

Mortality and Longevity

# U.S. Population Mortality Observations Updated with 2019 Experience



January 2021




# U.S. Population Mortality Observations

## Updated with 2019 Experience


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## Section 1: Introduction

The Society of Actuaries has developed this report to provide insights on the historical levels and emerging trends in U.S. population mortality. The most recently released U.S. population mortality experience from calendar year 2019 has been incorporated and added to prior available data to enable analysis of mortality experience over the period 1999-2019. This research is part of its ongoing longevity and mortality research initiatives.

The report begins in Section 2 with an Executive Summary broken into subsections of key highlights and other high-level summary observations obtained by looking across the overall population results and the results from the individual causes of death (CODs). Section 3 describes the methodology used in the report. The remaining content of the report is on-line in tables and graphs embedded on the same webpage where the pdf of this report is located. The report focuses on 11 individual CODs that were selected from the National Center for Health Statistics' (NCHS) list of rankable causes of death. The experience is shown for all CODs combined (total population mortality), individually for each of the listed 11 CODs, and with selected groupings or modifications to those CODs. The 11 listed CODs are also shown on a combined basis by physiological and external causes. Given the continued interest in opioid-related deaths, opioids are shown as a COD, as are the accidents without opioids analysis, and they are shown in an exhibit of deaths by opioid type for all ages and genders.

An analysis of experience by socioeconomic status is also included. A Socioeconomic Index Score<sup>1</sup> was computed for each county. The counties were then grouped into quintiles with each quintile holding 20% of the total U.S. population. Mortality rates were then calculated for each county quintile grouping. Quintile group 1 contains the counties with the lowest Socioeconomic Index Score and quintile group 5 contains the counties with the highest Socioeconomic Index Score. The method of assigning counties to groups in this report is different than the method used in prior U.S. Population Mortality Observation reports published by the SOA. The prior method assigned counties to groups based on county-level median household income alone. The Socioeconomic Index Score used for the groupings in this report is more robust and takes county-wide variables on education, occupation, employment, income, and housing price and quality into account. The on-line tables and graphs are contained in links to three dashboards on the webpage where this report pdf was found. The COD variation of interest can be viewed in the first two dashboards by using a drop-down box at the top right of the data board. The "U.S. Population Mortality by Gender" dashboard includes a graph of age-adjusted death rates from 1999-2019 by gender and both genders combined and a related table with corresponding average annual mortality improvement rates. The table shows experience by gender for all ages combined and by combined gender for age groups<sup>2</sup>. The average annual mortality improvement rates are shown for 2018-2019, 2014-2019, and 1999-2019. The drop-down box below the COD choice enables the by gender analysis to be filtered by a selected county quintile group. The "U.S. Population Mortality by County Socioeconomic Quintile Group" dashboard is like the "U.S. Population Mortality by Gender" dashboard, except that the graph shows county variation rather than gender variation with a drop-down box choice to filter by a selected gender. The third dashboard, "Opioid Deaths by Opioid Type and County Quintile Group," shows the exhibit of opioid deaths by opioid type with variation by county quintile group for all ages and genders combined. All data supporting this report and the dashboards are included in an appendix in the form of an Excel file that can be found on the same webpage where this report and these dashboards are located.

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<sup>1</sup>Society of Actuaries. Mortality by Socioeconomic Category in the United States. <https://www.soa.org/resources/research-reports/2020/us-mort-rate-socioeconomic/>. November 2020.

<sup>2</sup>The accidents without opioids COD variation does not contain any experience by age group for the county income groups other than 'All Counties.'



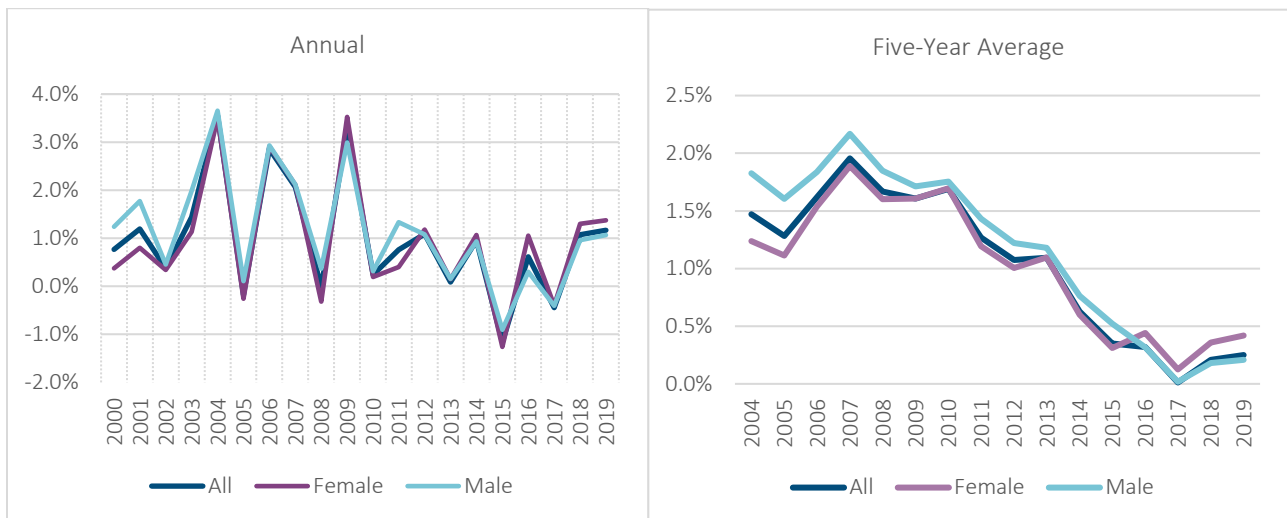
## Section 2: Executive Summary

### 2.1 KEY HIGHLIGHTS

#### 2.1.1 OVERALL MORTALITY IMPROVEMENT

The overall age-adjusted mortality rate<sup>3</sup> (both genders) from all causes of death decreased 1.2% in 2019 following a 1.1% decrease in 2018. Annual mortality improvement rates have been volatile over the full period of this report. Mortality experience in 2019 breaks a pattern of varying annual mortality experience swinging by at least 1.1% between improvement and disimprovement since 2015 shown in the Annual graph below. The Five-Year Average graph below shows a trend of decreased mortality improvement from a peak in 2007 to a low in 2017 that recently showed an uptick for 2018 and 2019. Annual mortality improvement was 0.3% from 2014-2019 versus 1.0% from 1999-2019. Recent experience is not long enough to show a reversal of the downward trend to higher levels of improvement.

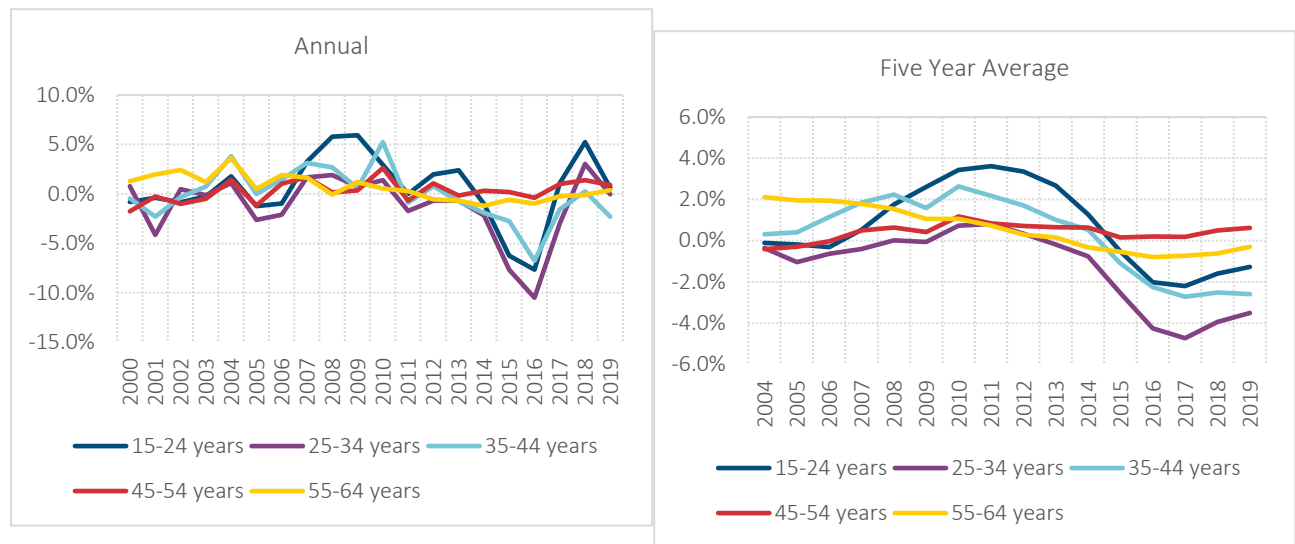
**Figure 1**  
**US POPULATION ANNUAL AND FIVE-YEAR AVERAGE MORTALITY IMPROVEMENT, YEARS ENDING 2000-2019**



<sup>3</sup> Age-adjusted rates are calculated assuming the mix of ages in the population stays the same each year. Life expectancy is a composite of mortality rates over a single person’s future lifetime. This report focuses on age-adjusted rates (2010 baseline year), as opposed to life expectancy, because actuaries generally require mortality rates, not life expectancies, as an input assumption for their work.

Mortality improvement has varied by age group. Improvement in ages 15-44 has had more volatility in recent years due to the impact of the opioid crisis and the fact that external, non-natural deaths are a larger portion of the overall deaths for younger age groups than for older ages as shown in Section 2.2.3. In 2019, age groups 15-24, 25-34, and 35-44 had annual improvement rates of 0.6%, 0.0%, and -2.3%, respectively. These improvement rates were down from 2018 but were significantly greater than in years 2014-2016. Other age groups saw improvement rates closer to and above zero from 2000-2019. The Annual graph below shows experience consistent with other research<sup>4</sup>, which is limited to age 35 and above, that highlights the recent multi-year trend of disimprovement at ages 35-45.

**Figure 2**  
**US POPULATION ANNUAL AND FIVE-YEAR AVERAGE MORTALITY IMPROVEMENT, YEARS ENDING 2000-2019 FOR SELECTED AGE GROUPS**



### 2.1.2 LIFE EXPECTANCY

The Centers for Disease Control and Prevention (CDC) reported that life expectancy at birth increased 0.1 years in each of 2019 and 2018<sup>5</sup>. The changes in life expectancy in these two years followed the general principle that a decrease in the mortality rate would be expected to produce an increase in life expectancy.

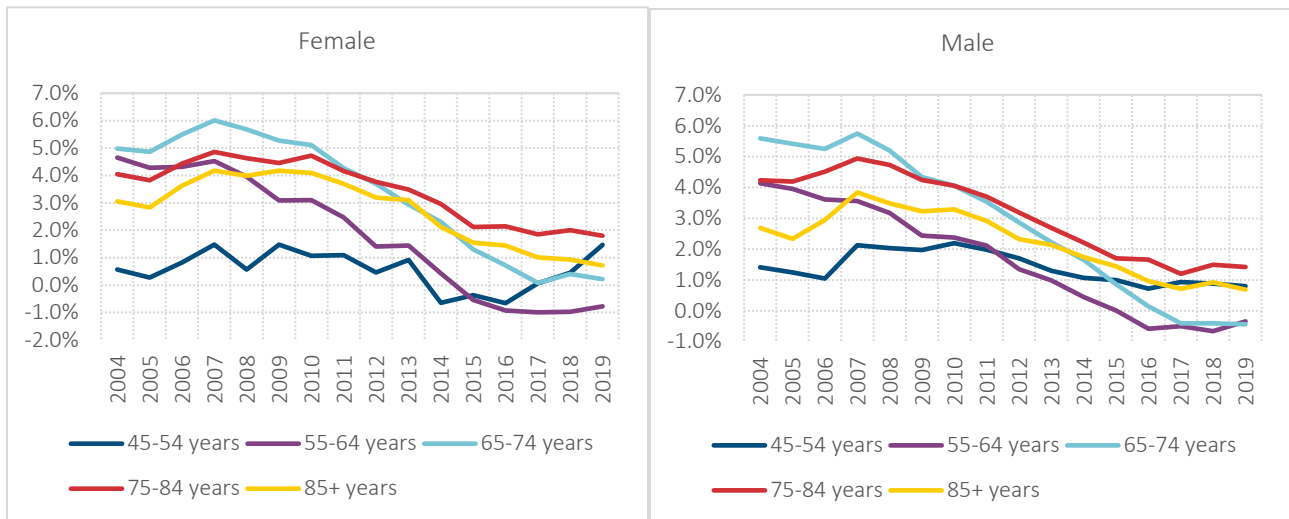
<sup>4</sup> <https://www.soa.org/globalassets/assets/files/resources/experience-studies/2020/mortality-improvement-scale-mp-2020.pdf>, page 26.

<sup>5</sup> Kochanek KD, Xu JQ, Arias E. Mortality in the United States, 2019. NCHS Data Brief, no 395. Hyattsville, MD: National Center for Health Statistics. 2020.

### 2.1.3 HEART DISEASE

The death rate from heart disease was down 1.2% in 2019, which followed a 0.8% decrease in 2018. This 2019 improvement was greater than the 0.6% annual improvement over 2014-2019, but it continued a trend where recent annual improvement was much lower than the 2.4% annual improvement from 1999-2019. The downward trend was similar for both genders but with slightly higher improvement rates for females than males when measured across all ages. When viewed across age groups, there are different trends by age group, which are similar for both genders. The downward trend in five-year annual improvement was the highest for female age group 55-64 and male age group 65-74. While starting with almost the highest five-year annual improvement rate for females in 2004, age group 55-64 went from 4.7% to -0.8%, the lowest age group rate in 2019. Similarly, male age group 65-74 decreased from 5.6%, the highest rate in 2004, to -0.4%, the lowest rate in 2019. Within age groups of each gender at or above 45-54, female age group 45-54 is the only one that had a higher five-year annual improvement rate in 2019 than 2014. It had the lowest five-year rate, -0.6% in 2014, which increased to the second highest rate of 1.5% in 2019.

**Figure 3**  
HEART DISEASE FIVE-YEAR AVERAGE ANNUAL MORTALITY IMPROVEMENT, YEARS ENDING 2004-2019

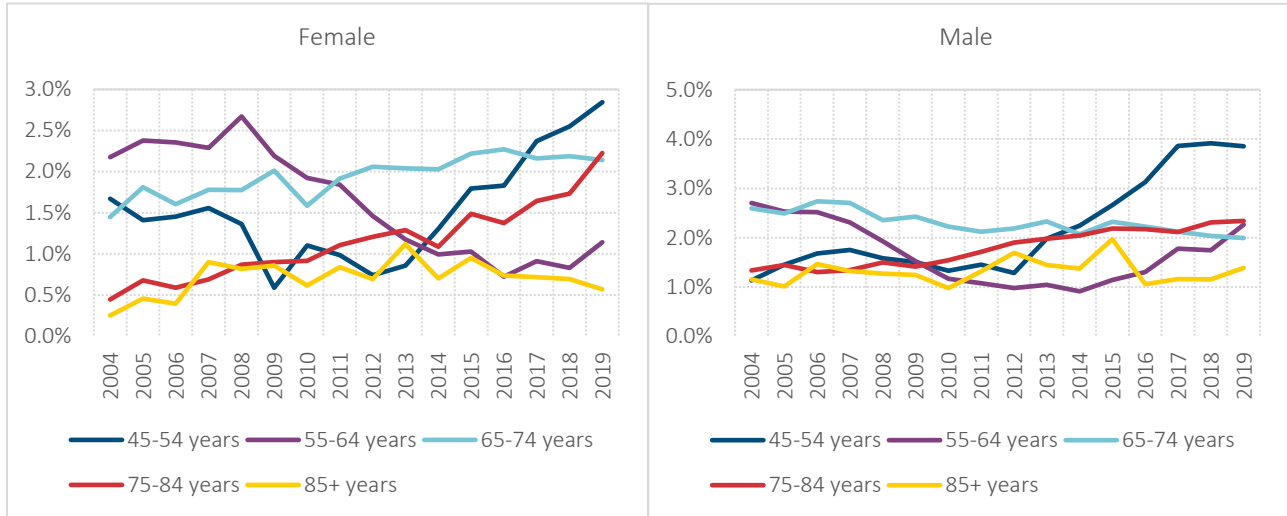


### 2.1.4 CANCER

The positive trend in the cancer death rate, which decreased, on an age adjusted basis every year from 1999-2018, continued in 2019. Cancer mortality improved by 2.0% in 2019 and 1.9% annually for all ages from 2014-2019. This continues a trend of accelerating improvement for all ages combined relative to annual improvement of 1.6% over 1999-2019. The trend was similar for both genders and slightly higher for males when measured across all ages. Like heart disease, the trend varied by age group and, to a degree, by gender. Whereas most age groups from 45 to 85+ have accelerating improvement, ages 55-64 slowed down for both genders. However, females in the 55-64 age group saw the only trend decrease for females, going from the highest age group five-year annual improvement rate of 2.2% in 2004 to 1.1%, the second lowest in 2019. Both genders saw a marked acceleration for age group 45-54 in recent years. It ended with the highest age group five-year annual improvement rate in 2019 for both genders. For males, that age group had the lowest improvement rate in 2004 of 1.1% that ended 2019 at 3.9%. That uptrend continued in 2019 for females, which recorded five-year rates of 2.4%, 2.5%, and 2.8%, respectively, for 2017-2019, whereas the trend for males flattened in 2017-2019 where males had five-year improvement rates of 3.9% in each year from 2017-2019.



**Figure 4**  
**CANCER FIVE-YEAR AVERAGE ANNUAL MORTALITY IMPROVEMENT, YEARS ENDING 2004-2019**



### 2.1.5 OPIOIDS

The Opioid drug overdose death rate, a key component of accidental deaths, increased 6.3% in 2019, which followed a 2.2% decrease in 2018. The increased death rate in 2019 leaves 2018 as the only year between 1999-2019 when the opioid death rate decreased. The average annual increase of the death rate over 1999-2019 was 9.0% and was 11.1% from 2014-2019. The decrease of improvement rates from 2018 to 2019 by gender was greater for males than females. The improvement rates in 2018 and 2019 were, respectively, 3.9% and -3.2% for females, and 1.2% and -7.9% for males. There was a wide range of experience by age groups in 2019 and every reported<sup>6</sup> age group for both genders combined saw an increased death rate in 2019. Deaths were concentrated in ages ranging from 15 to 64, which comprised 95% of the opioid deaths. Within this range of ages, greater increases of the death rate generally occurred with increasing age. Age groups 15-24, 25-34, 35-44, 45-54, and 55-64 had increases of 3.6%, 3.1%, 7.9%, 6.6%, and 9.2%, respectively. Although the increases for higher ages were greater ranging from 10.7% for age group 65-74 to 18.9% for age group 85+, they comprised only 5% of the total deaths. Generally, females saw less adverse mortality improvement experience than males across all age groups, except for age group 75-84 where the death rates in 2019 increased for females and males by 21.5% and 8.9%, respectively.

### 2.1.6 SUICIDE

The decrease in the suicide death rate in 2019 by 2.3% broke a negative trend of increased suicide death rates (on an age-adjusted basis) every year from 2006 through 2018. The decrease in the 2019 death rate contributed to lowering the five-year average improvement from -2.4% for 2013-2018 to -1.3% for 2014-2019. The mortality improvement rate varies widely and is volatile by age group. While age group 5-14 had the greatest decrease of 9.2%, their impact on the overall mortality improvement rate is limited because that age group comprised only 1% of all suicide deaths. Like opioid experience, most deaths are concentrated between the lower and higher age

<sup>6</sup> Cells with fewer than 20 deaths are suppressed in this report because the results are deemed unreliable by the CDC. A death rate was not reported for opioid age group <1.

groups. In 2019, 90% of suicide deaths occurred between ages 15 to 74 with each age group in that range comprising at least 10% of the total deaths. Age groups 15-24, 25-34, 35-44, 45-54, 55-64, and 65-74 saw decreased death rates in 2019 of 3.5%, 0.0%, 0.9%, 2.2%, 3.9%, and 5.2%, respectively. Age group 85+ had the only death rate increase, which was 5.5% but comprised only 3% of all deaths.

While there is little apparent trend from 1999-2019 across all age groups ranging from ages 15 to 74, age groups 15-24 and 45-54 are exceptions. Age group 15-24 saw the lowest relative performance going from third highest, -0.4%, to the lowest, -3.8%, five-year improvement rate in 2004 and 2019, respectively. Conversely, age group 45-54 saw the highest relative performance during that same period. That age group went from the lowest, -3.6%, to the highest, 0.6%, five-year improvement rate in 2004 and 2019, respectively. Generally, female suicide rates have increased faster than corresponding male rates over 1999-2019, but the gap has reversed in recent years. The female and male five-year improvement rates were -3.5% and -1.6%, respectively, in 2014, and -0.7% and -1.5%, respectively, in 2019.

## 2.2 OTHER OBSERVATIONS

### 2.2.1 MORTALITY IMPROVEMENT ATTRIBUTION BY COD

U.S. population deaths of 2,854,838 in 2019 were the highest in history<sup>7</sup>. Heart disease remains the number one killer and accidents continued to be the highest external COD in 2019. The number of deaths in 2019 for the population by the CODs studied in this report are shown below in descending rank order. Except for accidents, the top five CODs all had decreased mortality in 2019. Accidents, diabetes, liver, assault, and other<sup>8</sup> were the only CODs studied that had increased mortality in 2019. In an attribution of the 1.2% improvement in 2019 to CODs, cancer and flu & pneumonia each contributed the most, 0.4%, to the total improvement. Heart disease contributed 0.3% and Alzheimer's/dementia and pulmonary each contributed 0.2%. Accidents and other were the only CODs with increased mortality that had enough deaths to affect the attribution. Accidents contributed -0.2% and other contributed -.01% to the total improvement.

**Figure 5**  
2019 U.S. POPULATION MORTALITY BY COD

Cause of Death	Deaths	%	Age-Adjusted 2018-2019 Mortality Improvement	Attribution to All CODs*
Heart Disease	659,041	23.1%	1.2%	0.3%
Cancer	599,601	21.0%	2.0%	0.4%
Alzheimer's/Dementia	236,584	8.3%	2.8%	0.2%
Accidents	173,040	6.1%	-2.7%	-0.2%
Pulmonary	156,979	5.5%	3.7%	0.2%
Stroke	150,005	5.3%	0.3%	0.0%
Diabetes	87,647	3.1%	-1.2%	0.0%
Flu & Pneumonia	49,783	1.7%	17.2%	0.4%
Suicide	47,511	1.7%	2.3%	0.0%
Liver	44,358	1.6%	-2.5%	0.0%
Assault	19,141	0.7%	-1.6%	0.0%
Other	631,148	22.1%	-0.6%	-0.1%
<b>All CODs</b>	<b>2,854,838</b>	<b>100.0%</b>	<b>1.2%</b>	<b>1.2%</b>

\* The attribution method is described in section 3.

<sup>7</sup> Based on individual years 1933 and later, National Center for Health Statistics. *Vital Statistics of the United States*, Volume II: Mortality, Part A. Washington, D.C.: Government Printing Office, various years. (Data obtained through the Human Mortality Database, [www.mortality.org](http://www.mortality.org), on 2/3/2020).

<sup>8</sup> Other is the aggregate of all other causes of death than the 11 CODs studied in this report.

## 2.2.2 MORTALITY IMPROVEMENT ATTRIBUTION BY AGE GROUP

In an attribution of the 1.2% improvement in 2019 to age groups, the two highest age groups, 75-84 and 85+, contributed three-fourths of the total improvement, 0.4% and 0.5%, respectively. Age groups up to age 34 made no net contribution and age group 35-44 contributed -0.1% to the total. The contribution of age groups ranging from 45 to 74 in total, 0.4%, equaled that of age group 75-84. The five biggest contributors to 2019 mortality improvement for age groups 75-84 and 85+ were heart disease, cancer, Alzheimer's, pulmonary, and flu & Pneumonia. Those CODs for age groups 75-84 and 85+ combined produced virtually all of their total improvement for 2019. Further, because those same age groups comprised three-fourths of total improvement for all ages, those five CODs for those two age groups produced three-fourths of the total 1.2% improvement for all ages.

**Figure 6**  
2019 U.S. POPULATION MORTALITY BY AGE

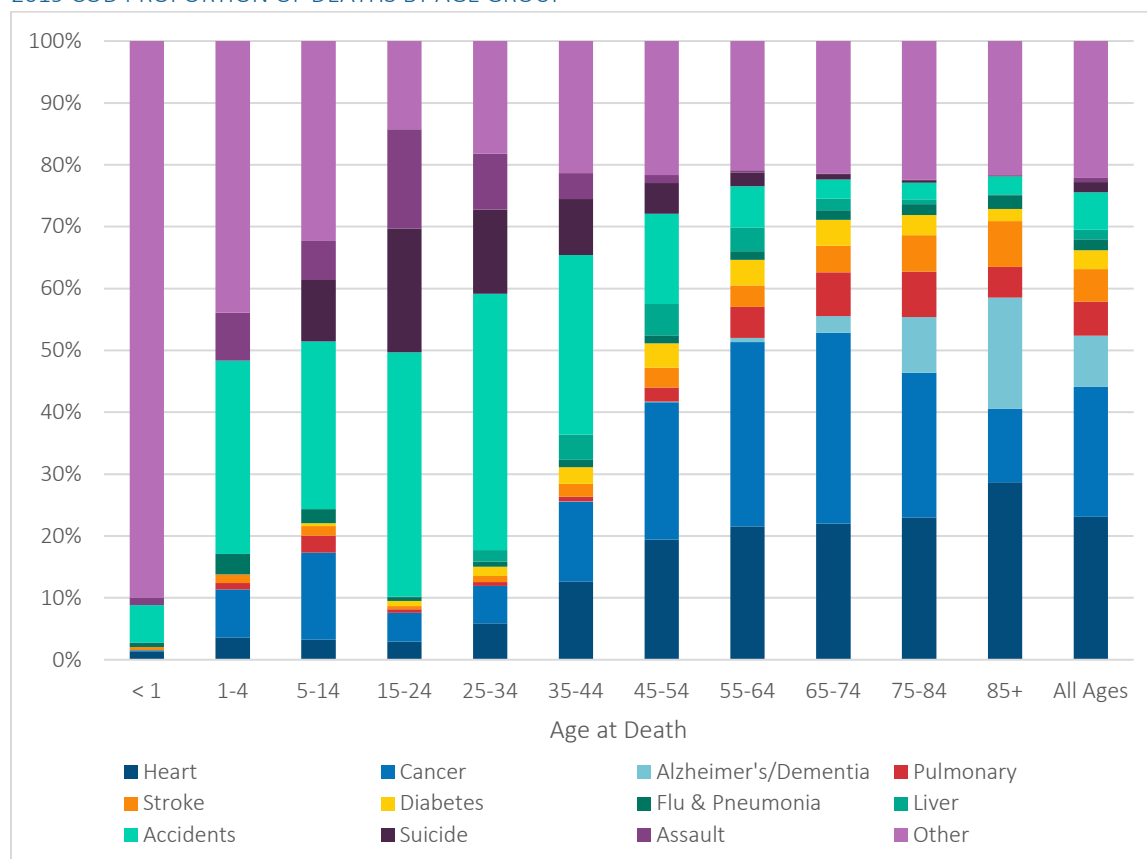
Age Group	Deaths	%	2018-2019 Mortality Improvement	Attribution to All Ages*
< 1 year	20,921	0.7%	0.9%	0.0%
1-4 years	3,676	0.1%	3.0%	0.0%
5-14 years	5,497	0.2%	-1.1%	0.0%
15-24 years	29,771	1.0%	0.6%	0.0%
25-34 years	59,178	2.1%	0.0%	0.0%
35-44 years	82,986	2.9%	-2.3%	-0.1%
45-54 years	160,393	5.6%	0.9%	0.1%
55-64 years	374,937	13.1%	0.4%	0.1%
65-74 years	555,559	19.5%	1.0%	0.2%
75-84 years	688,027	24.1%	1.8%	0.4%
85+ years	873,746	30.6%	1.7%	0.5%
Not Stated	147	0.0%		
<b>All Ages</b>	<b>2,854,838</b>	<b>100.0%</b>	<b>1.2%</b>	<b>1.2%</b>

\* Rounded COD values do not sum to All Ages. The attribution method is described in section 3.

### 2.2.3 COD DISTRIBUTION BY AGE GROUP

Physiological CODs predominated for older ages and external CODs (assault, suicide, and accidents) for younger ages. Age group 15-24 had the highest proportion, 75.5%, of external CODs in 2019. Heart, cancer, and Alzheimer's/dementia combined predominated within physiological causes for older ages. The combined deaths of those three CODs were at least 50% of the deaths for age group 55-64 and higher. The percentage of deaths from those three CODs ranged from 52.0% for age group 55-64 to 58.5% for age group 85+. Within the mix of those three CODs for those age groups, as the proportion of Alzheimer's/dementia increased with age, the proportion of cancer decreased. The combination of pulmonary, stroke, diabetes, and flu & pneumonia also contributed notably to deaths of age groups 55-64 and higher. The combined percentage of deaths of those four CODs for those age groups ranged from a low of 14.0% for age group 55-64 to 18.3% for age group 75-84. Within that mix of those four CODs for those age groups, stroke increased with age while diabetes decreased. When those seven CODs (heart, cancer, Alzheimer's/dementia, pulmonary, stroke, diabetes, and flu/pneumonia) are combined, their percentage of total deaths ranged from 66.0% for age group 55-64 and 75.1% for age group 85+.

**Figure 7**  
2019 COD PROPORTION OF DEATHS BY AGE GROUP



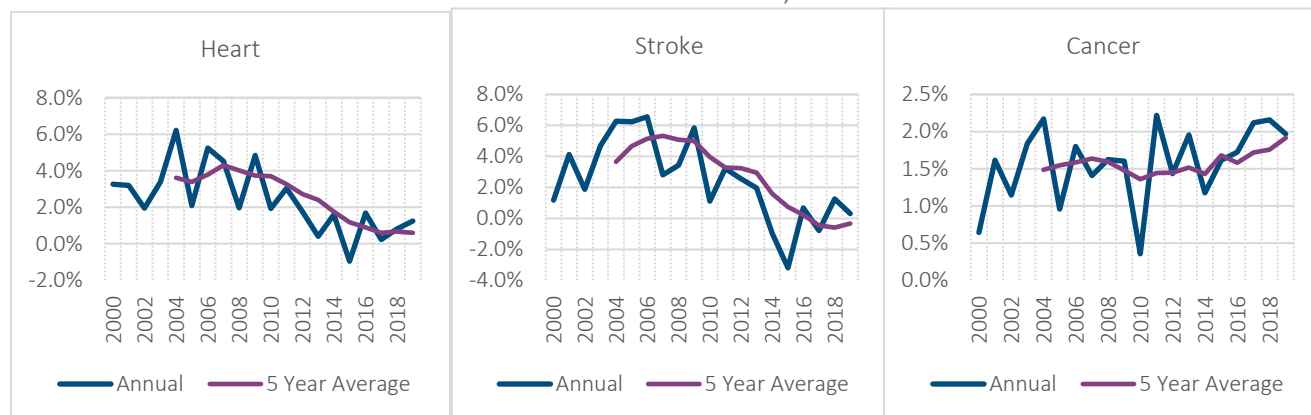
### 2.2.4 MORTALITY IMPROVEMENT BY SELECTED CODS

Three key physiological CODs with respect to the long-term progression of mortality rates (heart disease, stroke, and cancer) are shown below for all ages and genders combined on a national basis. Annual and average five-year mortality improvement rates are shown for each COD.

1. Heart disease improvement has slowed notably in more recent periods. The annual five-year improvement rate that peaked in 2002-2007 at 4.3% decreased to 0.6% for 2014-2019.
2. Stroke mortality improvement followed a similar trend. Its five-year mortality improvement rate also peaked in 2002-2007 at 5.3% and decreased to -0.3% for 2014-2019.
3. Cancer had mortality improvement that has trended up during 1999-2019 and is the only COD, of the 11 in this report, whose mortality improved every year during that time. The cancer five-year annual improvement rate increased from 1.5% in 1999-2004 to 1.9% in 2014-2019.

The slowdown of heart disease improvement and the near-term reversal of stroke improvement continues to be very significant because these two CODs have been the overwhelming contributors to overall mortality improvement over the past 20 years. While heart disease mortality improvement has seen a recent short-term uptrend, 0.2%, 0.8%, and 1.2% for 2017-2019, respectively, there is not enough experience to establish whether the flattening of heart disease improvement rates will continue or reverse to the higher improvement rates seen in earlier periods.

**Figure 8**  
ANNUAL AND FIVE-YEAR AVERAGE ANNUAL MORTALITY IMPROVEMENT, YEARS ENDING 2000-2019



Four other CODs, Alzheimer’s/dementia, diabetes, liver, and flu & pneumonia are shown below. The first three of those CODs have notable trend patterns, while flu & pneumonia are very volatile annually but with no apparent trend. Although neither diabetes nor liver contributed measurably to the 1.2% overall annual 2019 age-adjusted mortality improvement rate, both with long-term downtrends, they have held back overall mortality improvement.

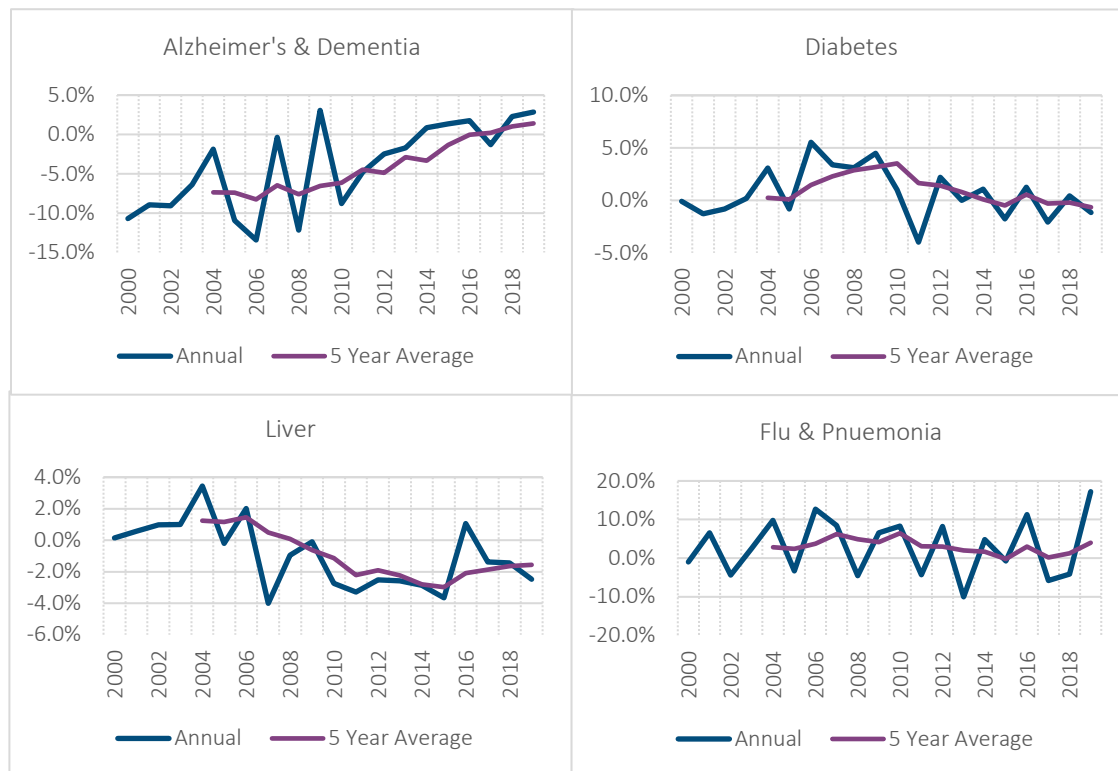
1. Alzheimer’s combined with dementia mortality improvement trended up strongly through the report period. The five-year average annual improvement rate increased from -7.3% in 1999-2004 to 1.4% in 2014-2019 with a 2.8% annual improvement in 2018-2019.
2. Diabetes five-year average annual mortality improved and then regressed to 0.9% below its starting level from years ending 2004-2019. Using the five-year measure, diabetes mortality improvement was 0.2% in 2004, peaked in 2010 at 3.5%, and then declined to -0.7% in 2019.
3. Liver mortality improvement also decreased during the reporting period but made a recent turnaround (on a five-year average annual basis) that started in 2016. However, even with recent improvement from an

earlier low in 2015, the annual and five-year mortality average annual improvement rates ended 2019 at -2.5% and -1.6%, respectively.

- Annual flu & pneumonia mortality improvement has been very volatile over 1999-2019. The lowest improvement, -10.0%, occurred in 2013 and the highest, 17.2%, occurred in 2019. The frequent oscillation of annual improvement rates resulted in a narrower five-year rate that ranged from -0.2% in 2015 to 6.4% in 2010. Although rates have varied notably over 1999-2019, the cumulative annual improvement rate during that time was 3.2% and it was 4.0% for the five-year period 2014-2019.

**Figure 9**

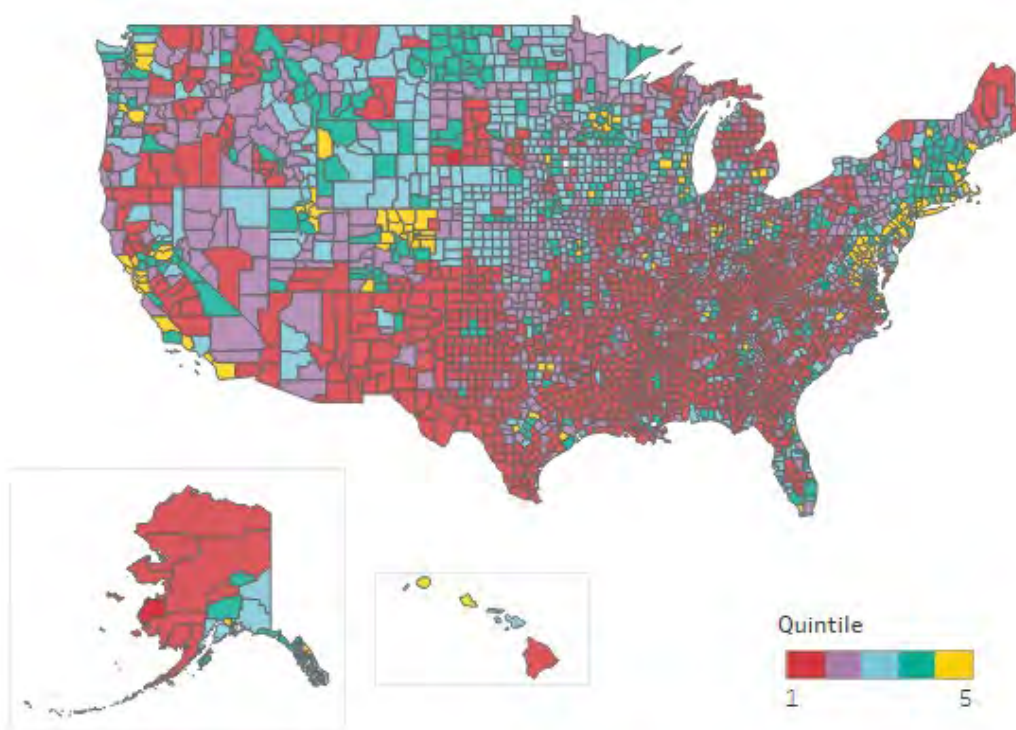
**ANNUAL AND FIVE-YEAR AVERAGE ANNUAL MORTALITY IMPROVEMENT, YEARS ENDING 2000-2019**



### 2.2.5 MORTALITY BY SOCIOECONOMIC QUINTILE COUNTY GROUPS

Mortality was analyzed over the entire U.S. population (All Counties) and compared to mortality in the socioeconomic quintile county groups. These quintile county groups were developed based on socioeconomic factors, as described in section 3. The map below shows the counties. Generally, quintile groups 1 and 2 are geographically large, but widely dispersed, rural areas. Quintile groups 4 and 5 are mostly, but not exclusively, geographically small metropolitan areas. For example, in addition to major metropolitan areas, quintile 4 regions can be seen in less populated New England areas, the oil patch of North Dakota, and the eastern front of the Sierras in California. Quintile group 3 does not show a distinct urban or rural pattern but is more geographically prevalent west of the Mississippi River than east of it.

**Figure 10**  
U.S. COUNTIES BY SOCIOECONOMIC QUINTILE GROUP



Generally, with few exceptions, mortality rates by county grouping follow a rank-order of the lowest mortality for quintile group 5 and highest mortality for quintile group 1. There is a corresponding rank-order pattern for mortality improvement, which is generally highest for quintile group 5 and lowest for quintile group 1. However, the rank-order of the quintile groups' mortality improvement is more fluid than their corresponding level of mortality and is the focus of discussion in this section. Examining five-year average annual mortality improvement of the county income groups over time gives insight on the counties' evolving mortality experience relative to one another.

The graphs below show five-year average annual mortality improvement by county groups for All CODs, which is representative of the general county relationships and five CODs that are exceptions to that. All following references to mortality improvement in this section imply a five-year annual average ending in the year noted. Note that, because the range of mortality improvement is wide across CODs, the scales are different in each of the six graphs.

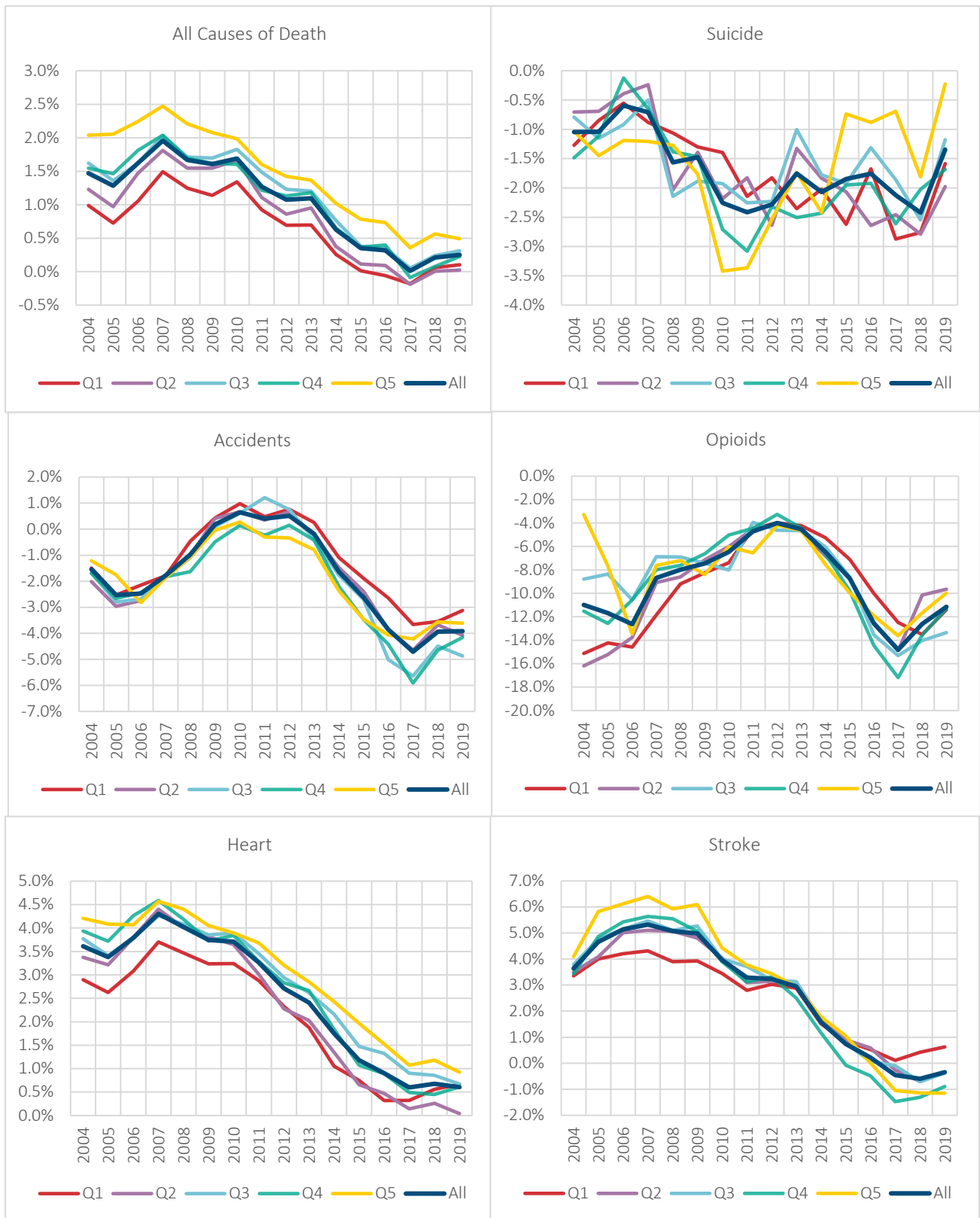


The All CODs show a similar pattern across time for each county group with rank-order generally preserved for the five quintile groups, but as mortality improvement slowed, the differences between those rates across the quintile groups compressed. The compression was greatest for quintile groups 1 and 5, which saw the difference between their improvement rates decrease by 0.6% for years ending 2004 and 2019. While quintile groups 2, 3, and 4 saw similar experience, their compression was only 0.1%. Notably, quintile groups 1 and 5 had the lowest and highest improvement rates, respectively, in every year except 2018 and 2019 when quintile group 1 crossed over and exceeded the quintile group 2 improvement rate by 0.1%. The compression between quintile groups 1 and 5 indicates that the speed of a continued widening mortality rate gap slowed down in the last few years.

There are five CODs that showed notable exceptions to the All CODs patterns.

1. Suicide showed substantial switching of rank-order over the full range of years studied and a widening of improvement rates between the quintile groups. Relative to All CODs, the rank-order is notable in that quintile group 1 was, in most years, not the lowest and, in some years, had the highest improvement rates. Also, quintile group 5 started the period in the middle of the rank-order, sank to the lowest rank-order in years ending 2010 and 2011 and its lowest level of disimprovement in 2010, then ascended to the highest rank-order rate (least disimprovement) in 2015-2019.
2. Accidents, like suicide, showed notable rank-order switching with a widening of improvement rates across ranks from the earliest to most recent years studied. While quintile groups 5 and 1 started the year ending 2004 as the highest and next highest improvement rates, respectively, they switched places in the years ending 2017-2019 with travel by quintile group 5 that included having the lowest improvement rates in the years ending 2006-2007 and 2011-2014. Conversely, quintile group 1 had the highest rank (most improvement or least disimprovement) in all years except 2004-2005 and 2011 when it was ranked number two.
3. Opioids showed a wide gap between the highest and lowest quintile groups in 2004 that almost merged in the year ending 2013 and then widened again, but by less than the starting point, by the year ending 2019. Quintile groups' rank-order across time was notable. Quintile groups 5 and 2 had the highest and lowest improvement rates in the year ending 2004 and ended 2019 with the next highest and highest improvement rates (least disimprovement), respectively. During this time, quintile group 1 started 2004 in fourth place, sank to fifth place in 2006-2008, rose to the highest rate in 2013-2017, and then reverted back to fourth place in 2019.
4. Heart shows a distinctive result in recent years where quintile group 1 crossed over from the lowest rank that was last held in the year ending 2016 to end 2019 as the third highest. At the same time, quintile group 2 sank from the next lowest in 2016 to the lowest improvement rate in the year ending 2019. Although the rank-orders are different, accident is the only other COD where, in 2019, quintile group 1 outranked quintile group 2 and where group 1 was rising and group 2 was falling in recent years. The same divergence also occurred for All CODs, but to a much lesser degree and with no decrease of the quintile group 2 rate in years ending 2018 and 2019.
5. Stroke had an unusual quintile pattern where a relatively narrow range in 2004 between the improvement rates of 0.8% widened to at least 2.0% in each year of 2007-2009, narrowed to 0.4% in 2012, and then widened again to close out 2019 with a span of 1.8%. Like other CODs discussed above, there was frequent rank-order switching with a notable switch between quintile groups 1 and 5. Quintile groups 1 and 5 had the lowest and highest improvement rates in 2004 but, by 2019, switched places putting quintile group 1 with the highest (and only positive) quintile group improvement rate in the year ending 2019.

**Figure 11**  
 FIVE-YEAR AVERAGE ANNUAL MORTALITY IMPROVEMENT BY COUNTY QUINTILE GROUPS YEARS ENDING 2004-2019



## Section 3: Methodology

The source of the mortality rates found in this report was the Centers for Disease Control and Prevention’s (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) database, released in December 2020<sup>9</sup>.

To analyze mortality by socioeconomic status, a Socioeconomic Index Score<sup>10</sup> was computed for each county. The counties were then grouped into quintiles with each quintile holding 20% of the total U.S. population. Counties in each of the quintile county groups were entered into WONDER and mortality rates for the group were retrieved. Quintile group 1 contains the counties with the lowest Socioeconomic Index Score, or the lowest socioeconomic status, and quintile group 5 contains the counties with the highest Socioeconomic Index Score, or the highest socioeconomic status. The county groups were held constant over the 1999-2019 period and based on total U.S. data from 2014-2018. Any reference to “All Counties” refers to the entire U.S. population or all U.S. counties.

The mortality rates from WONDER are based on annual death data and, generally, mid-year populations. For any mortality rate calculation, deaths for age  $x$  are equal to calendar year deaths between ages  $x$  and  $x+1$  and the populations are estimates from the U.S. Census Bureau. See the CDC WONDER ‘Dataset Documentation’ for more information<sup>11</sup>.

Age group mortality rates in this report are derived using calendar-year deaths and population from WONDER with rates per 100,000 rounded to six decimal places. All subsequent calculations for mortality improvement and age-adjusted mortality rates use these rounded rates.

Mortality improvement rates in this report are geometric average annual rates of improvement. They are derived as follows for age  $x$  over an  $n$  year period ending in calendar year  $CY$ .

$$1 - \left( \frac{q_x^{CY}}{q_x^{CY-n}} \right)^{\left( \frac{1}{n} \right)}$$

All mortality rates shown in this report, other than those shown for ten-year age groups, are age-adjusted rates based on the CDC’s non-standard population option of 2010. The non-standard population in 2010 was chosen here as opposed to the 2000 standard population, used in age-adjusted rates published by the CDC, because 2010 was more central to the mid-point of the years of data, 1999-2019, covered in this report. To achieve consistent comparisons across gender, all age-adjusted rates were determined using the 2010 combined female and male age group distribution. Age-adjusted mortality rates and improvement in this report are based on age only with no demographic adjustments for mixes of gender or race.

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<sup>9</sup>Centers for Disease Control and Prevention, National Center for Health Statistics. Underlying Cause of Death 1999-2019 on CDC WONDER Online Database, released in 2020. Data are from the Multiple Cause of Death Files, 1999-2019, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Accessed at <http://wonder.cdc.gov/ucd-icd10.html> on various dates December 2020.

<sup>10</sup>Society of Actuaries. Mortality by Socioeconomic Category in the United States. <https://www.soa.org/resources/research-reports/2020/us-mort-rate-socioeconomic/>. November 2020.

<sup>11</sup> Source: <https://wonder.cdc.gov/wonder/help/ucd.html#>

Age-adjusted rates in this report are calculated as follows using 2010 as the base year and rounded to six decimal places.

$$\sum_{n=1}^{11} Pct_{Age_n} * q_{Age_n}$$

Where:

$Age_n$  = Age group  $n$  (11 age groups)

$Pct_{Age_n}$  = % of age group  $n$  2010 Population

$q_{Age_n}$  = Calendar year crude  $q_x$  for age group  $n$

Attributions of mortality improvement by ages and CODs shown in section 2 are determined as follows:

**Age Group Attribution**

Age group  $n$  attribution to all ages improvement is:

$$\frac{Pct_{Age_1} * q_{Age_1}}{\sum_{n=1}^{11} Pct_{Age_n} * q_{Age_n}} * Improvement_{Age_1}$$

Where:

$Age_n$  = Age group  $n$  (11 age groups)

$Pct_{Age_n}$  = % of age group  $n$  2010 Population

$q_{Age_n}$  = 2018 Crude  $q_x$  for age group  $n$

$Improvement_{Age_n}$  = Age group  $n$  2019 mortality improvement rate

$q_{Age_n}$  and  $Improvement_{Age_n}$  are based on crude rates per 100,000 lives rounded to one decimal place, which is consistent with age-adjustment calculation methodology<sup>12</sup>.

**COD Attribution**

COD is simpler because COD mortality improvement is already expressed on an age-adjusted basis. Unrounded values are used.

$COD_n$  attribution to all causes mortality improvement is:

$$\frac{q^{COD_n}}{q^{COD_{All}}} * Improvement_{COD_n}$$

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<sup>12</sup> Source: <https://wonder.cdc.gov/wonder/help/ucd.html#>

Where:

$q^{COD_n}$  = 2018 COD<sub>n</sub> age-adjusted mortality rate

$q^{COD_{All}}$  = 2018 age-adjusted mortality rate for all causes of mortality

$Improvement_{COD_n}$  = COD<sub>n</sub> 2019 mortality improvement rate

To meet the CDC’s privacy data use requirements, calculated annual improvement values are not shown for age groups where the number of deaths for that age group was less than ten in any one year.

The NCHS’s rankable causes of death are a subset of its “113 Selected Causes of Death.” The selected 11 causes of death covered in the report are, with three exceptions, the top five rankable causes of death in 2019 for each of the ten-year age and gender groups available in WONDER. Because of limited interest, two of the top five rankable CODs for ages <1 were excluded<sup>13</sup>, while flu & pneumonia, which was not in the top rankable causes, was included due to interest in that COD. Below is a table of the 11 selected causes of death covered in this report and their International Classification of Diseases, Tenth Revision<sup>14</sup> (ICD-10) 113 Code and Cause List as they appear in WONDER.

Report Cause of Death	ICD-10 113 Code	ICD-10 113 Cause List (with ICD-10 codes)
<b>Physiological:</b>		
Alzheimer's/Dementia <sup>15</sup>	GR113-052	#Alzheimer's disease (G30)
Cancer	GR113-019	#Malignant neoplasms (C00-C97)
Diabetes	GR113-046	#Diabetes mellitus (E10-E14)
Flu/Pneumonia	GR113-076	#Influenza and pneumonia (J09-J18)
Heart	GR113-054	#Diseases of heart (I00-I09,I11,I13,I20-I51)
Liver	GR113-093	#Chronic liver disease and cirrhosis (K70,K73-K74)
Pulmonary	GR113-082	#Chronic lower respiratory diseases (J40-J47)
Stroke	GR113-070	#Cerebrovascular diseases (I60-I69)
<b>External:</b>		
Accidents	GR113-112	#Accidents (unintentional injuries) (V01-X59,Y85-Y86)
Assault	GR113-127	#Assault (homicide) (*U01-*U02,X85-Y09,Y87.1)
Suicide	GR113-124	#Intentional self-harm (suicide) (*U03,X60-X84,Y87.0)

For opioid deaths by opioid type, the method to identify drug overdose deaths involving opioids was taken from the Increases in Drug Overdose Deaths in the United States, 1999–2018<sup>16</sup>. These deaths were identified by the ICD-10 underlying cause-of-death codes X40–44 (unintentional), X60–64 (suicide), X85 (homicide), or Y10–Y14 (undetermined intent) in combination with any one of the following multiple cause-of-death codes: T40.0 (opium); heroin (T40.1); natural/semisynthetic opioids (T40.2); methadone (T40.3); synthetic opioids other than methadone (T40.4); or other and unspecified narcotics (T40.6).

<sup>13</sup> GR113-108 - Certain conditions originating in the perinatal period (P00-P96) and GR113-109 - Congenital malformations, deformations and chromosomal abnormalities (Q00-Q99)

<sup>14</sup> World Health Organization <https://icd.who.int/browse10/2016/en>

<sup>15</sup> Dementia is not one of the NCHS’s rankable causes of death but has been included with the review of Alzheimer’s. The ICD-10 codes for Dementia are (F01, F03)

<sup>16</sup> Hedegaard H, Miniño AM, Warner M. Drug overdose deaths in the United States, 1999–2018. NCHS Data Brief, no 356. Hyattsville, MD: National Center for Health Statistics. 2020.

Appendices with the following data and information can be found in an accompanying Excel file.

- A. Age-Adjusted Death Rates used to produce graphs, tables, and observations in this report.
- B. Age Group Rates used to produce tables and observations in this report.
- C. Age-Adjusted Rates by Opioid Type used to produce tables and observations in this report.
- D. Links to sample CDC WONDER queries<sup>17</sup> used to pull values for the 'All' and 'Opioid' CODs analyses.
- E. Listings of the counties in each of the five socioeconomic county groups.

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<sup>17</sup> The SOA is not responsible if these links do not continue to work and will not update them if they break.

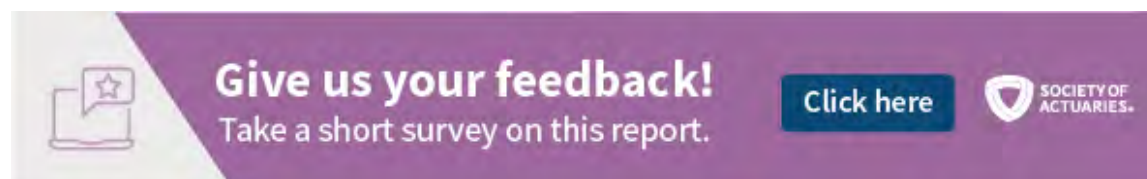
## Section 4: Reliances and Limitations



Data to calculate mortality rates in this report were drawn from the Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) database. There are limited instances where the mortality rates, associated mortality improvement, or comparative results between the quintile county groups and All Counties are not shown. This is because death counts of less than ten for sub-national data are suppressed by WONDER.

Data provided through WONDER is subject to restricted use for health statistical reporting and analysis. This research confines itself to those parameters. While the data may be useful for application in specific purposes, no assessment has been made concerning the applicability of this experience to other such purposes.

Opioid deaths overlap with the accident, assault, and suicide deaths analyzed in this report. The opioid deaths have a meaningful impact on the accident results and, therefore, have been removed from accident deaths in a separate COD analysis shown as Accident no Opioids. The impact of opioid deaths in the assault and suicide analyses was deemed to be immaterial and, therefore, not included in this report.

This report does not attempt to comment on changes or improvements in the process to record cause of death codes over the report horizon and their potential impact on observations noted in this report. For example, given some possible limitations regarding the accuracy or completeness of the assignment of COD, some of the deaths associated with the increases in 2016-2019, where opioid deaths were removed from the accident death analysis, could in fact be opioid-related. Potential changes in recording processes should be considered if utilizing the information provided in this report.



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