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LIFE EXPECTANCY AND MORTALITY RATES IN THE UNITED STATES, 1959-2017

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Abstract

IMPORTANCE—US life expectancy has not kept pace with that of other wealthy countries and is now decreasing.

OBJECTIVE—To examine vital statistics and review the history of changes in US life expectancy and increasing mortality rates; and to identify potential contributing factors, drawing insights from current literature and from a new analysis of state-level trends.

EVIDENCE—Life expectancy data for 1959–2016 and cause-specific mortality rates for 1999–2017 were obtained from the US Mortality Database and CDC WONDER, respectively. The analysis focused on midlife deaths (ages 25–64 years), stratified by sex, race-ethnicity, socioeconomic status, and geography (including the 50 states). Published research from January 1990 through August 2019 that examined relevant mortality trends and potential contributory factors was examined.

FINDINGS—Between 1959 and 2016, US life expectancy increased from 69.9 years to 78.9 years but declined for 3 consecutive years after 2014. The recent decrease in US life expectancy culminates a period of increasing cause-specific mortality among adults ages 25–64 years that began in the 1990s, ultimately producing an increase in all-cause mortality that began in 2010. During 2010–2017, midlife all-cause mortality rates increased from 328.5 deaths/100,000 to 348.2 deaths/100,000. By 2014, midlife mortality was increasing across all racial groups, caused by drug overdoses, alcohol abuse, suicides, and a diverse list of organ system diseases. The largest relative increases in midlife mortality rates occurred in New England (New Hampshire, 23.3%; Maine, 20.7%; Vermont, 19.9%) and the Ohio Valley (West Virginia, 23.0%; Ohio, 21.6%; Indiana, 14.8%; Kentucky, 14.7%). The increase in midlife mortality during 2010–2017 was associated with an estimated 33,307 excess US deaths, 32.8% of which occurred in four Ohio Valley states.

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CONCLUSIONS—US life expectancy increased for most of the past 60 years, but the rate of increase slowed over time and life expectancy decreased after 2014. A major contributor has been an increase in mortality from specific causes (e.g., drug overdoses, suicides, organ system diseases) among young and middle-aged adults of all racial groups, which began as early as the 1990s and produced the largest relative increases in the Ohio Valley and New England. The implications for public health and the economy are substantial, making it vital to understand the root causes.

INTRODUCTION

Life expectancy at birth, a common measure of a population's health,[1] has decreased in the US for three consecutive years.[2] This has attracted recent public attention,[3] but the core problem is not new, and has been building since the 1980s.[4,5] Although life expectancy in developed countries has increased for much of the past century, US life expectancy began to lose pace with other countries in the 1980s[6,7] and, by 1998, had declined to a level below the average life expectancy among Organisation for Economic Cooperation and Development countries.[8] While life expectancy in these countries has continued to increase,[9,10] US life expectancy stopped increasing in 2010 and has been decreasing since 2014.[2,11] Despite excessive spending on health care, vastly exceeding that of other countries,[12] the US has a longstanding health disadvantage relative to other high-income countries that extends beyond life expectancy to include higher rates of disease and cause-specific mortality rates.[6,7,10,13]

This Special Communication has two aims: to examine vital statistics and review the history of changes in US life expectancy and increasing mortality rates; and to identify potential contributing factors, drawing insights from current literature and from a new analysis of state-level trends.

METHODS

DATA ANALYSIS

Measures—This report examines longitudinal trends in life expectancy at birth and mortality rates (deaths per 100,000) in the US population, with a focus on *midlife*, defined here as adults ages 25–64 years. This age range was chosen because the literature has reported increases in mortality rates among both young adults (as young as age 25 years) and middle-aged adults (up to age 64 years); midlife mortality is used as shorthand for both age groups combined (ages 25–64 years). Life expectancy at birth is an estimate of the number of years a newborn is predicted to live, based here on period life table calculations that assume a hypothetical cohort is subject throughout its lifetime to the prevailing age-specific death rates for that year.[14] All-cause mortality and cause-specific mortality rates for key conditions were examined, using the *International Classification of Disease* (ICD-10)[15] codes detailed in the online Supplement. Age-specific rates were examined for age groups of 10 years or less, whereas age-adjusted rates were examined for broader age groups. Age-adjustment rates were provided, and calculated, by the National Center for Health Statistics, using methods described elsewhere.[16]

Data sources—Life expectancy data were obtained from the National Center for Health Statistics[17] and US Mortality Database.[18] The latter was used for long-term trend analyses because it provided complete life tables for each year from 1959 to 2016 and at multiple geographic levels.[19] The analysis examined two time periods. First, life expectancy was examined from a long-term perspective (from 1959 onward) to identify when life expectancy trajectories began to change in the US and the 50 states. Second, knowing from the literature that mortality rates for specific causes (e.g., drug overdoses) began increasing in the 1990s, a detailed analysis of cause-specific mortality trends was conducted for 1999–2017. Mortality rates were obtained from CDC WONDER.[20] Pre-1999 mortality data, although available, were not examined because the priority was to understand the conditions responsible for current mortality trends and because changes in coding in the transition from ICD-9 to ICD-10[15] could introduce artefactual changes in mortality rates. Methods that are available to make these conversions were therefore not pursued.

Analytic methods—Life expectancy and mortality data were stratified by sex and across the five racial-ethnic groups used by the US Census Bureau[21]: non-Hispanic (NH) American Indians and Alaskan Natives (AIAN), NH Asians and Pacific Islanders (API), NH blacks (or African Americans), NH whites, and Hispanics. Mortality rates were stratified by geography, including rates for the nine US Census divisions (New England, Mid-Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific), the 50 states, and urban and rural counties as defined in the online Supplement. Data for the District of Columbia and US territories were not examined.

Changes in mortality rates between two years (two-point comparisons) were deemed significant based on 95% confidence intervals. Trends in life expectancy and mortality over time were examined to identify changes in slope and points of *retrogression*—a period of progress (increasing life expectancy or decreasing mortality) followed by stagnation (slope statistically equivalent to zero) or a significant reversal. Temporal trends were analyzed using the Joinpoint Regression Program,[22] which models consecutive linear segments on a log scale, connected by joinpoints where the segments meet (i.e., years when slopes changed significantly). A modification of the program's Bayesian Information Criteria method (called BIC3[23]) was substituted for the Monte Carlo permutation tests to reduce computation time. Slopes (annual percent rate change [APC]) were calculated for the line segments linking joinpoints, and the weighted average of the APCs (the average annual percent change [AAPC]) was calculated for three time periods: 1959–2016, 2005–2016, and 2010–2016 for life expectancy and 1999–2017, 2005–2017, and 2010–2017 for mortality rates. Slopes were considered increasing or decreasing if the estimated slope differed significantly from zero. The statistical significance of the APCs and the change in APCs between consecutive segments was determined by two-sided t-testing ($p \leq 0.05$). Specific model parameters are available in the online supplement.

Excess deaths attributed to the increase in midlife mortality during 2010–2017 were estimated by multiplying the population denominator for each year by the mortality rate of the previous year, repeating this for each year from 2011 to 2017, and summing the difference between expected and observed deaths.[24,25,26] Excess deaths were estimated for each state and census division, allowing for estimates of their relative contribution to the national total.

LITERATURE REVIEW

To add context to the vital statistics described above and more fully characterize what is known about observed trends, the epidemiologic literature was examined for other research on US and state life expectancy and mortality trends. Using PubMed and other bibliographic databases, studies published between January 1990 and August 2019 that examined life expectancy or midlife mortality trends or that disaggregated data by age, sex, race-ethnicity, socioeconomic status, or geography were examined, along with the primary sources they cited. Research on the factors associated with the specific causes of death (e.g., drug overdoses, suicides) responsible for increasing midlife mortality was also reviewed. Research on the methodological limitations of epidemiological data on mortality trends was also examined.

To review contextual factors that may explain observed mortality trends and the US health disadvantage relative to other high-income countries, epidemiologic research was augmented by an examination of relevant literature in sociology, economics, political science, history, and journalism. A snowball technique[27,28] was used to locate studies and reports on: (1) the history and timing of the opioid epidemic; (2) the contribution of modifiable risk factors (e.g., obesity) to mortality trends; (3) changes in the prevalence of psychological distress and mental illness; (4) the evidence linking economic conditions and health, (5) relevant economic history and trends in income and earnings, wealth inequality, and austerity during the observation period; (6) changes in subjective social status (e.g., financial precarity) and social capital; and (7) relevant Federal and state social and economic policies, including the role of geography (e.g., rural conditions) and state-level factors. The study was exempt from institutional review under 45 CFR 46.101(b)(4).

RESULTS

LIFE EXPECTANCY

Life expectancy values for 1959–2016 are provided online (Table e1) for the United States, nine census divisions, and 50 states. Between 1959 and 2016, US life expectancy increased by almost 10 years, from 69.9 years in 1959 to 78.9 years in 2016, with the fastest increase (highest APC) occurring during 1969–1979 (APC=0.48, $p < 0.01$) (Figure 1). Life expectancy began to advance more slowly in the 1980s and plateaued in 2011 (after which the APC differed non-significantly from zero). The NCHS reported that US life expectancy peaked (78.9 years) in 2014 and subsequently decreased significantly for three consecutive years, reaching 78.6 years in 2017.[2,9] The decrease was greater among men (0.4 years) than women (0.2 years) and occurred across racial-ethnic groups; between 2014 and 2016, life expectancy decreased among non-Hispanic (NH) whites (from 78.8 to 78.5 years), NH blacks (from 75.3 years to 74.8 years), and Hispanics (82.1 to 81.8 years).[17]

ALL-CAUSE MORTALITY

The recent decrease in US life expectancy was largely related to increases in all-cause mortality among young and middle-aged adults. During 1999–2017, infant mortality decreased from 736.0 deaths/100,000 to 567.0 deaths/100,000, mortality rates among children and early adolescents (ages 1–14 years) decreased from 22.9 deaths/100,000 to 16.5 deaths/100,000 (Figure 2), and age-adjusted mortality rates among adults ages 65–84 years decreased from 3,774.6 deaths/100,000 to 2,875.4 deaths/100,000.[20]

Table e2 presents age-specific, all-cause mortality rates for infants, children ages 1–4 years, and subsequent age deciles. Individuals ages 25–64 years (and even those ages 15–24 years) experienced retrogression: all-cause mortality rates were in decline in 2000, reached a nadir in 2010, and increased thereafter. The increase was greatest in midlife—among young and middle-aged adults (ages 25–64 years), whose age-adjusted all-cause mortality rates increased by 6.0% during 2010–2017 (from 328.5 deaths/100,000 to 348.2 deaths/100,000) (Figure 3). The increase in midlife mortality was greatest among younger adults (ages 25–34 years), whose age-specific rates increased by 29.0% during this period (from 102.9 deaths/100,000 to 132.8 deaths/100,000).[20] Rising death rates among middle-aged adults (ages 45–64 years) were less related to mortality among those ages 45–54 years, which decreased (from 407.1 deaths/100,000 to 401.5 deaths per 100,000), than among those ages 55–64 years, whose age-specific rates increased during 2010–2017 (from 851.9 deaths/100,000 to 885.8 deaths/100,000).[20]

CAUSE-SPECIFIC MORTALITY

Although all-cause mortality in midlife did not begin increasing in the US until 2010, midlife mortality rates for specific causes (e.g., drug overdoses, hypertensive diseases) began increasing earlier (Figure 4).[29,30] Table e3 presents absolute and relative changes in age-specific mortality rates by cause of death between 1999 and 2017 (and between 2010 and 2017) for every age group (by age decile), from infancy onward. The table shows that mortality rates increased primarily in midlife for 35 causes of death. The increase in cause-specific mortality was not always restricted to midlife; younger and older populations were often affected, although typically not as greatly (in relative or absolute terms) as those ages 25–64 years.

Year-by-year midlife mortality rates by cause for 1999–2017 (Table e4) show that retrogression occurred across multiple causes of death, in which progress in lowering midlife mortality was reversed. From 1999 to 2009, these cause-specific increases were not reflected in all-cause mortality trends because they were offset by large, co-occurring reductions in mortality from ischemic heart disease, cancer, HIV infection, motor vehicle injuries, and other leading causes of death.[31,32,33] However, increases in cause-specific mortality rates before 2010 slowed the rate at which all-cause mortality decreased (and life expectancy increased) and eventually culminated in a reversal. The end result was that all-cause mortality increased after 2010 (and life expectancy decreased after 2014).[34,35]

Drug overdoses, alcoholic liver disease, and suicides—A major cause of increasing midlife mortality was a large increase in fatal drug overdoses, beginning in the

1990s.[28,33,36] Between 1999 and 2017, midlife mortality from drug overdoses increased by 386.5% (from 6.7 deaths/100,000 to 32.5 deaths/100,000).[20] Age-specific rates increased for each age subgroup: rates for those ages 25–34 years, 35–44 years, and 45–54 years increased by 531.4% (from 5.6 deaths/100,000 to 35.1 deaths/100,000), 267.9% (from 9.5 deaths/100,000 to 35.0 deaths/100,000), and 350.9% (from 7.2 deaths/100,000 to 32.7 deaths/100,000), respectively. The largest relative increase in overdose deaths (909.2%, from 2.3 deaths/100,000 to 23.5 deaths/100,000) occurred among those ages 55–64 years.[20] Midlife mortality rates also increased for chronic liver disease and cirrhosis;[29,32,37,38] during 1999–2017, age-adjusted death rates for alcoholic liver disease increased by 40.6% (from 6.4 deaths/100,000 to 8.9 deaths/100,000); age-specific rates among young adults ages 25–34 years increased by 157.6% (from 0.6 deaths/100,000 to 1.7 deaths/100,000).[20] The age-adjusted suicide rate at ages 25–64 years increased by 38.3% (from 13.4 deaths/100,000 to 18.6 deaths/100,000), and by 55.9% (from 12.2 deaths/100,000 to 19.0 deaths/100,000) among those ages 55–64 years.[20] As others have reported[39], suicide rates also increased among those younger than age 25 years. Table e3 shows that, across all age groups, the largest relative increase in suicide rates occurred among children ages 5–14 years (from 0.6 deaths/100,000 to 1.3 deaths/100,000).

Organ system diseases and injuries—The increase in deaths caused by drugs, alcohol, and suicides was accompanied by significant increases in midlife mortality from organ system diseases and injuries, some beginning in the 1990s.[26,29,32] Data for several examples are provided online (Tables e3 and e4). For example, between 1999 and 2017, age-adjusted midlife mortality rates for hypertensive diseases and obesity increased by 78.9% (from 6.1 deaths/100,000 to 11.0 deaths/100,000) and 114.0% (from 1.3 deaths/100,000 to 2.7 deaths/100,000) (Table e4), respectively.[20] The increase in mortality from hypertension is consistent with other reports.[40] Early studies reported increasing midlife mortality from heart disease and lung (notably chronic pulmonary) disease, hypertension, stroke, diabetes, and Alzheimer disease,[29,32,41] but the trend appears to be even broader. According to one study, the increase in midlife mortality among NH whites during 1999–2016 was associated with an estimated 41,303 excess deaths due to drug overdoses (N=33,003) and suicides (N=8,300) but also more than 30,000 excess deaths from organ system diseases (e.g., hypertensive diseases [N=5,318], alcoholic liver disease [N=3,901], infectious diseases [N=2,149], liver cancer [N=1,931]), mental and behavioral disorders, obesity, pregnancy, and injuries (e.g., pedestrian-vehicle accidents).[26] Table e3 shows that the increase in organ disease mortality extended beyond midlife and, for certain diseases, was more pronounced in older age groups. For example, the largest increases in mortality from degenerative neurologic diseases (e.g., Alzheimer disease) occurred among those ages 75 and older.

Decomposition analyses, which quantify the relative contribution of specific causes of death to mortality patterns, have confirmed the large role played by organ system diseases.[10,29,31] For example, a decomposition analysis of the decline in US life expectancy between 2014 and 2015 found that respiratory and cardiovascular diseases contributed almost as much as external causes (including drug overdoses) among US women; among men, drug overdoses explained almost all of the life expectancy decline.[10] In a more recent decomposition analysis, Elo et al.[31] examined changes in life expectancy among US whites between 1990–

1992 and 2014–2016, stratifying the results by sex and geography. Deaths from mental and nervous system disorders were second only to drug overdoses in influencing changes in life expectancy and were the leading contributors to decreased life expectancy among white females. Among white females, respiratory disease mortality was a larger contributor to changes in life expectancy than either suicides or alcohol-related causes and accounted for more deaths in rural areas than drug overdoses (Table e5).

SEX-RELATED PATTERNS

Absolute and relative increases in midlife mortality rates were higher among men than women.[20] Between 2010 and 2017, men ages 25–44 years experienced a larger relative increase in age-specific mortality rates than did women of that age, whereas women aged 45–64 years experienced a slightly larger relative increase in mortality than men of their age (see Figure e1). Similarly, although men across age groups generally had higher cause-specific mortality rates and larger relative increases in mortality than did women, a pronounced female disadvantage emerged for certain major causes of death. For example, between 1999 and 2017, the relative increase in midlife fatal drug overdoses was 485.8% among women (from 3.5 deaths/100,000 to 20.2 deaths/100,000), 1.4 times higher than among men (350.6%, from 10.0 deaths/100,000 to 44.8 deaths/100,000). The relative increase in midlife mortality among women was 3.4 times higher for alcoholic liver disease (increasing from 3.2 deaths/100,000 to 5.8 deaths/100,000 among women and from 9.8 deaths/100,000 to 12.2 deaths/100,000 among men) and 1.5 times higher for suicide (increasing from 5.8 deaths/100,000 to 8.7 deaths/100,000 among women and 21.3 deaths/100,000 to 28.6 deaths/100,000 among men). This is consistent with reports elsewhere of gender-specific influences on mortality and a growing health disadvantage among US women, including smaller gains in life expectancy than among US men, larger relative increases in mortality from certain causes, and inferior health outcomes in comparison with women in other high-income countries.[11,31,42,43,44,45,46]

RACIAL AND ETHNIC PATTERNS

Figure 5 stratifies mortality rates by race-ethnicity for adults ages 25–64 years, and Figure e2 does this for age subgroups (25–44 years and 45–64 years). Midlife mortality rates among NH AIAN and NH blacks exceeded those of other racial and ethnic groups,[20] consistent with other reports.[47,48] During 1999–2017, (other curves have the same overall direction of NH AIAN from beginning to end of the period – this paragraph needs to be carefully reviewed and edited to match the figure) – retrogression occurred in all racial-ethnic groups except NH AIAN adults, who experienced steady increases in midlife mortality rates on a larger relative scale than any other group.[5,20,32,36] Retrogression in the NH white population preceded its occurrence in NH black and Hispanic populations (Figure 5), perhaps explaining why early studies reported that midlife mortality rates had not increased in these groups and focused their research on the white population.[29,32,35,36,40] Mortality patterns varied significantly by race-ethnicity and age, as illustrated online (Figure e3), where absolute and relative changes in age-specific mortality rates for men and women are plotted separately for 20 combinations of race and age. Among the findings are that rates generally decreased after 1999 among NH API adults over age 35 and Hispanic adults over age 45 and—as Masters et al. reported[28]—that rates increased after 2010 among NH white women aged 45–54 years—but not men of that age.

Consistent with the larger US population, populations of color began experiencing increases in cause-specific mortality rates long before experiencing the retrogression in all-cause mortality.[20,29,36] Midlife death rates in these populations increased across multiple, diverse conditions. One study reported that midlife mortality rates increased for 12 causes in the NH AIAN population, 17 causes in NH black population, 12 causes in the Hispanic population, and six causes in the NH API population.[26] Each of these groups experienced large increases in fatal drug overdoses; between 2010 and 2017, the largest relative increase (171.6%) occurred among NH blacks (Figure 6).[27,49] As shown online in Table e6, each of the five racial and ethnic groups also experienced increases in midlife deaths from alcoholic liver diseases, suicides, and hypertensive diseases, among others.[26,47] For example, in the NH black population, midlife mortality from neurologic diseases increased from 10.2 deaths/ 100,000 to 14.1 deaths/100,000 between 1999 and 2017. The reversal (retrogression) in mortality rates that occurred among NH black and Hispanic populations erased years of progress in lowering mortality rates (and reducing racial-ethnic disparities). The increase intensified recently for certain conditions (notably drug overdoses[50]), with non-whites experiencing larger relative and absolute year-to-year increases in death rates than whites.[26]

SOCIOECONOMIC PATTERNS

Although an extensive literature links health to education, wealth, and employment,[32,51,52,53,54,55,56,57,58] direct evidence of their association with changes in life expectancy or mortality is limited, hampered by limited data to link deaths and socioeconomic history at the individual level. A growing body of evidence, however, indicates that the decline in US life expectancy and mortality risks have been greater among individuals with limited education (e.g., less than high school) and income.[32,35,59,60,61,62,63,64,65,66,67] The gradient in life expectancy based on income has also widened over time,[68] with outcomes at the lower end of the distribution explaining much of the US disadvantage relative to other countries.[69]

GEOGRAPHIC PATTERNS

Census divisions and states—The range in life expectancy across the 50 states widened after 1984, reaching 7.0 years in 2016 (Figure 1).[18] States' life expectancy rankings also shifted over time, as illustrated in Figure 7. In 1959, Kansas had the nation's highest life expectancy (71.9 years), but its position declined over time, ranking 29th by 2016. In 1959, life expectancy in Oklahoma (71.1 years), 10th highest in the nation, exceeded that of New York (69.6 years), which ranked 35th. By 2016, New York's life expectancy (80.9 years) was 3rd in the nation and Oklahoma's life expectancy (75.8 years) ranked 45th. State life expectancy trajectories often changed acutely after the 1990s, a finding that was more apparent when it occurred in adjacent states. For example, life expectancy in Colorado and Kansas differed by only 0.3 years in 1990 but increased to 1.5 years in 2016; the difference between Alabama and Georgia increased from 0.1 years to 2.3 years.[18]

The recent decrease in US life expectancy and increase in midlife mortality rates was concentrated in certain states, with the largest changes observed in New England and East North Central states and smaller changes in the Pacific and West South Central divisions (Figure 8). The chart book in the online supplement contains 120 graphs of life expectancy (and all-cause mortality) trends for the US, nine census divisions, and 50 states, as modeled by Joinpoint Regression Program. It shows that, in the years leading up to 2016, life expectancy trended downward in four census divisions and 31 states—beginning in 2009 (N=3), 2010 (N=4), 2011 (N=6), 2012 (N=9), 2013 (N=6), and 2014 (N=3)—and decreased significantly (based on APC) in Kentucky, Ohio, and New Hampshire.

Table 1 presents APC and AAPC data for life expectancy trends in the US, nine census divisions, and 50 states. The table displays the APC for the two most recent time intervals, how the slope changed between intervals, and the AAPC for 2010–2016. For example, life expectancy in New Hampshire increased significantly (APC = 0.2) from 1978 to 2012 but decreased significantly thereafter (APC = −0.4), with the joinpoint year of 2012 marking a statistically significant ($p \leq 0.05$) unfavorable reduction in slope (−6.3E-3). For the period of 2010–2016, the slope was significantly negative (AAPC = −0.20). Unfavorable reductions in slope occurred from 2009 onward in 38 states—i.e., life expectancy either decreased more rapidly or increased more slowly—and the slope change was significant ($p < 0.05$) in every census division and in 29 states. The largest decreases in life expectancy (based on AAPC for 2010–2016) occurred in New Hampshire, Kentucky, Maine, Ohio, West Virginia, South Dakota, New Mexico, Utah, Indiana, Mississippi, and Tennessee. Other states did not experience decreases in life expectancy; for example, life expectancy increased significantly in the Pacific division and in 13 states (Virginia, Delaware, South Carolina, Texas, Hawaii, New York, Oregon, New Jersey, Montana, Wyoming, Alabama, Arkansas, and Oklahoma).

Table 2 shows the increase in midlife mortality rates during 1999–2017. The table's green and red colors signify favorable (negative APC) and unfavorable (positive APC) mortality trends based on joinpoint analysis (bolded boxes represent joinpoints). Many states experienced retrogression—declining mortality followed by a mortality reversal. For example, in Connecticut, a period of decreasing midlife mortality during 1999–2008 (green shading) was followed by a statistically stable period in 2008–2014 (clear shading)—during which the lowest mortality rate (253.7 deaths/100,000) was reached in 2011—and then by a significant increase in midlife mortality during 2014–2017 (red shading). The remaining columns explain that midlife mortality in Connecticut increased by 9.0% between 2010 and 2017 ($p \leq 0.05$), that what appeared to be a long-term decrease in mortality during 1999–2017 (AAPC = −0.6) obscured progressively less favorable trends in recent time periods (AAPC = 0.2, 2005–2017; AAPC = 1.3, 2010–2017), and that the increase in mortality (APC = 3.2) in the most recent time period (2014–2017) was dually significant, differing significantly from zero (*) and from the slope of the prior segment (ǂ). The final column notes that year-to-year changes in mortality during 1999–2017 caused an estimated 441 excess midlife deaths in Connecticut.

The increase in midlife mortality was geographically widespread. Table 2 shows that the AAPC for 2010–2017 was positive in eight census divisions and all but four states (California, New York, Oregon, and Texas). Thirty-seven states experienced statistically significant increases in midlife mortality (positive APC) in the years leading up to 2017. However, the trend was concentrated in certain states. Between 2010 and 2017, the largest relative increases in mortality occurred in New England (New Hampshire, 23.3%; Maine, 20.7%; Vermont, 19.9%, Massachusetts 12.1%) and the Ohio Valley (West Virginia, 23.0%; Ohio, 21.6%; Indiana, 14.8%; Kentucky, 14.7%), as well as in New Mexico (17.5%), South Dakota (15.5%), Pennsylvania (14.4%), North Dakota (12.7%), Alaska (12.0%), and Maryland (11.0%). In contrast, the nation's most populous states (California, Texas, and New York) experienced relatively small increases in midlife mortality.

Five states (Iowa, New Mexico, Oklahoma, West Virginia, and Wyoming) experienced a nearly continuous increase in midlife mortality (only positive APC segments) throughout 1999–2017, the largest (33.8%) occurring in West Virginia. Thirty-eight states experienced progress (declining mortality) as the millennium began, followed by retrogression (time segments beginning in 1999–2003 with negative APCs, followed by periods of increasing mortality with positive APCs). These reversals occurred earlier in some states than others; for example, midlife mortality rates in Iowa and North Dakota reached a nadir in 2004, whereas nadirs in New Jersey and New York did not occur until 2014 and 2015, respectively. Cause-specific mortality trends also varied by state, sometimes in opposite directions. For example, whereas rates of firearm-related suicides increased nationwide during 1999–2017, they remained stable or decreased in California, Connecticut, Maryland, New Jersey, and New York.[20]

Between 2010 and 2017, year-to-year changes in midlife mortality accounted for an estimated 33,307 excess US deaths (Table 2). Population sizes influenced states' individual contribution to national mortality trends. For example, although several New England states (New Hampshire, Maine, and Vermont) experienced large (20–23%) relative increases in midlife mortality during 2010–2017, these states accounted for only 3.0% of excess deaths due to their small populations. The East North Central division accounted for 28.6% of excess deaths, and Ohio, Pennsylvania, Indiana, and Kentucky (which include 10.8% of the US population) accounted for the largest number of excess deaths: these four states accounted for approximately one third (32.8%) of excess deaths. Eight of the 10 states with the largest number of excess deaths were in the Industrial Midwest or Appalachia.

Counties and cities—As a group, rural US counties experienced larger increases in all-cause midlife mortality than did metropolitan counties,[29,31] but more complex patterns emerged when county data were disaggregated by population size, sex, race-ethnicity, age, and causes of death. For example, although the relative increase in midlife drug overdose deaths during 1999–2017 among NH whites was higher in rural (749.4%, from 4.0 deaths/100,000 to 33.8 deaths/100,000) than metropolitan (531.2%, from 6.7 deaths/100,000 to 42.5 deaths/100,000) counties, the largest relative increase in overdose deaths (857.8%, from 4.7 deaths/100,000 to 45.2 deaths/100,000) occurred in the suburbs of large cities (populations ≥1 million), where Hispanic populations also experienced their largest increase in midlife overdose deaths.[20] Among NH blacks, the largest increase in overdose deaths occurred in small cities (populations < 250,000), but the largest increase among blacks aged 55–64 years was in large cities.[29] The largest increase in midlife suicides among NH AIAN and Hispanic adults was in metropolitan areas, whereas the largest increase among non-

Hispanic blacks and whites occurred in rural counties.[20] Among young whites (ages 25–34 years), the largest increase in suicides occurred in the suburbs.[29] Mortality patterns for men and women also varied significantly across urban and rural areas, with residents of large cities experiencing the greatest increases in life expectancy.[31]

Geographic disparities in mortality were associated with demographic characteristics, and with community contextual factors independent of individual and household characteristics. For example, a multivariate analysis of drug-related mortality in 2006–2015 found that drug deaths were higher in counties with certain demographic characteristics (e.g., older adults, active duty military or veterans, Native Americans) and in counties with mining-dependent economies, high economic and family distress indices, vacant housing, or high rent. Mortality rates were lower in counties with more religious establishments, recent in-migrants, and dependence on public sector (i.e., government) employment.[70] Similarly, studies in five states (California, Kansas, Missouri, Minnesota, and Virginia) found that increases in midlife mortality from “stress-related conditions” (drug overdoses, alcohol poisoning, alcoholic liver disease, and suicides) were highest in counties with prolonged exposure to high poverty, unemployment, and stagnant household income. Examples included the Central Valley and northern rural counties of California[71], the Ozark and Bootheel regions of Missouri[72], and the southwestern coalfields of Virginia.[73]

DISCUSSION

US life expectancy increased from 1959 to 2014 but the rate of increase was greatest in 1969–1979 and slowed thereafter, losing pace with other high-income countries, plateauing in 2011, and decreasing after 2014. A major contributor was an increase in all-cause mortality among young and middle-aged adults, which began in 2010, and an increase in cause-specific mortality rates in this midlife age group, which began as early as the 1990s and involved deaths from drug overdoses, alcohol abuse, and suicides, and diverse organ system diseases, such as hypertensive diseases and diabetes. Although NH whites experienced the largest absolute number of deaths, all racial groups and the Hispanic population were affected. For certain causes of death (e.g., fatal drug overdoses, alcoholic liver disease, and suicide), women experienced larger relative increases in mortality than men, although the absolute mortality rates for these causes were higher in men than women.

By 2010, increases in cause-specific mortality rates at ages 25–64 years had reversed years of progress in lowering mortality from other causes (e.g., ischemic heart disease, cancer, HIV infection)—and all-cause mortality began increasing. The trend began earlier (e.g., the 1990s) in some states and only recently in others (e.g., New York, New Jersey). Gaps in life expectancy across states began widening in the 1980s, with substantial divergences occurring in the 1990s. Changes in life expectancy and midlife mortality were greatest in the eastern US—notably the Ohio Valley, Appalachia, and upper New England—whereas many Pacific states were less affected. The largest relative increases in midlife mortality occurred among adults with less education and in rural areas or other settings with evidence of economic distress or diminished social capital.

POTENTIAL EXPLANATIONS

The increase in midlife mortality after 1999 was greatly influenced by the increase in drug overdoses. Heroin use increased substantially in the 1960s and 1970s, as did crack cocaine abuse in the 1980s, disproportionately affecting (and criminalizing) the black population.[74,75] Mortality from drug overdoses increased exponentially from the 1970s onward.[76] The sharp increase in overdose deaths that began in the 1990s primarily affected whites and came in three waves: (1) the introduction of OxyContin in 1996 and overuse of prescription opioids, followed by (2) increased heroin use, often by patients who became addicted to prescription opioids,[77] and (3) the subsequent emergence of potent synthetic opioids (e.g., fentanyl analogues)—the latter triggering a large post-2013 increase in overdose deaths.[27,78,79] That whites first experienced a larger increase in overdose deaths than non-whites may reflect their greater access to health care (and thus prescription drugs).[5,80] That NH black and Hispanic populations experienced the largest relative increases in fentanyl deaths after 2011[81] may explain the retrogression in overdose deaths observed in these groups.[48] Geographic differences in the promotion and distribution of opioids may also explain the concentration of midlife deaths in certain states.[82]

However, the increase in opioid-related deaths is only part of a more complicated phenomenon and does not fully explain the increase in midlife mortality rates from other causes, such as alcoholic liver disease or suicides (85.2% of which involve firearms or other non-poisoning methods[83]). Opioid-related deaths also cannot fully explain the US health disadvantage, which began earlier (in the 1980s) and involved multiple diseases and non-drug injuries.[5,6,7] Two recent studies estimated that drug overdoses accounted for 15% or less of the gap in life expectancy between the US and other high-income countries in 2013 and 2014, respectively.[84,85]

The National Research Council examined the US health disadvantage in detail and identified nine domains in which the US had poorer health outcomes than other high-income countries: these included not only drug-related deaths but also adverse birth outcomes, injuries and homicides, adolescent pregnancy and sexually transmitted infections, HIV and AIDS, obesity and diabetes, heart disease, chronic lung disease, and disability.[7] Compared to the average mortality rates of 16 other high-income countries, the US has lower mortality from cancer and cerebrovascular diseases but higher mortality rates from most other major causes of death, including: circulatory disorders (e.g., ischemic heart and hypertensive diseases), external causes (e.g., drug overdoses, suicide, homicide), diabetes, infectious diseases, pregnancy and childbirth, congenital malformations, mental and behavioral disorders, and diseases of the respiratory, nervous, genitourinary, and musculoskeletal systems.[86] According to one estimate, if the slow rate of increase in US life expectancy persists, it will take the US more than a century to reach the average life expectancy that other high-income countries had achieved by 2016.[10]

Tobacco use and obesity—Exposure to behavioral risk factors could explain some of these trends. Although tobacco use in the US has decreased, higher smoking rates in prior decades could have produced delayed effects on current tobacco-related mortality and life expectancy patterns, especially among older adults.[6,87,88] For example, a statistical model that accounted for the lag between risk factor exposure and subsequent death estimated that much of the gap in life expectancy at age 50 that existed in 2003 between the US and other high-income countries—41% of the gap in men and 78% of the gap in women—was attributable to smoking.[89] Smoking explained 50% or more of the geographic differences in mortality within the US in 2004.[87,90] However, it is unclear whether smoking, which has declined in prevalence, continues to have as large a role in current life expectancy patterns or in explaining increases in mortality among younger adults is unclear.

The obesity epidemic, a known contributor to the US health disadvantage,[6] could potentially explain an increase in midlife mortality rates for diseases linked to obesity, such as hypertensive heart disease[91] and renal failure.[92] As long ago as 2005, the increasing prevalence of obesity prompted Olshansky et al. to predict a forthcoming decrease in US life expectancy.[93] By 2011, Preston et al. estimated that increases in obesity had reduced life expectancy at age 40 by 0.9 years.[94] Elo et al. noted that changes in obesity prevalence had the largest correlation with geographic variations in life expectancy of any variable they examined.[31]

However, neither smoking nor obesity can fully explain current mortality patterns, such as those among younger adults and increasing mortality from conditions without known causal links to these risk factors. Suggesting that other factors may be at play, Muennig and Glied noted that Australia and other countries with patterns of smoking and obesity similar to the US achieved greater gains in survival between 1975 and 2005.[13]

Deficiencies in health care—Deficiencies in the health care system could potentially explain increased mortality from some conditions. Although the US health care system excels on certain measures, countries with higher life expectancy outperform the US in providing universal access to health care, removing costs as a barrier to care, care coordination, and amenable mortality.[95,96,97] In a difficult economy that imposes greater costs on patients[98], adults in midlife may have greater financial barriers to care than children and older adults, who benefit from the Children's Health Insurance Program and Medicare coverage, respectively.[99] Although poor access or deficiencies in quality could introduce mortality risks among patients with existing behavioral health needs or chronic diseases, these factors would not account for the underlying precipitants (e.g., suicidality, obesity), which originate outside the clinic. Physicians contributed to the overprescription of opioids[100], and iatrogenic factors could potentially explain increases in midlife mortality from other causes, but empirical evidence is limited. Nor would systemic deficiencies in the health care system explain why midlife death rates increased for some chronic diseases while decreasing greatly for others (e.g., ischemic heart disease, cancer, and HIV infection).

Psychological distress—Despair has been invoked as a potential cause for the increase in deaths related to drug, alcohol, and suicides (referred to by some as 'deaths of despair').[29,35,65,101] Some studies suggest that psychological distress, anxiety, and depression have increased in the US, especially among adolescents and young adults.[65,102,103,104,105,106,107,108] Psychological distress and mental illness are risk factors for substance abuse and suicides[82,109,110] and may complicate organ system diseases, as when hopelessness erodes motivation to pursue health care or manage chronic illnesses.[111]

Chronic stress has neurobiological and systemic effects on allostatic load and end organs and may increase pain sensitivity (and thus analgesic needs).[112,113,114,115] However, the evidence that the prevalence of psychological distress or mental illness increased during the relevant time period is inconclusive. Epidemiological data about mental illness have methodological limitations,[116,117] and some surveillance studies report no increase in prevalence rates.[118,119] Moreover, even if the prevalence of certain mental illnesses did increase, a causal link to the full spectrum of midlife mortality deaths has not been established.

Socioeconomic conditions—Three lines of evidence suggest a potential association between mortality trends and economic conditions, the first being timing. The US health disadvantage and increase in midlife mortality began in the 1980s and 1990s, a period marked by a major transformation in the nation's economy, substantial job losses in manufacturing and other sectors, contraction of the middle class, wage stagnation, and reduced intergenerational mobility.[120,121,122,123,124,125] Income inequality widened greatly, surpassing levels in other countries, concurrent with the deepening US health disadvantage.[126,127,128,129,130,131,132] The second line of evidence concerns affected populations: those most vulnerable to the new economy (e.g., adults with limited education, women) experienced the largest increases in death rates. The third line of evidence is geographic: increases in death rates were concentrated in areas with a history of economic challenges, such as rural America[133,134] and the Industrial Midwest,[135,136] and were lowest in the Pacific division and populous states with more robust economies (e.g., Texas, New York). One theory for the larger life expectancy gains in metropolitan areas is an increase in the population with college degrees.[31]

Socioeconomic pressures and unstable employment could explain some of the observed increases in mortality spanning multiple causes of death. Financial hardship and insecurity limit access to health care and the social determinants of health (e.g., education, food, housing, transportation) and increase the risk of chronic stress, disease, disability, pessimism, and pain.[100,137,138,139,140,141,142,143,144] One study estimated that a 1% increase in county unemployment rates was associated with a 3.6% increase in opioid deaths.[145] However, the evidence to date has not proven that economic conditions are responsible for the recent increase in midlife mortality;[146] correlations with state and local indicators (e.g., employment, poverty rates) are not always consistent, and the causal link between income inequality and health is debated.[147,148]

The causes of economic despair may be more nuanced; perceptions and frustrated expectations may matter as much as absolute income or net worth.[149,150] For example, ethnographers describe the dismay among working-class whites over their perceived loss of social position and uncertain future,[100,151,152,153,154,155] a popular (but unsubstantiated) thesis for why this historically privileged population experienced larger increases in midlife deaths than did minority groups (e.g., NH blacks) with greater social and economic disadvantages.[156,157,158,159] Also unclear is the extent to which household socioeconomic status acts as a proxy for important contextual conditions in communities (e.g., social environment, services infrastructure, economy, labor market) that also shape health.[5,81,160,161,162,163]

The above explanations are not independent and collectively shape mortality patterns; major contributors like smoking, drug abuse, and obesogenic diets are shaped by environmental conditions, psychological distress, and socioeconomic status. The same economic pressures that force patients to forego medical care can also induce stress and unhealthy coping behaviors and can fracture communities. Fenelon, whose research quantified the contribution of smoking to mortality, also noted that it may “represent one critical piece of a broader cultural, socioeconomic, and behavioral puzzle that has implications for numerous health-related behaviors and outcomes.”[89]

Methodologic considerations—Any theory for decreasing life expectancy, whether opioids, despair, poverty, or social division, must account for the timing of exposure and lagged effects on outcomes. Whereas observed increases in mortality could occur shortly after increased exposure to certain causes, such as fentanyl or lethal firearms, increases in premature mortality from chronic conditions may require decades of prolonged exposure (Table e8). Some mortality patterns exhibit period effects, such as the increase in opioid deaths that began in the 1990s, and affected multiple age cohorts, whereas other causes show cohort-based variation. For example, Masters et al. identified a specific cohort—NH whites born in the 1950s—at heightened risk of midlife mortality from obesity, heart disease, diabetes, and hypertension.[28] Zang et al. documented a heightened mortality risk among cohorts born during 1973–91.[164]

Any theory for decreasing US life expectancy must explain why this trend is less pronounced in other industrialized countries.[10] A National Research Council panel, charged with this question, focused its research on how the US differs in terms of health care, unhealthy behaviors, socioeconomic factors, the physical and social environment, and public polices and priorities.[7] Social protection policies deserve special attention: countries with higher life expectancy spend more of their budgets on social services[143,165] and outperform the US in terms of education, child poverty, and other measures of wellbeing.[5,7]

Causal theories must also explain why US mortality trends have affected some states (and counties) more than others, and why their trajectories often diverged in the 1990s. The causes of geographical disparities may be compositional, as when states became more populated by people with risk factors for midlife mortality (e.g., rural whites with limited education) or large, growing cities that skew state averages. State statistics are also influenced by demographic shifts (e.g., immigration, depopulation, and in-migration) and economic trends. For example, the divergence in life expectancy between Oklahoma and New York (Figure 7) may reflect the fate of different economies, one reliant on agriculture and mining and the other on service industries (e.g., finance, information technology). The clustering of midlife deaths in certain states, such as recent increases in upper New England states or rural areas, may reflect differences in drug abuse rates and in the distribution and marketing of illicit drugs.[27,81,145,166,167,168]

To some extent, however, divergent state health trajectories may reflect different policy choices.[169] Policy differences seem more likely to explain disparities between adjacent states (e.g., Colorado/Kansas, Alabama/Georgia; Figure 7), where marked regional differences in demography or economies are uncommon. Many states diverged in the 1990s, soon after neoliberal policies aimed at free markets and devolution shifted resources (e.g., block grants) and authorities to the states.[120,170,171,172] States enacted different policies on the social determinants of health, such as education spending, minimum wage laws, earned income tax credits, economic development, mass transit, safety net services, and public health provisions (e.g., tobacco taxes, Medicaid expansion, preemption laws, gun control).[173,174,175,176,177,178] These decisions may have had health implications.[179] For example, Dow et al. found that changes in state policies on minimum wage and earned income tax credits predicted non-drug suicide trends.[180] In this study, the five states that experienced stable or reduced rates of firearm-related suicides during 1999–2017, countering the national trend, were those with stricter gun control laws.[181]

RESEARCH AND POLICY CONSIDERATIONS

Moving from speculation to evidence about root causes will require innovative research methods, including cohort studies, multivariate modeling, investigation of migration effects, and the application of machine learning to historical datasets. Fully understanding the timing of US mortality trends will also require interdisciplinary research involving epidemiology, demography, sociology, political science, history, economics, and the law. Clarifying the role of state policies may be especially important, given the divergent state trajectories reported here.

The implications of increasing midlife mortality are broad, affecting working-age adults and thus employers, the economy, health care, and national security. The trends also affect children, whose parents are more likely to die in midlife and whose own health could be at risk when they reach that age, or sooner. Recent data suggest that all-cause mortality rates are increasing among those ages 15–19 years and 20–24 years (increasing from 44.8 deaths/100,000 to 51.5 deaths per 100,000 and from 83.4 deaths/100,000 to 95.6 deaths/100,000, respectively, during 2013–2017) (Figure 2). Evidence-based strategies to improve population health seem warranted, such as policies to promote education, increase household income, invest in communities, and expand access to health care, affordable housing, and transportation.[182,183,184,185,186] The increase in mortality from substance abuse, suicides, and organ system diseases argues for strengthening of behavioral health services and the capacity of health systems to manage chronic diseases.[187]

LIMITATIONS

This review and analysis have several limitations. First, mortality data are subject to errors, among them inaccurate ascertainment of cause of death, race misclassification and undercounting, and numerator-denominator mismatching.[188,189] These are especially problematic in interpreting AIAN mortality rates, although disparities persist in this population even in studies that circumvent these challenges.[190] Other limitations include the weak statistical power of annual state mortality rates and their inability to account for sub-state variation, the limits of age adjustment, age-aggregation bias, and the omission of cause-specific mortality data from before 1999.[191] Purported rate increases may also reflect lagged selection bias.[192] Second, errors in coding, such as the misclassification of suicides as overdoses[193], or changes (or geographic differences) in coding practices could also introduce errors. For example, some increases in maternal mortality rates may reflect heightened surveillance and the addition of a pregnancy checkbox on death certificates.[194,195,196] Changes in coding or awareness may explain the increase in age-adjusted mortality rates from mental and nervous system disorders, an international trend.[197] Third, state mortality rates may also reflect demographic changes, such as immigration patterns (and the immigrant paradox[198,199,200]) or the out-migration of highly educated, healthy individuals.[5]

CONCLUSION

US life expectancy increased for most of the past 60 years, but the rate of increase slowed over time and life expectancy decreased after 2014. A major contributor has been an increase in mortality from specific causes (e.g., drug overdoses, suicides, organ system diseases) among young and middle-aged adults of all racial groups, which began as early as the 1990s and produced the largest relative increases in the Ohio Valley and New England. The implications for public health and the economy are substantial, making it vital to understand the root causes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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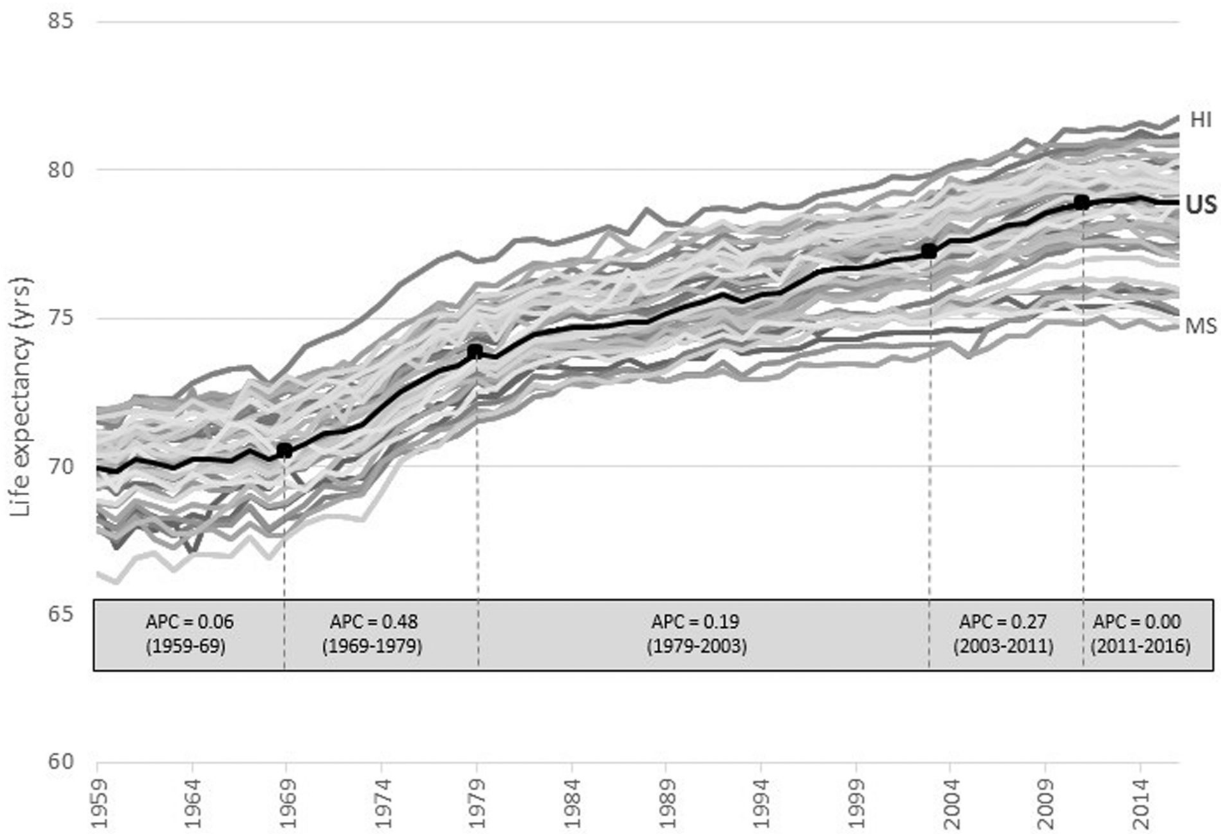

Figure 1. US life expectancy, 1959–2016.

Black line depicts U.S. life expectancy; boldened data points (■) denote joinpoint years, when the linear trend (slope) changed significantly based on joinpoint analysis. APC = average annual percent change for the five time periods identified on joinpoint analysis (1959–1969, 1969–1979, 1979–2003, 2003–2011, and 2011–2016). Grey lines depict life expectancy for the 50 states. Life expectancy data obtained from the US Mortality Database.

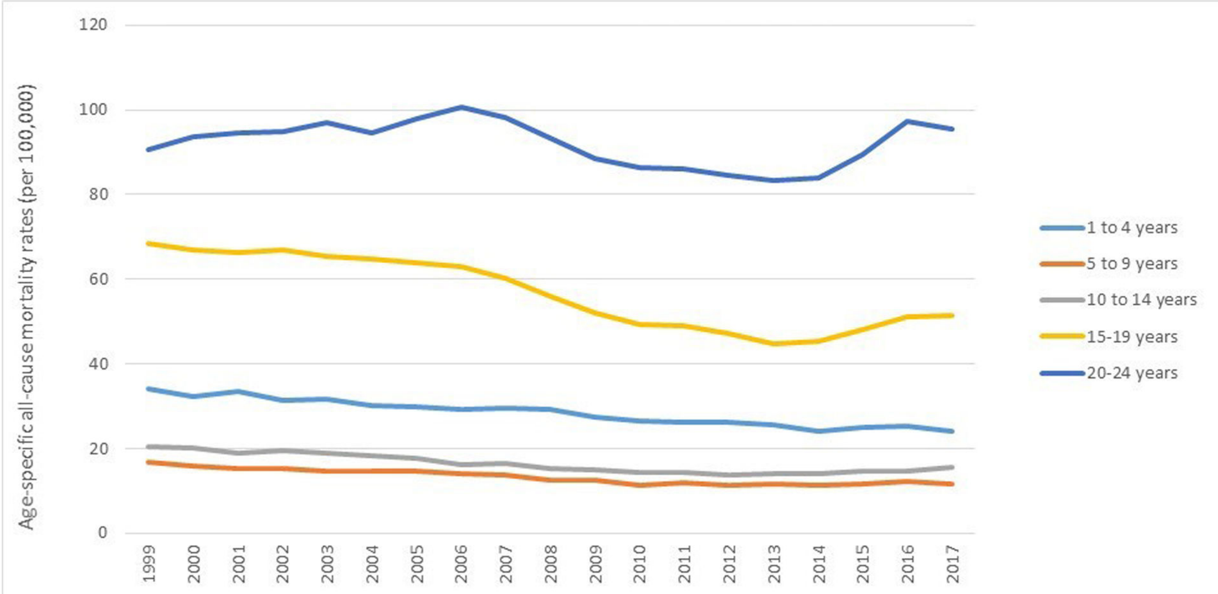

Figure 2. Age-specific, all-cause mortality rates among US youth, ages 1–24 years, 1999–2017.
Source: CDC WONDER.

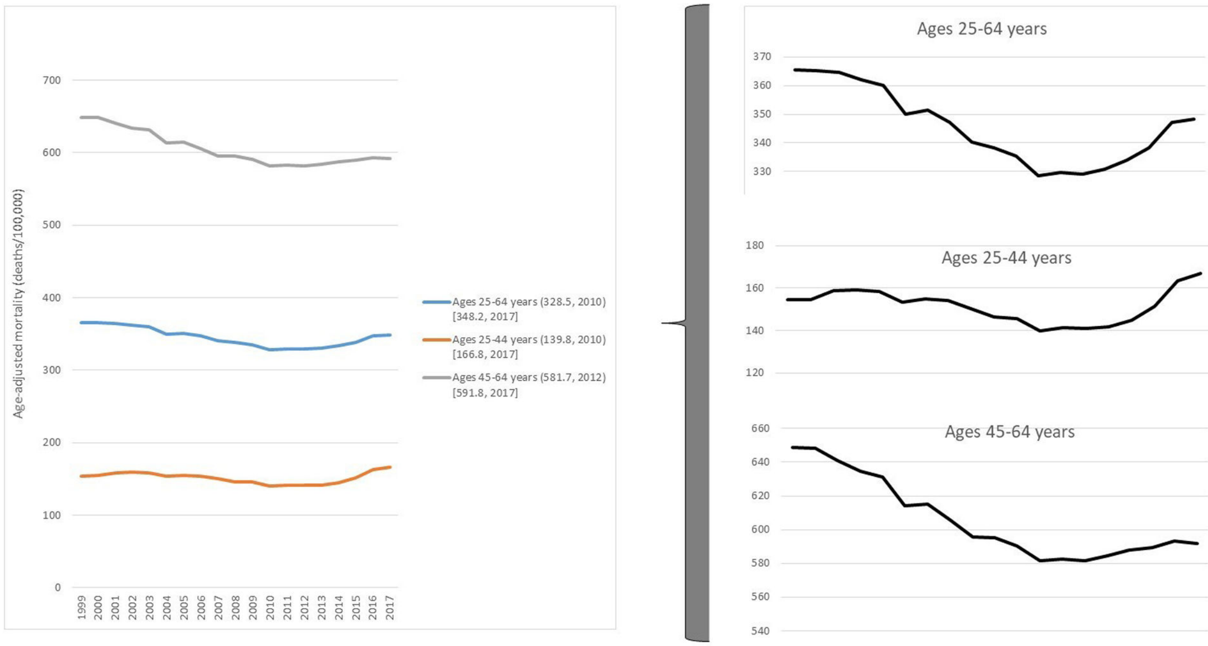

Figure 3. Age-adjusted, all-cause mortality rates, US adults ages 25–64 years, 25–44 years, and 45–64 years, 1999–2017.

The lowest mortality rates per 100,000 (and corresponding years) are listed in parentheses; 2017 mortality rates are listed in brackets. Source: CDC WONDER.

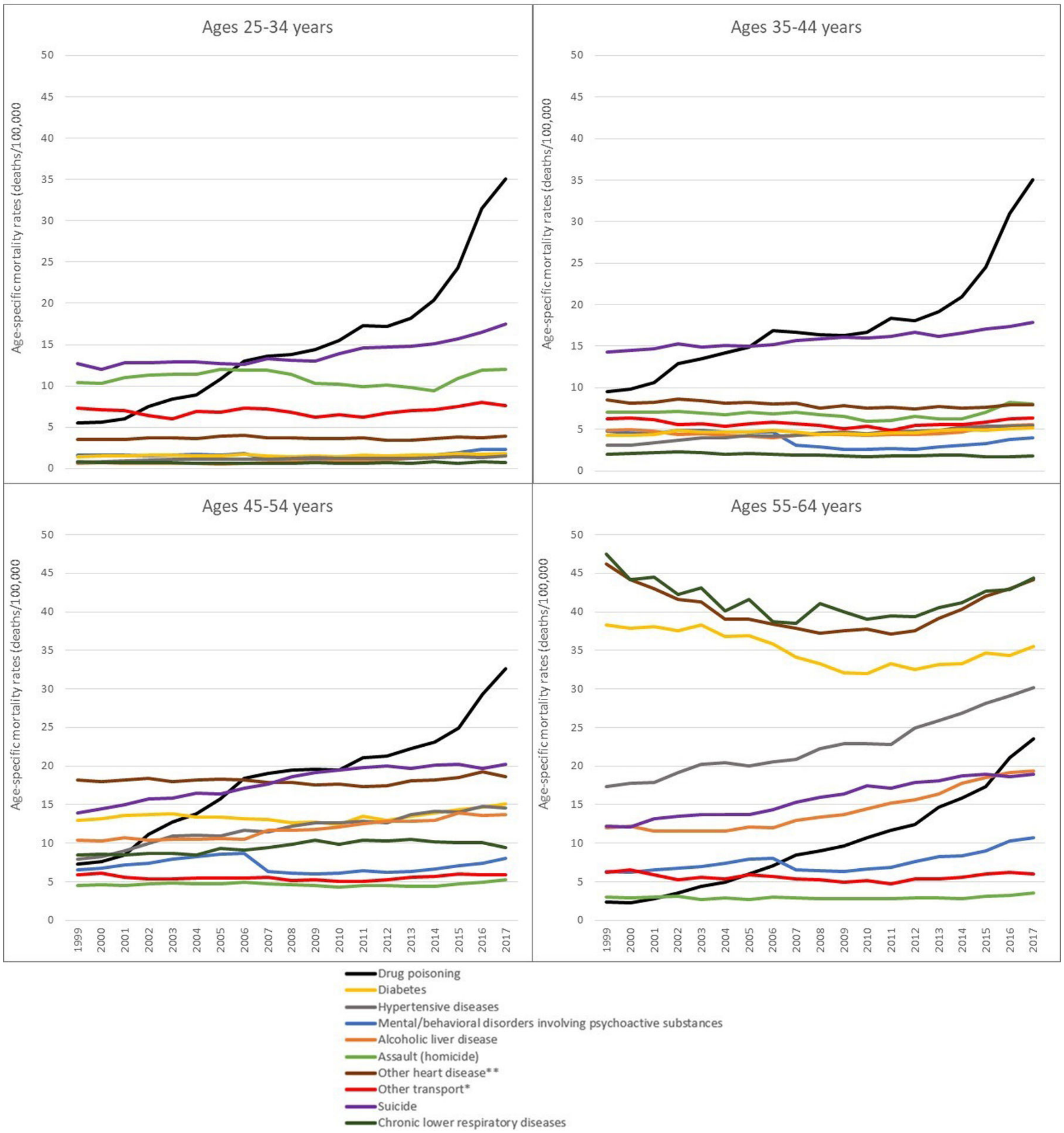

Figure 4. Age-specific mortality rates for selected causes, by age decile, 1999–2017.

* Other transport accidents include land, water, air, space, and other transport accidents (*V80-V99*).

** Other heart disease (*I30-I51*) includes arrhythmias and heart failure.

Other causes of death (and corresponding ICD-10 codes) include diabetes mellitus (*E10-E14*), mental and behavioral disorders due to psychoactive substance use (*F10-F19*), hypertensive diseases (*I10-I15*), accidental drug poisoning (*X40-X44*), intentional self-harm (suicide) (*X60-X84*), and assault (homicide) (*X85-Y09*). Source: CDC WONDER.

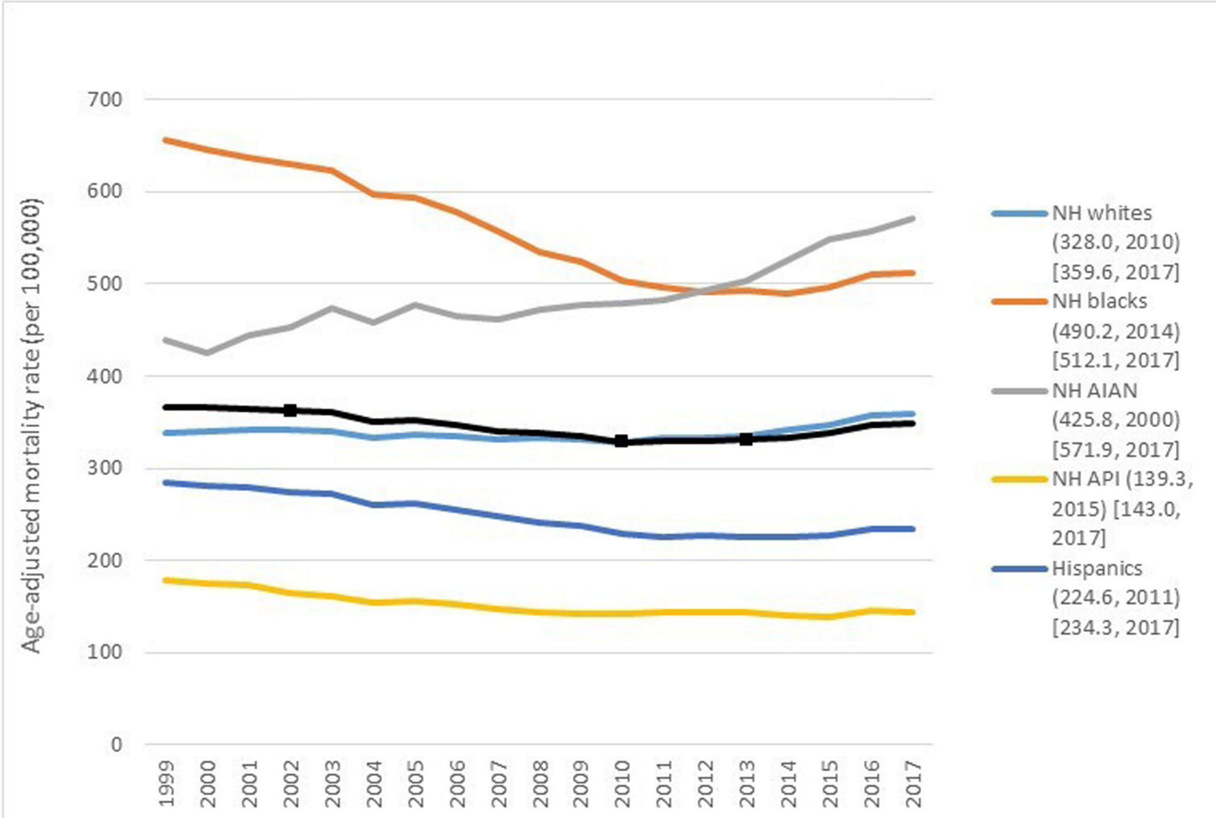

Figure 5. Age-adjusted mortality rates, US adults ages 25–64 years, by race-ethnicity, 1999–2017.

Boldened data points (■) denote joinpoint years, when the linear trend (slope) changed significantly based on joinpoint analysis. AIAN = American Indians and Alaskan Natives, API = Asians and Pacific Islanders (API), NH = non-Hispanic. The lowest mortality rates per 100,000 (and corresponding years) are listed in parentheses; 2017 mortality rates are listed in brackets. Source: CDC WONDER.

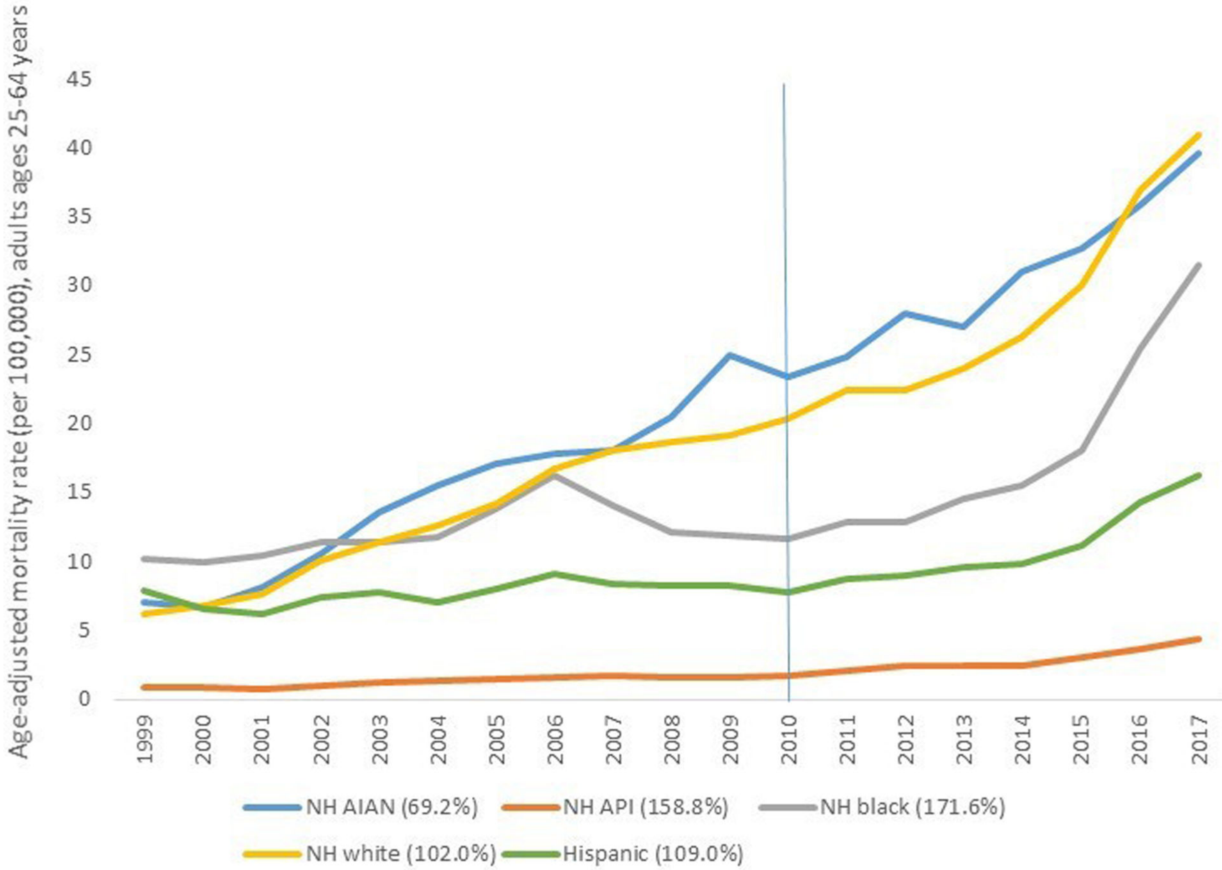

Figure 6. Age-adjusted mortality from accidental drug overdoses, by race-ethnicity, 1999–2017.
Source: CDC WONDER. Values in parentheses denote relative increases in age-adjusted mortality rates by race-ethnicity between 2010 and 2017. AIAN = American Indians and Alaskan Natives, API = Asians and Pacific Islanders (API), NH = non-Hispanic.

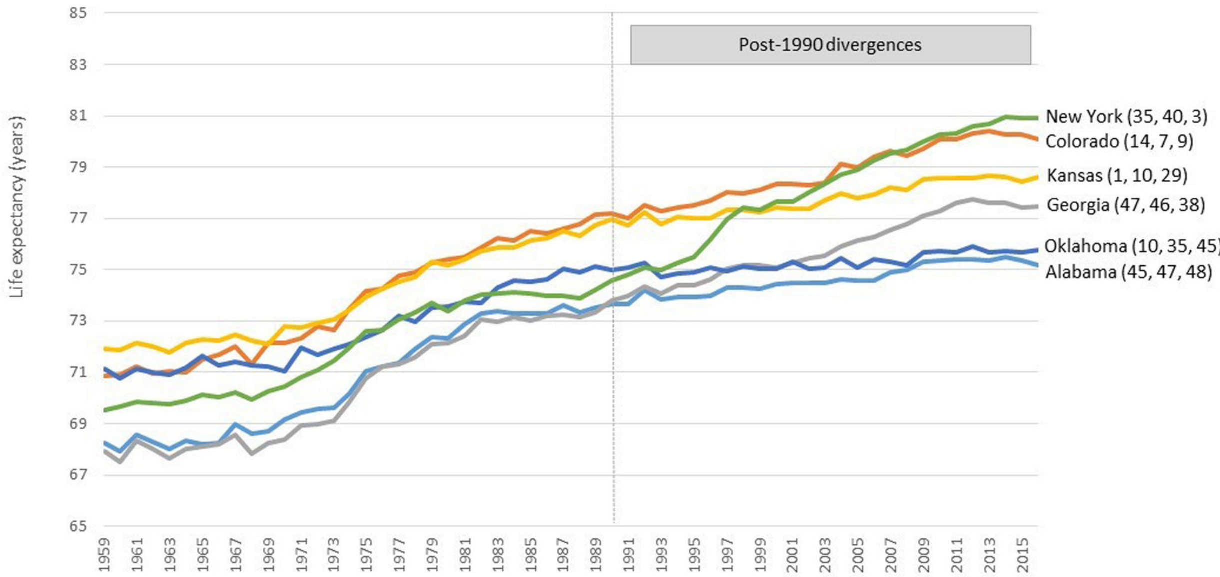

Figure 7. Life expectancy, selected states, 1990–2016.

Source: US Mortality Database. Graph highlights divergences in state-level life expectancy that began in the 1990s, featuring neighboring states (Alabama/Georgia and Colorado/ Kansas). Values in parentheses refer to state life expectancy rankings (among the 50 states) in 1959, 1990, and 2016, respectively. As the 1990s began, life expectancy in Oklahoma exceeded that of New York.

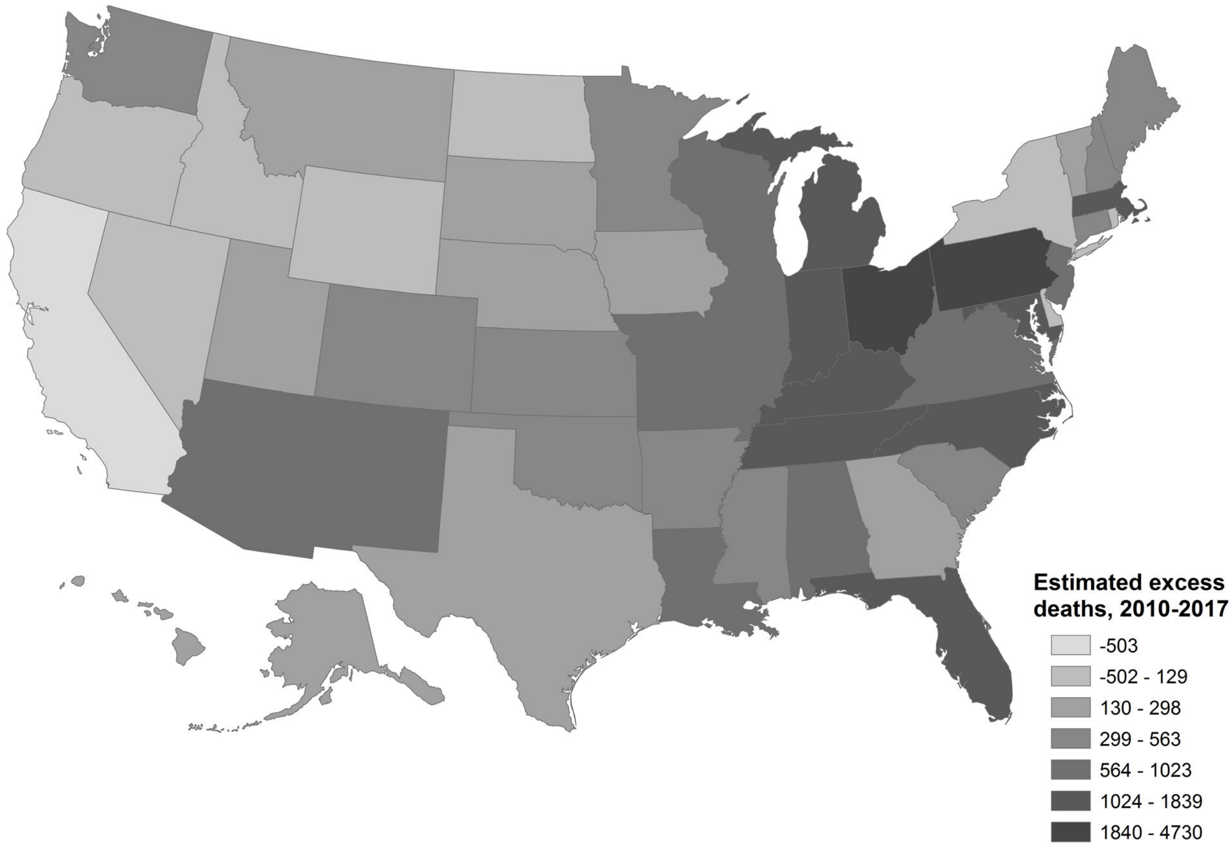

Figure 8. Estimated excess deaths from increasing midlife mortality, 2010–2017.

Estimated number of deaths caused by year-to-year increases in age-adjusted mortality rates among adults ages 25–64 years during 2010–2017. The map displays the number of estimated excess deaths (numerator) and not the population size (denominator) to clarify which states contributed the largest absolute number of deaths and exerted the largest influence on national trends. For example, although New Hampshire experienced a large (23.3%) relative increase in midlife mortality rates between 2010 and 2017, that state had a relatively small population (0.4% of US population) and therefore accounted for only 1.2% of excess deaths in the US. See text for more details about methods used to calculate excess deaths.

Table 1.

Joinpoint analysis of life expectancy trends--US, census divisions, and states

	Trends in last two segments (years, APC [95% CI)				Change in slope (% change, 95% CI)	AAPC[≠] (2010–16)
	Penultimate APC[≠]		Last APC[≠]			
UNITED STATES	**2003–2011**	**0.27 (0.21 to 0.34)**	**2011–2016**	**0.00 (−0.12 to 0.12)**	**−0.27 (−0.40 to −0.14)**	**0.05 (−0.05 to 0.14)**
Div 1: New England	**1977–2012**	**0.22 (0.22 to 0.23)**	**2012–2016**	**−0.09 (−0.32 to 0.14)**	**−0.32 (−0.54 to −0.10)**	**0.01 (−0.14 to 0.16)**
Connecticut	2000–2010	0.31 (0.26 to 0.36)	2010–2016	0.04 (−0.06 to 0.14)	−0.27 (−0.38 to −0.16)	0.04 (−0.06 to 0.14)
Maine	1978–2011	0.19 (0.18 to 0.20)	2011–2016	−0.16 (−0.34 to 0.02)	−0.35 (−0.52 to −0.17)	−0.10 (−0.25 to 0.04)
Massachusetts	1977–2013	0.23 (0.22 to 0.24)	2013–2016	−0.17 (−0.59 to 0.24)	−0.40 (−0.81 to 0.00)	0.03 (−0.17 to 0.23)
New Hampshire	1978–2012	0.22 (0.21 to 0.23)	2012–2016	−0.41 (−0.66 to −0.15)	−0.63 (−0.88 to −0.38)	−0.20 (−0.36 to −0.03)
Rhode Island	1979–2012	0.20 (0.19 to 0.21)	2012–2016	−0.06 (−0.36 to 0.24)	−0.26 (−0.55 to 0.03)	0.03 (−0.16 to 0.22)
Vermont	1977–2009	0.24 (0.23 to 0.25)	2009–2016	−0.05 (−0.15 to 0.06)	−0.28 (−0.39 to −0.18)	−0.05 (−0.15 to 0.06)
Div 2: Mid-Atlantic	**1988–2010**	**0.31 (0.29 to 0.32)**	**2010–2016**	**0.10 (−0.01 to 0.21)**	**−0.21 (−0.31 to −0.10)**	**0.10 (−0.01 to 0.21)**
New Jersey	1988–2012	0.30 (0.28 to 0.32)	2012–2016	0.05 (−0.16 to 0.25)	−0.25 (−0.45 to −0.05)	0.13 (0.00 to 0.26)
New York	1998–2012	0.31 (0.28 to 0.34)	2012–2016	0.10 (−0.07 to 0.27)	−0.21 (−0.38 to −0.05)	0.17 (0.06 to 0.28)
Pennsylvania	1981–2014	0.19 (0.19 to 0.20)	2014–2016	−0.41 (−1.03 to 0.21)	−0.60 (−1.21 to 0.00)	−0.01 (−0.21 to 0.19)
Div 3: East North Central	**1980–2012**	**0.19 (0.18 to 0.20)**	**2012–2016**	**−0.10 (−0.28 to 0.08)**	**−0.29 (−0.46 to −0.11)**	**0.00 (−0.12 to 0.11)**
Illinois	1994–2012	0.29 (0.26 to 0.31)	2012–2016	−0.03 (−0.23 to 0.18)	−0.31 (−0.51 to −0.11)	0.08 (−0.05 to 0.21)
Indiana	1981–2011	0.14 (0.13 to 0.15)	2011–2016	−0.10 (−0.24 to 0.05)	−0.24 (−0.38 to −0.10)	−0.06 (−0.18 to 0.06)
Michigan	1978–2011	0.20 (0.19 to 0.20)	2011–2016	−0.05 (−0.16 to 0.06)	−0.25 (−0.36 to −0.14)	−0.01 (−0.10 to 0.08)
Ohio	1983–2012	0.15 (0.14 to 0.16)	2012–2016	−0.22 (−0.41 to −0.04)	−0.37 (−0.55 to −0.19)	−0.10 (−0.22 to 0.02)
Wisconsin	2002–2009	0.25 (0.17 to 0.34)	2009–2016	−0.03 (−0.09 to 0.04)	−0.28 (−0.39 to −0.18)	−0.03 (−0.09 to 0.04)
Div 4: West North Central	**2001–2010**	**0.20 (0.15 to 0.25)**	**2010–2016**	**−0.02 (−0.09 to 0.06)**	**−0.21 (−0.30 to −0.13)**	**−0.02 (−0.09 to 0.06)**
Iowa	1980–2010	0.16 (0.15 to 0.16)	2010–2016	−0.04 (−0.13 to 0.05)	−0.20 (−0.28 to −0.11)	−0.04 (−0.13 to 0.05)
Kansas	2001–2011	0.16 (0.12 to 0.20)	2011–2016	−0.03 (−0.14 to 0.08)	−0.19 (−0.30 to −0.08)	0.00 (−0.08 to 0.09)
Minnesota	2000–2009	0.26 (0.20 to 0.32)	2009–2016	0.00 (−0.07 to 0.08)	−0.26 (−0.35 to −0.16)	0.00 (−0.07 to 0.08)
Missouri	1999–2012	0.18 (0.16 to 0.21)	2012–2016	−0.11 (−0.28 to 0.06)	−0.29 (−0.46 to −0.12)	−0.01 (−0.12 to 0.10)

	Trends in last two segments (years, APC [95% CI)				**Change in slope (% change, 95% CI)**	**AAPC[≠] (2010–16)**
	Penultimate APC[≠]		**Last APC[≠]**			
Nebraska	1979–2011	0.17 (0.16 to 0.18)	2011–2016	−0.04 (−0.18 to 0.11)	−0.20 (−0.34 to −0.06)	0.00 (−0.12 to 0.12)
North Dakota	2002–2005	0.39 (−0.69 to 1.48)	2005–2016	0.01 (−0.04 to 0.06)	−0.37 (−1.43 to 0.68)	0.01 (−0.04 to 0.06)
South Dakota	1982–2013	0.16 (0.15 to 0.18)	2013–2016	−0.32 (−0.80 to 0.16)	−0.48 (−0.95 to −0.01)	−0.08 (−0.31 to 0.16)
Div 5: South Atlantic	**2003–2012**	**0.30 (0.23 to 0.37)**	**2012–2016**	**−0.06 (−0.28 to 0.16)**	**−0.36 (−0.59 to −0.13)**	**0.06 (−0.09 to 0.20)**
Delaware	1969–1977	0.60 (0.46 to 0.73)	1977–2016	0.21 (0.20 to 0.22)	−0.39 (−0.52 to −0.25)	0.21 (0.20 to 0.22)
Florida	2005–2013	0.33 (0.22 to 0.44)	2013–2016	−0.14 (−0.55 to 0.26)	−0.47 (−0.88 to −0.06)	0.09 (−0.11 to 0.30)
Georgia	2003–2012	0.31 (0.22 to 0.40)	2012–2016	−0.12 (−0.39 to 0.16)	−0.42 (−0.71 to −0.14)	0.02 (−0.16 to 0.21)
Maryland	2001–2012	0.36 (0.31 to 0.41)	2012–2016	−0.11 (−0.33 to 0.12)	−0.47 (−0.69 to −0.24)	0.05 (−0.10 to 0.20)
North Carolina	2000–2012	0.26 (0.22 to 0.30)	2012–2016	−0.09 (−0.30 to 0.12)	−0.35 (−0.56 to −0.14)	0.02 (−0.11 to 0.16)
South Carolina	1972–1979	0.79 (0.61 to 0.96)	1979–2016	0.20 (0.19 to 0.21)	−0.59 (−0.76 to −0.41)	0.20 (0.19 to 0.21)
Virginia	1969–1979	0.53 (0.47 to 0.60)	1979–2016	0.22 (0.21 to 0.23)	−0.31 (−0.37 to −0.25)	0.22 (0.21 to 0.23)
West Virginia	1996–2014	0.05 (0.03 to 0.06)	2014–2016	−0.37 (−1.07 to 0.35)	−0.41 (−1.11 to 0.28)	−0.09 (−0.32 to 0.14)
Div 6: East South Central	**2005–2011**	**0.20 (0.07 to 0.33)**	**2011–2016**	**−0.10 (−0.23 to 0.03)**	**−0.31 (−0.49 to −0.13)**	**−0.05 (−0.16 to 0.06)**
Alabama	1969–1982	0.49 (0.45 to 0.53)	1982–2016	0.09 (0.09 to 0.10)	−0.39 (−0.43 to −0.35)	0.09 (0.09 to 0.10)
Kentucky	1992–2013	0.09 (0.08 to 0.11)	2013–2016	−0.38 (−0.73 to −0.03)	−0.47 (−0.81 to −0.13)	−0.14 (−0.31 to 0.03)
Mississippi	2005–2010	0.31 (0.06 to 0.55)	2010–2016	−0.06 (−0.18 to 0.06)	−0.36 (−0.63 to −0.10)	−0.06 (−0.18 to 0.06)
Tennessee	2003–2011	0.23 (0.14 to 0.32)	2011–2016	−0.10 (−0.26 to 0.06)	−0.33 (−0.51 to −0.16)	−0.05 (−0.17 to 0.08)
Div 7: West South Central	**2003–2011**	**0.25 (0.19 to 0.31)**	**2011–2016**	**0.03 (−0.08 to 0.14)**	**−0.22 (−0.34 to −0.10)**	**0.07 (−0.02 to 0.15)**
Arkansas	1973–1978	0.68 (0.44 to 0.92)	1978–2016	0.09 (0.08 to 0.10)	−0.58 (−0.82 to −0.35)	0.09 (0.08 to 0.10)
Louisiana	2005–2010	0.42 (0.18 to 0.66)	2010–2016	0.02 (−0.10 to 0.14)	−0.40 (−0.66 to −0.14)	0.02 (−0.10 to 0.14)
Oklahoma	1987–1995	−0.03 (−0.10 to 0.05)	1995–2016	0.06 (0.05 to 0.07)	0.09 (0.01 to 0.16)	0.06 (0.05 to 0.07)
Texas	1972–1977	0.65 (0.42 to 0.88)	1977–2016	0.19 (0.19 to 0.20)	−0.45 (−0.67 to −0.23)	0.19 (0.19 to 0.20)
Div 8: Mountain	**2005–2010**	**0.31 (0.15 to 0.48)**	**2010–2016**	**0.01 (−0.07 to 0.10)**	**−0.30 (−0.48 to −0.12)**	**0.01 (−0.07 to 0.10)**
Arizona	2006–2009	0.60 (−0.22 to 1.42)	2009–2016	0.05 (−0.05 to 0.16)	−0.55 (−1.34 to 0.25)	0.05 (−0.05 to 0.16)
Colorado	2002–2012	0.24 (0.19 to 0.29)	2012–2016	−0.07 (−0.28 to 0.13)	−0.31 (−0.52 to −0.11)	0.03 (−0.10 to 0.16)

	Trends in last two segments (years, APC [95% CI])				Change in slope (% change, 95% CI)	AAPC[ǂ] (2010–16)
	Penultimate APC[ǂ]		Last APC[ǂ]			
Idaho	1991–2010	0.16 (0.14 to 0.17)	2010–2016	−0.02 (−0.11 to 0.08)	−0.17 (−0.27 to −0.08)	−0.02 (−0.11 to 0.08)
Montana	1977–1988	0.34 (0.27 to 0.41)	1988–2016	0.12 (0.11 to 0.13)	−0.22 (−0.29 to −0.15)	0.12 (0.11 to 0.13)
Nevada	2005–2010	0.40 (0.20 to 0.61)	2010–2016	0.06 (−0.05 to 0.16)	−0.34 (−0.56 to −0.12)	0.06 (−0.04 to 0.16)
New Mexico	1983–2013	0.13 (0.12 to 0.15)	2013–2016	−0.27 (−0.70 to 0.16)	−0.40 (−0.82 to 0.02)	−0.07 (−0.28 to 0.14)
Utah	2004–2009	0.28 (0.10 to 0.45)	2009–2016	−0.07 (−0.14 to 0.00)	−0.34 (−0.53 to −0.16)	−0.07 (−0.13 to 0.00)
Wyoming	1971–1984	0.57 (0.49 to 0.64)	1984–2016	0.12 (0.11 to 0.14)	−0.44 (−0.51 to −0.37)	0.12 (0.11 to 0.14)
Div 9: Pacific	**1988–2013**	**0.27 (0.26 to 0.28)**	**2013–2016**	**0.01 (−0.24 to 0.26)**	**−0.26 (−0.51 to −0.02)**	**0.14 (0.02 to 0.26)**
Alaska	1984–2010	0.21 (0.18 to 0.23)	2010–2016	−0.04 (−0.27 to 0.18)	−0.25 (−0.47 to −0.03)	−0.04 (−0.27 to 0.18)
California	1988–2014	0.30 (0.29 to 0.31)	2014–2016	−0.12 (−0.70 to 0.45)	−0.42 (−0.98 to 0.14)	0.16 (−0.03 to 0.34)
Hawaii	1977–1997	0.14 (0.12 to 0.16)	1997–2016	0.18 (0.16 to 0.20)	0.04 (0.02 to 0.07)	0.18 (0.16 to 0.20)
Oregon	1971–1979	0.46 (0.35 to 0.58)	1979–2016	0.17 (0.16 to 0.18)	−0.29 (−0.40 to −0.18)	0.17 (0.16 to 0.18)
Washington	1980–2013	0.19 (0.19 to 0.20)	2013–2016	−0.03 (−0.32 to 0.26)	−0.22 (−0.51 to 0.06)	0.08 (−0.06 to 0.22)

[ǂ]Table presents slopes for the two most recent linear trends in life expectancy during 1959–2016. For the penultimate and most recent time periods, the table presents the annual percent change (**APC**), the years marking the beginning and end of each time period, and the degree to which the slope changed between the two comparison periods. The table also presents the average annual percent change (**AAPC**) for 2010–2016. The AAPC over any fixed interval is calculated using a weighted average of the slope coefficients of the underlying joinpoint regression line with weights equal to the length of each segment over the interval. The final step of the calculation transforms the weighted average of slope coefficients to an annual percent change. Life expectancy data obtained from the US Mortality Database.

Table 2.

Age-adjusted all-cause mortality rates, adults ages 25–64 years, for the US, census divisions, and states (1999–2017)

US census divisions and states	Age-adjusted mortality rates (deaths per 100,000), by year																			Relative increase (%, 2017 vs 2010)	Long-term trends (AAPC)			Recent trend (APC, yrs of last segment)		Excess deaths (2010-17)
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		1999-2017	2005-17	2010-17			
United States	**365.4**	**365.3**	**364.8**	**362.0**	**360.2**	**350.1**	**351.4**	**347.0**	**340.3**	**338.1**	**335.5**	**328.5**	**329.7**	**329.1**	**330.9**	**333.9**	**338.2**	**347.0**	**348.2**	**6.0***	-0.3	0.0	0.9*	**1.5***	**2013-17**	**33,307**
Div 1: New England	**302.1**	**307.3**	**304.4**	**304.3**	**301.1**	**286.1**	**283.2**	**280.1**	**275.4**	**269.9**	**269.6**	**265.0**	**265.8**	**264.1**	**269.1**	**275.8**	**286.9**	**296.3**	**299.5**	**13.0***	**0.0**	**0.6***	**1.8***	**2.9*‡**	**2012-17**	**2,718**
Connecticut	303.4	315.7	302.1	297.4	292.8	283.8	274.3	269.9	265.0	261.5	260.0	257.7	253.7	259.2	260.0	256.8	267.4	275.6	280.9	9.0*	-0.6*	0.2	1.3*	3.2*‡	2014-17	441
Maine	312.8	313.4	307.7	320.4	314.8	298.7	317.9	314.4	299.1	300.3	294.3	297.3	300.1	303.4	304.1	310.5	333.0	344.6	358.7	20.7*	0.8*	1.4*	2.6*	4.9*‡	2013-17	437
Massachusetts	300.3	307.3	309.6	308.4	306.2	289.9	282.8	279.4	274.8	264.4	268.9	260.2	259.3	256.2	262.2	272.6	280.0	287.4	291.8	12.1*	-0.1	0.4*	1.7*	2.9*‡	2012-17	1,155
New Hampshire	285.4	282.6	278.0	281.6	276.5	260.1	275.9	264.1	265.3	261.0	261.1	255.1	263.2	260.7	263.1	291.8	309.1	329.0	314.7	23.3*	0.7	1.5	3.3*	2.0	2015-17	429
Rhode Island	318.7	314.7	322.4	329.7	326.4	302.2	299.1	297.7	299.6	303.9	297.1	294.1	296.1	285.3	303.7	299.3	305.4	313.1	309.1	5.1	0.0	0.4*	0.9*	1.3*‡	2012-17	84
Vermont	299.1	289.6	284.9	275.8	274.7	267.0	253.4	278.5	272.3	271.1	251.1	260.3	284.0	261.8	276.8	271.6	294.4	309.4	312.2	19.9*	0.4	1.1*	2.6*	2.6*‡	2010-17	171
Div 2: Mid-Atlantic	**353.9**	**350.4**	**356.8**	**339.8**	**331.4**	**323.1**	**320.2**	**317.0**	**305.8**	**302.4**	**298.3**	**292.1**	**295.5**	**289.9**	**290.8**	**289.5**	**293.4**	**309.0**	**310.7**	**6.4***	**-0.8***	**-0.2**	**0.9**	**2.8*‡**	**2014-17**	**4,221**
New Jersey	344.2	342.1	350.8	328.1	318.6	309.9	307.1	309.9	287.0	286.0	276.4	276.1	279.4	273.1	274.0	270.2	271.6	288.5	297.0	7.6*	-0.9*	-0.2	1.1	5.1	2015-17	1,004
New York	349.8	341.9	353.6	330.8	321.5	311.7	304.5	298.4	292.8	286.8	282.5	275.0	273.4	270.5	270.2	268.0	267.5	280.5	275.3	0.1	-1.3*	-0.8*	-0.1	0.7*‡	2012-17	38
Pennsylvania	366.8	369.3	365.5	362.2	355.9	350.5	353.9	350.7	339.1	337.8	338.2	329.8	340.8	332.2	335.0	336.8	349.5	369.2	377.1	14.4*	0.1	0.7*	1.9*	4.2*‡	2014-17	3,179
Div 3: East North Central	**366.2**	**364.0**	**361.8**	**362.6**	**355.3**	**346.0**	**350.7**	**345.8**	**341.1**	**343.7**	**340.5**	**335.7**	**339.9**	**339.2**	**342.3**	**346.6**	**353.6**	**368.3**	**374.5**	**11.6***	**0.1**	**0.6***	**1.6***	**2.9*‡**	**2014-17**	**9,531**
Illinois	372.9	364.7	363.3	361.8	347.5	341.5	337.5	330.6	323.4	326.6	318.0	307.4	305.4	308.8	304.5	307.9	311.7	321.6	321.9	4.7*	-0.8*	-0.4*	0.5*	1.3*‡	2012-17	989
Indiana	373.9	377.7	375.9	373.0	379.0	362.9	365.2	374.0	358.4	366.7	368.6	364.4	373.7	375.7	378.5	387.1	391.8	407.1	418.4	14.8*	0.6*	1.1*	1.8*	3.0*‡	2014-17	1,839
Michigan	382.3	376.4	373.1	373.5	364.9	355.1	364.7	359.5	356.3	356.6	354.0	355.5	358.1	349.6	356.8	361.3	367.1	378.0	378.2	6.4*	0.0	0.5*	1.0*	1.5*‡	2012-17	1,167
Ohio	370.8	371.6	369.8	373.7	369.9	362.2	371.2	364.4	362.6	368.7	368.6	362.2	370.2	371.9	377.2	383.6	398.0	421.5	440.4	21.6*	1.0*	1.5*	2.8*	4.9*‡	2014-17	4,730
Wisconsin	301.5	306.6	304.3	308.9	297.2	286.6	296.7	284.9	289.9	282.6	278.6	278.9	285.9	284.1	292.1	289.3	293.7	306.3	305.6	9.6*	-0.1	0.4*	1.3*	1.3*‡	2010-17	806
Div 4: West North Central	**329.8**	**321.7**	**320.9**	**322.9**	**324.0**	**312.3**	**317.7**	**315.6**	**305.0**	**314.0**	**312.3**	**308.3**	**311.4**	**313.1**	**314.8**	**318.8**	**324.4**	**327.7**	**332.0**	**7.7***	**0.1**	**0.4***	**1.0***	**1.0*‡**	**2010-17**	**2,625**
Iowa	296.9	297.1	288.8	287.2	304.7	285.8	291.3	288.6	290.5	300.9	293.9	295.4	293.9	298.5	302.5	299.0	299.0	314.8	314.3	6.4*	0.5*	0.6*	1.0	2.1	2014-17	296
Kansas	342.7	329.5	337.2	342.0	337.3	334.5	339.4	336.6	326.0	323.8	328.4	328.4	333.1	333.3	329.7	335.9	348.0	342.3	353.6	7.7*	0.2	0.2	0.8*	0.8*	2008-17	369
Minnesota	274.3	269.5	264.8	262.4	257.5	253.3	254.7	251.9	242.9	247.4	249.6	241.6	244.8	245.1	247.1	242.1	249.5	255.3	258.8	7.1*	-0.3	0.2	0.8*	2.0*‡	2014-17	496
Missouri	395.4	387.9	387.5	391.8	394.7	380.9	387.4	386.6	369.2	387.4	380.9	378.0	380.7	381.6	386.4	395.0	399.9	404.9	407.5	7.8*	0.2*	0.5*	1.1*	1.4*‡	2011-17	931
Nebraska	312.5	291.7	298.3	314.4	295.2	284.6	286.2	289.1	285.7	290.5	285.4	279.3	287.7	284.6	281.6	303.1	303.0	292.3	300.9	7.8*	0.0	0.3	1.0*	1.0*‡	2010-17	206

North Dakota	303.4	289.1	299.2	293.0	300.6	267.0	286.6	286.0	269.7	295.7	299.6	280.4	290.8	313.0	322.1	302.5	328.7	318.1	316.1	12.7*	0.5	1.2*	1.4*	1.4*ǂ	2006-17	128
South Dakota	339.8	321.5	323.1	316.0	342.1	309.5	333.4	317.3	292.1	292.8	303.0	301.1	302.4	310.9	306.0	337.5	330.8	333.5	347.9	15.5*	0.3	0.5	1.9*	1.9*	2008-17	200
Div 5: South Atlantic	**399.8**	**404.0**	**398.8**	**394.5**	**395.7**	**385.1**	**383.7**	**379.6**	**372.2**	**366.3**	**363.5**	**356.2**	**352.0**	**351.5**	**352.4**	**355.9**	**361.1**	**375.2**	**375.8**	**5.5***	**-0.3**	**-0.1**	**0.9**	**2.3***	**2014-17**	**6,706**
Delaware	370.3	384.1	398.0	365.9	376.1	366.4	368.3	373.5	358.6	374.5	356.8	360.8	351.5	363.2	368.5	347.5	358.8	362.4	385.8	6.9*	0.0	0.3	0.8	4.1	2015-17	125
Florida	389.1	393.6	388.9	386.5	389.3	382.1	377.6	372.6	364.5	363.6	358.6	350.7	344.7	342.9	339.6	343.2	348.8	367.8	364.6	3.9*	-0.3*	-0.2	0.7*	2.3*ǂ	2013-17	1,513
Georgia	426.9	428.0	425.6	425.1	424.0	414.7	408.5	402.2	388.6	382.2	383.6	377.8	371.3	368.3	376.5	375.4	377.8	387.8	383.2	1.4	-0.6*	-0.4*	0.4*	0.9*ǂ	2012-17	298
Maryland	381.5	383.9	379.5	375.8	370.0	358.9	356.2	351.2	344.5	331.0	334.2	315.2	307.4	311.2	312.4	315.7	320.6	347.5	349.8	11.0*	-0.5	-0.1	1.6	4.2*	2014-17	1,123
North Carolina	401.2	412.2	398.4	393.4	394.2	386.8	385.6	385.6	376.5	369.1	364.4	358.5	357.2	360.0	360.7	364.8	368.6	378.6	383.7	7.0*	-0.3	0.0	1.1*	2.0*	2014-17	1,330
South Carolina	470.0	465.9	463.2	454.9	462.1	447.2	445.9	445.5	439.3	423.8	420.6	428.4	417.9	417.2	420.9	427.5	437.7	441.9	446.0	4.1*	-0.3*	0.1	0.8*	1.6*ǂ	2012-17	453
Virginia	347.9	352.2	344.5	337.3	338.5	319.9	329.4	319.4	317.4	311.5	308.0	300.6	300.8	299.1	300.7	307.0	310.6	317.6	320.4	6.6*	-0.5*	-0.1	0.8*	1.7*ǂ	2012-17	890
West Virginia	424.4	431.0	440.8	438.4	446.1	438.2	444.5	455.0	473.1	460.6	472.1	461.8	493.1	492.0	489.0	499.3	518.3	548.7	567.9	23.0*	1.7*	2.0*	2.6*	4.7*ǂ	2014-17	1,023
Div 6: East South Central	**457.0**	**458.9**	**461.2**	**467.2**	**472.4**	**463.3**	**469.6**	**467.5**	**455.2**	**456.3**	**458.6**	**457.0**	**462.5**	**466.4**	**467.4**	**478.0**	**486.5**	**496.3**	**497.3**	**8.8***	**0.5***	**0.6***	**1.3***	**1.3*ǂ**	**2010-17**	**3,991**
Alabama	469.7	467.8	470.3	471.0	482.9	478.6	485.3	487.3	472.1	478.5	475.0	468.5	473.5	479.1	483.3	482.2	493.9	501.9	497.4	6.2*	0.4*	0.3*	1.0*	0.9*ǂ	2010-17	729
Kentucky	425.5	424.9	439.2	443.7	442.4	429.2	434.5	430.0	428.2	429.9	448.5	445.9	449.7	462.9	448.8	470.8	490.4	510.3	511.7	14.7*	1.2*	1.6*	2.2*	3.1*ǂ	2013-17	1,524
Mississippi	516.9	519.0	512.6	521.5	518.4	515.8	531.0	527.2	506.0	508.1	492.1	497.6	505.2	499.7	517.7	525.2	525.3	532.7	529.2	6.3*	0.2	0.2	1.1*	1.1*	2009-17	482
Tennessee	441.8	448.1	445.8	456.0	464.4	451.5	454.3	451.8	438.5	434.7	438.4	437.8	444.3	445.0	446.4	459.0	461.6	467.3	474.2	8.3*	0.4*	0.4*	1.1*	1.1*ǂ	2009-17	1,257
Div 7: West South Central	**398.5**	**405.9**	**404.5**	**406.6**	**403.4**	**396.1**	**398.6**	**389.8**	**387.0**	**388.5**	**379.9**	**373.0**	**370.3**	**372.4**	**377.0**	**380.9**	**378.3**	**378.3**	**380.1**	**1.9***	**-0.3***	**-0.3***	**0.2**	**0.4*ǂ**	**2011-17**	**1,910**
Arkansas	439.5	451.6	447.0	461.8	457.5	461.5	457.0	460.8	456.4	473.7	463.7	449.6	457.5	461.4	462.1	475.2	479.5	485.1	486.8	8.3*	0.5	0.5	1.0*	1.3*	2011-17	563
Louisiana	481.0	491.4	494.2	487.4	497.1	489.7	509.5	489.4	477.9	472.0	460.1	453.8	442.4	453.9	468.4	474.0	472.1	475.1	481.8	6.2*	-0.1	-0.4	0.8	0.3	2014-17	681
Oklahoma	431.1	443.9	430.4	452.8	450.9	446.8	463.0	450.1	452.9	472.9	461.3	458.4	461.4	462.5	477.8	477.7	482.7	481.2	480.7	4.9*	0.6*	0.6*	0.6*	0.6*	NA	438
Texas	368.7	373.9	375.0	374.1	368.5	359.7	357.5	352.1	350.9	349.2	342.3	335.8	333.0	334.0	335.8	339.7	335.7	335.6	337.4	0.5	-0.5*	-0.5*	0.0	0.2ǂ	2011-17	228
Div 8: Mountain	**343.6**	**340.2**	**342.6**	**344.4**	**347.7**	**334.4**	**337.3**	**332.8**	**328.2**	**324.0**	**324.4**	**316.2**	**321.7**	**323.0**	**325.4**	**328.5**	**334.0**	**339.9**	**335.3**	**6.0***	**0.0**	**0.1**	**0.9***	**0.9*ǂ**	**2010-17**	**2,372**
Arizona	374.8	369.4	365.5	372.5	367.7	356.1	363.9	358.4	343.3	333.5	333.5	329.8	329.6	336.3	343.0	338.1	346.8	355.4	350.4	6.2*	-0.3	-0.2	1.0*	1.0*ǂ	2009-17	691
Colorado	297.0	295.5	296.9	300.2	301.8	289.6	285.4	279.4	281.6	283.7	285.1	271.8	282.9	280.2	275.0	282.9	281.2	291.7	288.0	6.0*	-0.1	0.1	0.6	1.1	2013-17	469
Idaho	300.0	299.4	304.8	302.6	316.6	299.0	292.3	293.1	285.6	287.9	304.5	291.1	294.7	290.4	315.5	304.7	310.6	307.1	307.2	5.5	0.3	0.5	0.7*	0.7*	2006-17	129
Montana	330.1	330.2	337.5	351.3	349.2	326.4	344.7	332.8	332.9	333.4	345.9	323.9	342.3	343.4	348.2	337.7	380.7	361.5	355.6	9.8*	0.4*	0.7*	1.3*	1.3*ǂ	2010-17	166
Nevada	415.3	418.4	404.8	403.8	412.7	390.2	407.4	386.0	381.2	374.3	370.4	361.9	365.3	360.1	365.0	361.8	365.8	371.9	367.2	1.5	-0.7*	-0.6*	0.3	0.3ǂ	2010-17	79
New Mexico	371.5	362.3	384.5	386.3	388.7	379.0	379.5	389.6	385.3	396.8	385.6	374.4	390.6	396.8	395.6	424.5	427.5	443.2	439.9	17.5*	1.0*	1.3*	2.1*	2.4*ǂ	2011-17	694
Utah	296.7	291.2	302.0	287.5	303.8	300.4	284.5	291.4	297.3	280.8	284.8	280.3	283.7	287.1	282.6	293.9	295.9	298.4	291.5	4.0	0.0	0.2	0.7*	0.9*ǂ	2011-17	151
Wyoming	346.3	339.0	354.4	348.5	367.1	331.1	349.9	352.0	357.7	348.4	328.9	353.4	340.2	345.5	340.7	356.8	371.2	353.7	350.7	-0.8	0.1	0.1	0.1	0.1	NA	-7
Div 9: Pacific	**319.7**	**316.4**	**316.8**	**313.7**	**314.6**	**303.7**	**304.0**	**299.4**	**294.4**	**286.3**	**285.2**	**272.3**	**274.4**	**273.2**	**272.4**	**272.7**	**274.5**	**275.6**	**273.5**	**0.5**	**-0.8***	**-0.8***	**-0.1**	**0.1ǂ**	**2011-17**	**318**
Alaska	340.2	343.3	357.3	378.4	340.0	327.4	332.7	326.5	343.4	335.3	331.9	331.1	346.2	345.5	356.7	361.6	369.8	379.3	370.8	12.0*	0.6	1.3*	1.3*	1.3*	2005-17	159
California	323.0	319.1	319.5	313.1	315.9	304.6	304.4	300.0	293.4	283.4	281.0	267.3	268.9	267.7	266.0	263.9	266.2	269.4	264.9	-0.9	-1.1*	-1.1*	-0.2	-0.2ǂ	2010-17	-503
Hawaii	302.4	300.8	301.0	296.1	285.6	288.1	295.9	293.3	281.5	277.8	287.5	275.6	283.2	284.3	280.1	296.5	286.8	280.3	296.7	7.7*	-0.2	0.0	0.6	0.6ǂ	2010-17	156
Oregon	324.6	317.5	326.5	329.4	331.9	318.6	320.3	316.1	316.4	309.2	314.3	301.8	306.0	304.6	304.7	313.0	312.2	308.2	305.5	1.2	-0.3	-0.4	-0.1	-1.2	2015-17	72
Washington	301.5	301.9	296.0	304.7	301.3	292.1	291.7	286.0	285.5	286.3	285.2	275.9	276.7	275.1	277.9	283.2	285.0	279.1	287.1	4.1*	-0.4*	-0.2	0.3	0.7ǂ	2012-17	434

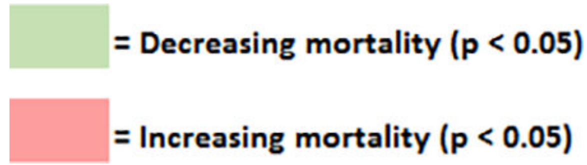

Table presents age-adjusted, all-cause mortality rates (per 100,000) among US adults ages 25–64 years for 1999–2017, along with the relative increase in mortality rates between 1999 and 2017, and the slopes modeled by the Joinpoint Regression Program. See text and Supplement for methods. Slopes presented here include the average annual percent change (*AAPC*) for three time periods—1999–2017, 2005–2017, and 2010–2017—and the annual percent change (*APC*) for the most recent linear trend in the joinpoint model. Also shown are the estimated number of excess deaths in the US caused by year-to-year changes in midlife mortality rates between 1999 and 2017. Green shading depicts years during which mortality rates decreased (statistically significant negative APC), red shading denotes years of increasing mortality (statistically significant positive APC), and cells with no color depict periods when the APC did not differ significantly from zero. Cells with bolded borders denote joinpoint years, when changes occurred in the modeled linear trends. Underlined mortality rates denote the lowest mortality rates (nadir) for 1999–2017. Asterisks (*) denote a slope (APC or AAPC) that differed significantly from zero ($p < 0.05$) and hashtags (ǂ) denote a statistically significant slope change estimate, a measure of the change in slope from that of the previous time period; see Table e7 for 95% confidence intervals. NA = Not applicable; joinpoint plotted a single trend line for 1999–2017, thus no last segment. Mortality rates obtained from CDC WONDER.