted for not-reported age on the death certificate (see reference 7 for details on the application of Beers' method). Beers' interpolation is not applied to deaths at ages 0–4.

For states with zero death counts in the age range 1–4 years, those counts needed to be replaced using linear interpolation; otherwise, zero death counts would have resulted in the discontinuation of the age-specific mortality distribution. In a few other cases, application of Beers' interpolation of deaths in the age range 6–12 resulted in zero or negative death counts because of very small numbers of deaths, so linear interpolation was also applied. The assumption of linearity is warranted because mortality declines somewhat linearly between ages 1 and 10 or so, and the results led to smooth age patterns of mortality (see Table II for a list of states and ages where linear interpolation was used).

Table II. Application of linear interpolation for selected states, by sex and age

Area	Age (years)	
	Male	Female
Connecticut	…	3
Delaware	4,10,11	3
District of Columbia	2, 4	4
Hawaii	4	…
Idaho	…	4
Iowa	…	3
Kansas	…	3
Kentucky	4	…
Maine	3	2,3
Montana	4	2,4
Nebraska	…	2
New Hampshire	2	4,6,7
New Mexico	…	4
North Dakota	…	2,3
Oregon	4	…
Rhode Island	…	2,3
South Dakota	3,10,11	…
Vermont	3	3
West Virginia	…	11,12
Wyoming	3	1,2

… Category not applicable.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Calculation of probability of dying (q_x)

The first step in the calculation of a complete period life table is the estimation of the age-specific probability of dying, q_x, which is derived from the age-specific death rate, m_x (2,4). In the life table cohort,

$$m_x = \frac{d_x}{L_x}$$

where d_x is the number of deaths occurring between ages x and $x + 1$, and L_x is the number of person-years lived by the life table cohort between ages x and $x + 1$. The conversion of the age-specific death rate, m_x, to the age-specific probability of death, q_x, is:

$$q_x = \frac{m_x}{1+(1-a_x)m_x} \qquad [2]$$

where a_x is the number of person-years lived in the age interval by members of the life table cohort who died in the interval. When the age interval is 1 year, except at infancy, a_x = 1/2; in other words, deaths occur on average midway through the age interval. As a result,

$$q_x = \frac{m_x}{1+\frac{1}{2}m_x} \qquad [3]$$

Because the complete period life table is based on the age-specific death rates of a current population observed for a specific calendar year, the life table death rate is equivalent to the observed death rate of the current population:

$$m_x = \frac{d_x}{L_x} = M_x = \frac{D_x}{P_x}$$

where D_x is the Beers' smoothed (or linearly interpolated) number of deaths adjusted for not-stated age and P_x is the Beers' smoothed population at risk of dying between ages x and $x + 1$. Then,

$$q_x = \frac{M_x}{1+\frac{1}{2}M_x} = \frac{D_x}{P_x + \frac{1}{2}D_x} \qquad [4]$$

This procedure is used to estimate vital statistics age-specific probabilities of death for ages 1–84.

Calculation of q_x at age 0

The higher mortality observed in infancy is associated with a high concentration of deaths occurring at the beginning of the age interval rather than in the middle. As a result, assigning deaths to the appropriate birth cohorts is best whenever possible. Therefore, the probability of death at birth, q_0, is calculated using a birth cohort method that uses a separation factor (f) defined as the proportion of infant deaths in year t occurring to infants born in the previous year (t – 1). The value f is estimated by categorizing infant deaths by date of birth. The probability of death is then calculated as:

$$q_0 = \frac{D_0(1-f)}{B^t} + \frac{D_0(f)}{B^{t-1}} \qquad [5]$$

where D_0 is the number of infant deaths adjusted for not-stated age in 2019, B^t is the number of live births in 2019, and B^{t-1} is the number of live births in 2018.

Probabilities of dying at oldest ages

Medicare data are used to supplement vital statistics data for the estimation of q_x at the oldest ages because these data are more accurate, given that proof of age is required for enrollment in the Medicare program. Medicare data are used here to estimate the probability of dying for ages 66–99.

For this method, these steps are followed: First, vital statistics and Medicare death rates are blended in the age range 66–99. Second, a logistic model is used to smooth the blended death rates in the age range 85–99 and to predict death rates for ages 100–120. Third, final resulting death rates, M_x, are converted to probabilities of dying, q_x.

For the national life tables, vital statistics, M_x^V, and Medicare, M_x^M, death rates are blended in the age range 66–94 with a weighting process that gives gradually declining weight to vital statistics data and gradually increasing weight to Medicare data. For ages 95–99, M_x^M is used exclusively. Due to the unavailability of census state population estimates for ages 85–100, calculating M_x^V for this age span is not possible.

As a result, the blending technique was modified such that M_x^V and M_x^M are blended in the age range 66–84 and M_x^M is used exclusively in the age range 85–99. Blended M_x is thus obtained as:

$$M_x = \frac{1}{20}[(85-x)M_x^V + (x-65)M_x^M] \qquad [6]$$

when x = 66,...,84, and

$$M_x = M_x^M$$

when x = 85,...,99.

M_x^M is estimated as:

$$M_x^M = \frac{D_x^M}{P_x^M}$$

where D_x^M is the age-specific Medicare death count, and P_x^M is the age-specific Medicare midyear population count.

The exclusive use of Medicare death rates beginning at age 85 for the state life tables is expected to have a negligible biasing effect on mortality at older ages in the life tables compared with the national life tables. As Figures I–III show, while large differences are found between Medicare and vital statistics death rates at ages 85 and over for the U.S. population, blended Medicare and vital statistics death rates are very similar to Medicare death rates for ages 85 and over.

A logistic model proposed by Kannisto is then used to smooth M_x in the age range 85–99 and predict M_x in the age range 100–120 (8). The start of the modeled age range varies by sex because it is a function of the age at which the rate of change in the age-specific death rates peaks. In current times, the rate of change in the age-specific death rate rises steadily up to about ages 80–85 and then begins to decline. As a result, modeling a large age span such as 65–100 with one simple model is difficult without oversmoothing and thus altering the underlying mortality pattern observed in the population of interest (9). Further, the observed data for the age range 65–85 or so is reliable and robust, as indicated by the very close similarity between vital statistics and Medicare death rates, making it unnecessary to model, or smooth, the entire age span (65–100).

The Kannisto model is a simple form of a logistic model in which the logit of u_x (or the natural log of the odds of u_x) is a linear function of age x (8). It is expressed as:

$$\ln[\frac{u_x}{1-u_x}] = \ln(\alpha) + \beta x \qquad [7]$$

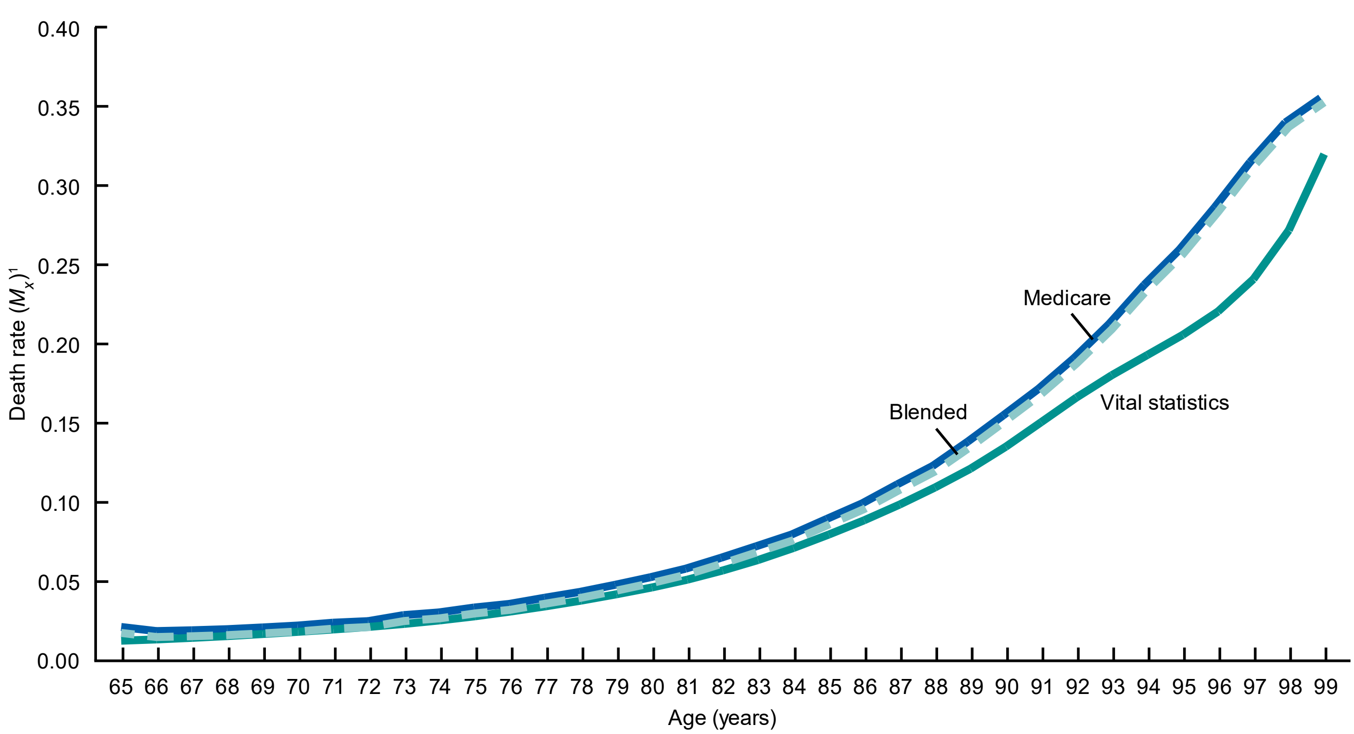
where u_x, the force of mortality (or the instantaneous death rate), is defined as:

$$u_x = \frac{\alpha e^{\beta x}}{1+\alpha e^{\beta x}}$$

Because u_x is not directly observed but is closely approximated by m_x, and $m_x = M_x$, then the logit of M_x is modeled instead. A maximum-likelihood generalized linear model estimation procedure is used to fit the following model in the age range 85–99:

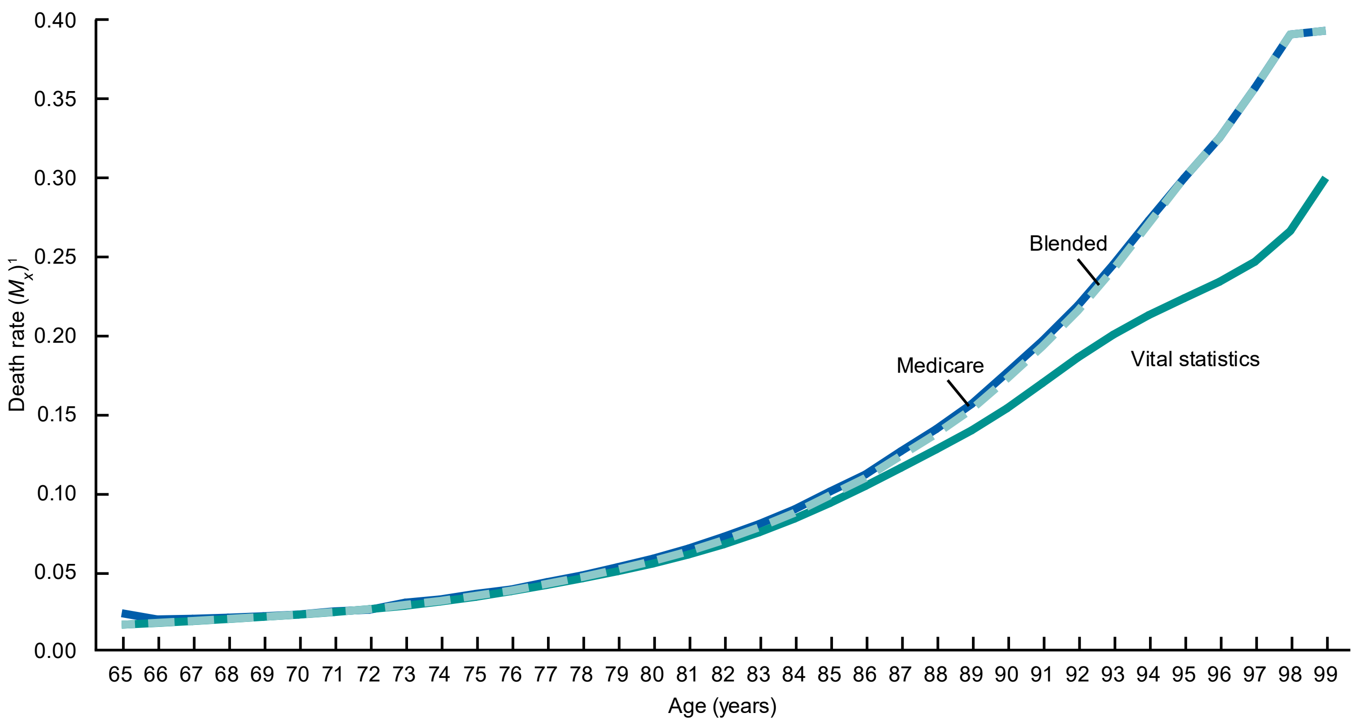
$$\ln[\frac{M_x}{1-M_x}] = \ln(\alpha) + \beta x \qquad [8]$$

Figure I. Age-specific vital statistics, Medicare, and blended death rates for total population: United States, 2019



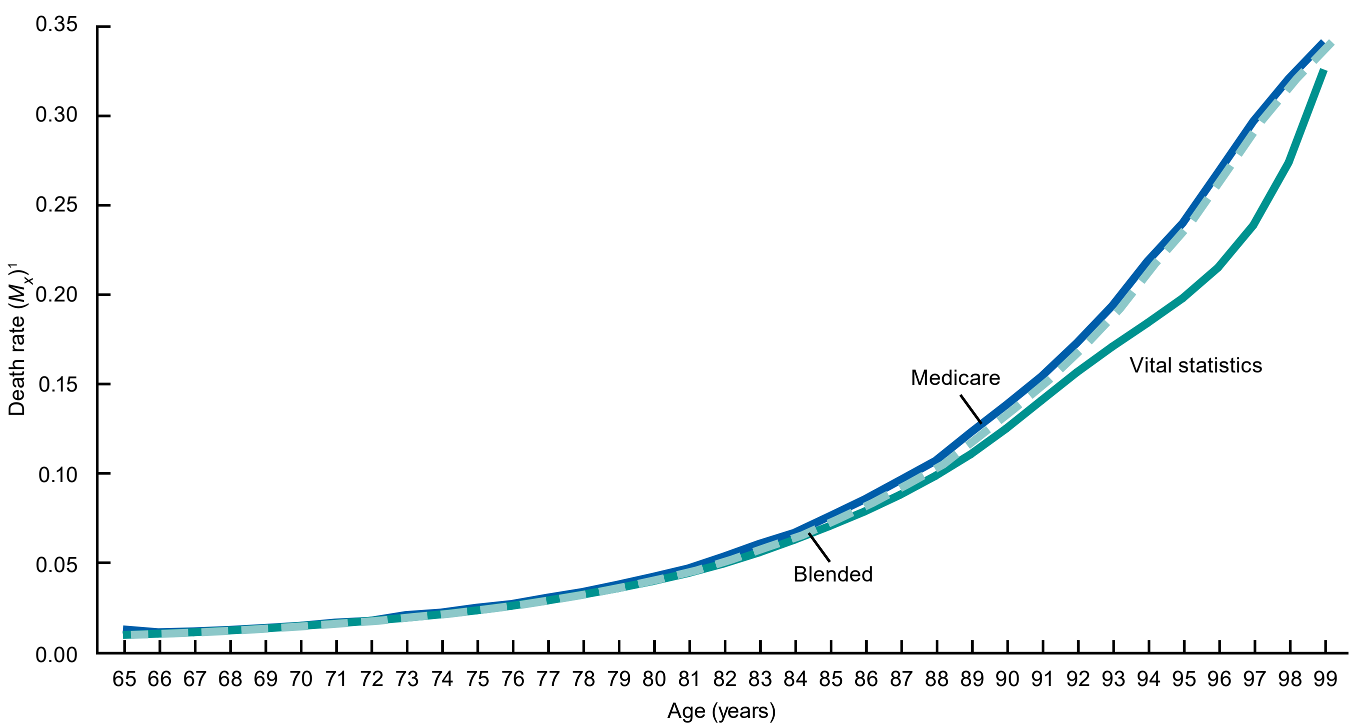
[1]Rate (M_x) is defined as the number of deaths during the year divided by the midyear population (D_x/P_x).
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure II. Age-specific vital statistics, Medicare, and blended death rates for male population: United States, 2019



[1]Rate (M_x) is defined as the number of deaths during the year divided by the midyear population (D_x/P_x).
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure III. Age-specific vital statistics, Medicare, and blended death rates for female population: United States, 2019



[1]Rate (M_x) is defined as the number of deaths during the year divided by the midyear population (D_x/P_x).
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Then, the estimated parameters are used to predict $\overline{M}_x$ as:

$$\overline{M}_x = \frac{e^a e^{bx}}{1+e^a e^{bx}} \text{ or, equivalently, } \overline{M}_x = \frac{e^{a+bx}}{1+e^{a+bx}} \qquad [9]$$

where a and b are the predicted values of parameters ln(α) and β, respectively, given by fitting model [8].

Finally, the predicted probability of death, q_x, for ages 85–120 is estimated by converting $\overline{M}_x$ as:

$$\overline{q}_x = \frac{\overline{M}_x}{1+\frac{1}{2}\overline{M}_x} \qquad [10]$$

The probability of death is extrapolated to age 120 to estimate the life table population until no survivors remain. This information is then used to estimate L_x for ages 100–120, which is used to close the table with the age category 100 and over, combined (see following discussion).

Figures IV–VI show the age-specific probability of dying, q_x, estimates for each of the 50 states and D.C. compared with the values for the United States in 2019. The observed probabilities for the states and D.C. are shown as circles, which appear as vertical bars where they overlap, and the U.S. probabilities are shown as an intersecting connected line. The state estimates fall about the U.S. values as expected, with a few outliers in the youngest childhood ages. These few cases are predominantly the result of a very small number of deaths, consistent with very low mortality in this age range, combined with very small populations in states such as Vermont, Wyoming, and North Dakota. Overall, age-specific estimates for the 50 states and D.C. follow the expected age pattern of mortality and are consistent with the mortality pattern observed for the entire United States.

Calculation of remaining life table functions for all groups

Survivor function (l_x)

The life table radix, l_0, is set at 100,000. For ages over 0, the number of survivors remaining at exact age x is calculated as:

$$l_x = l_{x-1}(1-q_{x-1}) \qquad [11]$$

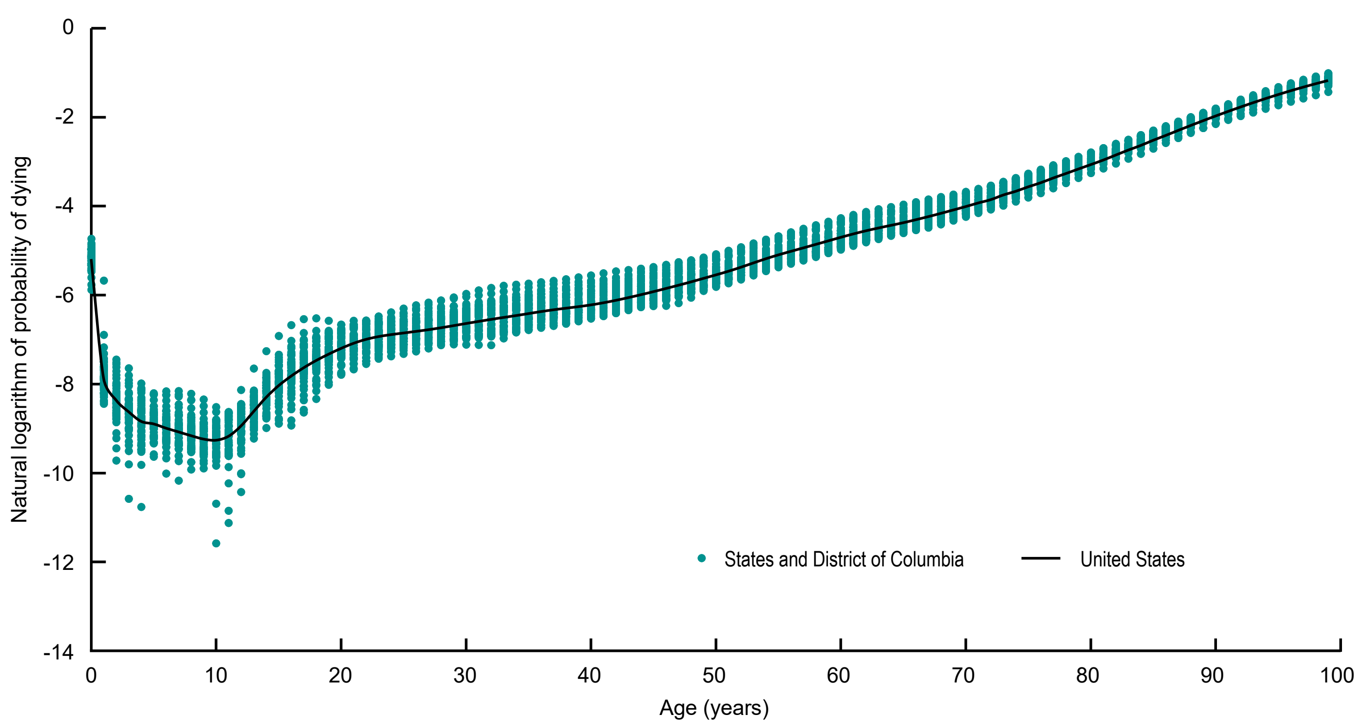
Decrement function (d_x)

The number of deaths occurring between ages x and $x+1$ is calculated from the survivor function:

$$d_x = l_x - l_{x-1} = l_x q_x \qquad [12]$$

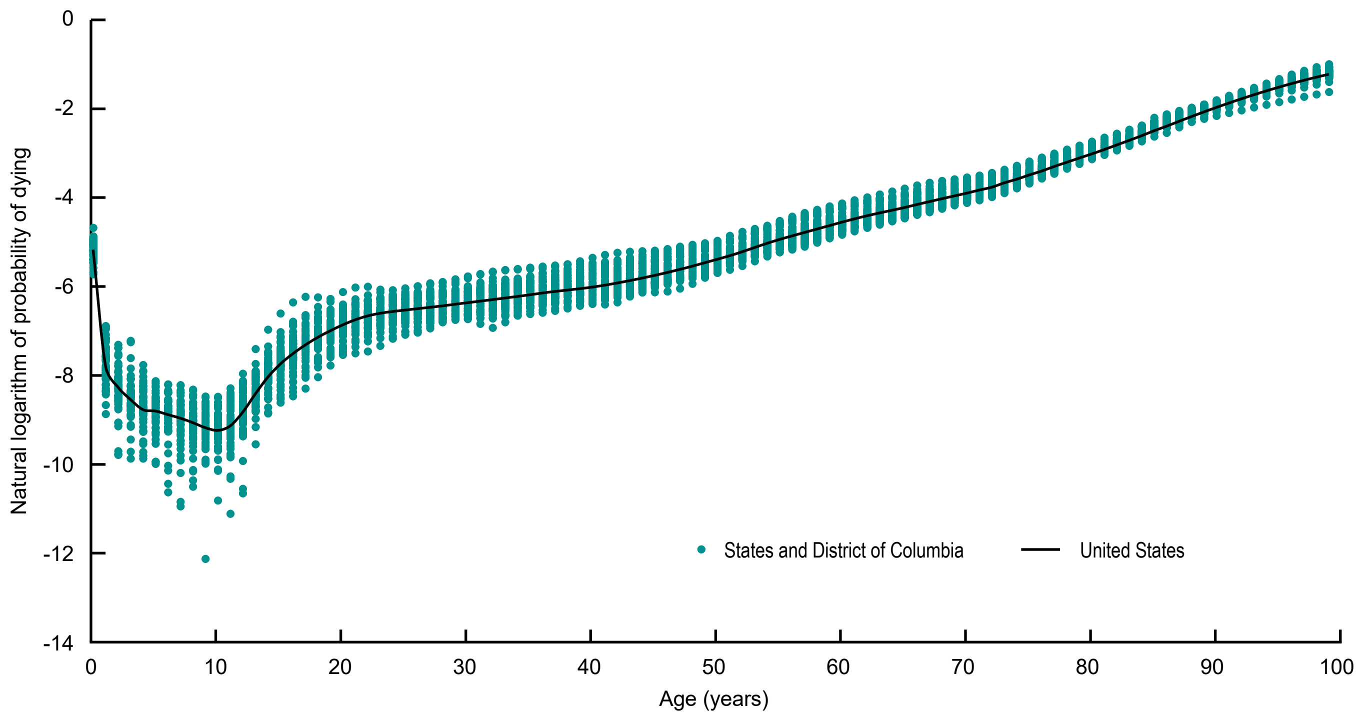
Note that ${}_{\infty}d_{100} = {}_{\infty}l_{100}$ because ${}_{\infty}q_{100} = 1.0$.

Figure IV. Age patterns of mortality for states and District of Columbia compared with United States, 2019



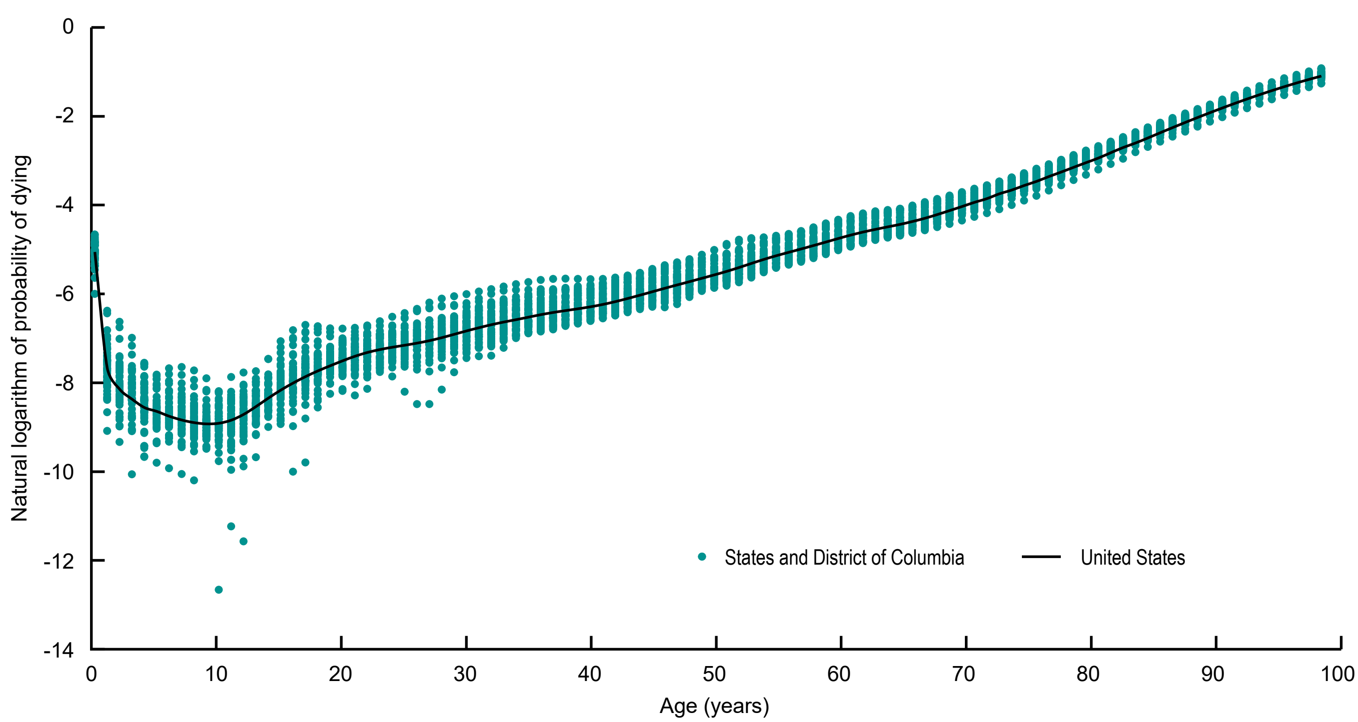
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure V. Male age patterns of mortality for states and District of Columbia compared with United States, 2019



SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure VI. Female age patterns of mortality for states and District of Columbia compared with United States, 2019



SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Person-years lived (L_x)

Person-years lived for ages 1–99 are calculated assuming that the survivor function declines linearly between ages *x* and *x* + 1. This gives the formula:

$$L_x = \frac{1}{2}(l_x + l_{x+1}) = l_x - \frac{1}{2}d_x \quad [13]$$

For *x* = 0, the separation factor *f* is used to calculate L_0:

$$L_0 = fl_0 + (1-f)\, l_1 \quad [14]$$

Finally, ${}_{\infty}L_{100}$ is estimated as the sum of the extrapolated L_x values for ages 100–120.

Person-years lived at age *x* and over (T_x)

T_x is calculated by summing L_x values at age *x* and over:

$$T_x = \sum_{x=0}^{\infty} L_x \quad [15]$$

Life expectancy at age *x* (e_x)

Life expectancy at exact age *x* is calculated as:

$$e_x = \frac{T_x}{l_x} \quad [16]$$

Variances and standard errors of the probability of dying and life expectancy

The mortality data on which the life tables are based are not affected by sampling error because the data are based on complete counts of deaths, and, as a result, variances and standard errors reflect only random variation. While measurement errors such as age misreporting are known to affect mortality estimates, they are not considered in the calculation of the variances or standard errors of the life table functions. Because the state life tables presented in this report are based on relatively large numbers of deaths, the variances and standard errors presented are rather small.

The methods used to estimate the variances of q_x and e_x are based on Chiang (10) with some necessary modifications due to the use of statistical modeling for smoothing and prediction of older-age death rates. Based on the assumption that deaths are binomially distributed, Chiang proposed the following equation for the variance of q_x:

$$Var\,(q_x) = \frac{q_x^2(1-q_x)}{D_x} \quad [17]$$

where D_x is the age-specific number of deaths. This equation is used to estimate $Var(q_x)$ throughout the age span with a modification where, for ages under age 66, D_x is the deaths from vital statistics data, smoothed by interpolation and adjusted for the number of deaths with age not stated. For ages 66 and over, D_x is obtained by treating the population as a cohort population and calculated from q_x because blended vital statistics and Medicare data were used for estimation (11):

$$P_x = \frac{(P_{x-1} - 0.5D_{x-1})(2-q_x)}{2}$$

$$D_x = \frac{q_x P_x}{1-0.5q_x}$$

Standard error of q_x

$$SE\,(q_x) = \sqrt{Var\,(q_x)} \quad [18]$$

Variances of the life expectancies for ages 0–99 are estimated using Chiang's equation:

$$Var(e_x) = \frac{\sum_{x=0}^{x=99} l_x^2 \bullet [(1-0.5) + e_x]^2 \bullet Var\,(q_x)}{l_x^2} \quad [19]$$

Chiang assumed that because q_{100+} = 1.00, then $Var\,(q_{100+}) = 0$, and therefore $Var\,(e_{100+}) = 0$. Silcocks et al. proposed that in the final age group, life expectancy is dependent on the mean length of survival and not on the probability of survival, and, therefore, the assumption of no variance is incorrect, and $Var\,(e_{100+})$ can be approximated as (12):

$$Var\,(e_{100+}) \approx \frac{l_{100+}^2}{M_{100+}^4} \bullet Var\,(M_{100+}) \quad [20]$$

Standard error of e_x

$$SE\,(e_x) = \sqrt{Var\,(e_x)} \quad [21]$$

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Contents

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